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SUDAN

AGRICULTURAL STRATEGY ASSESSMENT

SUMMARY REPORT

prepared for the
UNITED STATES AGENCY FOR INTERNATIONAL DEVELOPMENT

by



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PREFACE

A team of five consultants was contracted by USAID/Khartoum with DAI and RTI in 1981 in order to help the Mission design a strategy for assistance to agricultural development.

In accordance with the terms of reference, the team was to perform its task essentially through a review of relevant documents, "particularly those related to the development of the southern region and the country's traditional rainfed areas", and through consultations with officials and specialists of the Government of Sudan (GOS) and of the USAID and other donor organizations. Analysis was to "focus primarily on specific constraints to increased agricultural production and marketing in traditional rainfed farming areas." Findings regarding constraints were to be summarized, and "alternatives and realistic approaches for helping the GOS to overcome these constraints" were to be outlined with GOS and USAID staff. A draft report was to be submitted to USAID/Khartoum prior to the team's departure, as well as to AID/Washington, and a "final report" was to be submitted within a month of the team's return.

The field team that visited the Sudan for about seven weeks between August and October, 1981 was composed of Donald Humpal and James Ogborn (DAI) - agronomists; Eric Shearer (RTI) agricultural economist, and Abdi Zahedani (DAI) - economist and team leader. David Franklin (RTI Consultant) visited Khartoum towards the end of the field work in order to look into the macro-economic policy aspects.

The field team reviewed virtually all relevant documentation and interviewed key GOS and donor personnel in Khartoum. The team also visited the South for approximately ten days, and several members also visited other areas and projects in Western and Central Sudan.

A draft report on the South, with recommendations for priority action, and an executive summary, were delivered to USAID/Khartoum shortly after the team's visit to the region; these were discussed with the Mission Director and other key personnel in an all-day meeting. Other drafts, on the West and on selected national aspects and issues, were delivered shortly before the team's departure; there was no opportunity to discuss these drafts.

Preparation of a final report was postponed pending receipt of USAID Mission comments on the material submitted in Khartoum. In late November, DAI and RTI were informed that the Mission had requested preparation of a 50-page summary report. The project deadline was extended until January 31, 1982. Substantive guidance from the Mission was provided in the form of a suggested outline.

The present Summary Report reflects efforts by Don Humpal and Eric Shearer in December and January to condense the team's key findings, conclusions and recommendations into a useful and readable document.

Aside from acknowledging the courteous cooperation of the USAID Director, Arthur Mudge, and of several other Mission officers and staff, the team wishes to express its special appreciation to the personnel of the Southern Manpower Development project in Juba for their hospitality and cooperation, and to Dr. E.A.A. Zaki, Deputy Undersecretary of the Ministry of Planning, for valuable comments during an extended visit to the Triangle area, in December.

The strategy priorities and alternatives suggested here are not meant to be definitive; they represent the best judgment of the DAI/RTI team based on available information and time available to digest it. The final choices of USAID approach and concrete project assistance will of course, be determined by the Mission in consultation with the GOS.

TABLE OF CONTENTS

	<u>Page</u>
A. EXECUTIVE SUMMARY	1
B. MAJOR PRODUCTION SYSTEMS AND REGIONS	4
1. The Regions	4
a. The East	4
b. The West	4
c. The South	5
2. The Farming Systems	5
a. The Irrigated Sub-Sector	6
b. Rainfed Agriculture	8
i. Mechanized Rainfed Agriculture	9
ii. Traditional Rainfed Agriculture	11
iii. The Role of Livestock: Productivity and Environmental Degradation	12
c. The Wage Labor Conundrum: Economic/Social Aspects	13
C. CONSTRAINTS TO AGRICULTURAL DEVELOPMENT	15
1. Ecological Constraints	15
a. Land	15
b. Desertification	15
c. Long-Term Climatic Change	18
d. Other Man-Made Environmental Problems	18
2. Physical Infrastructure	19
a. East	19
b. West	19
c. South	20
3. Farm Level Constraints In Rainfed Agriculture	21
4. Institutional, Economic and Financial Policy Constraints	22
D. APPROACHES TO OVERCOMING KEY CONSTRAINTS	25
1. Overcoming Policy Constraints	25
2. Overcoming Institutional Constraints	26
3. Overcoming Infrastructure Constraints	26
4. Overcoming Farm Level Constraints	28

	Page
E. SUGGESTED PRIORITIES	33
1. Policy Sensitive Investment	34
2. Choice of Sub-Sector Concentration	34
3. Geographic Focus	36
4. Priorities of Strategy Elements	36
a. Policy	36
b. Institutions	37
c. Infrastructure	38
d. Macrotechnology	39
e. Farm Technology	39
f. Research	40

EXECUTIVE SUMMARY

Based on review of past development history in Sudan and the current state of the economy, institutions, and infrastructure, only policy and price changes are likely to have a significant, nationwide short-term impact on agricultural production. This requires a fundamental shift in how donors and lenders view project type development assistance in Sudan. Current donor emphasis should be on better management of their project portfolios while a vigorous effort is made to promote policy change and support it with new and reorganized medium and long-term development projects to protect and extend the improvements expected if policy changes are implemented.

Frank recognition of the policy and institutional problems by the Head of State in his courageous speech of November 9, 1981 may well be the turning point in the economy's downward drift of the past decade. If it is not, all the objectively valid advice from external consultants and institutions will not further Sudan's development. The policy changes on which the IMF and the World Bank have been insisting for some time were either implemented or announced for gradual introduction in the near future in the President's speech. They have to do with the near future in the President's speech. They have to do with the exchange rate, import and export taxation, subsidies on mass consumption commodities and the treatment of cotton growers. Remaining policy issues - mainly the internal tax structure - are discussed briefly in the report.

Sectorial and Regional Priorities.

There is a natural temptation to assume that - if reliable comparative data were available - marginal return analysis may suggest that investment of project assistance in the irrigated subsector will produce the greatest impact, especially on the Sudanese balance of payments and in the comparatively short run. Unfortunately, comparative data are not available; the performance of the irrigated sector in the past decade has been discouraging, and the imaginary marginal analysis probably does not account for external economies, social costs and returns and the special discount factor that - based on experience - must be applied to development projects in the Sudan to allow for extra-long gestation. Finally, one has the impression that current IBRD assistance to the subsector is about all the present institutions can profitably absorb.

On the other hand, the rapid response of the rainfed subsector to the appropriate policy incentives, and its relatively modest requirements for imported investment and operating capital, are being increasingly recognized by national and external officialdom, as illustrated in President Nimeiry's November speech.

It would appear that considerations of production diversification, regional socio-political equity (especially in view of recently begun political and administrative decentralization) and long-term environmental protection should suggest to external lenders/donors that development projects should be in support of rainfed agriculture in the West and in the South. While entrepreneurial schemes, such as the mechanized farming leases, will doubtless yield faster returns, the long-term rate of return is probably higher for investment in the simple, intermediate-technology improvements in traditional rainfed agriculture. The latter

concerns the vast majority of Sudan's rural population despite the enormous amount of seasonal wage labor demanded by the other two sub-sectors.

The following is a summary of our recommendations for donor/lender strategy, with special reference to USAID, in the fields of institution building and reform, basic infrastructure, applied technology and research.

Institutions.

Both ministerial and parastatal institutions have major organizational and management problems, compounded by inappropriate involvement in production, transportation, and processing. The creation of new regional ministries of agriculture has increased the need for institutional capacity building and human resource development. In the East and West organizational and management training is needed at all levels to ensure that development inputs are efficiently used. In the Southern region a massive long-term training program with a ten-year time horizon and commitment is essential. Without such an effort tangible signs of development of the South will not be evident for at least another generation.

Medium-term returns can be expected from careful scrutiny of the parastatal institutions to determine which functions ought to be reallocated to the private sector. Management contracts with expatriate businesses, private voluntary organizations, and perhaps Sudanese enterprises will probably have to be employed as a stop-gap managerial measure until commercial feasibility can be determined and Sudanese managerial capacity is improved. Consideration will have to be given to non-coercive measures designed to stem the brain drain to the Arabian peninsula. "Devolution" of functions to the private sector may contribute importantly to this end as well.

Infrastructure.

Sudan has greatly handicapped its agricultural sector by permitting its long-distance river and rail transport systems to deteriorate. Instead of concentrating on infrastructure building and maintenance and on regulation, the public sector has done a terrible job of trying to provide the transport services. Donors should support moves to reallocate transport service to the private sector (at the very least for the river transport system) and to shift state responsibility to better regulation and maintenance of the traffic arteries.

The importance of road transport for the agricultural markets and, thus, for production, is paramount in the West and South. While on-going construction will fill out main trunk routes and road-to-rail-links, measures to institutionalize maintenance capacity have so far been ineffectual. For the foreseeable future, donor investment in roads should be designed first and foremost to develop regional maintenance capacity.

Lack of storage infrastructure has unfavorable price effects for producers and consumers and acts as a disincentive for market production throughout the nation. In the East, the biggest problem appears to be transport programming and intermediate storage of the cotton crop. In the West, low storage capacity and quality restricts both cereal and oilseed production and greatly increases vegetable oil costs. In the

South, lack of adequate central and town stores has frustrated implementation of strategy for assuring adequate urban grain supplies.

It is recommended that donors study storage needs and then use a combination grant/loan program to build and manage adequate grain stores in the Southern Region. In the West, a loan program should be sufficient to spur storage construction if combined with private sector management contracts.

Macrotechnology.

Current concerns about the short-term impact of desertification on production and land degradation cannot be effectively addressed by the localized scope of operations proposed by DECARP and UNSO, although the measures appear to be technically quite feasible. However, it is believed that both short-term productivity and long-term environmental protection can be positively affected by large scale phosphate applications on semi-arid areas. A pilot program is recommended for the near term.

Tsetse fly infestation restricts animal production and the range of application of animal traction technology. However, while control technologies are available, marketing problems limit the potential for rational expansion of livestock production and animal traction. Surveys and control measures do not warrant major investment at this time.

Farm Technology.

Farm technology development is constrained by the overall policy, institutional and infrastructure problems. As some of these constraints are relieved, a range of technologies may be introduced for increasing production, incomes and productivity.

- o Short-term effects may be obtained with on-farm storage, small-scale processing and specific pesticide applications.
- o Medium-term impact may be expected from takeover by private management contract of parastatal farming and machinery services, small holder herbicide measures, some localized sand dune stabilization techniques, and private sector takeover of seed production.
- o In the long-term, animal traction has an attractive payoff potential.

Research.

Agricultural research in the rainfed subsectors has been weakly supported and has had much of its technological scope determined by inappropriate transfer from the irrigated subsector.

- o In the near-term, rapid reconnaissance of farming systems to determine labor, practice and varietal potentials and problems is critical for orientation of research programs.
- o Agroclimatological analysis using available data is a quick way to prescreen technology for the semi-arid and sub-humid zones.

- o Herbicide use trials and economic analysis should lead to resolution of the seasonal labor constraint encountered in both mechanized and traditional systems.
- o Special emphasis should be placed on screening of delayed shattering and nonshattering sesame varieties.
- o Periodic range and livestock surveys are urgently needed to inform policymakers on the rapidly deteriorating range conditions in Kassla.
- o Medium-term impact can be expected from research on sesame harvesters, tall platform harvesters for sorghum, better organized and staffed variety trials, seed bulking, farm technology testing, and reclassification of agronomic potential zones according to more realistic development criteria.
- o Long-term impact may be expected from tsetse survey and field evaluation of control measures.

Perhaps the most valuable advice that can be given to external donor/lenders bent on helping Sudan is that - except in isolated cases - expectation of short-term payoff from development investments of any kind can only lead to continued national and international frustration. Agriculture anywhere in the developing world is not a quick payoff sector; in Sudan experience shows that returns can be expected only in the medium and long run. This calls for much donor patience and for long-term commitments of both funds and expatriate manpower.

B. MAJOR PRODUCTION SYSTEMS AND REGIONS

The three major systems of farming in Sudan, in addition to the limited areas of pure nomadic and semi-nomadic livestock herding in the extreme north and northwest are:

1. irrigated agriculture, concentrated mostly along the Blue and White Nile Valleys between the 11th and 15th parallels;
2. mechanized, rainfed agriculture, typical of the east-central Sudan where rainfall exceeds 600 mm, and
3. traditional rainfed agriculture, typical of the west and south, and including most of the country's livestock.

Climate and soils, together with the native flora and fauna, create the potential and restrictions for use of the landscape for agricultural purposes. The vastness of Sudan translates into great ecological, human and institutional diversity and corresponding complexity in rainfed and irrigated agriculture. It should be borne in mind that these are broad geographic groupings, not to be confused with the administrative regions established in early 1981.

1. THE REGIONS

a. The East

The East is dominated by the Blue and White Niles and the riverine ecology and economies developed under their influence. It is an area of massive irrigation schemes and large-scale mechanized production. Among and around these schemes are zones of traditional crop and livestock producers who are gradually, but inexorably, being squeezed by the continuing expansion of the modern mechanized schemes. While the rivers provide water security for the irrigated sector, both mechanized and traditional production units depend on a semi-arid rainfed environment similar to that of the West. The major ecological distinction between the East and the West -- which are both climatically semi-arid -- apart from the rivers, is the greater proportion of heavy cracking and non-cracking clays in the former. A much more important difference is the relatively well-developed physical, financial and administrative infrastructure of the East in comparison with the West and South. Population densities of both people and livestock are high and the level of social services and employment opportunities much greater than in other areas. Agriculture is highly integrated with the export and processing sectors of the national economy.

b. The West

In the West, agriculture is almost completely rainfed. It succeeds or fails according to annual rainfall and management of the available soil and vegetation resources. Large differences in soils and their drainage and water holding characteristics impose restrictions on the

types of crop grown and the patterns of rangeland use. The more coarsely textured "qoz" sand belts with lower water holding capacity support millet production and wet season grazing for the transhumant pastoralists. The intermediate clays and cracking clays support dura (sorghum) and sesame production by sedentary small-scale cultivators, large-scale mechanized sorghum (and some cotton) production, and dry season grazing for the pastoralists. Besides crops and livestock, the West supports a very important gum arabic gathering economy now threatened by environmental degradation in the major habitats for Acacia senegal. Population concentrations have developed in the principal areas of rainfed cultivation, and urbanization has accelerated as more and more of the transhumant population has become sedentary.

c. The South

The South's main distinguishing ecological feature is the vast White Nile drainage system which creates the barrier marsh or Sudd, long the effective demarcation between northern, Arab cultures and southern, Black African ones. In general, the South's higher rainfall gives it a greater natural production potential than the East or West. However, seventeen years of civil disturbances destroyed the limited physical and social infrastructure that had been put in place before independence. The Nilotic tribes form the major ethnic groups. Most are agropastoralists whose existence is finely tuned to subsistence needs and to the potential of the various environments in which they live. Their subsistence systems enable the South's people to support themselves with minimal material inputs.

Population distribution varies considerably. While overall population density is low, concentration occurs where road infrastructure has been developed, rainy season flooding can be avoided, tsetse exposure is reduced, and more fertile soils are found.

The South's comparatively high crop diversification at the farm level, combined with the high levels of consumption of milk products from cattle (among the Nilotes and other pastoral groups) and the consumption of game, appear to provide many rural inhabitants with diets relatively high in protein. The general picture of diversity of the farm production base does not translate into a picture of regional well-being because of the extreme fragmentation of the area, the tremendous difficulties in transportation and communication both within the Region and with the rest of the country, the rudimentary administrative structures (and their low operational capabilities), and the weak revenue base.

2. THE FARMING SYSTEMS

Traditional agriculture is said to be the way of life of about 80 percent of the country's rural households; it covers more than half the total cultivated area. Irrigated farming is probably next in employment -- though mostly as temporary wage labor -- but covers only about 20 percent of the cropland. Employment in the mechanized areas is smaller, even though they cover almost one-third of the cultivated area. (Table 1.)

Table 1. Sudan: Estimated Cultivated Area by Farming and Operating Systems, 1979

<u>Cultivated Areas</u>		
-OVERALL-		
<u>Farming System</u>	<u>Million Feddans</u>	<u>Percent</u>
Irrigated	4.17	16
Mechanized Rainfed	5.76 ^{1/}	22
Traditional Rainfed	<u>16.75</u>	<u>62</u>
Total	<u>26.68</u>	<u>100</u>
-In Irrigated Systems-		
<u>Operating System</u>		
Corporation Tenants	3.8	91
Government Estates	.24	6
Private Independent Operators	<u>.13</u>	<u>3</u>
Total	<u>4.17</u>	<u>100</u>
-In Mechanized Rainfed System-		
<u>Operating System</u>		
Licensed Private Farmers	3.5 ^{1/}	61
State Farms	.36	6
Estates	<u>1.9</u>	<u>33</u>
Total	<u>5.76</u>	<u>100</u>

^{1/} Unlicensed acreage is estimated variously from about 3 million feddan to "more than the licensed area", i.e., over 3.5 million feddan. If this is added, total cultivated areas rised to about 30 million feddan, and rainfed mechanized area to about nine million, i.e., about 30 percent of the new total.

SOURCE: Agricultural Bank of the Sudan, Agricultural Services Project, Preparation Report, Vol. I, Main Report, August, 1979 (except for unlicensed estimates).

a. The Irrigated Sub-Sector

Irrigated farming has been practiced in the traditional fashion in the Nile valley at least since the beginning of recorded history. But the British colonial administration's creation of the publicly owned and managed irrigated Gezira cotton growing scheme near Wad Medani south of Khartoum in 1925 pointed the way to what has become the most important economic activity in the country and the biggest earner of foreign exchange. There are now four million feddans under irrigation in the 20 publicly promoted (and/or managed) schemes that depend on the Nile River; only about 150,000 feddans included in irrigation schemes are not dependent on water from the Nile.

Two-thirds of all irrigated land is gravity-fed. Large-scale irrigation schemes (20,000 feddans and more) cover three-fourths of the total irrigated area, and nearly three-fourths of the three million feddans are concentrated in 13 schemes. Medium-sized schemes (200 to 20,000 feddans) -- mainly nationalized pump schemes -- occupy less than one million feddans. Several thousand small-scale, private schemes cover about 300,000 feddans (seven percent of the total).

The largest and best-known of the public schemes is the Gezira Scheme. This currently comprises over two million feddans, managed and controlled by the giant Sudan Gezira Board (SGB) with headquarters in Wad Medani.

Of the total gross area under irrigation in the Sudan only about 55 percent was actually in crops in 1972/73. In 1978/79, more than one-third of the nearly 2.5 million irrigated feddans in crops were planted to cotton; sorghum and wheat each accounted for about one-fourth of the area.

Sugarcane has been confined to two schemes and the area has not varied materially in recent years. Four new projects are under construction, however, and these are expected to raise sugar production about 50 percent above domestic requirements by 1984/85, compared with 50 percent of domestic requirements at present.

While irrigated agriculture still supplies the bulk of the Sudan's exports (mainly long staple cotton), there is widespread dissatisfaction with the performance of the irrigation schemes. It is probably fair to say that the underlying problem is the size of the schemes which makes completely centralized, public control of all operations impractical. Declining maintenance of facilities and poor water programming over the past two decades, as well as ever-worsening relations with the schemes' tenants, have led to declining factor productivity. Yields are static or declining, especially for cotton, but also in the case of the foodcrops -- groundnuts, dura and wheat -- whose yields are substantially below those achieved with irrigation in other tropical and sub-tropical zones of the world.

Government price policies and contractual arrangements with tenants are great disincentives for growing cotton, but tenants are obliged to grow minimum allotments under threat of being evicted. They stay on the schemes because the economy does not offer any better opportunities. Also, the other crops are profitable (in part because all land rent and water fees are charged to the cotton crop), leading farmers to minimize their inputs into cotton growing and even harvesting.

It is now generally recognized that an important strategic error in recent years has been the channeling of substantial resources into new irrigation schemes while starving the existing ones. The World Bank and the GOS are now beginning to devote considerable financial and manpower resources to rehabilitation efforts -- especially in the Gezira complex -- comprising engineering, agronomic, economic and managerial aspects. However, while the government has committed itself to undertaking largely unspecified reforms of a structural and policy nature, there is no assurance that the political power of the autonomous scheme corporations (especially the SGB) and of the tenants will allow the introduction of the objectively desirable changes. These would probably involve essentially (a) greater freedom of decision-making and co-responsibility in management by tenants, (b) tenure reforms to reduce absenteeism and extra-legal subterfuges, and (c) the modification of land and water charges so as to allocate costs appropriately among crops, intensify land use, rationalize water use and provide the State corporations with sufficient funds to maintain the schemes in proper working order, and (d) new directions in, and better enforcement of, plant protection measures.

The effects of recent and present economic policies (prices, foreign exchange, taxation) on the output and profitability of irrigated crops are discussed at the end of this section and in Section C.

b. Rainfed Agriculture

Rainfed agriculture covers the greatest cultivated surface area (about 23 million feddans) and ranges from the practical northern limit for rainfed cultivation (300-400 mm of rainfall) to humid, nearly sub-tropical conditions in the higher elevations of the Southern Region. The northern limit represents the point at which the likelihood that crop and livestock production will succeed -- i.e., produce acceptable amounts of food and forage -- is exceeded by the likelihood that it will fail and/or induce unacceptable degradation of the natural resource base. Under existing conditions of soil nutrient status, crop and forage production is mainly a function of the amount of rainfall and its distribution during the growing season.

Overall, rainfed agriculture contributes most of the country's production of sorghum and all of its millet. In a good year and with appropriate incentives the rainfed areas alone could probably ensure Sudan's cereal self-sufficiency. The rainfed sector also contributes over 90 percent of the total output of groundnuts and sesame, both also major food and export crops. The rainfed sector accounts for one-third of all exports and it generates 60 percent of total agricultural output, equivalent to 25 percent of the gross domestic product.

Two types of agricultural systems can be distinguished in the rainfed areas: large-scale mechanized farming and small-scale traditional farming and livestock keeping. By and large, they are found in different areas -- the former in the East and the latter in the West and South. However, it is not unusual for mechanized farming schemes to displace traditional farmers and pastoralists (especially the semi-nomadic among the latter) in the East.

i. Mechanized Rainfed Agriculture.^{1/}

Towards the end of World War II the colonial administration began to sponsor several large-scale mechanized farming projects designed to help overcome food shortages. The early projects, which never covered more than 31,000 feddans until 1953 (with an annual average of 14,000), were started as state farms but were later converted to a sharecropping system with local farmers, based on 23-feddan units, when it became evident that full mechanization of all operations was not feasible. The sharecropping system, too, was abandoned in 1953.

A 1954 commission made a series of well-conceived recommendations, of which only rapid horizontal expansion of mechanized schemes with maximum private sector participation was implemented. At this time there are less than 1/2 million feddans in five State farms. The remainder of the 5.2 million feddans in official schemes as of 1977 are almost^{2/} entirely allocated to tenants in blocks of 1,000 to 1,500 feddans each. The Mechanized Farming Corporation (MFC) is now in the process of turning over its State farming projects to the private sector. The MFC is currently cropping only about 80,000 feddans for its own account.

The MFC was created in 1967 as a part of the IBRD's first mechanized farming loan project. At present it administers all of the schemes where rainfed mechanized farming is practiced by "licensed" tenants. It is also being made responsible for rationalizing the estimated 3 million-plus feddans in "unlicensed" mechanized farming blocks that have sprung up. The principal criteria in the rationalization process will be (a) assurance that the land falls above the 600 mm isohyet - a sine qua non of rainfed mechanized schemes; and (b) limitation of the rental contract for each individual to the maximum 1,500 feddans.

Rental contracts are made for 25 years. From 1971 until December, 1981, rental charges had been a nominal five to ten piasters per feddan. Beginning on January 1, 1982 (partly under World Bank prodding) rentals will be a flat LS 1 per feddan. This will be more than enough to cover the MFC's operating expenses, although it will still fall short of the land's economic rent, as indicated by the LS 3 to LS 4 being charged for (extra-legal) subtenancies near roads.

The MFC's services in the leased schemes - aside from land clearance - are now limited to providing maintenance, service and repair facilities for the tractors. However, the MFC does not try to monopolize the service facilities; in fact, MFC management freely admits that their private competitors tend to be more efficient. The tractors are sold to the farmers by the Agricultural Bank on five-year credit, normally one for each 1,000 - 1,500 feddans. Land clearing is either the tenant's responsibility, or it is done for them by the MFC with the use of hand

^{1/} See World Bank map No. 13055.

^{2/} The amplification to 1,500 feddans was introduced in order to leave sufficient margin for fallowing; it was found that tenants preferred to utilize their tractors to their full 1,000-feddan capacity.

labor and, in some cases, heavy rooting equipment, for an average charge of LS 10 per feddan.^{1/}

In an attempt to attract large-scale entrepreneurs, including foreign investors, to the expansion of mechanized farming in the Sudan, the government allocated nearly 900,000 feddans to seven large companies in 1977, and was processing applications for another one million feddans. Only 55,000 feddan of these concessions have been developed to date.

Sorghum has been the dominant crop on the land of the tenants, followed by sesame. Cotton is grown by very few tenants. Despite the rising cost of both machinery and fuel and to some extent of farm labor (see below) - sorghum prices have been strong enough to continue making this a profitable crop with the prevailing technology. Sorghum production in the Sudan has been rising at a compound rate of 2.5 percent in the 20 years from 1959/60 to 1978/79. Virtually all the marketable sorghum has come from the mechanized schemes.

Two important facts stand out as one examines the farming system known as "mechanized rainfed agriculture": (1) it is only partly mechanized, and (2) it is extremely land extensive. Tractors are used only for soil preparation and planting. The low price of hand labor has apparently prevented the generalized use of combines for harvesting sorghum even where combinable varieties are grown.^{2/} This means that the schemes - as do the irrigated ones - require enormous amounts of seasonal farm labor for weeding and harvesting (see below).

While the rainfed mechanized farming in the Sudan is thus both labor and capital (tractor) intensive, it is quite land extensive. Not only are yields low (around 300 kg per feddan for dura), but the system also requires that one-fourth to one-fifth of the area farmed be in fallow in order to let nitrogen build up without having to resort to fertilizer.^{3/}

Since the Sudan still has an estimated 100 million feddans that could be brought into this type of agriculture, it would seem that the system is quite rational as regards national resource allocation.

It also appears that the allotment of at least 1,000 feddans per tenant is quite justified as long as one of the main objectives of the system is to attract entrepreneurial types who have - or can borrow - the initial capital, and the opportunity cost of whose time in alternative ventures is relatively high. The standard acreage, of course, was originally meant to support economically one large tractor and harrow. It was rightly decided that the machinery would be used and serviced appropriately only if it were sold to individual farmers. Public machine rental was, fortunately, abandoned quite early; cooperatives were non-existent, and illiterate small farmers could not be trained fast enough in tractor operation, maintenance and repair. The World Bank estimates

^{1/} Roads and water development - costing about LS 20 per feddan - are apparently not included in the charge.

^{2/} In the Gedaref Scheme, only one-third of the farmers use combines although the cost per sack of dura is only one-fourth of that of manual harvesting with or without mechanical threshing.

^{3/} Unfortunately, many tenants do not practice fallowing, and the MFC obviously does not enforce it.

that, if weather and market risk is accounted for, the average farmer could net only between LS 3,000 and LS 5,000 from his 1,000-feddan spread at 1976 prices. Yet, in three case studies of private farms in three different schemes (two with 1,500 feddans each, and one with 2,000), net returns in the study year ranged from LS 9,000 to LS 16,000.

The rationality of the system for the national economy can also be gauged from a slight rearrangement of these case study data. For example, at market prices, in the case of the farmer with 1,500 feddans (1,125 cropped) in the Simsim scheme, added value was equivalent to 5.5 times the annual charge for imported investment and operating expenditure. None of the three used any imported goods aside from the machinery and oil products, and all employed hand labor for harvesting.

There remains the important socio-political question regarding the extra-official but tolerated combining of allotments by some of the more enterprising tenants, a few of whom are known to control as much as 30,000 to 40,000 feddans and to have become millionaires. However, until and unless day laborers are prepared to jointly manage such large farms with at least the same efficiency as the large operators, there would seem to be no alternative to the present system. Higher rents and taxation should be able to satisfy distributional considerations somewhat in the meantime, without at the same time becoming disincentives for middle-class entrepreneurs.

There may also be cause for concern over "unauthorized" expansion of mechanized farming into areas with an average of less than 600 mm of rainfall and into the lighter textured, more erodible soils, both in the east and in the west. The concerns are ecological and economic i.e., over soil and vegetation degradation, on the one hand, and the extinction of the gum arabic tree as an income source and the returns to the investment in imported machinery, on the other. The government apparatus may be put to a hard test if it attempts, as it should, to control this phenomenon.

While attempts have been made to introduce mechanization to the Southern region where environmental conditions are more favorable for crop production, there has been little success mainly due to infrastructure, organizational, and managerial problems. There are also serious ecological constraints for mechanization on the Ironstone plateau.

ii. Traditional Rainfed Agriculture.

Traditional rainfed farming in the Sudan is a bit like the weather: everybody talks about it but nobody does much about it. However, unlike the weather, it appears that some things can be done to raise output, productivity and incomes among the approximately 80 percent of the Sudan's rural population who depend on it.

A combination crop and livestock economy is typical of small farmers in virtually all well-populated areas. The main exceptions are the tsetse-infested wooded areas in the South -- where livestock cannot be kept now -- and the very dry areas (less than 300 mm rainfall) in the extreme North -- where only nomadic livestock herders are found. As rainfall increases from North to South, the traditional farms become both more diversified and smaller. In the East -- outside the irrigation districts -- and in the West, under equal rainfall conditions, the size of farm and the cropping pattern are determined by the type of soil.

The majority of traditional farmers -- particularly in the South -- produce little or no crop surplus for the market; on the other hand, most of their "offtake" of cattle and small ruminants goes to market. The traditional farm household, as elsewhere in the world, represents a producing and consuming unit whose minimum needs are given by the total size of the household, while its maximum capacity to produce is given by the number of able-bodied household members available for farm work at critical times.

Yet, a very rough calculation indicates that about half the traditional crop area produces for the market. In fact, the traditional sector is estimated to produce all of the nation's millet, 40 percent of the sesame, and a large share of the one-third of the nation's exports that is supplied by rainfed agriculture. Gum arabic is of substantial importance in the semi-arid zone; possible measures to prevent the disappearance of this resource are discussed in Sections D and E.

Subsistence rainfed farming in the semi-arid and subhumid region continues to be based on a fallow rotation whose length, agronomically speaking, depends basically on soil and rainfall. As in the case of the mechanized farms, this is an economically rational system because it substitutes a still amply available resource -- land -- for purchased (and, in the Sudan, imported) inputs in the form of fertilizer. However, in some areas, population pressure and concern with short-term benefits are beginning to reduce fallow duration below the agronomically desirable period.

Both crop production and household food consumption levels in many areas are handicapped by the disappearance of drinking water sources during part of the dry season. This forces both people and animals to migrate over considerable distances twice every year. The long trek limits the quantity of grain that can be taken, thus leading to distress sale of temporary surpluses at the time of migration away from the farmstead area, and equally to distress sale of cattle at the dry season location when the time comes to repurchase part of the grain requirement. Sometimes it leads to lengthy subsistence on a diet of nothing but milk, blood and meat (including game where this still exists). As population pressure rises, the semi-nomadic treks are also leading increasingly to friction with sedentary farmers (especially in the mechanized rainfed schemes).

iii. The Role of Livestock: Productivity and Environmental Degradation.

As in many Sahelian and sub-Saharan environments livestock and crop agriculture are closely interrelated, except in the driest environments where crop production is not possible. Livestock raising in Sudan is practiced almost entirely by traditional farmers and herders. In the more humid zones crops and livestock may be linked through the use of the same land in different seasons, such as occurs when transhumant herds forage on crop trash; the use of the same land in different years in areas of shifting cultivation; competition for the same land when either forage or water is in short supply; or, in more tightly linked systems where milk and manure are exchanged for crops or animals are directly involved in crop production (animal traction).

In the East overstocking has resulted from the growth of the huge irrigated and mechanized schemes, together with the arrival of a large livestock population which accompanied the refugee influx from Ethiopia after 1976, with continued growth in transhumant herds and increasing numbers of small ruminants along with increasing sedentary human population. It is very likely that the range would deteriorate severely in the event of an unusually dry season -- and especially after a succession of dry seasons -- as only a small grazing reserve appears to exist.

In the West livestock specialists tend to argue that there is no overgrazing. Most ecologists, however, believe that the range is overgrazed in the sense that the nomadic herds are too large for the grazing resources in certain areas. Animal census data, corrected for previous dubious assumptions, indicate that the Western provinces have an aggregate potential grazing surplus on the order of 60 percent. However, localized overgrazing does occur in the West, particularly adjacent to inhabited areas. The establishment of water supply points in areas in which rainfall is marginal for cultivated crops leads to a well-recognized succession of deterioration in concentric rings around the water-point. The overgrazing is worst close to the village where the livestock spend the night before being taken out on a daily journey in search of forage. The farthest zone of deterioration marks the limit of this daily journey. Within the radius there is another zone where almost continuous arable cropping is carried on. In this zone the land is completely cleared of trees and is so infertile that the very low crop yields scarcely permit any land to be rested in fallow. Even if some land is fallowed, it will almost inevitably be overgrazed so that there is almost no chance of a vigorous fallow vegetation developing.

The Southern Sudan has not experienced intense grazing pressure. It supports the only large populations of wild herbivores in the country, as well as the domestic stock. The region does, however, suffer from the low animal productivity and herd offtake in common with the rest of Sudan.

In general, it can be said that where crop production has created displacement of livestock populations, the process has generated increased pressure on the land. The evidence of this pressure can be seen in the deterioration of the natural vegetation around irrigation and mechanization schemes and growing settlements. People seek firewood, animals seek forage and browse, and mechanized farmers abandon land that has lost its productivity. One can expect that this pressure, and the resulting land competition and conflict will grow. Livestock, however, are not the sole cause of land degradation but part of a large set of interacting multiple uses (and misuses) of the natural land resource base.

c. The Wage Labor Conundrum: Economic/Social Aspects

The seasonal nature of cropping and the generally labor intensive technologies used up to now in the irrigated and mechanized farming schemes combine to produce an enormous demand for temporary wage labor during certain parts of the year. In strictly economic terms, this can be considered highly positive because it represents a rational use of resources; moreover, it provides great numbers of traditional farm households with some cash income, at the same time as it has helped introduce them to the money economy. Whether the net effect in social terms is turning out to be equally positive is largely a question of subjective valuation, but it is undoubtedly not as clearly positive.

A rough calculation indicates an average monthly requirement of nearly one million workers in these schemes between the months of July and February. This happens to coincide with estimates of the number of Sudanese workers moving about the country each year in search of work (including those migrating to urban areas), representing 14 percent of the total labor force.

Most of the hand labor during the "off-season," particularly in the irrigated schemes, is furnished by resident manpower from (a) the irrigation tenants and their families, (b) permanently established wage workers in the villages that dot the irrigation schemes, and (c) traditional rainfed farming households surrounding both the irrigated and the mechanized schemes.

The opportunity for both resident and migrant traditional farm family members to earn wages, however, is not an unmixed blessing even in purely economic terms. Obviously, peak labor requirements coincide more or less between the schemes and the traditional farms. Since labor insufficiency at the peak demand period -- weeding -- is the main constraint on increased traditional farm output (see Section C), it can be concluded that the seasonal (as well as permanent) drain of able-bodied labor towards the schemes is aggravating this situation. Only in certain areas are large-scale and small-scale farmers able to make some kind of adjustment that permits the latter to cultivate their own fields while earning cash wages. This is usually achieved by the small farmers' delaying their planting until after sowing is completed on the large farms, and it is possible because the small farmer who does not use mechanical power for planting can get into his fields after the rains have started. In this way, weeding can also be delayed until it is done on the large farm. Elsewhere, small farmers have started to rent the tractors from their larger neighbors.

Concern about the growing "labor shortage" is being expressed at all levels, from the traditional farm household to the entrepreneurial farmer and government planners. For the large farmer, this means essentially -- and in the foreseeable future -- having to pay higher wages and/or providing more fringe benefits such as better food and shelter and paid return travel for migrants. Nominal wages have already risen tangibly in the last few years. Payment for travel to the place of temporary employment is already the rule. So far, the schemes have represented an apparently irresistible attraction for underemployed members of traditional farming families whose opportunity cost on the home farm -- even at weeding and harvesting time -- is obviously smaller even than the meager wages in cash and food.

The social effects of this massive migrant day labor movement on the community and on the family have apparently not been studied in any detail, nor have the social conditions of the day laborers permanently settled in the small villages that dot the irrigation schemes. But a mass of farm labor without any employment security, the bulk of which is migratory, and which in its totality and at certain times of the year may encompass as much as one-fifth of the country's working population, constitutes a potential social problem of the first order, both in the short and in the long run.

C. CONSTRAINTS TO AGRICULTURAL DEVELOPMENT

1. ECOLOGICAL CONSTRAINTS

The subdivision of the country into three main geographic areas and its component agricultural systems as discussed in the previous section, is useful for distinguishing among levels of development in different parts of Sudan. It also highlights the relative importance of selected constraints to further development. However, each area contains great ecological diversity and, hence, variations in agricultural production potential. An agricultural strategy for the Sudan must be based on an understanding of the nature and extent of these variations and of how they limit development plans and projects.

a. Land.

These limits are often underestimated or ignored when Sudan's land resources are characterized as having a vast untapped potential. The truth is that recent trends in the costs of bringing new lands into production may not enable the biological potential of many areas to be economically exploited in the foreseeable future.

The first ecological constraint, then, is a land-based one. Virtually all economically utilizable land, while perhaps underutilized, is "occupied". Thus, displacement of occupants or major modification of the existing uses would have to take place before further development can occur.

The agricultural potential regions of Sudan as defined by the Sudan Soil Survey the major natural constraints of each ecological region are summarized in Table 2.

The most important point to be gathered from the table is that soil related ecological constraints are site-specific rather than country or even region-wide. Moisture stress in crops and forage plants may be due to insufficient rainfall in one area, poorly distributed rainfall in another, and poor infiltration or water-holding capacity in yet a third. In other areas, the problem is excess water rather than insufficient water. Soil constraints need to be defined locally before solutions are sought.

b. Desertification.

A large area of the western Sudan is subject to desert encroachment. Desertification is the deterioration of ecosystems to the point where sand dunes are destabilized, resulting in large scale loss of arable crop, grazing, and shrub land and consequent socioeconomic dislocation. It is the major immediate peril to the existing arid and semi-arid land-use systems and to the future development of sustainable agricultural systems with higher productivity levels. Most observers agree that human population growth and the accompanying increase in exposure of bare soil surfaces and nutrient export through agricultural activities are the prime initiators of this environmental deterioration.

TABLE 2. MAJOR SOIL-RELATED NATURAL CONSTRAINTS

(Page 1)

Mapping Unit	Geographic Area	Major Constraint
Red Sea Coastal Plain and Hills (RC & RH)	Eastern Sudan	limited rainfall
Tokar and Gash Deltas (RT & G)	"	limited rainfall, spate-type surface water flow
Central Clay Plain, Arid (CA)	"	limited rainfall
Central Clay Plain, Semi-Arid (CS)	"	erratic rainfall distribution, erodibility
Central Clay Plain Dry Monsoon (CM)	"	erodibility
Piedmont Zones (EP)	"	limited rainfall
<hr/>		
Semi Desert Zones	Eastern and Western Sudan	
(a) Basement Complex (XB)		poor rainfall, slow infiltration
(b) Nubian Sandstone (XN)		poor rainfall, low nutrient status
Qoz Stabilized Sands (Q)	Western Sudan	wind erosivity, very low nutrient status, poor water holding capacity
Jebel Marra (J)	"	erodibility
Darfur Erosive Plain (D)	"	erodibility, slow infiltration rate
Central Kordofan Basin, Baggara Repeating Pattern, and Raqaba Overflow Plain (K, BB, and BR)	"	flooding, occasionally high sodium content
Nuba Uplands (N)	"	shallowness, infertility

TABLE 2

(Page 2)

Mapping Unit	Geographic Area	Major Constraint
Green Belt and Sub-humid Highlands (F & EH)	Southern Sudan	erodibility, acidity
Ironstone Plateau and Jebels (IP & IJ)	"	shallowness, erosivity
Ironstone Traditional Zone and Southern Clay Plains -- Western Section (IT & SW)	"	seasonal drought
Southern Clay Plains, Central Section and Adjacent Marshes (SC & M)	"	water logging, infertility, creeping floods
Southern Clay Plains -- Eastern Sections (SE)	Southern Sudan	As above
Central Clay Plains -- (CS & CM)	"	None
Arid South Eastern Plains (EA)	"	severe seasonal droughts

The most visible and alarming signs of these processes are in the arid and drier semi-arid parts of Sudan. In extensive areas of Northern Kordofan and Northern Darfur, long-term trends in land productivity and visible movements of sand, as well as short-term changes in the condition and composition of natural vegetation, indicate that the carrying capacity of the land is being exceeded.

The impact of this process is also being felt in the slightly more humid areas of Southern Darfur and Southern Kordofan. Transhumant pastoralists have shortened their migratory routes and thereby increased the overall level of pressure on land. At the same time acceleration of mechanized scheme development on the Qoz sand and intermediate soil types has created new points of sand destabilization and wind erosion. The socioeconomic effect of this environmental deterioration is increased conflict among herding populations and between herding populations and sedentary cultivators.

c. Long-Term Climatic Change.

There appear to be long-term changes in total rainfall and annual variations in the rainfall in Sudan in parts of western Sudan. At El Obeid, comparisons of rainfall records showed long-term climatic deterioration between the decades 1943-52 and 1970-79. The earliest safe sowing date had shifted forward by 12 days and had become more unreliable; the mean length of the growing season decreased from 78 to 63 days. Most important of all, the number of growing seasons during the decade that were too short for a 60-day dukhn millet crop to mature fully increased from 3 to 5. In other words, the traditional farmer's chances of successful cropping declined from over 2:1 to 1:1 in this marginal semi-arid environment.

A similar long-term decline in the rainfall in the wetter areas of the Sudan is unlikely to have had the same dramatic effect on traditional crop production. Traditional farmers in the dry monsoon climates grow several sorghum varieties with different maturation periods, and the longest term varieties are particularly tolerant of late sowing and moisture stress during grain swelling.

Analysis of data for the most recent decade from 11 stations in three climate zones of Sudan show that the trend to drier conditions in the rainfed areas has not continued. Thus, while firm conclusions should not be drawn without more sophisticated and comprehensive analysis, the long-term drying trend may be leveling off.

d. Other Man-made Environmental Problems.

Beyond the land, soil, desertification and climatic constraints to improvement of Sudanese agriculture, a number of other environmental problem areas of great significance, brought about or originated by human changes to the natural environment, can only be mentioned briefly here.

In the irrigated subsector a massive problem has been created by dam siltation proceeding at about twice the expected rate. The problem is due to the enormous increase in the sediment load of the Blue Nile owing to removal of the plant cover of the Ethiopian highlands, aggravated because the original designs excluded siltation structures as being too costly at the time of construction.

Another ecological problem in the irrigated subsector is the increasing difficulty with water hyacinth both in reservoirs behind dams and in the major irrigation canals on the large schemes. There is also a health problem. The canals have served as breeding sites for parasitic pathogens and vectors such as malaria mosquitos, schistosomiasis snails, hookworms and Guinea worms, among others.

In some areas poor drainage has led to increasing salinity of farm lands and a decrease in productivity.

Animal pests are a serious problem in both irrigated and rainfed agriculture in Sudan. In common with many of the Sahelian countries, desert locusts and granivorous birds cause extensive damage to sorghum and millet crops. In some years losses as high as eighty percent have been estimated by provincial authorities. Once the crops are harvested, storage pests become a major problem. Rats and insect pests cause great losses each year. Control measures have, for the most part, not dealt with the underlying ecological dynamics of these problems.

2. PHYSICAL INFRASTRUCTURE

a. East.

The eastern portion of the country is relatively well supplied with roads, railroads, airports, river transport, and telecommunication services. However, while the large irrigation schemes are served well, albeit expensively, the rainfed subsector experiences many of the difficulties and uncertainties in input supply and output movement that more remote regions of the country do. While there are important gaps in the transport and communications network and severe seasonal disruptions in traffic, the basic infrastructure problems in the East relate much more to maintenance, organization and management than they do in the West and South.

The glaring exception to this general statement is the link between Port Sudan and the rest of the country. As the nation's sole seaport it is vital that this facility have the capacity to handle essentially all imports and exports in a safe and cost-effective manner. Currently, Port Sudan's operations are best described as nightmarish, causing long delays and adding excessive, needless charges to imports and exports.

b. West.

Transport is probably the biggest infrastructural constraint to increasing agricultural production in western Sudan. The weakest link is the railroad. Its level of service has been declining at a time when it should be providing low cost transport to and from the West. Since 1976, roads have become the major transport mode during the dry season, but road transport can only operate at very high cost and risk during the rainy season. At the farm level delay in the transport process means that mechanized operations lag behind the optimum dates, which, in turn, tends to lower crop yield. Beyond these direct effects, investors have to question the risks and greater costs which the weak road system imposes on large scale operations. At the other end of the cropping calendar, producers must deal with the difficulties of getting their crops to market, or even to their home storage sites, over badly degraded roads. And, if the harvest is delayed until the roads become more passable, losses to granivorous birds and storage pests increase.

The low capacity of the railroad to handle the increasing demand for transport of agricultural inputs and commodities to and from the West means long delays and high costs. Producers have to turn to alternative modes of transport. For livestock this means continued dependence on the traditional stock trails which imposes extra marketing costs because of huge weight losses. Also, these trails cannot be used for three months each year because of the lack of forage along the way.

Lack of water infrastructure also acts as a brake on agricultural production in several ways: i. the lack of water points restricts the amount of clearing and pre-planting operations that can be undertaken during the dry season; ii. on rangelands, the lack of water in some good grazing areas prevents their full utilization while it increases the pressure on already overgrazed lands; iii. the inappropriate placement and spacing of water points leads to inappropriate crop cultivation in areas which are marginal for arable agriculture, and iv. stands of gum arabic which are beyond the normal reach of cultivators and herders due to the lack of drinking water remain unexploited.

c. South.

Virtually all analysts and policymakers agree that the most fundamental constraint impeding the Region's development is the utterly inadequate transportation and communications network. True economic integration of the South with the rest of the country will remain a dream until an efficient, low-cost transport network is created. Until then, the South will remain much more dependent for its "external" trade on Uganda and Kenya (and to a lesser degree, Zaire) than on the northern Sudan, and it will not be able to exploit whatever latent comparative advantages it possesses in agriculture, mining and manufacturing.

For the traditional farmer, as well as any other economic operator, the primitive transport system means, above all, low prices for his output and higher prices for what he buys, both from inside and outside the Region. Indeed, in the southern Sudan, it means that during part of the year there is no market at all for surplus farm production.

The poor transport and telecommunications network in the South also represents a grave impediment to the political integration of the Region's tribal groups, to the effectiveness of the Region's civil government and administration in general, and to agricultural administration in particular.

The problems and potential of Nile river freight and passenger traffic have been analyzed and documented sufficiently. It is generally agreed that the barge service between Juba and Kosti is completely unreliable and inadequate.

The railway system has also been studied expertly and recommendations for its improvement have been made, not only with regard to communication with the South. Rehabilitation of the line between Khartoum and Wau, and establishment of faster and more frequent service, could materially improve the commercial links between the western portion of the South and the rest of the country.

Intra-regional telecommunications are virtually non-existent. Although a number of the larger district seats are equipped with microwave transceivers, the station functions only in Juba. This makes efficient public administration and modern business communication virtually impossible. Non-government institutions are obliged to install and

operate their own communications equipment if they want to maintain contact with the outside world and with outlying facilities in the Region.

Lack of properly designed and operated storage facilities at the regional, local and on-farm levels reduces the likelihood that surplus production can be stored and that foodstuffs can be successfully distributed to deficit areas. It also leads to substantial post-harvest losses.

3. FARM LEVEL CONSTRAINTS IN RAINFED AGRICULTURE¹

In general, the principal constraint on the farm household's total crop output without the introduction of new technologies is that of labor availability. (The major environmental constraint, of course, is the variability of rainfall which can mean the difference between an adequate diet the year round and serious food shortage as the new harvest approaches. Farmers in many areas attempt to insure themselves against unpredictable rainfall patterns by staggering their planting and/or sowing varieties with growing cycles of different lengths.)

In both semi-arid and subhumid areas the key operation in which the labor constraint appears is weeding, and not planting or harvesting, except for sesame, which has special harvesting problems. This is perhaps the most important consideration to bear in mind in devising strategies and technologies for rainfed farm development; it is reflected in the suggestions contained in Section D.

Of course, to the extent that the weeding constraint can be successfully overcome, the labor constraint may arise in harvesting, and breaking through this barrier may require other technological improvements.

In most of the South, there is a complete lack of incentives for the traditional farmer to devise ways, and secure the means, for producing a marketable surplus because there is no market. This usually has to do with the absence or poor state of the road or other means of transportation as described earlier; *ceteris paribus*, the disincentive also tends to increase with the distance between primary and final markets.

Secondarily, market production is discouraged by the absence or shortage of adequate storage facilities at various levels. If bulk storage is lacking, a short-term increase in saleable surplus cannot be marketed in an orderly manner; at best the farmers take a price beating and will be discouraged from expanding output in the longer run. Inadequate or absent farm or community-level storage facilities (as well as urgent cash needs) often lead subsistence farmers to sell part of their crop at harvest time when prices are low, only to buy back all or part of it later in the year at much higher prices. (Pest damage in storage also reduces their usable output by as much as 25 percent).

¹The team did not study the technological problems of the irrigated sub-sector sufficiently to include them in this discussion. Moreover, as indicated elsewhere, the problems tend to be even more basically institutional, rather than technological, than in the case of the rainfed sub-sector.

In both the East and the West livestock productivity is limited by management practices which emphasize herd size rather than per animal productivity. The pastoralists' strategy is to reduce the risk of herd loss under adverse environmental conditions. This is particularly the case for cattle, which have important roles to play in many societies' social and religious processes. Where there are strong links to livestock markets, there appear to be few incentives to maximize animal liveweight gain rather than number. Most producing areas are distant from the consumption centers. Weight loss is high during the trek to town markets. Hence, survivability rather than weight is a major buyer consideration. Besides the marketing problems, reduced dry season forage and water supplies limit weight gains in the more humid environments and cause weight loss in the drier ones. While herders could increase dry season standing forage by not burning rangelands, they continue to do so to stimulate succulent regrowth and to reduce ectoparasite populations. While forage conservation, fodder storage, and better animal health care could be applied by herders, these practices may well not be economic under current market conditions.

The main constraints to greater livestock productivity in the South (in addition to the market constraint), unfortunately, are beyond the cattle herding household's control: tsetse fly, seasonal droughts and seasonal flooding. The main problem caused by the dry season in many areas is not so much the lack of fodder as the lack of surface water for both men and animals. Among the constraints that seem to be within the herder's capacity to overcome -- provided the necessary incentives and aids are forthcoming -- are genetic, nutritional and veterinary measures for increasing cow fertility and decreasing calf mortality.

Soil conditions, input availability and cost and labor shortages in growing areas combine to make mechanized rainfed agriculture more land extensive than it is in most countries. Much mechanized sorghum and sesame production takes place on heavy cracking clays which become very slick when wet, preventing weeding by tractor. Soil active herbicides and application equipment require scarce foreign exchange and may not be effective at normal doses on the heavy clays. High doses may well be uneconomic and environmentally unsafe. Foliar active herbicides have not yet been extensively tested in Sudan. Growers seek to avoid early competition from weeds and the high labor requirement of early hand weeding by delaying secondary land preparation and planting until after most weed species have sprouted. In addition to being reluctant to pay the labor costs, farm entrepreneurs have learned that they cannot obtain sufficient labor at low cost early in the growing season because small holders sow and weed their own crops at the same time. The staggered planting also helps avoid later competition for weeding and harvesting labor. However, it also reduces yield by decreasing the effective length of growing season, and probably by increasing exposure to insect and pathogen infestation. These cultural constraints have been made worse by poor site selection and layout during the early demarcation of mechanized blocks in the 1940's which have resulted in avoidable problems of field access and drainage.

4. INSTITUTIONAL, ECONOMIC AND FINANCIAL POLICY CONSTRAINTS

Unlike some neighboring countries, the Sudan's basic present developmental constraints are not rooted primarily in an unfavorable environment and a lack of technical answers. Rather, they arise from the inadequacies

of the national institutions to respond to the challenges, firstly, of the long-term developmental potential and, secondly, of the short-term economic and fiscal problems that the Sudan shares with most non-oil producers in the developing world.

The decline in export earnings has been due basically to a combination of inadvertent disincentives to maximizing cotton yields on irrigated farms with poor management of infrastructure and water allocation. Some of the disincentives were removed in November of 1981, but export taxes on cotton are apparently due to continue.

Several other sources of distortions adversely affect the incentives for producers in the rainfed sector. Until quite recently, the official exchange rate overvalued the Sudanese pound. This effectively increased the demand for imports and taxed exports -- a perverse result, given the current importance of agriculture in the Sudanese economy and its long-run potential for solving the balance of payments crisis and providing a foundation for stable growth and development.

The present critique, of course, is not meant to imply that all, and probably not even most, government policy decisions or their consequences are negative as far as agricultural development is concerned; for example, the GOS decision to refrain from imposing export and/or price controls on sorghum -- which probably called for some political courage -- helped materially to elicit a highly satisfactory response of the private producing and trading sectors in terms of sharply higher output and exports. Also, a series of hard decisions in November, 1981, have removed some of the major disincentives and called for the gradual elimination of others despite the short-term political price in terms of protests and riots against the loss of subsidies on PQL, sugar and wheat.

On the other hand, public sector acts of commission are characterized by the assignment of entrepreneurial functions to public agencies that are not prepared to cope with the task. Almost inevitably, these agencies end up doing the job worse than even a moderately efficient private entity would have done it, aggravating the public fiscal deficit. Two parastatals alone, the PAPC and the Kenana Sugar Corp., cost the GOS almost Ls 100 million per year in operating deficits. Admonishments to "improve management" of these agencies in the process tend (with exceptions) to be futile because the agencies have a built-on tendency to run aground. (The involvement of parastatal organizations in the production and marketing of certain agricultural products also constitutes another distortion in the structure of incentives.)

In the agricultural production sector proper, the government still does not seem to have quite convinced itself that it should not attempt to farm through public corporations, despite the dramatic examples of the huge irrigation schemes (especially Gezira) and of the limited and disastrous experiences with State farming of the Mechanized Farming Corporation compared with the rather successful schemes where land is leased and tractors are sold to small private entrepreneurs.

Outstanding among the acts of omission of the public sector is the neglect of the transport system. In this field, too, public entities attempt to monopolize services - and perform them badly - when private enterprise, suitably licensed and controlled, could provide them more efficiently (e.g., river and air transport); at the same time, the public sector is emphatically not doing the job that is expected to do in providing and adequately maintaining the transport infrastructure, such as roads, the railroad track (if not the railway's operation) and safe Nile river navigation.

Much of the problem of institutional inefficiency is the result of the enormous brain drain towards the oil-rich countries of the Arabian peninsula. Public and private institutions in those countries are said to pay up to ten times the salaries that a well-trained Sudanese can expect to earn in his own country's public administration. And there are at present few if any incentives in Sudan for the internal and external private sectors to expand in such a way as to become an important employer of highly trained Sudanese personnel.

Sudan's tax structure is regressive, particularly as it affects low income producers, in that most taxes are explicit on a quantity basis rather than ad-valorem. At the farm level this increases taxes when farm incomes are low, and it contributes to a non-buoyant revenue structure for the central government. Tax reform in the Sudan would probably help both improve the structure of incentives and increase government revenues.

The current fiscal problems of the public sector are both cause and effect of this situation: on the one hand, inappropriate taxation policies and laws are failing to produce needed public revenue while some of them discourage production and trade; on the other hand, unnecessary and inefficient public agencies are squandering the scarce moneys that should be allocated to priority infrastructure investments. Insofar as the scarcity and misallocation of public money prevent the assured funding of development projects, especially those supported by external donors, the fiscal crisis will continue to have an increasingly negative impact on agricultural progress.

Another important financial institutional constraint is that institutional credit to date does not exceed one percent of rural lending in the Sudan at present. "Shell" lending continues to be the prevalent form of credit despite government efforts to curb it. The system obviously keeps small farmers (and perhaps not a few larger ones) in a permanent state of debt. Whether it truly reduces production incentives - as claimed by some - depends on whether one measures the shell system against a hypothetical universal institutional credit (which often does not provide emergency consumption loans), or against no credit at all. Lending institutions and the public institutions dealing with technical and organizational support to small farmers have a lot to learn, but an ascending learning curve for them would seem to be the only hope for the establishment of the kind of strong and capillary credit system needed for helping market oriented small farmers get started. The Agricultural Bank's lending to date has been oriented primarily towards the entrepreneurial tenants in the mechanized farming schemes, where the Bank has been performing an indispensable financing, supply and purchasing/storage function.

D. APPROACHES FOR OVERCOMING KEY CONSTRAINTS

The discussion that follows is organized in a sequence proceeding from the policy level to the farm level. We wish to make it clear that we consider it crucial that a development strategy approach the constraints in this order. Without policy reform the economic structure of Sudan will continue to maintain its disincentives for production and entrepreneurial activity. Without substantial institutional reform and strengthening, the national government, in all fairness, cannot be expected to implement either the proposed infrastructure improvement or the socio-economic and technological research and action programs that are suggested here. Finally, we wish to point out that we have purposely devoted a substantial portion of this section to a summary presentation of some of the most important technological issues and possibilities which were discussed in greater detail in the material that we delivered to USAID/Khartoum in October, 1981. We feel strongly that too much attention is paid to issues of development strategy, policy and priorities in a technological vacuum, and that too many policymakers dismiss technological alternatives and solutions as so much administrative detail.

1. OVERCOMING POLICY CONSTRAINTS

At the time of the Team's visit to the Sudan in the early fall of 1981, there was considerable scepticism among external donor/lender agencies with regard to achievement of the overall policy changes that seemed to be required as a basis for a national development strategy. The picture has brightened considerably with President Nimeiry's sweeping and courageous policy announcements of November 8, 1981. Implementation of these policies will increase the confidence of external agencies in the viability of long-term development projects.

Unification of the exchange rate has brought the nominal rate close to that of the real price of foreign exchange. This should serve to create incentives for increased domestic production of cotton, wheat, and sugar in the irrigated subsector and some readjustments in the rainfed subsector's cropping patterns. Irrigated cotton production should also benefit from elimination of (1) the practice of charging the operating costs of all irrigated crops to the tenant's cotton account, (2) the export tax, and (3) the delay in paying tenants for their cotton deliveries.

An additional policy matter that might be examined is the Gum Arabic Corporation's marketing monopoly. The artificially low producer prices imposed by the monopoly have probably resulted in an undervaluation by farmers of the gum arabic shrub relative to family fuelwood requirements. Thus, higher farm prices resulting from competitive buying could be an important step towards establishing a more reliable supply and reinstating some of the traditional practices which preserved the acacia shrub stands in semi-arid and arid areas.

The gum arabic monopoly is but one of the many rainfed agricultural policies that need to be re-examined and adjusted. Donors would be well-advised to initiate a dialogue on a new policy emphasis on the rainfed subsector as a whole, especially in regard to land tenure and rent, credit, the de-facto short staple cotton quotas, and livestock marketing.

2. OVERCOMING INSTITUTIONAL CONSTRAINTS

Development of traditional agriculture requires at least as much input from the public sector as that of irrigated farming. However, the quality of the input is quite different, at least insofar as public sector participation in irrigated farming has been -- and continues to be -- conceived in the Sudan. Whereas the irrigated schemes call for a combination of relatively sophisticated management and technical know-how, the support of traditional agriculture requires more basic skills as regards both institutional management and technology. It also involves a much higher ratio of personnel to beneficiaries.

Because of the huge size of the country and the defective transport and communications infrastructure (see below), decentralized management of agricultural programs is perhaps more important than in some other countries. The Sudanese government's recent moves towards greater regional political and administrative autonomy appear to be a long-run step in the right direction. On the other hand, this multiplies the need for institution building and training assistance.

Generally speaking, and taking cognizance of the continuous brain-drain towards the oil-rich nearby nations, a strategy designed to bring out the latent potential of the traditional farming sector requires a crash effort by the national government and external agencies to train sizeable cadres of (i) institutional management personnel, (ii) specialists in adapting/developing and transferring simple technological improvements, and (iii) middle-level field workers with the minimum background for effectively spreading the improved technologies in the various natural and social environments. One sees no reason why this kind of program should be any less effective in Africa than it turned out to be in a number of Asian and Latin American countries.

As an interim measure -- and while sorting out the costs and benefits of greater or lesser private sector involvement in agricultural production and service delivery -- donors will have to supply and support expatriates to bridge the managerial gap. In crop production, seed production, input supply, pesticide application, maintenance and repair operations and agricultural processing, serious consideration should be given to breaking up parastatal operation into management units which could be run under contractual agreements with domestic and/or foreign businesses or private voluntary organizations. The management contract would be used to reorganize and improve performance and would have to include specific guidelines for Sudanese personnel development. These contracts should probably cover a guaranteed five year period, after which options for local incorporation by foreign firms, financing of capital takeover by Sudanese enterprises, or re-establishment of a parastatal institution would be exercised.

3. OVERCOMING INFRASTRUCTURE CONSTRAINTS

Agricultural development, especially of the Southern and Western regions, requires, at a minimum, seasonal access to farms for input and service delivery and marketing of production. Market and storage facilities are next in strategic importance. The different types and degrees of infrastructural constraints in the three geographic areas of concern are treated separately here.

a. East.

Donor organizations and the GOS have carried out extensive study of the transport problems in the East Central portion of the country, including road, river, rail and air transport. The construction and rehabilitation programs are limited by foreign exchange funding, contractor availability, and materials import problems. However, much of the existing infrastructure, especially the rail and river systems, are inefficiently organized and managed. Turning over the maintenance and operations of the rail and river portions of the system to private sector management and restricting government's role to regulation of the industry would be likely to improve service.

There are specialized storage problems in the East which are best treated by those studying and working in the irrigated sector. The team did not investigate these problems but noted that facilities for storage and processing of by-products, such as cottonseed, were inadequate and that the poor use of the existing transport system can cause extensive storage losses.

b. West.

In the West the GOS plans to improve the railroad network with donor support. However, much greater provision needs to be made for the maintenance requirements of this network and the organization of the work force and materials to carry out regular maintenance.

Marketing and storage infrastructure in the West is badly needed, both for crops and livestock. Both cereal crops and oilseeds need to be stored for fairly long periods to make up for transport deficiencies and to ensure that adequate supplies are maintained for the town areas of the two Western regions. While the construction of the facilities should probably be financed by the public sector, more efficient product storage is likely to occur if the private sector is permitted to manage them competitively.

There is a water infrastructure problem in the West. GOS policy to rehabilitate and maintain existing water points and yards should be supported with equipment and spare parts. One way to do so effectively would be to contract with major suppliers for both delivery and training services.

c. South.

The South's infrastructure is deplorable in two main senses. First, there is an absolute lack of roads, rails, river ports, and air strips and the accompanying transport equipment and POL. Second, the region has next to no capacity to maintain the existing facilities and those scheduled to be constructed. Roads, in particular, are deteriorating at rates equal to, or higher than, the progress of new construction. It is extremely important that support be given to develop the regional capacity to maintain the road network at minimum commercial access standards.

Since only a small portion of the national rail track is located in the Southern Region, there is little hope that improvements will occur here at the same rate as they are planned to take place in the East and West.

River transport is potentially the strongest economic link between the Southern region and the Northern part of the country. From studies carried out by the World Bank and other donors it is clear that the River Transport Corporation needs to get out of the business of trying to provide transport services in order to concentrate on the improvement of river channels and regulation and licensing of traffic and trade. All boat and barge operations should be turned over to the private sector which, to date, has been legally excluded.

In common with the West, there is the need to provide storage facilities at the major port and roadside towns in the region. Regional food commodity stores are most urgently needed. As in the West, a combination of public funding of construction and private sector operation is probably the best pattern to follow, although care must be taken in both areas that public design and construction respond to the needs of efficient private sector management.

d. Air Transport.

Sudan Airways has repeatedly demonstrated its inability to provide reliable air cargo and passenger services. It is strongly recommended that the private sector be invited to compete in providing the needed domestic service, at the risk of having to abandon the official airline if it cannot stand the competition.

4. OVERCOMING FARM LEVEL CONSTRAINTS

Traditional agricultural production systems in Africa were generally well adapted to their environments. But recent growth in human and animal populations increased pressure on the accessible land resources, reducing their productivity potential through higher nutrient export rates and surface disturbance brought about by decreased fallow periods and overstocking. Urbanization and the growth of the public service sector have increased national food demand at the same time that they reduce the proportion of agriculturally productive labor in rural communities. In Sudan, there appears to be a general consensus that there is a growing seasonal labor shortage among rural households. This seems to constitute the key factor limiting the output of smallholders, because they cannot significantly expand the area under cultivation or intensify land use with present techniques.^{1/} The implications of this consensus

^{1/} Data on the degree and extent of the labor shortage and its ranking as a limiting factor are exceedingly scant. The team found no study of farming systems that presented field data rather than inferences based on observations of field size and weeding status. Labor supply may well depend on the incentives provided by alternative economic activities, e.g. herding, hunting, fishing, and non-agricultural sector employment opportunities, and on social attitudes.

are that producers must move to, or create, more productive environments or that the technology must change to alleviate the labor constraints to permit more efficient use of the available environmental productivity potential. While there are underutilized environments, the direct and indirect costs of resettlement would be high. The following discussion will, therefore, concentrate on technologies designed to alleviate the labor constraints and to improve the productivity of the agricultural environments. Storage measures are also discussed as additional means for enhancing the net cash incomes of farmers without requiring additional peak season labor input.

a. Technologies that can alleviate labor constraints and increase efficiency of land use in the mechanized sub-sector.

In the face of a labor constraint, mechanization offers the opportunity to greatly expand surface area cultivated. In the East and West, private sector mechanization has been successful in increasing sorghum and sesame production. Land surveys and realignment of farm access roads will lead to better access and reduce waterlogging problems. However, selective introduction of weed control through hand or aerial spraying, of combines adapted to harvesting tall sorghum cultivars, of non-shattering sesame varieties and of a practical rotation to maintain soil fertility can help remove weeding, harvest, and fertility constraints in this system.

In the South, experience to date indicates that mechanized technology is not likely to play an important role in making up the region's food deficit for some time, especially if the environmental damage that may be caused by excessive tractor cultivation of some of the region's more fragile soils is considered.

b. Technologies that can alleviate labor constraints and increase the efficiency of land use in the traditional rainfed sub-sector.

i. Labor enhancing technologies.

Zero tillage techniques for traditional farmer use in the humid and sub-humid zones of the South can be used to increase surface area. Standing vegetation is killed with glyphosphate herbicide. This herbicide is probably applied most effectively with a "spinning disc" to produce a "killed sward" through which a crop can be planted with an injection planter. It can also be applied with the most rudimentary equipment, i.e., a "wiper" consisting of a piece of cloth wound around the end of a stick. The choice will depend on the availability of labor in the family, including all ambulant members. Studies will need to be made to determine the actual labor requirement, but weeding will almost certainly go faster in this manner than at present with weeding by hoe or hand-held blade done only by adult able-bodied men or women.

The case for using animal traction in the semi-arid zones is very strong where soil type and low or zero tsetse fly infestation permit cattle to tolerate the extra strain imposed by being worked without constant veterinary attention. Unlike a tractor, the draft animals continue to be part of the family herd and do not depreciate with time. On the contrary, in the case of oxen, their value continues to increase as they mature. The very simple backbone cultivators, which should be

the first equipment purchased in most areas, are almost unbreakable in normal use and may be expected to last for twenty years if provision is made for the local manufacture of wearing parts (ideally by indigenous blacksmiths). An expansion of the cultivated area per family by as much as 75 percent is possible through the use of animal traction for weeding.

Experience in the Sudan to date has failed to generate much acceptance of animal traction by farmers. Besides some of the social problems involved (e.g. farmer reluctance to train their own animals), most of the programs have been attempting to introduce the wrong equipment packages and have been using substandard training approaches. The SATEC program at Kadugli is a notable exception to this general rule.

ii. Technologies for intensifying land productivity.

Nationwide efforts to introduce new, higher yielding varieties have only begun during the past decade. The South has depended almost entirely on this approach to increase yields. In all areas of the country there is a need more carefully to match the introduced or selected material with the environment and constraints encountered in the local farming systems. Manpower allocation to this effort has been woefully inadequate throughout the country.

Seed dressing is a proven and simple way to increase crop establishment and reduce seedling disease and thus increase yields. On the other hand, the standard use of pesticides to protect staple crops grown under smallholder conditions has not been particularly successful. There have been difficulties in maintaining area-wide control of pests scattered in many small fields and natural plant habitats, with inappropriate identification of the pest problem, with the complicated logistic trains required, and with development of pest resistance. Pesticides are valuable, however, in controlling large-scale outbreaks of pests. In Sudan, the effectiveness of pest outbreak control has been limited by organizational, manpower and logistic constraints.

While there are areas of the East and West where fertilizer application may be economic, data are extremely limited. In the South the high transport costs make it unlikely that fertilizers can be employed cost-effectively in the foreseeable future.

Zero and reduced tillage techniques that permit area expansion also may have important yield effects. Lower competition for light, minerals and water permit greater crop growth. The main costs of the technologies are the supply and service infrastructures which would be required to ensure that the herbicides are correctly applied. The cost of this infrastructure would, however, be materially less than the equivalent organization required to supply tractor cultivation to the same area.

iii. Desertification.

Several known technologies deal with treatment of localized desertification, mainly sand dune stabilization and reclamation, fireline construction to maintain surface cover, range exclusions to permit natural regeneration of the vegetation, and integrated village development to reduce the desertification effects of town formation. Of special concern are the large areas of Qoz sands in the West. It seems unlikely that localized treatments will be effective in slowing or reversing the large-scale desertification. Experimental work with crops in the Sudan

and other Sahelian countries has shown that phosphate applications can more than double biomass and yield under semi-arid conditions. The ecological argument for applying phosphate fertilizer directly to range land is compelling. It would increase surface biomass and hence carrying capacity for livestock. By increasing the surface cover, it would definitely slow down desertification. Unlike many other forms of assistance to agricultural development, such a one-time investment in fertility would last for over a decade and would be almost unaffected by subsequent changes in social or economic conditions. However, the economics would need to be studied and a pilot project would be advisable.

iv. Striga weed control.

Most of the traditional varieties of sorghum are tolerant of quite heavy levels of infestation by Striga hermonthica (witchweed), but it is not unusual for farmers to lose 40 percent of their potential grain yield. In more advanced agriculture systems, abnormally high levels of nitrogen fertilization are often used profitably to reduce the attack. It is also possible to control the level of the parasite seed in the soil by long rotational breaks with immune non-cereal crops. Neither of these steps is available to the traditional farmer who has to grow a high proportion of cereal crops on his land every season.

Control measures based on removal of Striga plants before maturity still result in significant grain losses and only marginally reduce weed seed populations. While breeding of more resistant varieties of sorghum and millet adapted to smallholder conditions is probably the best long-term approach, short-term control can be effected by contact or spinning disc applications of selective foliar herbicides.

c. Overcoming on or near-farm storage constraints.

Lack or inadequacy of storage at the farm or village level entails three serious problems for the farm family and the farm economy:

- (i) many subsistence-level families are forced to sell part of their grain crop for a low price at harvest time and to buy grain at scarcity prices later in the year;
- (ii) spoilage is considerable, said to average around 25 percent nationally and to go much higher locally;
- (iii) traditional farmers have an added disincentive for not producing for the market.

In many cases, simple improvements to - and perhaps expansion of - the traditional storage facilities may be sufficient. The most common measure is the introduction of insecticides. This should be accompanied by appropriate training of a selected number of individuals in each community because most of the pesticides in use have high mammalian toxicity. However, storage insect pests have a high ability to develop resistance to these insecticides. One of the best systems that can be recommended for use by the farmer is some method of sealed storage in airtight containers to reduce oxygen levels to the point where insects cannot survive.

A separate problem is the storage of crop seed from one season to the next. While the same method of sealed storage can be used, seed dressing or fumigation is also effective for seeds which are certain not to be consumed.

Centralized village stores may require an effective protection process that can be applied regularly. Calcium or aluminum phosphide is probably the easiest fumigant that can be used without extensive training of personnel and investment in special equipment.

d. Livestock Improvement.

As in the case of subsistence crop farming, it appears that higher cattle productivity can be achieved through well-proven technological and management practices, but that the basic incentive for the application must come from the creation of a market or the reform of the existing market. Unlike cropping practices, which are constrained by labor, cattle management practices need to be oriented towards increasing yield per animal, in view of the land pressures. Any measures of a veterinary or other nature that - advertently or not - result in larger herds must be absolutely avoided. It is most probable that if the technical improvements are to achieve the desired objective, they must be accompanied by appropriate market reforms conducive to maintaining the ecological balance by increasing the offtake.

Improvement in animal productivity through an increase in the growth rate per animal can most practically be achieved by a reduction in grazing pressures across much of the rangeland in Sudan. It is the availability of forage at the most limiting phase of transhumance that determines herd productivity. In some cases this may be limited dry season grazing and in others limited rainy season grazing. In either case it is unlikely that grazing pressure will be reduced until offtake can be increased through market outlets. An alternative approach would be to improve the quality of the forage itself through the introduction of range forage species such as Stylosanthes humilis (Townsville lucerne), a legume that, once established, can improve the protein status of the range.

Throughout Sudan expansion of grazing area to more evenly utilize available forage could be accomplished through the improvement of seasonal water supplies. However, well placement, timing of water distribution and maintenance of the water point infrastructure to avoid overconcentration of stock and environmental damage all require information on range condition and control of stocking rates that is not available at present. In the South and in the more humid portions of the East and West it may be possible to expand grazing area through tsetse fly surveys and control measures. However, the cost-effectiveness of this approach is unknown.

E. SUGGESTED PRIORITIES

Lenders and donors recognize the economic and development crisis in which Sudan finds itself. The balance of payments and national debt burden have convinced some that external aid provided at this time must have a short-term impact (3-5 years), particularly on the balance of payments. At the same time the GOS and the lender/donor community realize that genuine, long-term economic development support cannot be significantly delayed without seriously jeopardizing the possible short-term production gains and the pursuit of broader objectives.

That some balance is needed in the approach to short-term objectives --which are defined in financial terms -- and long-term objectives which generally incorporate social return considerations -- is commonly agreed. The specific balance that is struck only rarely can be validated objectively. For Sudan the quality of the information base is low. Reliable production and cost data are only available from the irrigated subsector. The mechanized rainfed subsector has yet to generate even basic reliable time series on output and marketing, let alone farm management studies that fully account for costs and accurately measure returns. Realistic farm management information on the traditional rainfed subsector is almost totally lacking. "Comparison" of the relative rates of return from investment in the three subsectors is therefore based on generally non-comparable information. While quantitative analysis is thus impossible, certain qualitative predictions can be made regarding the probable effects of any given donor strategy.

With very few exceptions (e.g., a crash project for expanding mechanized rainfed area at any cost), only policy and price changes are likely to have significant, nationwide short-term impact on agricultural production. These changes can be effective in loosening the constraints against which production and marketing systems are pressing to the extent that the policy announcements of November 8, 1981 are implemented, including the requisite allocation of domestic financial resources. In some cases, such as expedited payment to cotton tenants, change can occur rapidly. In other cases, such as the establishment of a new rate structure for irrigation and input charges, two to three years may elapse before system-wide change occurs.

Other program or project options, requiring reorganization of existing institutions, new supply channels, personnel, and contracts, can only be expected to have nationwide impact over the medium (5-15 years) or long term (15-25 years). Even those development projects that are already underway cannot be expected to alter output significantly in the short run owing in part to the focus and design of all but the most recent projects, reflecting donor philosophy and priorities of the last three to five years. The impact lag also reflects the time constraints arising from the exchange of commodities, personnel, and knowledge between donor and Sudanese institutions, and the institutional and infrastructural failings of the Sudanese system. A further timing consideration is that the recent regionalization moves are likely to increase organizational confusion and reduce the functional efficiency of public service institutions for the next two or three years. This realistic assessment of the practical time constraints on the rate at which change appears in the national accounts has two important implications for selection and priority ranking of strategy elements:

- i. choice of programs and projects should reflect realistic assessment of design and implementation periods required before tangible impact can be expected and achieved;
- ii. such assessment should specify medium and long-term development objectives to be built upon the short-term gains and structural adjustments expected from implementation of the recent policy changes.

Development experience in Sudan has demonstrated that new designs or reshaping of existing projects can easily absorb two or more years, that establishment of operations can take two to three additional years, and that achievement of impact can be delayed far beyond what donor officials would like to admit in their project appraisals and justifications.

The following sections discuss three major areas of strategy choices: policy-sensitive development investment, subsector concentration, and geographic focus. We then proceed to examine some specifics of the strategy elements designed to overcome key constraints.

1. POLICY SENSITIVE DEVELOPMENT INVESTMENT

In the case of project-type assistance to Sudan, a distinction can usefully be made between projects whose successful implementation (a) requires changes in overall policies (e.g., exchange rate, relative price levels, general tax levels, import controls), or (b) calls essentially for project-specific measures (e.g., a change in official price policies or marketing practices for a specific product or the imposition of a tax or user fee for a specific project output). It should be clear from the preceding discussions that both types of policy reforms will have to take place if satisfactory returns on investment are expected. Economic, budgetary and commodity support can, and should, be linked to overall policy changes, insofar as possible in concert among all lender/donors.

Individual projects, on the other hand, while they may benefit from the general policy change, should wherever possible be designed so as not to have their effectiveness dependent on such changes. Finally, it bears to be underlined that regardless of the objective validity of any given strategy and set of measures in the eyes of the external lender or donor, their design and implementation must respond basically to the felt needs of the host country government.

2. CHOICE OF SUB-SECTOR CONCENTRATION

A major strategy choice, for both the government and the external donor/ lenders is that of the sub-sector system on which to put relative or absolute emphasis. Leaving aside the political objectives of the choices, one would expect the decisions to be based on considerations of short- and/or long-term economic needs and advantages. In view of the critical state of Sudan's balance of payments, short-term considerations seem to favor the highly market and export-oriented irrigated sector where, it is argued -- at least by the World Bank -- the short-term marginal return to investments in "rehabilitation" is likely to be greatest in terms of output and foreign exchange earnings. However, it must be borne in mind that rehabilitation of this sub-sector depends heavily on - and requires heavy investment in - enormous improvements in

management practices of the schemes (for which the policy changes announced in November, 1981 are but a prelude). Also, the political power and resistance of the tenant population to changes in the service charge structure indicate that investment in this subsector may be subject to significant risks unrelated to the quality of design of the rehabilitation effort. In any event, it is likely that the national institutions involved could not at present absorb additional external aid beyond that provided and planned by the World Bank. Moreover, the heavy preponderance of cotton in the irrigated subsector probably makes it politically unattractive (if not legally off-limits) for USAID investment.

In contrast to the irrigated systems, the rainfed subsector is almost entirely under the control of private sector commercial and subsistence farmers. Historically, rainfed farms have been responsive to economic policy and pricing changes. The two rainfed subsectors also dominate the production of the country's cereal supply, and play a major role in export production. Livestock production as well is almost totally concentrated in the traditional rainfed subsector. The advantage to the economy of the lower level of capital use in the rainfed systems is somewhat offset by the greater risks sustained in the production, transportation and marketing of the rainfed crops. Overall, there is significant potential for improvement in performance following the recent modification in the exchange rate and other relevant policies and perhaps in conjunction with further donor influence on agricultural pricing policy and because of the proven responsiveness of private operators in the rainfed subsectors, and the greater degree of flexibility in approach available to both the institutional and technical problems of the subsector.

Substantial marginal returns could probably be obtained from investment in further expansion of privately operated mechanized rainfed farming with present technology in order to cash in on the high demand and price levels for sorghum for export. In view of the present low yields, the required additional investment in imported machinery and fuel, however, may not make this an attractive choice for the balance of payments. Moreover, both the government and external agencies may wish to devote some study to this phenomenon's environmental impact, and to possible technological modifications, before permitting a further expansion.

This leaves the traditional rainfed sector, represented principally in the country's Southern and Western regions. For the obverse of the reasons why higher short-term returns might be expected from investments in irrigated and mechanized rainfed farming, no such expectations are possible from investments in the traditional sub-sector. On the other hand, there are indications that the long-term returns may be measurably higher in the latter if comprehensive social accounting methods are applied to the analysis, including the social costs of continued neglect of traditional farming and of indiscriminate development of mechanized farming.

It must be underlined here that the state of existing data and analyses does not permit formulating anything approaching a meaningful judgement regarding either the financial or the economic returns of alternative investments in the three sub-sectors, or regarding the most advantageous choice of crops in any of them under given assumptions. Nor is there sufficient information on the labor conundrum -- briefly referred to in Section B above -- to be able to predict what might

happen to the supply and price of wage labor if labor productivity in traditional farming were to be tangibly enhanced.^{1/} It is, of course, important that no measures are taken - or allowed to be taken - that reduce the demand for wage labor drastically in the short run (such as massive imports of harvesting machinery or of herbicides for the large farms and irrigation schemes). If untoward economic and social consequences are to be avoided, simultaneous measures will have to be designed and taken to allow the traditional farm household to make up for the lost cash wages by earning income from market production, and at the same time increase the marginal productivity of the labor that remains on the farm.

3. GEOGRAPHIC FOCUS

Most lenders and donors of significant size have spread development assistance across the country. They have done so in response to economic and political equity considerations which are still valid today, perhaps even more so in light of recent regionalization moves. In the absence of such considerations, development investment criteria would probably be concerned solely with physical access, institutional capacity and comparative advantage: followers of World Bank assessments would locate solely in the East; donors who saw the mechanized rainfed and livestock potentials of the East and West would split their investments; funding in the South would be based only on products for which the region has absolute long-term environmental advantages (timber, coffee, tea, fish and game) and relative environmental advantage, e.g., rice.

The medium-term development potential of the rainfed cropping and livestock system undoubtedly warrants external lender/donor commitments in the West, although some reliable research results should be available before any investments are made in projects that go beyond a few obvious activities such as are suggested in the following section.

In the almost completely undeveloped South, there is little or no potential for short or even medium-term payoff of development investments. Absolute priority must be given in this region simultaneously to transport and communications infrastructure and to institution building through training and advisory services, as outlined below.

The following sections describe the strategy elements recommended to retarget development assistance in these areas.

4. PRIORITY OF STRATEGY ELEMENTS

a. Policy.

Donors should use every opportunity to initiate dialogue and devise support mechanisms for change in agriculture related policy. Greatest short-term effort should be focused on price management of export crops and imported commodities to try to provide immediate incentives for an increase in rainfed cereal and oilseed production.

^{1/} It is suggested that, far from being academic, such studies should receive the highest priority in order to furnish the underpinnings of policy and strategy decisions. Some specific suggestions are made in Section E below.

Second priority should be given to tax policy and its effect on revenue generation and production and investment incentives.

Third priority should be a concerted program to shift economic functions better performed by private enterprise out of the public sector and to restructure business investment codes and regulation so as to make long-term investment in Sudan more attractive.

Donors should be prepared to provide the funds and external expertise for policy studies to inform the dialogue.

b. Institutions.

Reforms are needed in both governmental public services and parastatal institutions. The 1981 decentralization moves have created ministries of agriculture, food and natural resources in each new region, staffed by individuals many of whom have advanced technical training but who lack management training and experience. The well-known managerial deficiencies and functional ineffectiveness of the parastatals call for exploration of the possible role of the private sector in assuming temporary responsibility for management as well as for personnel training during a transitional phase that would lead to subsequent decisions regarding the private or public nature of the institution in the long run.

Indeed, one way of attacking the institutional and human resource problems is to work through management contracts with official or private international entities (including production/marketing cooperatives or agribusiness firms). Part of the contract could include training abroad (in farm management for top managers of large-scale sorghum and sesame farms, machinery and storage facilities, etc.) and Sudan based training (in programming, budgeting, controlling operations and finances, etc.). These contracts should be seen as stop-gap measures to be employed until greater incentives result in retaining more trained Sudanese professionals in the country to work in the rainfed areas and to promote the establishment of private sector enterprises.

However, care must be taken not to fall into a trap of a different kind. Private business enterprise in the Sudan - especially of a truly indigenous nature - is still in its infancy; there are few entrepreneurs, and management know-how is about as undeveloped as it is in the public sector. Also, the market returns to internationally mobile capital in the Sudan today are unlikely to be sufficient for most foreign enterprises to face the problems of investing in the Sudan in view of its present physical and administrative infrastructure. Temporary subsidies - direct or indirect - may be necessary to attract foreign firms.

Given the 1981 establishment of regional ministries of agriculture, there is a great need for training in organizational and management skills. USAID has two projects: Rural Planning Support, and Agricultural Policy and Statistics, which may be able to assist in this regard. Additional efforts must be urgently initiated.

In the South a massive effort must be made jointly by the Regional government and the donors to design a medium-term training program with a minimum ten-year horizon and commitment. Such a program should be based on a rapid inventory of existing manpower and on a realistic projection of probable needs for the next generation, based on certain -- equally realistic -- assumptions, in the private as well as in the public sector. The training program should be conceived essentially as

an effort to produce indigenous trainers who are capable of multiplying the benefit of their domestic and foreign education by imparting their newly acquired notions to ever-growing numbers of their compatriots, starting with the university and going all the way down to rural primary school teachers. A simultaneous track would be the continued formation of a qualified cadre of public administrators and development agents at various levels, who would gradually be replacing large numbers of expatriates who will be filling or advising key positions in the meantime.

While a good deal of the training would need to be at foreign institutions because of the limited capacity and scope of the national ones, a good deal --perhaps the bulk -- of the program would be devoted to building up, and even creating, regional institutions that will have to be staffed initially for the most part by expatriates.

Failure to mount such a massive training effort will delay the appearance of tangible signs of development of the South way beyond the life expectancy of anyone presently old enough to be concerned with the process.

The brain drain problem seems insoluble without resort to coercive measures, which - aside from their intrinsic undesirability - would be likely to be counterproductive. Yet, allowing the private sector to expand dramatically and shifting to it some important functions that are at present handled inefficiently by the public sector might be part of the answer; the private sector in principle might be able to compete to some degree with the remunerations offered by the oil-rich countries. In addition, the latter might be persuaded to reimburse the Sudanese government for the cost of training each Sudanese national who is employed there. Such payments could be deposited into a fund that is used exclusively for financing internal and foreign training for more Sudanese.

c. Infrastructure.

Sudan has greatly handicapped its agricultural sector by permitting its river and rail transport systems to deteriorate gravely. This is partly the result of the policy of allocating rail and river transport to the parastatal sector. Together with abominable sea and river port facilities and management procedures, the system has added immense risks and charges and permitted trucks to dominate the long distance hauling industry.

Rationalization of transport infrastructure and its management should be key elements on donor agendas. IBRD and other donors are working on rehabilitation of Port Sudan, the rail network and road construction. But the plans lack an approach to institutionalized maintenance and efficient management, without which the capital replacement will be rather futile. AID may help in providing CIP commodities and PL 480 sales proceeds to promote maintenance procedures, and development assistance funds for training.

In the South AID should above all help promote (a) shifting the River Transport Corporation functions to navigation improvement and regulation, and (b) bringing the private sector in to furnish and operate the actual transport. AID is already investing in needed road construction along with other donors and the World Bank is attempting to introduce a maintenance system.

Nevertheless, the South's transport problem is so enormous that additional external resources could well be earmarked for this sector,

provided the national or regional administrative capacity is not stretched too thin in the process. The most effective way, it is suggested, is for foreign contractors to build roads that require a minimum of maintenance in the short and medium term.

Storage infrastructure in the West and South is another priority item. Immediate survey of locations for structures should be made. In the South the needs for major river, railroad and, secondarily, provincial and district capital, storage facilities should be examined at once. AID might consider using the centrally funded Kansas State University program to provide technical specifications, but use the US private sector to build and manage the facilities while they train managers. In the West, a similar procedure should be followed but with storage designed for a broader range of commodities and faster integration with the Sudanese private sector.

d. Macrotechnology.

In view of its potential for both short and long-term impact and its relative ease of implementation, a first priority should be accorded to the pilot testing of large scale phosphate application to semi-arid grazing land in Sudan. The International Fertilizer Development Institute in Muscle Shoals should provide initial technical guidance and operational evaluation. A private sector contractor or set of contractors could be selected to demonstrate the most cost effective means of carrying out the applications.

While an effective tsetse fly insecticide has been developed, its large-scale application should not be undertaken until adequate surveys of the tsetse distribution and habitats have been carried out. However, compared with other nation-wide problems in agricultural production and the need to develop livestock markets and successful animal traction programs before animal production is expanded, this activity does not warrant major investment at this time.

e. Farm Technology

Near-Term Impact. Throughout the nation the most appealing short-term technology for increasing crop production and family welfare is on-farm storage. Use of the sealed container method would preserve crops that are now subject to high loss rates. Once delivered, the technology itself is relatively simple. While requiring some distribution and extension effort, it is a low-risk, low-capital technology with a multi-year impact.

Small scale groundnut and sesame seed processing units can be usefully installed in producing areas to help maintain production incentives by expanding the local market and to ensure local oil availability at reasonable prices. This is especially important in the West and South.

Three pesticide technologies have short-term impact potential. One is seed dressing, which is now being done by the Ministry of Agriculture but, with appropriate assistance, could be extended to a much greater number of farmers. One of the important linkages between this and the storage technologies is that extension agents can use the food storage containers to transmit messages on both food and seed storage. The second is large-scale aerial application of herbicides on sorghum fields.

With appropriate foliar herbicides, and on the basis of well organized pilot programs, significant yield increases may be obtained. A supply and management contract would appear to be an effective way to proceed. A third short-term impact pesticide technology is support for the control of insect and bird pests. This program needs better organization, wide coverage capacity, and faster response times.

Medium term improvement in organization and management could vastly improve the performance of certain parastatals that have to do with mechanized production in such aspects as block layout and equipment maintenance. Management contracts with US firms would be the quickest way to turn these operations around. This type of management contract should be accompanied by an independent farm management analysis of the private and public sector schemes to determine the future role of each in the mechanized rainfed sector, as well as by training programs for Sudanese managers.

Weed control on small holdings using wiper applicators may be a viable medium term technology. In view of the many linkages in the logistic chain, the need for substantial organizational efforts and the diversity of application conditions and settings, a management contract with a herbicide manufacturer would probably be appropriate for this effort in the semi-arid West and East.

As was discussed earlier, sand dune stabilization technologies are well-known. A hardheaded look at the organizational and financial requirements to implement them should lead to a determination of feasibility. Whether the impact of these technologies will be felt in the medium or in the long term depends on the degree of success of the phosphate application strategy.

Improved management of the State seed farms would be extremely beneficial to the nation. Reports indicate that isolation distances are inadequate, weed control is almost non-existent, there is little roguing, grading or germination testing going on, and storage and packaging procedures are untidy. This undoubtedly is another instance where the private sector could do a far better job.

Long-Term. Animal traction equipment is being perfected by SATEC for the cracking clays, lighter soil textures, and some of the non-cracking clays of Kordofan. Much of this equipment should be adaptable to other areas of Sudan. Diffusion of equipment, acquisition of skills, and development of a working spares and repair organization to the point where wide areas will be affected will take more than a decade. In view of the need to economize on POL imports, the animal traction option deserves priority support which does not ignore or disrupt the very good technological advances made by SATEC.

f. Research.

It is probably no exaggeration to state that the lack of data and information is one of the prime reasons why apparently pressing policy decisions were delayed for years, and also why so many development projects have failed to produce anything approaching the expected results. Reference has also been made repeatedly in this summary report to the difficulty of arriving at the appropriate analyses to support strategy options because of the almost complete absence of data and studies. Thus, in the face of the understandable eagerness of lender/donor officials to continue promoting action projects, we must suggest strongly

that in many cases the first priority is the design and implementation of a series of applied research projects. Some of the projects can probably be undertaken by Sudanese personnel and institutions with only marginal expatriate advice; others may require almost entirely expatriate staffing. In many cases, equipment may have to be included. In all cases it will be important to assure long-term funding and continuity of expatriate personnel, in part to compensate for the manifold start-up and implementation problems that will no doubt be encountered.

In view of the impossibility for the team to investigate any of the themes in depth during the limited time available, and of the prescribed brevity of this summary report, the list is rather sketchy. Moreover, it should be considered indicative rather than definitive, and the team suggests that an appropriately composed follow-up mission be organized to deal in greater detail with the information and research requirements for agricultural development. Some research needs are mentioned in earlier sections in connection with specific action recommendations, such as the phosphate enrichment of the Qoz sands and animal traction implements. They will not be repeated here.

However, it does bear reiterating that the foundation for any successful, modern action and research program for agricultural development is a minimum package of reliable time series on production and marketing. We strongly recommend that the resources of the AID-funded Agricultural Policy and Statistics project be programmed strictly in accordance with priority requirements for such series (as well as for farm management research) in accordance with the determinations of an inter-institutional ad hoc committee comprising public and private sector, academic and donor representatives.

Not all research proposed here is necessarily designed for long-term payoff. Some projects could be capable of furnishing in a relatively short time information that could be immediately applied to the design of investment projects. The following list of research needs and opportunities is thus ordered in accordance with the expected payoff time.

Near-Term Impact. A farming systems survey in selected high potential areas would lead to identification of the exact management and technological practices and their implications for factor productivity. Combination of this information with agroclimatological analysis and review of past research efforts will help avoid duplication of past effort and establish more farm-oriented research directions. Of particular interest would be the likely economic return to the farm enterprise and subsistence farm family from herbicide use. Rapid pre-screening of cereal varieties for use in short, medium and long maturity positions in the cropping cycle would also have a relatively quick payoff.

The range condition in Kassala appears to be precarious. The recommended twice annual survey would highlight the problem for policy-makers.

Matching the growing environments with the requirements of the non-shattering sesame varieties under development in the USA and elsewhere may generate fruitful returns in the short run.

Medium-Term Impact. The following is a list of medium term research projects which are believed to have production impact potential.

The tasting of sesame harvesters for both shattering and non-shattering varieties would permit a rapid expansion of sesame production in the large scale farming blocks.

Tall platform harvesters for sorghum would help remove the harvest labor constraint that may occur following adoption of new weed control recommendations by small farmers.

Variety trials and seed bulking deserve much more organized support on the part of donors to ensure that improved materials are being developed and distributed wisely.

Farming systems research should be expanded to include on-farm tests designed to determine the most useful practices and alternatives.

Classification of soils according to their intrinsic agronomic potential and their requirements for capital will make it possible to develop a medium-term land use and investment policy and to correct some of the misconceptions about the quality of the land resource base of Sudan.

Long-term. The tsetse survey has the potential for being useful when control measures can be used to stimulate production following improvement in the livestock marketing systems and the widespread acceptance of animal traction. Shorter term impact may be expected if the tsetse flies are found to be consistently expanding into currently unaffected areas.

A major research project is recommended to investigate the economic, social and technological dimensions of the "wage labor conundrum" outlined in Section B, as it reflects on farm productivity and output, migration, family incomes and the quality of family and village life.

A final recommendation concerns the urgent need for a systematic collection and review of existing data and research results under one roof and under Sudanese control (with such expatriate assistance as may be required). The Ministry of Planning or the Ministry of Agriculture must set up such a documentation center, with adequate retrieval capability, and all external agencies and contractors must be legally obliged to furnish to this center a copy of all appropriate technical reports and analyses.