SUDAN

AGRICULTURAL RESEARCH PROJECT

STAFF APPRAISAL REPORT

June 6, 1978
CURRENCY EQUIVALENTS

Currency Unit = Sudanese Pound, 100 Sudanese piastres
US$2.50 = £Sd 1.00
US$1.00 = £Sd 0.40
US$2.5 million = £Sd 1.0 million

WEIGHTS AND MEASURES

1 hectare (ha) = 10,000 m² = 2.47 acres (ac)
1 feddan (fd) = 1.04 ac = 0.42 ha
1 ha = 2.38 fd
1 square kilometer (km²) = 100 ha
1 kilometer = 1,000 meters (m)
1 imperial gallon (Ig) = 4.545 liters

ABBREVIATIONS

AOAD - Arab Organization for Agricultural Development
APRA - Animal Production Research Administration
ARC - Agricultural Research Corporation
CIMMYT - International Center for the Improvement of Maize and Wheat
CIP - International Potato Center
EC - European Community
ERTS - Earth Resources Technology Satellite
FF - Ford Foundation
GOS - Government of Sudan
IADS - International Agricultural Development Service
ICARDA - International Center for Agricultural Research in the Dry Areas
ICRISAT - International Crops Research Institute for the Semi-Arid Tropics
ICB - International Competitive Bidding
ILCA - International Livestock Center for Africa
ILRAD - International Laboratory for Research on Animal Disease
IRRI - International Rice Research Institute
MAFNR - Ministry of Agriculture, Food and Natural Resources
MFC - Mechanized Farming Corporation
NCR - National Council for Research
ODM - British Ministry of Overseas Development
PAC - Project Advisory Council
PEU - Planning and Evaluation Unit
PSU - Project Support Unit
SDP - Savannah Development Project
SYP - Six Year Development Plan
TEU - Training and Extension Unit
VRA - Veterinary Research Administration
WSDC - Western Savannah Development Corporation

GOVERNMENT OF SUDAN FISCAL YEAR
July 1 - June 30

1/ The effective parity relationship for the US dollar is £Sd 1 = US$2.87156. An effective exchange rate of £Sd 1 = US$2.50 is applied to all exchange transactions other than the purchase of proceeds from exports of cotton, to which the exchange rate of £Sd 1 = US$2.87156 continues to apply, as a result of the application of exchange taxes and subsidies of 5.18 piastres per US dollar (i.e. 15%) to the rate of £Sd 1 = US$2.87.
# SUDAN

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This report is based on the findings of an IDA mission which visited the Sudan in October 1977 comprising Messrs. Tamboli, Silbiger (part time) and Fransen (part time) (IDA) and Messrs. Melville, Tribe and Haworth (Consultants).

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The Government of the Sudan (GOS) has requested IDA to develop and finance an agricultural research project (Project) for the rainfed arid and semi-arid areas of Western Sudan (West). This Project would aim to develop improved production systems for livestock and crops, to conserve and rehabilitate national resources and to improve the standard of living of the subsistence farmers and pastoralists in the arid and semi-arid areas of the West. The Project would also strengthen the national agricultural research effort through the development of support services at the Agricultural Research Corporation's (ARC) headquarters to be moved to Khartoum.

Recognizing the importance of research for unlocking the existing potential, the Minister of Ministry of Agriculture, Food, and Natural Resources (MAFNR) in 1975 requested the Ford Foundation (FF) to make a study of selected crop and discipline research capabilities and to suggest ways and means of strengthening the Sudan's agricultural research and related services. A summary of FF's reports on 10 basic food crops, seven disciplines, and four administrative services was discussed at an International Workshop on Agricultural Research and Development in the Sudan held in Khartoum, November 1976. Subsequently, a 'Joint Team' of Sudanese and American scientists under the aegis of the International Agricultural Development Service (IADS) and supported by the FF, prepared a master plan for strengthening the national capability for research and for application of improved technology. This plan proposes a long-term broadly based program to develop the Sudan's agricultural research capabilities, and has become the blueprint for the agricultural research policies and programs of GOS. In support of this overall framework, the project would develop the agricultural research capability for the West.

II. THE SECTOR

A. The Importance of Agriculture in the Economy

The Sudan, the largest country in Africa, covers about 2.5 million km². The population is about 15.9 million growing at a rate of 2.2% per year; per capita GNP for 1976 averaged about US$290. The agricultural sector provides the livelihood for around 80% of the population; it contributes about 40% of GNP, 95% of exports and over 50% of Government revenues. The value of agricultural exports increased from £8d 123 million in 1972 to £8d 193 million
in 1976. The major export commodities in 1976 were cotton (51% of total agricultural exports), groundnuts (20%), sesame (9%), and gum arabic (6%). Exports of livestock and livestock products range between 6% and 10% of total exports between years. Imports of agricultural products have also been increasing sharply, from ESD 26 million in 1971 to ESD 62 million in 1975, but declining to ESD 45 million in 1976. Agricultural imports during 1975 consisted of 61% sugar with wheat accounting for a further 13%. Imports of agricultural inputs (fertilizers, insecticides, sacks and machinery) have risen from ESD 12 million in 1971 to ESD 23 million in 1975. The proximity of the Sudan to markets in the Middle East places it in a favorable position for agricultural exports, and oil-producing Arab countries have increasingly come to consider the Sudan as a primary future source of agricultural imports.

2.02 Although the northern third of the country is largely desert, the remaining two thirds of the country contain some 85 million feddans (fd) of arable land (of which less than 30% has been cultivated), 240 million fd of grazing land, and 60 million fd of natural forest. Of the 26 million fd gross cultivated area, some 4 million is under irrigation, 5-1/2 million under rainfed mechanized farming and 16-1/2 million under traditional cultivation. The balance of 59 million fd either forms part of a long fallow rotation or is unused due to lack of water or the heavy nature of the soils. Similarly, lack of water or in some areas the presence of tsetse flies prevents utilization of grazing areas, but much of the range is heavily used by the large livestock population - 15 million cattle, 16 million sheep, 11 million goats and 2 million camels - in nomadic, transhumant or sedentary livestock farming systems. The market offtake is put at 5% for cattle, 15% for sheep, 20% for goats and 4% for camels, allowing for an annual per capita consumption of about 6.1 kg of red meat and exports of 25,000 MT equivalent. Traditionally, the principal livestock owners were nomadic pastoralists but in recent years, economic, political and climatic pressures have gradually changed the nomad's way of life and led to increased settlement; but the pastoralists continue to depend primarily on livestock.

2.03 The economy's growth over the past fifty years has been linked firstly to irrigation from the Nile waters, largely for cotton production, but more recently also for groundnuts, wheat and sugarcane. A second spur occurred with the development of large-scale rainfed mechanized production of sorghum (dura) since the early 1950's. Both of these developments were concentrated between the confluence of the Niles and the adjoining clay plains of East/Central Sudan so that modern sector development stood in strong contrast to traditional subsistence agriculture in the remote areas of the west and south, giving a dual nature to the economy. A third stimulus took place in the 1960's when the railway reached Nyala and when rainfed groundnut production got an outlet from the western provinces; currently about 1/4 of the country's groundnut product is coming from South Darfur Province and is expanding rapidly.

2.04 Much of industrial development is related to the processing of agricultural products. Textile development has been the largest, but oil expressing, sugar processing, milling, tanning and sack production from kenaf are
all being expanded. Agriculture is likely to remain the base on which indus-
trial expansion will rely.

B. Contribution of Agriculture in the West to the Economy

2.05 The West, comprising the four provinces of North and South Darfur
and North and South Kordofan, covers an area of about 850,000 km² or 35% of
the Sudan with about 5 million or about 30% of the country's total popula-
tion. The West contributes about 90% of the Sudan's millet, 52% of the
sesame, 46% of the groundnuts, 17% of the sorghum, 6% of the cotton and 90%
of the gum arabic; an estimated 45% of the cattle (about 7 million), 37% of
the sheep (about 6 million), 32% of the goats (about 3.5 million) and 65% of
the camels (about 1 million) are raised in the region.

Crop Production

2.06 Small-scale subsistence agriculture is the most important economic
activity in the West, and other sectors, particularly transportation and indus-
try, are critically linked to agriculture. Only about 3% of total culti-
vation is commercial agriculture, largely in South Kordofan and to a small
degree in South Darfur. Rainfed agriculture predominates with small irri-
gated plots in the Jebel Marra, at Sag el Naam in North Darfur, and around
Nyala as the only exceptions. The main crops are millet, sorghum, ground-
nuts and sesame, with cotton and maize of lesser importance. Recorded yields
reflect not only poor soils and unfavorable weather conditions but also poor
husbandry practices and, in some areas, over-exploitation of the land. For
all the major crops, the area under cultivation has been increasing steadily
over recent years with incremental aggregate production but yields have re-
mained stagnant or fallen, a trend which must be reversed if farmer's in-
comes are to be increased.

Animal Production

2.07 The conflict between individual ownership of livestock and communal
land use, and the seasonal movement of the predominantly transhumant livestock
producers inhibit the proper utilization of resources including range, water
and the production potential of the herds. During the last 20 years, the
number of animals has increased considerably through efficient veterinary
services; but increased herd numbers have led to range deterioration without
noticeable incremental output.

Constraints to Production

2.08 There are two main constraints to increased production: (i) eco-
ological limitations imposed by a low and extremely variable rainfall, high
evaporation, recurring drought, soils of low fertility, and limited access-
ibility of ground water; and (ii) increases in the human and livestock
populations which change social traditions and engender pressures and eco-
logical degradation. The steadily worsening man/livestock population ratio
forces many pastoralists to turn to sedentary cultivation and become settled farmers; but new and more efficient systems of land use and water management ought to be introduced into existing livestock and crop production systems if this trend is to be successful.

2.09 Many other constraints are related to these basic issues, and these can be classified as ecological and socio-economic. Some ecological issues are: deterioration of rangelands; grass fires; parasites and pests; low protein and mineral intakes by grazing stock; reciprocal pressures of livestock and crops in competing production systems; lack of effective technologies of crop husbandry; crop diseases, weeds and pests; inadequate tillage methods; unimproved crop varieties; low soil fertility; and poor water management. The socio-economic constraints include: the conflict between individual ownership of livestock and communal land use (para. 2.07); socio-economic insecurities in a fragile ecosystem; attempts to buffer social groups against environmental vicissitudes by overstocking, shifting cultivation and increased sedentarization; lack of market opportunities, and insufficient demand for consumer goods and few opportunities for investment of capital other than in livestock.

2.10 These constraints do not generally represent discrete disciplinary problems capable of solution by traditional techniques of experimental agriculture. Rather they constitute interconnecting links which could only be strengthened through the study of production systems by multi-disciplinary teams, in order to increase crop and animal production and provide security to producers through the long-term optimum use of resources, with particular emphasis on water/soil/plant/animal/human inter-relationships.

C. The Future Strategy for Livestock and Crop Production in the West

2.11 The Sudan’s agricultural development strategy laid down in the Six-Year Development Plan (1977-83) (SYP) emphasizes the need to make full use of existing resources and at the same time to correct the wide variance in productivity and incomes between the commercial (irrigated and mechanized rainfed) sector and subsistence agriculture. As part of this strategy, GOS is according high priority to launching development programs for subsistence cultivators and pastoralists in the West and this is reflected in several new regional development projects such as the ODM/Abu-Dhabi, IDA/Saudi Fund and EC financed projects in Southern Darfur, and the ODM assisted Nuba Mountains Project and IDA financed MFC project in South Kordofan (para. 4.34). Intensified use of arable land, range, livestock and water could contribute to reaching the plan targets in the country and a steady improvement in living standards of the population in the West, but this is critically dependent on the transfer, development and adoption of improved technical packages which call for a back-up by a largely increased agricultural research program. In the short term, the Savannah belt is the climatically most suited area in the Sudan for the expansion of rainfed agriculture, and the plan targets for increased surpluses in sorghum, groundnuts and sesame, and in better crop/livestock integration, would crucially depend on the success of development projects in the West.
III. THE SUBSECTOR

A. Structure and Present Status of Agricultural Research

National Council for Research (NCR)

3.01 Overall responsibility for research policy formulation is vested in the National Council for Research (NCR) 1/, a high-level policy making body headed by a president of cabinet rank who reports directly to the President of the Republic. NCR acts as an adviser and a consultant to the Government, to its agencies, to public corporations and to the private sector in matters related to scientific research. NCR's Central Board is comprised of 22 distinguished members of Sudanese society representing: planners and decision-makers including several cabinet ministers; known and recognized scientists; users of research from the public and private sectors; and non-Government scientific organizations and associations. Day-to-day operations of NCR are being handled through its general secretariat which also comprises the liaison staff of the four specialized sub-councils: (i) agriculture including animals; (ii) economics and sociology; (iii) medicine; and (iv) science and technology. Each of these have a high degree of autonomy.

Agricultural Research Responsibility

3.02 Agricultural research is mainly the responsibility of the MAFNR through: (i) the ARC (para. 3.03); (ii) the Animal Production Research Administration (APRA) and Veterinary Research Administration (VRA) (para. 3.07) and the Services Departments (para. 3.09). In addition, some agronomic and social science research is being carried out by the University of Khartoum through its Faculties of Agriculture, Veterinary Science, Animal Husbandry, Economics and Social Sciences, and the Development Studies Institute (para. 3.10). The Sudan also participates in several regional and multilateral research activities and is being supported by some of the international research centers (para. 3.12).

Agricultural Research Corporation

3.03 Almost all agricultural research in the Sudan is now the responsibility of the ARC 2/ based at Wad Medani, a semi-autonomous body administered by the Agricultural Research Council (Board of Management), and directly responsible to the Minister, MAFNR. The Director-General of ARC (DG) is appointed by the President after nomination by the Minister, MAFNR; he is also the chairman of the Board of Management. Board members include: the Deputy Director of ARC; the Directors General of the Corporations (Gezira, Public Agricultural Production Corporation, Mechanized Farming Corporation-MFC, Rahad Agricultural Corporation); the Under Secretaries of Agriculture, Animal Resources and Natural Resources of MAFNR; the Director of Agriculture, Southern Region; the Deans of the Faculties of Agriculture at Khartoum and Gezira and of the Faculty of Natural Resources at Juba; representatives of

1/ Established by the NCR Act of 1973 which was amended in 1975.
2/ Established under the Agricultural Research Corporation Act of 1977.
the Ministries of Finance and Industry, the NCR and the Agricultural Bank; and three members appointed by the Minister. The Board meets at least twice a year and: plans the general agricultural research policy for the Sudan; approves the budget; approves and appoints scientists and officials; and submits proposals to the Minister for the appointment of the Deputy Director General, heads of sections and main stations. A Technical Committee and an Administrative and Finance Committee support the Board in carrying out its functions.

3.04 ARC is funded by: an annual Government contribution based on the Board's budget proposals endorsed by the Minister, MAFNR, and approved by the Council of Ministers; and to a lesser extent from the sale of crops and other products; grants from local and international institutions; and income from the sale of publications or services rendered. Recurrent fund allocations to ARC have increased from £Sd 1.1 million in 1970/71 to £Sd 3.1 million in 1977/78.

3.05 Originally, ARC was set up as the Gezira Research Station for irrigated agriculture with emphasis on cotton but it has gradually taken over more responsibilities (Chart 18269). Recently, GOS has transferred research in forestry, pasture and range, wildlife and game, land use and soil conservation, fisheries and marine biology, and food processing to ARC.

3.06 ARC operates five regional stations and twelve sub-stations. Its current staff is about 250 senior staff, 420 technicians, 175 administrative support staff and about 3,000 laborers.

Animal Research

3.07 Animal production research is mainly the responsibility of APRA and veterinary research that of VRA, both departments under the direction of the Under Secretary of Animal Resources in the MAFNR, and funded from the normal Government budget. APRA is operating six research stations with 34 scientists plus support staff. Its budget allocation in 1977/78 was £Sd 0.45 million.

3.08 VRA operates one veterinary research center near Khartoum and five provincial veterinary laboratories, with 75 professionals plus support staff. Its 1976/77 budget allocation was £Sd 1.0 million.

Service Departments

3.09 Service Departments, which contribute in varying degrees to agricultural research include the Tambul Pilot Farm (Under the Rahad Agricultural Corporation) conducting studies on mechanized/irrigated farming; the Plant Protection Department doing operational research, mainly on the desert locust and aerial spraying; the Department of Soil Survey and Testing, working mostly on soil survey and classification under the Gezira Scheme; the MFC studying improved farming techniques at Sim Sim and Habila and smallholder mechanized farming at El Fuda; the Department of Agricultural Economics and Statistics responsible for crop statistics; the Social Research Unit at
Gezira and the Social Studies Division of the Department of Soil Conservation, Land Use and Water Programming which conduct social surveys related to rural development.

University of Khartoum

3.10 Research programs of the University of Khartoum under the Ministry of Education are organized along traditional disciplines. Cooperation between the Faculties, APRA and ARC is poor, and because of insufficient research funds, University staff are underutilized for research purposes. However, some ARC stations are being used by post-graduate students for the preparation of theses. Because of the different objectives between University and ARC research, a further improvement of research cooperation will take time and can only come about through a strengthening of ARC.

3.11 Faculty of Agriculture staff have produced significant results (having been published in more than 300 papers) in national and international journals including: studies on field crops such as sorghum, sesame, legumes and vegetables; pests and diseases; animal nutrition; agricultural mechanization; and economics of production. Recently, the need for multi-disciplinary research into the production systems of the important agro-ecological zones has been recognized and a few of these projects have been introduced. Research funds are obtained mainly from the University and to a lesser extent from NCR and the private sector. Research policies are directed by the Faculty Research Board guided by proposals for research projects from staff members. ARC's DG is a member of the Faculty Board and the Deputy Director a member of the Faculty Research Board. Some of ARC's senior scientists do some lecturing at the Faculty.

International, Regional and Bilateral Cooperation

3.12 The Sudan participates in several regional research activities with neighboring countries and multi-lateral organizations including: (i) the FAO Near East Field Crops Improvement and Production Project which has identified improved varieties of wheat, barley, maize, sorghum and millet for distribution to farmers; (ii) the Desert Locust Control Organization for East Africa, with other countries in the Desert Locust Invasion Belt through FAO; and (iii) the UNDP/FAO Grain Eating Bird Control Research Project. Regional cooperation in agricultural research is maintained with Central and East African countries through the technical Research Commission of the Organization of African Unity. Research links with the International Atomic Energy Commission and Center for Overseas Pest Research are being maintained through exchange of personnel for training, equipment supply, and consultants. Ciba-Geigy Ltd. undertakes research on new methods of air spraying (particularly ULV) at the Gezira, in collaboration with scientists of the ARC.

3.13 Links have been established with the international research centers specifically through FF with regard to potatoes (CIP) and rice (IRRI) and directly with regard to sorghum and millet (ICRISAT). Contacts are also being maintained with CIMMYT, IITA, ILCA and ILRAD (Annex 1).
3.14 The Sudan is also a member of several FAO regional commissions which have both research and development functions. Furthermore, it is a member of the Arab Organization for Agricultural Development (AOAD) of the Arab League with headquarters in Khartoum. Bilateral assistance in research training, in setting up training centers and in collaborative research has been received from the U.K., U.S.A., Federal Republic of Germany, U.S.S.R., Canada, Switzerland, China, The Netherlands, Denmark, Sweden, Egypt and other countries.

Issues

3.15 While these research institutions have effectively supported the irrigation subsector, the research facilities for the two major agro-ecological regions of the country (rainfed arid and semi-arid in the West and East, and rainfed tropical in the South) continue to be under developed, under staffed and under financed. Little research has been carried out in the subsistence farming/pastoralist areas of the West (and the South), and what has been done is rarely relevant to the needs of local producers. While groundnut varieties have been introduced and useful research is being done on gum arabic, little work has been done on millet, pulses and legumes, or on improved range management and animal husbandry techniques, especially for small stock and camels. Most important, adaptive research is required on appropriate farming systems and cultural practices.

3.16 So far, most of ARC's research has been conducted on a disciplinary or subject matter basis. While this is desirable in terms of fruitful cooperation between workers of the same discipline, it lacks inter-disciplinary co-ordination for resolving production problems. Although most research within the sector has been transferred to ARC (para. 3.05), the responsibilities for animal production and animal health research (para. 3.07), as well as for socio-economic research in the rural sector (para. 3.09) remain under different Under Secretariats in the same Ministry, which makes it difficult to organize research on an integrated, multi-disciplinary production systems basis to attack the problems limiting output.

3.17 The transmission of limited available research results to the producer breaks down at several points, in particular through the absence of a capability within ARC or the MAFNR Extension Department to digest and simplify research results into usable form (Charts 18269 and 18270). Moreover, since ARC has little contact with development planning, it is insufficiently aware of crop and livestock research priorities considering local demand and export opportunities.

B. Present Status of Extension

3.18 Except in the Gezira, Khashm El Girba, and Rahad Irrigation Schemes and in Khartoum Province, agricultural extension services in the Sudan are weak. Extension is decentralized as a provincial service being financed and directed by the province. Because of lack of funds, the shortage of qualified personnel, limited extension messages, and low priority accorded to it
by provincial leaders, extension work is inadequate in most provinces. There are about 200 extension staff; of these 30% are university graduates, 20% are diploma holders from the Shambat Training Institute and the rest—50%—are graduates from intermediate school with a brief in-service training in general agriculture. Thus one extension officer on average has to cover as many as 30,000 farmers. The extension staff are mostly working in the East and have hardly any access to new information for the farmers since there is no link nor effective functional relationship with ARC (para. 3.17). Field staff in the West are inadequate, have very little mobility and are inadequately trained; for example, in South Darfur, there are five extension officers of which only two work at the village level.

3.19 Some successful extension efforts in the Sudan include the public production corporations which have modernized agriculture, but to date this has been largely limited to irrigation schemes. The transfer of research results is more efficient in commercial farming like the Gezira scheme and schemes of the Public Agricultural Production Corporation than in the subsistence sector. Research is being carried out by these corporations and applied directly on farms. Similarly, the Veterinary Service is successfully implementing disease control programs (para. 2.07).

C. **Present Status of Formal Education**

3.20 The Faculties of Agriculture and Veterinary Medicine of the University of Khartoum have well trained academic staff and produce about 200 B.Sc. graduates and 50-70 M.Sc. graduates every year. Although this number seems to be high, there is a shortage of staff in the field relative to requirements. Reasons for this are: unattractive living conditions and career prospects, low and irregular salaries, and difficult working conditions. In addition, the University curriculum is insufficiently oriented towards field work, and there are ample employment opportunities in other sectors of the economy and abroad.

3.21 Some of the junior scientists return to the University for postgraduate studies at the M.Sc. level and then carry out research programs at one of the ARC stations which are recognized by the University (para. 3.10). Facilities of the University itself include two demonstration farms of 600 fd and 60 fd, respectively.

3.22 Two new universities, the University of Juba and the University of Gezira (Wad Medani), are being developed. Juba University was opened recently and is expected to admit its first students in 1978. Instruction and research in agriculture and veterinary science will be in the Faculty of Natural Resources. An Agricultural Faculty is being organized at the Gezira University and students are expected to enter soon.

3.23 The training of agricultural technicians is undertaken by the newly created College of Agricultural Studies of the Institute of Technical Colleges through its divisions:
(a) Shambat Institute of Agriculture enrolling 120 students annually for a three-year diploma course in general agriculture;

(b) Soba Forest Rangers College training forest rangers for three years;

(c) Kuku Veterinary and Animal Husbandry Training Institute enrolling about 60 students annually for a three-year course;

(d) Abu Haraz and Abu Huyar Agricultural Colleges currently being developed with IDA assistance for an annual intake of 90 and 120 students, respectively, for three-year diploma courses in agriculture and animal husbandry;

(e) Yambio Agriculture Institute currently enrolling 60 students for a two year course but with plans to increase to 100 student capacity to train technicians and extension staff for the South.

3.24 Starting in 1978, the three agricultural secondary schools at New Halfa, Talha and Um-Dawan-Ban are offering a three year course, in line with the normal three year course at academic secondary schools. Agricultural secondary school leavers have experienced difficulties in finding employment.

D. The Proposed National Agricultural Research Strategy

3.25 The SYP recognizes the importance of agricultural research to achieve the set targets (para. 2.11), and has allocated moderate resources to the further development of the ARC (£5.4 million), the APRA (£4.6 million) and the VRA (£4.8 million) over the plan period but it gives no guidelines regarding the organization and focus of the future research effort. As to the subsectors, animal disease and animal production including range and crop/livestock integration are being given more emphasis than crops alone; and geographically, investments in the Northern, Central and Eastern Regions are vastly larger than those in the West and in the South.

3.26 The 'Joint Team' (para. 1.02) reviewed the SYP with regard to agricultural research needs 1/. Although it is acknowledged that the Sudan has an agricultural research capability superior to that of many countries at a similar development level, the Joint Team's master plan, which has become the blue-print for the long-term development of agricultural research in the Sudan, lists seven areas in which the research system should be improved:

(a) strengthen the organization and operations of the ARC; integrate crops and livestock research and development (as recently directed by the Minister, MAFNR); and be responsive to needs of the different farming systems and geographic areas of the Sudan;

(b) replace the fragmented disciplinary research approach by a coordinated multi-disciplinary team approach along commodity and non-commodity problem area lines (factor or agro-ecological production systems);

(c) strengthen the national research station network in the subsistence areas of the West, and the tropical regions in the South, but maintain research services for the food-producing irrigated areas and the mechanized farming schemes;

(d) establish long-term manpower planning and training for professional and technical staff, and improve personnel management policies and procedures;

(e) strengthen research on production economics, marketing and human resources;

(f) strengthen capabilities for evaluation and application of new technology, including more effective linkages with extension; and

(g) strengthen linkages with external technical assistance organizations, including the international agricultural research centers.

Organization and Operations

3.27 The ARC headquarters would be moved from Wad Medani to a new site near Khartoum to provide offices and facilities for the reorganized ARC, according to the Agricultural Research Corporation Act 1977 (Charts 18379 and 18266). This new organization plan provides for the transfer of (i) the administrative services (Director General, three Deputies, and research support services); (ii) the six heads of research divisions (crops; animal production; soils, water and engineering; natural resources; socio-economics; and agricultural processing); and (iii) the leaders of some research sections (to be determined). ARC's research management capability would be strengthened through: (a) a Planning and Programming capability responsible for planning, coordination and budgeting of research programs; producing feasibility studies for new programs and facilities; the planning of manpower requirements and training programs; and carrying out policy studies and studies on research management and organization; and (b) Technical Services responsible for research station development; the procurement of goods; and the provision of transport. An office for special linkage with Integrated Area Development Research Programs would include technical and support staff
to handle the services for three regional research programs (West; South; North and East), and for the external agencies cooperating in various research and development activities.

Research Coordination

3.28 Three types of program coordination are envisaged:

(a) National Commodity Research Programs (Chart 19266):
These are proposed for major commodities such as cereal crops (wheat and barley, rice, sorghum, millet, maize), oil seeds (groundnuts, sesame, sunflower), fiber crops (cotton, kenaf), root crops, medicinal and special plants, fruits, vegetables, sugarcane, coffee, tea, tobacco, kerkadeh (*hibiscus sabderiffa*, used as a beverage and as a dye), large ruminants (beef and dairy cattle, camels), small ruminants (sheep and goats), and poultry.

The research to be carried out would be related mainly to plant and animal improvement and production techniques. Management of each commodity program would be provided by a National Program Coordinator who would be based at a station where the commodity has its greatest regional importance. He would be responsible for: the technical aspects of the commodity program at his station and at the various satellite research stations; transmitting information between stations and from international sources; advising the Government on his commodity; organizing meetings for all program staff; preparing annual commodity reports; and reviewing research programs and proposals in their field. Because of local importance, two National Program Coordinators would be stationed in the Project area: gum arabic at El Obeid and millet at Nyala. Furthermore, it would be desirable to place the national coordinators for: kerkadeh at El Obeid, camels at El Fasher, and sheep and goats at Ghazala Gawazat.

(b) Factor (Discipline) Programs: Specific programs would be carried out in food technology, fishery management and marine biology, game and wildlife management; forestry; animal health, crop protection; plant introduction; seed technology; agricultural engineering; soil and water management; range and pasture management; and human resources. Factor Programs would be coordinated in a similar way as the commodity programs (para. 3.28a). Because of the regional importance, the National Coordinators of the following factor programs would be stationed in the Project area: soil and water management, and range and pasture management.

(c) Agro-Ecological Production Systems Research Programs:
Three production systems research programs corresponding to the main agro-ecological zones are being proposed:

- the rainfed arid and semi-arid areas (West and East):
the irrigated arid and semi-arid areas (East and Central); and

the high rainfall areas (South).

Their objective would be to study effective ways of increasing agricultural production by optimizing the use of available resources. They would build on the production functions being studied in the commodity or factor programs and emphasize factor combinations (para. 2.10). Each of the programs would be headed by a Program Coordinator based at the headquarters station within each agro-ecological region. The research themes and composition of research teams to study them would vary with the agro-ecological sub-zone concerned.

3.29 This threefold classification and coordination of agricultural research raises problems of line responsibilities: In many situations, a research project would be part of a commodity and production systems and factor program. Responsibility for research projects would be with the production systems program or sub-program leaders because of their area orientation, while the commodity and factor program coordinators would serve in an advisory capacity.

3.30 A 'research project system' would be introduced as the basic work unit which in aggregate would constitute the national commodity, production systems and factor programs. In the disaggregate, the component 'research projects' would form the basis for program planning, budgeting and accounting; for guidance of research staff; for direction and management; and for reporting and evaluation.

Research Station Network

3.31 The Joint Team proposals include the further development of main research stations and field stations, of which one main station and 6 field stations would be located in the West. Many recommendations could be activated with existing facilities. Others could be implemented with fairly modest investments. Some could be set up as part of specific development projects such as mechanized farming schemes, area development projects, or regional research and development projects, in particular in the West and the South.

Manpower Development and Management

3.32 To implement the Joint Team proposals, manpower requirements would increase from 250 to about 700 senior staff and from 420 to about 1,500 technical support staff. All agricultural research staff in the Sudan would be members of ARC's scientific cadre, to ensure a uniform approach to recruitment policies, career development, in-service training, positions standards and grades of service, and criteria and procedures for the evaluation of personnel. Under ARC's staff development program, about 60 scientists are currently abroad for advanced degree training, and many of these would be expected to join the Project upon their return. The Joint Team has proposed a Manpower Development and Management Office to enable ARC to handle staff matters more effectively.
Long-term Research Funding

3.33 To guarantee the long-term funding of a substantially enlarged agricultural research program, the government should introduce a strategy of financing agricultural research both by direct contributions of benefitting organizations and corporations and possibly also by the introduction of a cess on livestock and crop produce as a means of taxing other beneficiaries. An assurance was obtained during negotiations that GOS will prepare a study for the mid-term review of the Project (para. 7.02) on possible means of financing future agricultural research from sources other than budgetary allocation.

IV. THE PROPOSED RESEARCH PROGRAMS FOR THE WEST

A. The Project Area

Location and Climate (IBRD Map 12956)

4.01 The Project area includes the provinces of North and South Kordofan and North and South Darfur and extends from the Bahr el Arab in the South to the Libyan desert in the north, and from the Nile in the east to beyond the Jebel Marra massif in the west. The habitable southern two thirds of the Project area is located approximately between 9°30 and 16° N latitude and 20° and 32° longitude. The north-south rainfall gradient increases from very arid (about 25 mm per annum) in the northern desert to semi-arid (up to 900 mm) along the Bahr el Arab in the south, embracing the ecological zones of the sahara, sub-sahara, sahel, and sudanian savannah. In the south, the rainy season extends over about five months (June to October) and becomes gradually shorter towards the north.

Soils (IBRD Map 12955)

4.02 Fragmentary soil surveys have identified three broad soil groups in the inhabited southern part of the Project area:

(a) the stabilized (Qoz) sands complex is predominant and has low fertility but can be cultivated by hand;

(b) the non-cracking clays which are widely scattered, with sparse vegetation because of low permeability; grazing is the most common use of these soils but they are also suited for cropping once the hard surface pan has been broken up; and

(c) cracking clays, the most fertile and stable soils which are predominant in the Nuba Mountains and occur over much of the southern project area.
Population and Economy

4.03 The economy of the Project area has been summarized in paras. 2.05-2.10. Until recently, the nomadic livestock-owning Baggara people were predominant though a few Baggara and some non-Baggara people have been settled agriculturalists for a long time. Because of human and livestock population pressures, more and more pastoralists are turning to crop production in association with livestock in areas with annual rainfall over 400 mm thus reducing the land requirements per family and increasing the output per unit of land. The range areas once seasonally rested during cyclic migratory livestock movement are now subject to intense degradation. Furthermore, cash surpluses accumulated by settled cultivators are invested in livestock. Thus a continuum now exists with varying degrees of settled, semi-sedentary and fully nomadic populations, with their overlapping needs and competitive demands for resources (para. 2.08).

B. The Production Systems and their Research Needs

4.04 The variation in natural conditions and economic behavior of the inhabitants can be differentiated into five agro-pastoral production systems, of which two are purely pastoral and three are crop/livestock combinations:

(a) arid livestock production at the desert fringe;
(b) semi-arid livestock production in the south of the Project area, interspersed with crop production;
(c) integrated crop/livestock production on stabilized sands;
(d) integrated crop/livestock production on non-cracking clays; and
(e) integrated crop/livestock production on cracking clays.

There is considerable overlap between these systems: For instance, the northern (wet season) limit of the semi-arid cattle range coincides with the southern (dry season) limit of the arid camel/sheep range, thus being effectively grazed year-round and having no opportunity to recovery. Year-round livestock production is difficult on non-cracking clays due to flooding problems and on cracking clays because of mud. Livestock have to be moved to dry ground outside the area or fodder conservation is required to maintain the animals during the wet weather. The special features, constraints, research requirements of and proposals for each system are described in the following sections.

Arid Livestock Production at the Desert Fringe

4.05 The System. Nomadic pastoralists exploit the desert fringe with camels, sheep and some goats in response to and sometimes in anticipation of irregular rainfall and shifting plant cover. Seasonal movements range from...
250 to 500 km and may reach 800 km in years of exceptional rainfall with browse flushes in the desert. To maximize productivity, great experience, endurance and skill are required in manipulating the herds and flocks; for example camels are moved according to their nutritional needs, leaving people to feed on sheep and goats, and grain acquired through the barter or sale of animals.

4.06 Constraints on Production. The rainfall variability and lack of permanent water dictate repeated animal movement diverting most food energy to maintenance rather than production; body weight losses and mortalities are being incurred during the long and severe dry seasons; further constraints are loss of grazing through fire, and inadequate animal disease treatment.

4.07 The Research Program. The potential for improving the productivity of this fragile but highly adapted system through technical innovations must be regarded as limited, but studies on range condition and trend and manipulation through different livestock species, water regimes, fire and range management are indicated with a view to stopping the advance of the desert. Studies would also include the structure and productivity of camel herds, sheep and goat flocks with the underlying technical coefficients, the effect of improved disease control, feeding of mineral supplements and drought proofing mechanisms and strategies. Human resources would be studied for a longer time span with regard to demographic structure and trends, nutritional and health status, the organizational and social context of the production unit, decision-making, socio-economic value patterns, marketing processes, animal management patterns, and inter-population pressure through competition for resources. The program would be carried out in close coordination with the range section at Ghazala Gawazat under the Western Savannah Development Corporation (WSDC).

4.08 An interdisciplinary systems research team would be established at El Fasher, comprising a range specialist (sub-program leader), a camel specialist, a sheep and goat specialist, a second range specialist, and a sociologist (based at Nyala) plus support staff (Annex 2).

Semi-Arid Livestock Production in the Sudanian and Sahelian Zones

4.09 The System. The operating zone is a series of parallel longitudinal grazing orbits (from below 10°N almost to latitude 13°N) by cattle-owning Baggara pastoralists moving either towards fresh grazing (dry season) or away from biting fly and heavy mud (wet season). Seasonal movements range from 300 to 600 km. Cattle are the main class of stock, with some sheep and goats tended in mixed bunches. Dairy produce is being consumed for subsistence or sold at local markets in exchange for grain, tea, sugar or clothing.
Cattle offtake for sale is about 5% (mainly mature stock) but small ruminants serve as the main meat supply for subsistence. The labor intensive livestock system of the Baggara is reasonably efficient in relation to the natural potential, with calving rates 65%, lambing rates 120% and kidding rates 200% being recorded. Millet production for subsistence on the easily tillable Qoz soils is expanding rapidly.

4.10 **Constraints on Production.** Expanding cultivation by both cattle owners and sedentary farmers as well as grass fires reduce the availability of dry season grazing, the major bottleneck in feed supply during the year; cyclical growth and weight losses are common; natural grazing and crop residues are deficient in protein and minerals; animal diseases and parasites are more important than in the north; there are local water shortages and widespread overstocking of the range; and lack of permanent water supplies along the routes of transhumance force herders to complete the southward irrigation to the Bahr el Arab before the grazing can be fully utilized.

4.11 **The Research Program.** The area offers more scope for technical innovation than the area to the north (para. 4.07). The objective would be to improve the economic position of the predominantly transhumant pastoralists by improving livestock output through better range, water and livestock management, resulting in higher offtakes and increased subsistence. New technologies need to be developed that are both environmentally advantageous and socially acceptable. The main lines of research would include:

(i) **rangeland production:** the assessment of range condition and trend; its primary productivity and improvement possibilities through controlled grazing, water and fire management; the introduction of new species (particularly leguminous trees and shrubs), the strategic use of localities with better soils or water availability; and to a lesser extent, reseeding and bush control;

(ii) **livestock production:** the structure and productivity of cattle herds and sheep and goat flocks, with the underlying technical coefficients; the effect of improved disease control, mineral supplements and the feeding of crop residues and by-products on herd productivity; herd productivity changes through the early extraction and fattening of young males;

(iii) **pastoral security:** human resources would be studied along the same lines as stated in para. 4.07, including investigations of the opportunities for capital investment other than in livestock;

(iv) **pastoral systems:** research results on rangeland, livestock and human resources would be integrated into proposals for
improving traditional systems of husbandry and lifestyles of the people. The key to such changes would be the definition of basic limitations in available resources (particularly soil, vegetation and water) and therefore the need to conserve and use rationally what is available, and what extra can be produced, for example, by the introduction of new water management technology, by balanced numbers of people and livestock, and by increased subsistence cultivation. Basic concepts of land and water use, grazing control, organized land use for pastoralism and agriculture, animal disease control and drought proofing technology would all have to be studied and brought together so that final technology packages could be formulated and demonstrated in a manner appropriate to, and accepted by, the livestock producers.

4.12 A range and a livestock research division would be established under the WSDC at Ghazala Gawazat including two range specialists, a forage agronomist, four livestock research officers, a veterinary parasitologist and support staff (para. 4.33). WSDC would operate the range and livestock programs until ARC would take over the operation and management of all agricultural and livestock research in the West (para. 7.02).

Integrated Crop/Livestock Production on Stabilized Sands

4.13 The System. Livestock and crops are integrated in differing proportions and with varying efficiency on the stabilized sands in the middle belt of the Project area, between the 250 and 600 mm isoyets. Millet and groundnuts are the leading crops with some bamia (lady's finger), sesame and peppers. In the northern part, Acacia senegal is tapped in the dry season for gum arabic, thus providing a marketable production without labor competition for wet season crop harvesting. The shifting cultivation technique includes 4-5 years of cropping with gradually declining yields, and 8-12 years of bush fallows. Longer fallow periods in the north allow the creation of more efficiently manageable gum gardens but there is mounting land pressure to reduce the fallow period. A typical production unit would consist of a family (man, wife or wives and their children) cultivating 2-4 ha of land and living in villages of 10-30 huts. Livestock (desert sheep and goats used for milk and meat production and for low volume marketing) are required to stabilize the system because of crop failures in one year out of five. Local distribution of settlements is a function of water sources which are abundant over much of the area provided that boreholes have been developed.

4.14 Constraints on Production. Marginal and variable rainfall and low soil fertility are the main reasons for a fragile farming system with high demand on land. Overstocking is prevalent around villages and grass fires are destroying most of the pasture; over exploitation of crop land through shortening fallow periods encourages erosion and dune encroachment;
there is no technology which would allow crop yields to increase by means other than increased cultivation areas; and there are reciprocal pressures of livestock and cultivation demands in adjoining and competing production systems.

4.15 **The Research Program.** Research on this integrated livestock/crop production system would include: differential efficiencies and costs of crops and livestock within the integrated production systems; the study of integrating factors such as risk immunization, even use of labor, utilization of unsaleable products and the effect of manure on soil fertility; evolution of permanent crop/fodder/pasture rotations; small farm economic studies; the social structure of production units; marketing procedures and opportunities; and institutional requirements in the subsistence sector. Technology packages would be developed which would be easily applicable by subsistence farmers. The environmental impact of innovations would be constantly monitored.

4.16 In developing these packages, particular emphasis would be laid on:

(i) **crops:** the testing of food and cash crops, particularly new millet and groundnut varieties supplied by ARC stations or ICRISAT; minimum tillage and water management technology, crop protection, cultivation practices and their timing; weed control; and - to a lesser extent - fertilizer use;

(ii) **livestock:** the use of draught animals; milk and meat production; nutritional values of crop by-products and residues; fertilizer values of animal wastes; comparative productive and reproductive efficiencies of local cattle, sheep and goats at low and variable feed supplies;

(iii) **pasture and forage:** possible new species such as *Stylosanthes* (pasture legume) and *Cenchrus* (grass) to improve range production; the impact and economics of forage crops, fertilizers, and irrigation to increase feed supply at critical times; conserved fodder cut from pasture and forage crops; crop residues and grain supplements for the maintenance or survival feeding of stock during the dry season.

4.17 The research program would be implemented by the WSDC through the crop division at Ghazala Gawazat (para 4.33). The Project would support the program by providing socio-economists and two groundnut breeders (para. 4.29). The trial program to be financed under the Mechanized Farming Project (MFC III) at El Fuda would be expected to complement the research program and demonstrate practical solutions to farmers.
Integrated Crop/Livestock Production on Non-Cracking Clays

4.18 The System. Non-cracking clays are elements of existing production systems in the Project area: they do not constitute a production system in their own right. They are most detectable in the clay pan-sand alternation of the Baggara pattern; interspersed with cracking clays around the Nuba Mountains; and in a stabilized sands/non-cracking clays mosaic south of El Obeid. Non-cracking clays are used mainly for livestock, as water catchments, and are capable of providing range grasses and browse of high mineral content.

4.19 Constraints on Production. The hard surface pan of these basically fertile soils prevents their use by smallholders: traditional tillage techniques cannot break them up for cropping on a significant scale. Otherwise similar problems prevail in the production system as described in para. 4.14.

4.20 The Research Program. The general approach would be the same as for the integrated crop/livestock systems on stabilized sands (para. 4.15 and 4.16) with greater risks of drought (El Obeid receives 420 mm average annual rainfall with a coefficient of variation of 28%). Crop production research would include millet, and focus on improved tillage technology, including animal traction at the smallholder level. The wild-growing plant kerkadah would be studied regarding its suitability both in an integrated farming system or as a plantation crop.

4.21 A specialized study on gum arabic (mainly growing on stabilized sands) would include the establishment and culture of Acacia senegal; gum arabic secretion; harvesting and marketing; the grid planting of A. senegal to form shelter breaks, control soil erosion, improve soil fertility through the fixation of atmospheric nitrogen, and improve the water-holding capacity of the soil through increased organic matter; the use of the tree as animal fodder; and its inclusion in an appropriate long-term rotation under range conditions.

4.22 A multi-disciplinary team comprising a systems agronomist (sub-program leader), two gum arabic specialists, agricultural engineer, farm management economist, millet breeder, livestock specialist, kerkadah specialist, research liaison officer and support staff would be established under the Project at El Obeid (Annex 2).

Integrated Crop/Livestock Production on Cracking Clays

4.23 The System. Cracking clays are characteristic of the south-east of the Project area. The major differences between this system and that on stabilized sands (para. 4.13) would be the replacement of millet as the major crop by sorghum, which is more tolerant of heavy soils, and the replacement of groundnuts by sesame as the major support crop. In the Nuba Mountains, cotton is important, replacing gum arabic of the stabilized sands as a cash crop. Livestock differences also exist: desert sheep decline in importance and are replaced by goats and cattle.
4.24 Constraints on Production. In addition to the problems common to all cultivators in the Project area (para. 4.14), specific problems exist with regard to the short period for seed bed preparation and planting on cracking clays; traditional tillage technology limiting the area that can be cultivated; unimproved sorghum and sesame varieties; weed competition (striga) in sorghum and post-harvest pests in sesame. Livestock is seriously affected by mud and flies in the wet season. Nevertheless, it should be noted that the cracking clays have the greatest development potential of all production systems under consideration.

4.25 Further to the research program described under the stabilized sands (paras. 4.15 and 4.16), emphasis would be on:

(i) crops: sorghum, sesame, cotton and soybeans suitable for reasonable rainfall conditions as in the case of Kadugli (average rainfall 760 mm/year; coefficient of variation 18%);

(ii) livestock: animal traction; milk and meat production of local and introduced breeds of cattle, sheep and goats, and their crosses;

(iii) pasture and forage: because of the difficulties of grazing clay soils during the wet season, techniques of fodder conservation, in particular hay; and

(iv) cultural techniques: examination of hand and mechanized tools for more rapid and more efficient cultivation of the difficult black cotton soils; tillage practices by hand, animal traction and varying degrees of mechanization in relation to optimal water use, root penetration and plant growth, soil erosion, timing of tillage, labor requirements and economic evaluation.

4.26 A multi-disciplinary systems research team would be stationed at Kadugli, comprising a plant breeder/agronomist as sub-program leader; two farm management economists, two agricultural engineers, sorghum breeder, livestock specialist/forage agronomist, research liaison officer, and support staff (Annex 2). Close linkages would be established with one ODM group of scientists expected to be placed with the Nuba Mountains Corporation shortly.
C. Supporting Research

Water and Land Use Management Research Program

4.27 This program, to be based at Nyala, would support the five multi-disciplinary systems research teams in the Project area, including the survey, monitoring and classification of available land and water resources, and their rational use in crop or livestock production. The efficient use of limited rainfall is the key to the optimization of crop and animal production in the West. The main lines of research would include:

(a) resource potential: an inventory and the analysis of previous investigations, and of existing environmental data for the Project area such as meteorological records, air photographs and satellite imagery; the inventory (including maps) would set out overall system parameters, such as water balance, primary productivity, pedology, ecological trend, and human and animal demography;

(b) water management technology: water conservation, infiltration, penetration, run-off, harvesting, surface, soil profile and underground storage, evaporation, and efficient minimum use for crops, livestock and human populations;

(c) socio-economics of water management: comparative costs and benefits of the techniques of harvesting, storing and using water; social structures and economic pressures as mechanisms to control and restrict water use in order to control livestock numbers, improve rangeland management and improve crop farming;

(d) land use planning: preparation of a land use classification system for the West based on suitability of land for crop or livestock production; preparation of land use plans avoiding conflicts between the interests of pastoralists and cultivators and including dry season grazing reserves for pastoralists; stock route planning; improvement of traditional crop farming, and identification of further settlement areas and localities for large-scale, mechanized farming and irrigation development; operational (or pilot) research projects involving land use on a catchment basis and the main soil types;

(e) solar energy: adapting new solar energy technologies for cooking, transportation, and the recovery, distillation and recycling of water.

4.28 The water and land use management research team based at Nyala would comprise a program leader and deputy leader; soil physicist; soil chemist; two agro-climatologists; water engineer; and technical support
staff. Field project officers and technical support staff would also be stationed at El Obeid and Kadugli (Annex 2).

Socio-Economic Support Services

4.29 A group consisting of two sociologists, two economists and a biometrician would be established at Nyala (Annex 2), in order to be available to the multi-disciplinary research teams in matters concerning economics and human resources and in project design and analysis. The group would not carry out its independent research program but be strictly integrated into the multi-disciplinary sub-programs. The advantages of stationing the group at Nyala would be to control technical supervision and utilization of research staff for more than one production system.

Training and Extension Unit (TEU)

4.30 The TEU would organize short refresher courses for scientists and technicians and prepare brochures and pamphlets for extension staff. It would be headed by a scientist with training experience, supported by an assistant training officer (Annex 2). The unit would not be established until Year 5 when the first research results will become available for extension and when the first refresher courses are expected to be needed.

Testing and Application of Technology

4.31 Agricultural research on stations risks becoming academic if not closely linked to farm level problems. New technology would, therefore, not only be tested at the research station or on a simulated smallholding, but also on farmers' fields. The research liaison officers to be stationed at Nyala, El Obeid and Kadugli would be responsible for the adaptation of the technology packages to practical farming conditions; they would also be responsible for the transfer of technical language into simple leaflets for extension staff and for field days. The most important delivery systems of new technology to farmers would be the field services of the WSDC in Southern Darfur (paras. 4.32-4.34), and the MFC (para. 4.35) and the Nuba Mountains Corporation in Southern Kordofan. Several other regional development projects in Southern Kordofan including one ODM Project (para. 4.26), are expected to establish agricultural extension services after the first research results have become available for application.

D. Linkages with Regional Development Projects

Western Savannah Development Corporation (WSDC)

4.32 The WSDC has been established to coordinate and undertake comprehensive development projects in the South Darfur Province, including initially an ODM/Abu-Dhabi financed project in the Southern District and the IDA/Saudi Fund financed Savannah Development Project (SDP).
4.33 WSDC would operate a sizeable investigational program at Ghazala Gawazat covering range management, animal production and crops. This program would meet the research needs of two production systems in the West: (i) the semi-arid Livestock Production Systems Program for the traditional cattle-owning populations of Southern Darfur and the camel/cattle tribes at the western edge of Northern Darfur (para. 4.12); and (ii) the Integrated Livestock and Crop Production Systems Program for the stabilized sands (Qoz) of Southern Darfur (para. 4.17) at a cost of about US$16.6 million over a six-year Project life. As stipulated in the Credit Agreement of the SDP, all research in the West would be transferred to the Agricultural Research Project as soon as ARC is equipped and fully operational to handle the research program. The Research Plan for the West (para. 7.02) would include detailed proposals for the transfer of WSDC research to ARC, not later than five years after Project effectiveness. Meanwhile, Project and ARC headquarters staff would serve in an advisory capacity to WSDC for experiment program planning and design through the production systems program leader, and in turn staff of WSDC would make available their knowhow in range, livestock and crops research. Assurances were obtained during negotiations that: (i) GOS shall cause WSDC to transfer to ARC all of WSDC’s research facilities in the West not later than five years after Project effectiveness, in accordance with a schedule to be agreed upon during the mid-term Project review; (ii) GOS shall, until the completion of such transfer, ensure effective technical cooperation between ARC and WSDC; and (iii) the Saudi Fund as co-financier of SDP and all other external financiers assisting in WSDC’s research programs in the West (Abu-Dhabi Government, ODM and EC) will be given a reasonable opportunity to comment on the measures for effecting such transfer.

4.34 WSDC would also operate a field trials program on six small nucleus development centers for crops and three range stations which would not be transferred to ARC. Equally, WSDC’s extension and training facilities would not be transferred, but serve as a delivery mechanism of new technology to the producers.

Mechanized Farming Corporation (MFC)

4.35 MFC is proposing to establish a development center at El Fuda in Southern Kordofan being financed under the Third Mechanized Farming Project. It would, inter alia, comprise a field trials program to identify suitable farming systems including livestock on sandy soils which would comprise farm mechanization with tractors. Such mechanized farming development would be oriented towards small-scale farmers, and to a lesser extent to extensive large-scale operations. It is anticipated that the trial program would be implemented in close cooperation with the WSDC field trials and experimentation component, and backed up by the Research Project’s team to be stationed at Kadugli.
5.01 The Project would, over a six-year period, develop and operate ARC's research capability in the West, and provide support services at ARC's new Khartoum headquarters to be established under the Project. In particular, the Project would include:

(a) two research programs dealing with: (i) livestock and crop production systems at El Obeid (integrated crop/livestock on non-cracking clays), Kadugli (integrated crop/livestock on cracking clays) and El Fasher (arid livestock) - in close cooperation with WSDC - Ghazala Gawazat (integrated crop/livestock on stabilized sands and semi-arid livestock); and (ii) water and land use management research at Nyala, including research support services;

(b) development of an ARC research center and regional headquarters at Nyala; and of research stations at El Obgid, Kadugli and El Fasher, including 128 houses, about 4,200 m² of office space and field laboratories, and about 2,700 m² of farm buildings, landscaping and fencing; plus furniture and office/housing equipment;

(c) 7 mobile research units, 21 four-wheel-drive vehicles, 32 motor cars, 1 minibus, 5 tractors plus farm implements, and 1 aircraft;

(d) purchase of an office building (about 2,400 m²) for ARC's headquarters to be moved to Khartoum;

(e) strengthening of ARC's headquarters through the establishment of a Project Support Unit (PSU) and a Planning Evaluation Unit (PEU);

(f) employment of 46 scientists of which ten would be internationally recruited for a total of 49 man-years; and about 90 scientific and about 160 other supporting staff;

(g) 80 man-months of short-term consultancies;

(h) funds for contract research to be carried out by specialised research institutions other than ARC;

(i) 28 research fellowships (6 for Ph.D, 5 for M.Sc. and 17 for non-degree specialization courses) for Sudanese scientists;
(j) limited funds for Project scientists to attend international conferences; and

(k) a small purchases fund.

5.02 The Project would be implemented by ARC through a regional headquarters to be established at Nyala, supported by the new ARC headquarters at Khartoum. The Project would consist of two phases: a development phase of about three years and a research phase of a further three years.

B. Detailed Features

Research Station Development

5.03 Funds would be provided for the following facilities:

(a) **Nyala**: development of a research center and Project headquarters facilities would comprise 1,500 m² offices, laboratories, a documentation center and a conference room; and 55 staff houses;

(b) **El Fasher**: development of a research station including about 550 m² offices and field laboratories, 300 m² farm buildings, 16 staff houses and minor fencing;

(c) **El Obeid**: development of a 300 fd research station, with about 1,000 m² offices and field laboratories, 1,200 m² farm buildings, 28 staff houses, land-scaping and fencing; and

(d) **Kadugli**: development of a 500 fd research station with about 1,100 m² offices and field laboratories, 1,200 m² farm buildings, 29 houses and landscaping and fencing.

The specifications and space provisions of the housing, offices, field laboratories and farm buildings at the four research stations conform with those adopted for similar World Bank projects in Indonesia, Brazil and Spain, and with recently built international agricultural research centers. The estimated base cost of a light weight building system for which parts would be prefabricated abroad and airfreighted to the construction sites is £££d 225/m² for offices and laboratory facilities, £££d 190/m² for housing, and £££d 112/m² for farm buildings as at Khartoum; these costs would be increased by 15% at Nyala to 25% at Kadugli due to the remoteness of the area.

Furniture, Equipment and Vehicles

5.04 Furniture and equipment would be provided for all houses, offices and laboratories constructed under the Project. In addition, the seven
Mobile units, 21 four-wheel drives, 32 cars, 1 minibus, 1 aircraft, 5 tractors plus implements and 14 radios (receiver/transmitter) would be deployed as specified in Table 1. Mobile units would be provided to the Research Teams to enable them to carry out field testing of research results. Each unit would consist of a converted four wheel drive truck with basic laboratory facilities together with camping equipment. Appropriate spaces would be obtained for all equipment to avoid later difficulties. Sufficient fuel supplies would be stored at each Project station to avoid possible breakdowns of supplies.

**Strengthening of ARC Headquarters**

5.05 To enable ARC to effectively operate and administer a nation-wide balanced agricultural research program, it would be essential to move its headquarters from Wad Medani to Khartoum. The Project would provide for the purchase of a suitable office building in Khartoum including office furniture and equipment; included also would be conference facilities, a documentation center, and an illustration and graphics studio. The space needs are estimated at about 2,400 m² at a cost of about US$1.6 million.

5.06 The Project would establish two units in the ARC headquarters designed both to support Project implementation in the West and to strengthen ARC's central research administration capability.

(a) the **Project Support Unit** (PSU) would be established in year 1 and would comprise the Senior Research Adviser to the DG of ARC, the Project Liaison Officer, the Project Architect/Planner and an accountant/procurement officer (Annex 2); its functions would include (i) advice to the DG on research policies and programs; (ii) technical back-up for the Project in the West such as the procurement of goods, planning and administration of civil works and assistance to the Nyala Project headquarters in financial control and budget preparation; and (iii) liaison for the Project with Government and the Universities; and

(b) the **Planning and Evaluation Unit** (PEU), to be established in year 1, would strengthen ARC's planning and evaluation capacity and would be headed by a Research Planning and Evaluation Adviser (Annex 2); its functions would include: (i) developing a uniform 'project system' within ARC for effective planning, direction, evaluation and overall management of research which would be adopted; (ii) the development and operation of a Project monitoring and evaluation system; (iii) assisting in the preparation of a detailed Research Plan for the West (para. 7.02); (iv) arranging for an external Project review in years 3 and 6 by internationally recognized scientists; (v) carrying out an annual internal review of all ARC research programs with regard to their priority order, technical soundness and progress in implementation; and (vi) the preparation of a Project completion report according to World Bank guidelines.
Staffing

5.07 A total of 46 scientists and senior administrators, about 90 scientific and about 160 other supporting staff would be employed under the Project, at five different locations, in four different programs and in twelve different disciplines (Table T1 and Annex 2). 16 of them would be key staff: The Project Director; Deputy Project Director; Project Liaison Officer; a land and water use specialist - program leader and his deputy; an agro-climatologist; a range specialist - sub-program leader arid livestock production system; a sociologist - discipline leader; a production systems specialist - production systems research program leader; a sub-program leader - cracking clays; a sub-program leader - non-cracking clays; a farm management economist - discipline leader; an agricultural engineer - discipline leader; the Senior Research Adviser to the DG; the Project Architect/Planner and the Research Planning and Evaluation Adviser. The Project Director, a Sudanese national, to be stationed at Nyala, would have the rank of a Chief Scientist with wide experience in livestock/crop research. In particular, he would need to be a person strongly oriented towards applied production, with the experience and ability to lead a multi-disciplinary research team and to cooperate with extension services and development authorities. He would be supported by a Deputy Project Director who would be a scientist with experience in livestock, plant or soil research, and in directing a research program. The Senior Research Adviser to the DG would be stationed at ARC headquarters in Khartoum, head PSU, and advise the DG in all matters concerning research policies and programs. An assurance was obtained from Government that senior Project staff will have qualifications and experience satisfactory to IDA; the appointment of the Project Director, Deputy Project Director, and Senior Research Adviser to the DG, is a condition of Credit effectiveness. The Minister, MAFNR, has already nominated a Project Director who participated in the Project negotiations and is acceptable to IDA. Continuity would be important for the successful implementation of the Project. Therefore, an assurance was obtained during negotiations that staff appointments will be for a minimum of 5 years in case of the Project Director, his Deputy, the Senior Research Adviser to the DG, and the Production Systems Research Program Leader; and not less than 2 years for all other senior staff.

5.08 For ten key posts of the 16, it would be unlikely to find suitable candidates within the Sudan and these would be recruited internationally: the Senior Research Adviser to the DG, Project Architect/Planner, and Research Planning and Evaluation Adviser would be based at Khartoum; the Deputy Project Director, Production Systems Specialist, Land and Water Use Specialist, Agro-Climatologist and Sociologist at Nyala; and the Farm Management Economist and Agricultural Engineer at Kadugli. Base costs for 49 man-years are estimated at US$3.7 million. USAID would provide the 7 expatriates for the West under its Title 12 procedures through a management contract with the Consortium for International Development (CID) of the Western Universities; and would be expected to contract IADS for providing the three expatriates for ARC's Khartoum headquarters. These contracts would stipulate that the Deputy Project Director and the Production Systems Research Program Leader would stay no less than 5 years and the other individual research staff a minimum of 2 years on the Project.
Short-Term Consultancies

5.09 The Project would provide US$0.4 million (base cost) for 80 man-months of short-term consultancies (12-14 man-months per year) to be used for the preparation of the Research Plan due in year 3 (para. 7.02); project monitoring (para. 7.17); specialized consultancies in the research programs; procurement assistance; and the external Project reviews in Years 3 and 6. During negotiations, an assurance was obtained that consultants to be employed will have qualifications and experience satisfactory to IDA.

Contract Research

5.10 Funds are also being provided (US$0.5 million) for special research problems that are important but cannot be handled within the framework of ARC. Specialized institutions, mainly outside Sudan, would be contacted for this task. An assurance was obtained during negotiations that such research institutions shall be selected by the Project Director in consultation with IDA.

Overseas Training and Conferences

5.11 The Project would provide US$0.5 million for 28 overseas research fellowships for scientific staff of which 6 would be for Ph.D. degrees (four years); 5 for M.Sc. degrees (two years) and 17 for non-degree specialization courses from 3 to 12 months. Candidates would be selected from among those staff who have served at least six months under the Project in the West to ensure that they are fully familiar with existing problems. Candidates would be selected by the DG, the Project Director and the Senior Research Adviser to the DG in consultation with IDA.

5.12 Limited funds (US$0.01 million) would be provided for Project scientists to attend international meetings and conferences of their discipline. Candidates would be selected by the DG, the Project Director and the Senior Research Adviser to the DG in consultation with IDA.

Building Consultancies

5.13 Funds (US$1.0 million) would be provided for the Project to recruit an international firm of executive architects (para. 7.07), to prepare a development plan study and report, and to give procurement assistance to PSU.

Small Purchases Fund

5.14 A small purchases fund (US$0.5 million) would be provided to enable the Project to buy and maintain experimental animals and necessary inputs, and to cover other small expenses.
Table T1

SUDAN
AGRICULTURAL RESEARCH PROJECT

Staff and Physical Inputs by Location

<table>
<thead>
<tr>
<th>Staff</th>
<th>Unit</th>
<th>Khartoum</th>
<th>Nyal</th>
<th>Fasher</th>
<th>Kadugli</th>
<th>El Obeid</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Senior Staff</td>
<td>No</td>
<td>2</td>
<td>22</td>
<td>4</td>
<td>8</td>
<td>10</td>
<td>46</td>
</tr>
<tr>
<td>- of which internationally recruited</td>
<td>No</td>
<td>(3)</td>
<td>(5)</td>
<td>--</td>
<td>(2)</td>
<td>--</td>
<td>(10)</td>
</tr>
<tr>
<td>Administrative Staff</td>
<td>No</td>
<td>3</td>
<td>4</td>
<td>2</td>
<td>3</td>
<td>3</td>
<td>15</td>
</tr>
<tr>
<td>Technicians</td>
<td>No</td>
<td></td>
<td>24</td>
<td>4</td>
<td>14</td>
<td>12</td>
<td>54</td>
</tr>
<tr>
<td>Asst. Technicians</td>
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<td></td>
<td>15</td>
<td>5</td>
<td>9</td>
<td>8</td>
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<tr>
<td>Secretaries</td>
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<td>2</td>
<td>12</td>
<td>3</td>
<td>6</td>
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<tr>
<td>Head Drivers</td>
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<td>1</td>
<td>1</td>
<td>1</td>
<td>5</td>
</tr>
<tr>
<td>Drivers</td>
<td>No</td>
<td>5</td>
<td>14</td>
<td>5</td>
<td>17</td>
<td>15</td>
<td>56</td>
</tr>
<tr>
<td>Laborers</td>
<td>No</td>
<td>1</td>
<td>6</td>
<td>5</td>
<td>34</td>
<td>12</td>
<td>58</td>
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<tr>
<td>Total Staff</td>
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<td>98</td>
<td>29</td>
<td>92</td>
<td>68</td>
<td>301</td>
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Buildings

<table>
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<tr>
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<th>Unit</th>
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<th>Fasher</th>
<th>Kadugli</th>
<th>El Obeid</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Offices and Labs</td>
<td>m²</td>
<td>-</td>
<td>1,500</td>
<td>550</td>
<td>1,100</td>
<td>1,000</td>
<td>4,150</td>
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<tr>
<td>Farm Buildings</td>
<td>m²</td>
<td>-</td>
<td>300</td>
<td>1,200</td>
<td>1,200</td>
<td>2,700</td>
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<tr>
<td>Houses</td>
<td>No</td>
<td></td>
<td>55</td>
<td>16</td>
<td>29</td>
<td>28</td>
<td>128</td>
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Vehicles

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<tr>
<th>Vehicles</th>
<th>Unit</th>
<th>Khartoum</th>
<th>Nyal</th>
<th>Fasher</th>
<th>Kadugli</th>
<th>El Obeid</th>
<th>Total</th>
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<tbody>
<tr>
<td>Mobile Units</td>
<td>No</td>
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<td>2</td>
<td>1</td>
<td>2</td>
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<tr>
<td>Motor Cars</td>
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<td>6</td>
<td>8</td>
<td>1</td>
<td>10</td>
<td>7</td>
<td>32</td>
</tr>
<tr>
<td>Minibus</td>
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<td>--</td>
<td>--</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>Total Vehicles</td>
<td>No</td>
<td>6</td>
<td>18</td>
<td>6</td>
<td>16</td>
<td>15</td>
<td>61</td>
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Aircraft

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<tr>
<th>Aircraft</th>
<th>Unit</th>
<th>Khartoum</th>
<th>Nyal</th>
<th>Fasher</th>
<th>Kadugli</th>
<th>El Obeid</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>No</td>
<td></td>
<td></td>
<td>1</td>
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Tractors

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<tr>
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<th>Fasher</th>
<th>Kadugli</th>
<th>El Obeid</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>No</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>4</td>
<td>1</td>
<td>5</td>
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Radios

<table>
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<tr>
<th>Radios</th>
<th>Unit</th>
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<th>Fasher</th>
<th>Kadugli</th>
<th>El Obeid</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>No</td>
<td></td>
<td></td>
<td>1</td>
<td></td>
<td>5</td>
<td>2</td>
<td>3</td>
</tr>
</tbody>
</table>

1/ Status during Year 6 (except expatriates: Year 5)

May 23, 1978
Table T2

SUDAN
AGRICULTURAL RESEARCH PROJECT

Project Cost Summary

<table>
<thead>
<tr>
<th></th>
<th>Local</th>
<th>Foreign</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>($)</td>
<td>($)</td>
<td>($)</td>
</tr>
<tr>
<td></td>
<td>($)</td>
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<td></td>
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<td></td>
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<td></td>
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</tr>
<tr>
<td></td>
<td>($)</td>
<td>($)</td>
<td>($)</td>
</tr>
<tr>
<td>Capital Costs</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Construction</td>
<td>2,132</td>
<td>3,958</td>
<td>6,090</td>
</tr>
<tr>
<td>Professional Fees and Site Supervision</td>
<td>403</td>
<td>--</td>
<td>403</td>
</tr>
<tr>
<td>ARC Headquarters Building</td>
<td>650</td>
<td>--</td>
<td>650</td>
</tr>
<tr>
<td>Furniture and Equipment</td>
<td>136</td>
<td>290</td>
<td>426</td>
</tr>
<tr>
<td>Vehicles, Farm Machinery</td>
<td>190</td>
<td>136</td>
<td>326</td>
</tr>
<tr>
<td>Aircraft</td>
<td>11</td>
<td>32</td>
<td>42</td>
</tr>
<tr>
<td>Farm Development</td>
<td>26</td>
<td>64</td>
<td>90</td>
</tr>
<tr>
<td>Total Capital Costs</td>
<td>3,732</td>
<td>4,603</td>
<td>8,331</td>
</tr>
<tr>
<td>Operating Costs</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Local Salaries</td>
<td>1,822</td>
<td>--</td>
<td>1,822</td>
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<tr>
<td>Accommodation</td>
<td>42</td>
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<tr>
<td>Office Expenditure</td>
<td>21</td>
<td>42</td>
<td>63</td>
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<td>Transport</td>
<td>46</td>
<td>95</td>
<td>141</td>
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<tr>
<td>Building Maintenance</td>
<td>146</td>
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<td>522</td>
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<tr>
<td>Equipment Maintenance</td>
<td>130</td>
<td>130</td>
<td>260</td>
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<tr>
<td>Aircraft Operation</td>
<td>50</td>
<td>150</td>
<td>200</td>
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<tr>
<td>Farm Costs</td>
<td>34</td>
<td>84</td>
<td>118</td>
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<tr>
<td>Total Operating Costs</td>
<td>2,188</td>
<td>670</td>
<td>2,813</td>
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<tr>
<td>Technical Assistance</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Internationally Recruited Staff</td>
<td>206</td>
<td>1,267</td>
<td>1,473</td>
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<tr>
<td>Training</td>
<td>60</td>
<td>126</td>
<td>186</td>
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<tr>
<td>Conferences</td>
<td>--</td>
<td>11</td>
<td>11</td>
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<tr>
<td>Short-term Consultancies</td>
<td>--</td>
<td>960</td>
<td>960</td>
</tr>
<tr>
<td>Building Program</td>
<td>--</td>
<td>800</td>
<td>800</td>
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<tr>
<td>Total Technical Assistance</td>
<td>266</td>
<td>2,164</td>
<td>2,430</td>
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<tr>
<td>Physical Contingencies</td>
<td></td>
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<td></td>
</tr>
<tr>
<td>Expected Price Increase</td>
<td>1,266</td>
<td>1,726</td>
<td>3,072</td>
</tr>
<tr>
<td>Total Contingencies</td>
<td>2,566</td>
<td>2,300</td>
<td>4,866</td>
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<tr>
<td>TOTAL BASE COST</td>
<td>6,192</td>
<td>2,638</td>
<td>8,830</td>
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<tr>
<td>Physical Contingencies</td>
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<tr>
<td>Expected Price Increase</td>
<td>1,266</td>
<td>1,726</td>
<td>3,072</td>
</tr>
<tr>
<td>Total Contingencies</td>
<td>2,566</td>
<td>2,300</td>
<td>4,866</td>
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<tr>
<td>TOTAL PROJECT COST</td>
<td>8,458</td>
<td>4,768</td>
<td>13,226</td>
</tr>
</tbody>
</table>

May 26, 1978
VI. PROJECT COST AND FINANCING

A. Cost Estimates

6.01 Total Project costs, including contingencies, are estimated at US$45.4 million of which about US$24.2 million or about 53% would be in foreign exchange. Costs are detailed in Annex 3 and are summarized in Table T2.

6.02 Cost estimates are based on prices projected to April 1978 and include (a) a 15% physical contingency for construction works, and (b) expected price increases totalling 27% of total base Project cost. Expected price increases have been estimated as follows:

<table>
<thead>
<tr>
<th></th>
<th>Equipment</th>
<th>Civil Works</th>
<th>Other Costs</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Foreign</td>
<td>Local</td>
<td>Foreign</td>
</tr>
<tr>
<td>1978</td>
<td>7</td>
<td>13</td>
<td>8</td>
</tr>
<tr>
<td>1979</td>
<td>6.5</td>
<td>11</td>
<td>7.5</td>
</tr>
<tr>
<td>1980-85</td>
<td>6</td>
<td>8</td>
<td>7</td>
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</tbody>
</table>

Import duties and other taxes, estimated at US$6.8 million, have been included. Costs of internationally recruited personnel are estimated at US$72,000 per man-year of which 86% would be in foreign exchange. Local salaries have been increased by 30% above present ARC scales, as a hardship allowance for the West and in line with salary arrangements for the SDP. It would be a condition of Credit effectiveness that ARC has completed a study comparing its salaries and benefits with those provided by other comparable institutions, such as the universities, employing high calibre staff, and has adopted incentives satisfactory to GOS and IDA for its staff to be assigned to work on the Project.

B. Proposed Financing

6.03 It is proposed that Project costs be shared in the following amounts and proportions:
The proposed IDA Credit of US$15.0 million would be on standard terms to GOS which would pass it on as a grant to ARC. The Credit would cover about US$15.0 million or 62% of the foreign exchange costs, corresponding to about 39% of net Project costs. USAID would contribute US$20.0 million or 52% of net Project costs. The USAID grant would finance US$9.2 million or 38% of foreign exchange costs and US$10.8 million of local costs. GOS would contribute the remaining US$10.4 million or 23% of total Project costs (including taxes and duties of US$6.8 million), or US$3.6 million or 9% of net Project costs.

Contributions by IDA, USAID, and Government would be channelled as a grant directly to the ARC, which would establish a separate bank account for the Project. A Project Agreement has been negotiated between ARC and IDA regarding the use of the IDA Credit. Conditions of Credit effectiveness are that (i) all conditions precedent to the effectiveness of the USAID Grant Agreement have been fulfilled; and (ii) GOS has deposited into ARC's Project account an amount of no less than £5d 200,000 to meet start-up expenditures. GOS gave an assurance during negotiations that, based on the approved work plan (para. 7.17), it will credit the Project account every six months with sufficient funds to meet expenditures expected to be made directly by ARC in respect of the Project during the next six months and required to carry out the approved work plan. Major investment items would be paid directly from the IDA Credit or be reimbursed to the Project account upon appropriate documentation.

C. Budgetary Implications

Following Project completion, the annual recurrent costs of agricultural research in the West on the same scale as under the Project would be about US$3.3 million, in 1983 prices. After deduction of GOS's present
fund allocation to agricultural research in the West (US$0.4 million in 1983 terms), about US$2.9 million would have to be provided from the GOS budget annually. Although this means a substantial increase from present allocations, it would only be about 1/2% of the projected agricultural output of the West in 1983 terms, 1/ thus being below agricultural research allocation in the Center and East.

VII. PROJECT IMPLEMENTATION

A. Phasing

7.01 During the first three years, the Project would primarily be concerned with the development of research facilities, the procurement of vehicles and equipment, and the hiring of scientific and support staff. There would be limited scope to carry out an integrated multi-disciplinary research program during this phase. However, several preparatory activities would be undertaken: overseas training of Sudanese scientific Project staff (para. 5.11); preparation of the research program planning and budgeting system (para. 7.17); introduction of cost accounting for research programs (para. 7.16); preparation of and agreement on the detailed Research Plan for the West (para. 7.02); development of the Project monitoring and evaluation system (para. 5.06b); and Project reporting (para. 7.17).

7.02 By the end of the first half of Year 3, the Project Director would, with the assistance of PSU and PEU in Khartoum, prepare a detailed Research Plan for the West and estimate the costs until Project completion in Year 6. This plan would form the basis of a mid-term Project review by a panel of three distinguished international scientists, and representatives from USAID and IDA; it would also include detailed proposals for the transfer of the research activities of WSDC in the West (including Ghazala Gawazat) to ARC, at an appropriate time, but not later than five years after Credit effectiveness. The results of this review would form the basis of the work programs for Years 4-6 to be agreed between GOS, USAID and IDA. An assurance was obtained from GOS that a mid-term Project review will be carried out involving three distinguished international scientists, USAID and IDA to review the detailed Research Plan proposals by the Project for Years 4-6 and to review the plan of transferring the research facilities from WSDC to the ARC, which shall be completed no later than five years after Credit effectiveness.

7.03 A second Project review would be arranged in Year 6 when the first research results would be forthcoming, and when the stage would have to be set for the future orientation of agricultural research in the West.

1/ 1977 output per family of 6: about US$400; real growth per year 5%. 
B. Organization and Management

7.04 ARC's DG would have overall responsibility for Project Implementation; he would be the chairman of the Project Advisory Council (PAC) (para. 7.09); nominate the Project Director candidate for approval by the Minister of Agriculture and IDA (already done); approve the annual work plans, and the research program monitoring and evaluation systems (para. 7.18).

7.05 Day-to-day management of the Project would be under the responsibility of the Project Director to be stationed at Nyala. He would direct and coordinate all agricultural research programs in the West (para. 3.29); in particular, he will be authorized to (i) assign the scientific and administrative staff under the Project; (ii) direct and operate the research stations under the Project; coordinate the activities of PSU and PEU at Khartoum and TEU at Nyala; and (iv) be responsible for financial and budget control and ARC has given assurances to this effect. He would be supported by the Deputy Project Director in all matters, by the Production Systems Program Leader in systems research matters, and in stations management by the Station Superintendent who would also be in charge of the administration of the Nyala Center.

7.06 Substations and their research programs would be managed by the sub-program leaders (para. 3.29), supported by farm managers at El Obeid and Kadugli. The farm managers would run the research farms on a day-to-day basis, referring difficulties to the sub-program leader. The water and land use research program would be coordinated by its program leader; socio-economic support would be coordinated by the Production Systems Research Program Leader.

Civil Works

7.07 A firm of international executive architects would be hired by March 31, 1979 to prepare the building plans, implementation schedules, bidding and contract documents, carry out bid analysis, advise on the awards of contracts, and supervise construction. The Project Architect/Planner would supervise the executive architects and liaise closely with research staff on building design. Resident site supervision would be provided by the Ministry of Construction and Works with customary periodic supervision by the executive architects. Assurances were obtained during negotiations that (a) ARC shall employ, not later than March 31, 1979, executive architects with adequate qualifications and experience; and (b) GOS shall cause the Ministry of Public Works to provide qualified personnel in adequate numbers to assist the executive architects in supervising the construction of civil works.

7.08 GOS would transfer to ARC the land and land rights required for the research stations in the West; this land would be selected in consultation with the executive architects (para. 7.07) and would be suitable for the purposes of the Project. During negotiations, GOS gave assurances to
this effect. Furthermore, utilities (water, roads, and, where appropriate, electricity) which are not expected to be significant, would be provided to the site boundaries; an assurance was obtained at negotiations that this would be provided at no extra cost to the Project.

Project Advisory Council (PAC)

7.09 PAC would be appointed to assist in identifying priority problems and needs, in guiding the research programs and in encouraging the most effective dissemination and application of improved technology. This Council, which would serve in an advisory capacity and not in a management role, would be chaired by ARC's DG, and the Project Director would serve as its secretary. It would appropriately include representatives of the:

(a) concerned departments of MAFNR;
(b) WSDC;
(c) University of Khartoum;
(d) International agricultural research centers such as ICRISAT, ILCA and ICARDA;
(e) the provincial authorities at the governorate level; and
(f) such other public or private agencies as ARC's DG shall decide.

PAC would meet once a year and would aim particularly to keep the research programs directed to the priority needs and practical problems of both the area development projects and the traditional farming community.

Scope of ARC Research

7.10 The organization plan for ARC as proposed by the Joint Team is shown in Chart 18379. While the Project was designed to fit the newly proposed structure, it could largely be implemented without these changes taking place, except for those central units which are being financed under the Project to strengthen the ARC headquarters (para. 5.06). It would, however, be indispensable that animal production research be fully integrated with crops research, if the concept of agro-ecological systems research (para. 3.28) is to succeed. An assurance was given at negotiations that GOS will cause MAFNR to integrate fully all agricultural and animal production research.

Linkage with other ARC Research

7.11 The Project would for the first time introduce a production systems approach within ARC (para. 3.28c) which would require close linkages with national commodity and factor programs for optimum results, however, the
Project would not provide for the funding of national commodity and factor program coordinators, who would mainly be located outside the Project area anyway. Part of the coordinators to be stationed in the Project area have already been provided by ICRISAT and are currently located at Wad Medani (1 millet breeder and 1 assistant millet breeder). These staff would be moved to the research stations in the West as soon as physical facilities had been developed and research teams assembled. In addition, kerakodeh and gum arabic would be mainly of local importance and not in need of a strong national coordinating mechanism: the specialist research officers provided under the Project would be available for advice to other regions if and when required.

7.12 To ensure that agricultural research under the Project would benefit from research advances and the professional capabilities of the International Agricultural Research Centers (Centers) (Annex 1), several mechanisms would be employed:

(a) representatives of the relevant Centers would be invited to serve as members on the PAC (para. 7.09);

(b) the Senior Research Adviser to the DG and the Deputy Project Director would monitor the Centers' activities and assess how they could be utilized for agricultural research in the Sudan, particularly in the West;

(c) the Project would provide facilities for national commodity and factor program research coordinators to be located in the Project area, and supplied by the Centers, such as in the case of millet (para. 7.11); and

(d) it would be expected that the three distinguished international scientists to be invited for the mid-term Project review in Year 3 would be members of the Centers.

C. Procurement 1/

7.13 Procurement of civil works construction (US$15.2 million); and one aircraft (US$0.3 million) would be subject to international competitive bidding (ICB) in accordance with World Bank guidelines in the case of contracts over US$75,000. Tenders would be lumped together in order to attract major international and/or local contractors and suppliers, and this would be monitored through the annual work programs to be submitted to IDA (para. 7.17). The total amount of ICB would be US$16.5 million or 49% of the Project's base cost. In the case of contracts of less than US$75,000 but more

1/ Amounts expressed without contingencies.
than US$10,000, procurement would be through competitive bidding in accordance with standard GOS procedures which are satisfactory to IDA. For contracts under US$10,000, direct competitive purchasing would be employed. USAID would finance the purchase of an office building for ARC in Khartoum; office and laboratory equipment and furniture, vehicles and farm machinery under USAID's regulations. The services of internationally recruited staff (para. 5.08), executive architects (para. 7.07), short-term consultants (para. 5.09) and contracted research institutions (para. 5.10) would also be obtained following USAID procurement procedures. Assurances were obtained during negotiations that the described procurement procedures be followed for goods to be financed under the IDA Credit and that GOS will, upon ARC's request, promptly grant the necessary import licenses and foreign exchange for the Project.

D. Disbursement

7.14 The IDA Credit would be disbursed against 100% of foreign expenditures for civil works construction (US$9.9 million), and the purchase of an aircraft (US$0.3 million) and aircraft spare parts and services (US$50,000); and against 60% of the locally procured aircraft operating costs (US$250,000). Disbursements against aircraft operating costs would be made against certificates of expenditures, the documentation of which would not be submitted for review, but would be retained by ARC and available for inspection by IDA supervision missions. An amount of US$4.5 million would be unallocated.

E. Accounting, Auditing and Reporting

7.15 ARC's budget procedures are laid down in the 1977 ARC Act. Each station prepares its (Chapter II) expenses budget. This is discussed and consolidated at headquarters, whose staff add the (Chapter I) salaries and development budgets. Chapters I and II are submitted to the Ministry of Finance and the development budget to the Ministry of National Planning. The agreed budgets constitute the cash operating limits of the stations, which they must not exceed without the approval of headquarters. Salaries are paid by headquarters. Most of the travel and office expenses are also paid directly by headquarters and charged to the stations. The stations keep simple records of income and expenditure, and submit monthly statements to headquarters where they are consolidated. Monthly accounts are presented to the Director General or his Deputy. Annual accounts are produced within 6 months of the year-end (June 30); they take the form of an income and expenditure statement, similar to the monthly consolidated statement. There is no balance sheet. Audit of ARC by the Auditor General's Office is thorough, but the auditors have not assessed the adequacy of the accounting system. They prepare a detailed review of transactions, but no short-form report.

7.16 ARC would establish a Project accounting system which would reflect, in accordance with consistently maintained and sound practices, a true and fair view of the use of funds for each of the different programs in the West
and for the ARC headquarters in Khartoum. Project expenditures would be consolidated at the Nyala headquarters. All accounts would be audited annually. During negotiations, assurances were obtained from GOS that ARC shall maintain separate Project accounts and shall (i) have such accounts audited by independent auditors acceptable to IDA; and (ii) furnish IDA with certified copies of the auditor's report not later than six months after the closing of each financial year, of such scope and in such detail as IDA may reasonably request.

F. Planning, Programming and Budgeting

7.17 Beginning with year 2, the Project Director assisted by the PSU in Khartoum would prepare annual Project work plans and budgets three months in advance of the beginning of the next fiscal year which would be forwarded to IDA in time to comment. The annual work plans would set out the objectives of each research program and the demand on the Project's facilities, manpower and funds. Detailed proposals would be given for the allocation of funds to each research program and station on a quarterly basis. Progress would be monitored against this plan and budget, and quarterly progress reports would be forwarded by the Project Director to IDA.

G. Monitoring and Evaluation

7.18 The PEU financed under the Project (para. 5.06) would design ARC's research project monitoring and evaluation system and implement it.

H. Environmental Impact

7.19 The Project would be a major effort to stop environmental degradation, and to develop technology for the rehabilitation and sustained productive utilization of semi-arid and arid areas which are ecologically fragile.

VIII. ASSUMPTIONS ON BENEFITS AND JUSTIFICATION

8.01 Ex ante measurement of net benefit from research is difficult and quantification of the resources required to achieve research results is highly speculative. The result of a rate of return calculation depends, to a large extent, on the amount of time that elapses between the expenditure of resources and the production of useful results, and also on the time-lag until research results are applied by producers. For these reasons, no rate of return calculation has been attempted for this Project.
8.02 Although Sudanese agricultural research expenditures fall short of the 1% of output allocation that is generally accepted 1/, the Sudan allocates a reasonable level of resources to agricultural research. In 1975, the Sudan spent about US$10-12 million or about 0.6-0.7% of agricultural production for agricultural research and extension; this is much higher than the 0.045% of agricultural production quoted as an average for sub-Saharan countries back in 1965, 2/ and the 0.25% quoted as an average for developing countries in 1975. 2/ Account should also be taken that much research for developing countries has been financed by developed countries, especially during the post-independence years in sub-Saharan Africa.

8.03 The research program in the West would have a long-term demand on resources corresponding to no more than about 0.5% of the Region's agricultural production (para. 6.06). To extend the same intensity of research coverage to other neglected areas such as the South and the East would increase the budgetary requirements to about US$20 million annually (in 1983 terms) or less than 1% of agricultural output. But it would correct the current heavy tilt towards the commercial sector. Furthermore, any reasonably expected production increase would reduce the relative resource allocation, which is therefore justified.

8.04 In view of the low productivity of agriculture and livestock in the West in comparison to the untapped (though limited) potential, the concept of relating research expenditure to the output of an industry must be challenged. It may be more appropriate to relate resource allocations for research to the perceived production potential of the Region and the research needs to activate it. Considering that potential yield increases are estimated at 50% for groundnuts 3/ and 70% for sorghum 4/, and millet yields are far below those obtained elsewhere in the World, significant economic gains could be realized from relatively small increases in factor productivity, given the availability of unused land and labor. This would, in turn, increase family incomes from the present level of US$400 for a family of six, which just equals the estimated poverty income level of US$65 per capita for the Sudan. However, much of the expected production increases could not be credited to research because the application of known improved technology and better input supplies are purely organizational problems and would also increase production. Nevertheless, there is ample evidence that investments in agricultural research have high rates of return and are especially important in fostering technology transfer from more advanced countries.


8.05 The allocation of resources for agricultural research should also be justified in relation to the ecological potential of the area in which rainfall and soil quality are the most important factors. For example, fertile cracking clays and relatively good rainfall at Kadugli offer better possibilities for increased production than sandy soils at Nyala; and these, in turn offer more scope for improvement than the range areas around El Fasher. Farming systems research at Kadugli is, therefore, well justified with high probability of economic returns. For the stabilized sands, farming systems research is urgently required to develop a soil-conserving and less land-demanding system to replace shifting cultivation in order that a growing population can be sustained without deterioration of resources. For the dry range areas to the north, no revolutionary breakthrough should be expected in terms of increased output; but methods have to be developed to stop the advance of the desert, to minimize the drought risks for the people and to obtain maximum sustained range production. Because of the ecological similarities, some of the research results may also be applicable in the East of the Sudan. All the research programs to be financed under the Project are, therefore, well justified.

Risks

8.06 There are three kinds of risks which could affect the overall success of the Project: (i) implementation risks; (ii) unsatisfactory transfer of research results to the producer; and (iii) speed of acceptance and adoption of the new technology by the producer. In order to reduce the implementation risk, great care was taken to strengthen ARC's management capability through organizational arrangements, training programs and provision of technical assistance. Regarding the transfer of research results to the producer, recent GOS steps to bring more effective extension to the producer through the WSDC, MFC and Nuba Mountains Agricultural Production Corporation are commendable. However, these Corporations only cover part of the area. The Government has about 5 years until the new research begins to produce results, and this should be used to expand delivery systems in the region. Discussions about expanding the extension service are taking place in several contexts, including discussion of the Sector Report and individual projects, especially a Smallholder Package Project under consideration by IDA. In respect of the third risk, rejection or slow acceptance of new technology by the producer, measures have been taken to ensure that research results will be tested under practical farming conditions before advocating them through the extension system. These risks must be balanced against the greater certainty that, without the Project, the long-term degradation of the West would be accelerated, and the incomes and the way of life of the inhabitants seriously jeopardized.
IX. SUMMARY ON AGREEMENTS REACHED ON CREDIT CONDITIONS

9.01 At negotiations, assurances were obtained from GOS that:

(a) Government will prepare a study on possible means of financing future agricultural research from sources other than budgetary allocation for the mid-term review of the Project in Year 3 (para. 3.33);

(b) (i) Government shall cause WSDC to transfer to ARC all of WSDC's research facilities in the West not later than five years after Project effectiveness, in accordance with a schedule to be agreed upon during the mid-term Project review; (ii) Government shall, until the completion of such transfer, ensure effective technical cooperation between ARC and WSDC; and (iii) the Saudi Fund as co-financier of SDP and all other external financiers assisting in WSDC's research programs in the West will be given a reasonable opportunity to comment on the measures for effecting such transfer (para. 4.33);

(c) senior Project staff will have qualifications and experience satisfactory to IDA (para. 5.07);

(d) staff appointments will be for a minimum of 5 years in case of the Project Director, the Deputy Project Director, the Production Systems Research Program Leader and the Senior Research Adviser to the DG; and 2 years for all other senior staff (para. 5.07);

(e) consultants to be hired under the Project will have qualifications and experience satisfactory to IDA (para. 5.09);

(f) institutions to be hired for contract research shall be selected by the Project Director in consultation with IDA (para. 5.10);

(g) GOS will credit the Project account every six months with sufficient funds to meet expenditures expected to be made directly by ARC in respect of the Project during the next six months and required to carry out the approved work plan (para. 6.05);

(h) a mid-term Project review will be carried out involving three distinguished international scientists, USAID and IDA to review the detailed research program proposals by the Project for Years 4-6 and to review the plan of transferring the research facilities from WSDC to ARC (para. 7.02);
(i) (i) ARC shall employ, not later than March 31, 1979, executive architects with qualifications and experience, and (ii) Government shall cause its Ministry of Public Works to provide qualified personnel in adequate numbers to assist the executive architects in supervising the construction of civil works (para. 7.07);

(j) Government will transfer to ARC the land and land rights required for the research stations in the West; this land will be selected in consultation with the executive architects and will be suitable for the purposes of the Project (para. 7.08);

(k) utilities such as water, roads and, where appropriate, electricity will be provided to the construction site boundaries at no extra cost to the Project (para. 7.08);

(l) Government will cause MAFNR to integrate fully all agricultural and animal production research (para. 7.10);

(m) procurement procedures as described in para. 7.13 will be followed; and

(n) ARC shall maintain separate Project accounts and shall (i) have such accounts audited by independent auditors acceptable to IDA, and (ii) furnish IDA with certified copies of the auditor's report not later than six months after the closing of each financial year, of such scope and in such detail, as IDA may reasonably request (para. 7.16).

9.03 Conditions of Credit effectiveness are that:

(a) the Project Director, Deputy Project Director and Senior Research Adviser have been appointed (para. 5.07);

(b) ARC has completed a study comparing its salaries and benefits with those provided by other comparable institutions such as the universities employing high calibre staff, and has adopted incentives satisfactory to GOS and IDA for its staff to be assigned to work on the Project (para. 6.02);

(c) all conditions precedent to the effectiveness of the USAID Grant Agreement have been fulfilled (para. 6.05); and

(d) ARC has deposited an amount of not less than bSd 200,000 to meet start-up expenditures (para. 6.05).

9.04 Subject to the above assurances and conditions, the proposed Project is suitable for an IDA Credit of US$15 million to the Government of the Sudan.
## APPENDIX 1

### PRESENT STRUCTURE OF THE INTERNATIONAL AGRICULTURAL RESEARCH NETWORK

<table>
<thead>
<tr>
<th>Center Name</th>
<th>Location</th>
<th>Research</th>
<th>Coverage</th>
<th>Date of Initiation</th>
</tr>
</thead>
<tbody>
<tr>
<td>IRRI (International Rice Research Institute)</td>
<td>Los Baños, Philippines</td>
<td>Rice under irrigation; multiple cropping systems; upland rice</td>
<td>Worldwide; special emphasis in Asia</td>
<td>1959</td>
</tr>
<tr>
<td>CIMMYT (International Center for the Improvement of Maize and Wheat)</td>
<td>El Batan, Mexico</td>
<td>Wheat (also triticale, barley); maize</td>
<td>Worldwide</td>
<td>1964</td>
</tr>
<tr>
<td>IITA (International Institute of Tropical Agriculture)</td>
<td>Ibadan, Nigeria</td>
<td>Farming systems; cereals (rice and maize as regional relay stations for IRRI and CIMMYT); grain legumes (cow peas, soybeans, lima beans, pigeon peas); root and tuber crops ( cassava, sweet potatoes, yam)</td>
<td>Worldwide in lowland tropics; special emphasis in Africa</td>
<td>1965</td>
</tr>
<tr>
<td>CIAT (International Center for Tropical Agriculture)</td>
<td>Palmira, Colombia</td>
<td>Beef; cassava; field beans; farming systems; maize (minor); rice (regional relay stations to CIMMYT and IRRI)</td>
<td>Worldwide in lowland tropics; special emphasis in Latin America</td>
<td>1968</td>
</tr>
<tr>
<td>WARA (West African Rice Development Association)</td>
<td>Monrovia, Liberia</td>
<td>Regional cooperative effort in adaptive rice research among 13 nations with IITA and IRRI support</td>
<td>West Africa</td>
<td>1971</td>
</tr>
<tr>
<td>CIF (International Potato Center)</td>
<td>Lima, Peru</td>
<td>Potatoes (for both tropics and temperate regions)</td>
<td>Worldwide including linkages with developed countries</td>
<td>1972</td>
</tr>
<tr>
<td>ICARDA (International Crops Research Institute for the Semi-Arid Tropics)</td>
<td>Hyderabad, India</td>
<td>Durum; pearl millet; pigeon pea; chick-pea; farming systems; groundnuts</td>
<td>Worldwide; special emphasis on dry semi-arid tropics, semi-arid farming. Special relay stations in Africa under negotiation</td>
<td>1972</td>
</tr>
<tr>
<td>ICARDA (International Board for Plant Genetic Resources)</td>
<td>FAO, Rome, Italy</td>
<td>Conservation of plant genetic material with special reference to cereals</td>
<td>Worldwide</td>
<td>1973</td>
</tr>
<tr>
<td>ILADD (International Laboratory for Research on Animal Diseases)</td>
<td>Nairobi, Kenya</td>
<td>Trypanosomiasis, theileriasis (mainly east coast fever)</td>
<td>Africa</td>
<td>1974</td>
</tr>
<tr>
<td>ILCA (International Livestock Center for Africa)</td>
<td>Addis Ababa, Ethiopia</td>
<td>Livestock production systems</td>
<td>Major ecological regions in tropical zones of Africa</td>
<td>1974</td>
</tr>
<tr>
<td>ICARDA (International Center for Agricultural Research in Dry Areas)</td>
<td>Ibadan</td>
<td>Crop and mixed farming systems research, with a focus on sheep, barley, wheat, and lentils</td>
<td>Worldwide, emphasis on the semi-arid winter rainfall zone</td>
<td>1976</td>
</tr>
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</table>


November 15, 1977
SUDAN
AGRICULTURAL RESEARCH PROJECT

Summary of Senior Staff

Staffing, Grades and Training for Senior Project Staff

<table>
<thead>
<tr>
<th>Year 1/ and Grade 2/</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
</tr>
</tbody>
</table>

1. **ARC Headquarters - Khartoum**

- *Senior Research Advisor to DG* | ES | ES | ES | ES | ES | ES |
- *Research Planning and Evaluation Advisor* | ES | ES | ES | ES | ES | ES |
- *Project Architect* | ES | ES | ES | ES | ES | ES |
- *Project Liaison Officer* | SS | SS | SS | SS | SS | SS |
- Accountant | SC | SC | SC | SC | SC | SC |

2. **Nyala**

(a) **Director's Office**

- *Project Director 3/ (June)* | CS | CS | CS | CS | CS | CS |
- *Deputy Project Director 3/ (June)* | ES | ES | ES | ES | ES | ES |
- Station Superintendent | SC | SC | SC | SC | SC | SC |
- Accountant | SC | SC | SC | SC | SC | SC |
- Communications Officer Pilot 3/ (Mar.) | SC | SC | SC | SC | SC | SC |

(b) **Water and Land Use Research**

- *Program Leader 3/ (Oct.)* | ES | ES | ES | ES | ES | ES |
- *Deputy Leader* | -- | -- | -- | SS | SS | SS |
- Soil Physicist | AS | AS | AS | AS | RS | RS |
- Soil Chemist | -- | RS | RS | RS | RS | RS |
- Agro-Climatologist | -- | AS | AS | RS | RS | RS |
- *Agro-Climatologist* | -- | ES | ES | ES | ES | ES |
- Water Engineer | -- | -- | -- | RS | RS | RS |
(c) Research Support Services

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<tr>
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<th>Year</th>
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<tbody>
<tr>
<td><strong>Program Leader - Production System</strong></td>
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<td>2</td>
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<tr>
<td>*</td>
<td>ES</td>
<td>ES</td>
</tr>
<tr>
<td><strong>Sociologist</strong></td>
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<td>AS</td>
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<tr>
<td><strong>Economist</strong></td>
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<td>AS</td>
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<tr>
<td><strong>Biometrician</strong></td>
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<tr>
<td><strong>Groundnut Breeder</strong></td>
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<td>RS</td>
</tr>
<tr>
<td><strong>Research Liaison Officer</strong></td>
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(Oct.)

(d) Training and Extension Unit (TEU)

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<td><strong>Training Officer</strong></td>
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<tr>
<td><strong>Assistant Training Officer</strong></td>
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3. El Fasher

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<tr>
<th>Position</th>
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<tr>
<td><strong>Sub-Program Leader</strong></td>
<td>SS</td>
<td>SS</td>
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<tr>
<td><strong>Camel Specialist</strong></td>
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<tr>
<td><strong>Sheep and Goat Specialist</strong></td>
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<tr>
<td><strong>Range Specialist</strong></td>
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(Oct.)

4. Kadugli

(a) Crop Livestock System Cracking Clays

<table>
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<tr>
<th>Position</th>
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(Apr.)
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<tr>
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<th>3</th>
<th>4</th>
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<tr>
<td>Agricultural Engineer</td>
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5. El Obeid

(a) Crop Livestock System Non-Cracking Clays

*Sub-Program Leader
Non-Cracking Clays 3/
   (Oct.)
Gum Arabic Specialist
   (Sept.)
Gum Arabic Specialist
   --| RS| RS⁴| RS| RS| RS|
Agricultural Engineer
   --| RS| RS⁴| RS| RS| RS|
   (Oct.)
Farm Management Economist
   --| AS⁷| RS| RS| RS|
   (Sept.)
Millet Breeder
   --| --| RS⁴| RS| RS| RS|
   (Oct.)
Livestock Specialist
   --| --| RS⁴| RS| RS| RS|
   (Oct.)
Kerkadeh Specialist
   --| RS⁴| RS| RS| RS| RS|
Research Liaison Officer
   --| --| RS⁴| RS| RS| RS|
   (Oct.)

(b) Water and Land Use Research
Field Project Officer
   --| --| RS⁴| RS| RS| RS
Notes:

1. It is assumed that the Project would begin on January 1, 1979. Therefore Years 1 to 6 refer to 1979 to 1984 respectively.

2. The levels referred to are:
   - CS - Chief Scientist;
   - SS - Senior Scientist;
   - RS - Research Scientist;
   - AS - Assistant Scientist;
   - ES - Internationally Recruited Scientist;
   - SC - Special Category.

3. Initially these staff may be located in Khartoum.

4. Undertaking a non-degree specialization course (3 to 12 months' duration).

5. Undertaking Ph.D training.

6. Undertaking Ph.D training with two years of supervised field work in the Western Region.

7. Undertaking M.Sc training.

8. Preferably posted to Ghazala Gawazat

9. Possibly located at Khartoum

* Key Project Staff

May 23, 1978
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May 18, 1978
# Capital Costs

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### Buildings

- **Site Works**
- **Central Facilities**
- **Field Laboratories**
- **Houses**

### Sub-total

- **Total Foreign Duties**
- **Total Exchange**
- **Total Duties and Taxes**

### Total Buildings

- **Furniture**
  - **Office**
  - **Radio**
  - **Laboratory**
  - **Vehicles**
  - **Motor Cars**
  - **Minibuses**
  - **Farm Tractors**
  - **Equipment**
  - **Aircraft**

- **Total Furniture and Equipment**

### Farm Development

- **Fencing**
- **Land Clearing**

- **Total Farm Development**

### Small Purchases Fund

- **Total Base Cost**

### Physical Contingencies

1/ Details in Annex 2 of the implementation volume.
2/ See Annex 2 of the implementation volume, in line with previous research projects.
3/ See Annex 2 of the implementation volume, in line with previous research projects.
4/ Headquarters radio $10,000 each.
5/ Radio in aircraft included in aircraft cost.
6/ Costs based on an MF System.
7/ Headquarters radio $10,000 each
8/ Vehicles at $1,000 each.
9/ Motor Cars at $1,000 each.
10/ Minibus at $1,000 each.
11/ Fencing at $1,000 per km.
12/ Land development - chiseling

### Equipment Costs

- Equipment cost as 1% of tractor costs: wide range of equipment would be held for trial purposes.
- For purchases of experimental animals and other inputs.

### Physical Contingencies

- Physical Contingencies are 15% of construction costs.

---

May 18, 1978
## Table 3

**Operating Costs**

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<th>Year</th>
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<th>Accommodation</th>
<th>Office Expenditure</th>
<th>Transport</th>
<th>Building Maintenance</th>
<th>Equipment Maintenance</th>
<th>Aircraft Operation</th>
<th>Farm Costs</th>
<th>Total Operating Costs</th>
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**Duties & Taxes**

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May 18, 1978
### Sudan Agricultural Research Project

**Technical Assistance (US$ '000)**

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March 6, 1978
## SUDAN

### AGRICULTURAL RESEARCH PROJECT

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May 25, 1978
SUDAN
AGRICULTURAL RESEARCH PROJECT

STAFF APPRAISAL REPORT
(Implementation Volume)

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<th>Page No.</th>
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<td>Table 2: Capital Costs</td>
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<td>2.3 El Obeid..............................</td>
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<td>2.4 El Fasher.............................</td>
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<td>2.5 Khartoum..............................</td>
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SUDAN

AGRICULTURAL RESEARCH PROJECT

Selected Documents and Data Available in the Project File

A. Selected Reports and Studies on the Sector or Sub-sector

   (a) Agriculture
   (b) Agricultural Research for Western Savannah

A2 - The SUDAN in Quest of a Surplus, Part I - Dreams and Realities by John Waterbury, 1976, American University Field Staff, Inc.

A3 - SUDAN - Country and Intercountry Programming - 1972-1976, UNDP.


A6 - Animal Production Research Administration - Ministry of Agriculture, Food and Natural Resources - Animal Resources in the Sudan.

A7 - Millet Research and Improvement in the Sudan, by Bhal Somaroo, Ford Foundation, 1976.


A9 - Sorghum Research in the Sudan, by Dr. Bhal H. Somaroo and Mr. Leland R. House, Ford Foundation, 1976.

A10 - Food Legume Research in the Sudan, by Dr. Geoffrey Howtin; Ford Foundation, 1976.


A12 - SDEC and Rehabilitation Programme

A13 - Faculty of Agriculture - University of Khartoum
A14 - Animal Production Research in the Sudan, Dr. E. Creswell, 1974.

A15 - Agricultural Extension as it Relates to Agricultural Research, Dr. Shawki M. Barghouti, 1976.

A16 - Project for Consolidation of Agricultural Extension Services in the Sudan.


B. Selected Reports and Studies Relating to the Project


B2 - Background Information on Western Sudan; Report to East Africa Division of World Bank by E.D. Carter, The University of Adelaide, Waite Agricultural Research Institute, November 1977.


B4 - Agricultural Extension as it Relates to Agricultural Research, by Dr. Shawki M. Barghouti; the Ford Foundation, Ammon, Jordan, April 1976.

B5 - Experiment Station Development in the Sudan, by Dr. Gordon W. McLean; Ford Foundation, 1976.


B7 - Exploratory Soil Survey of North and South Kordofan, by Rafael Pacheo and Hashim Al Dawoud, Soil Survey Report No. 81, Soil Administration Wad Medani; 1976.


B9 - Agricultural Research Capabilities and Scope in the Sudan, by Dr. Hussein Edris, Khartoum, 1975.


B14 - Sudan Agricultural Research Review: July - August 1977, Terms of Reference and Guidelines.

B15 - Studies and Training Courses valid on 9th September 1976.

C. Selected Working Papers, Tables and Maps

C1 - Rainfall Data and Maps.

C2 - Agricultural Research Corporation - Data about Budget etc.

C3 - Aircraft Related Data.

C4 - Yellow Cover Staff Appraisal Report.

C5 - Green Cover Staff Appraisal Report.

Khasm el Girba; Toker; White Nile; Blue Nile Pump Schemes, etc.
SUDAN
AGRICULTURAL RESEARCH PROJECT

ORGANIZATION OF THE AGRICULTURAL RESEARCH CORPORATION 1

AGRICULTURAL RESEARCH COUNCIL 2

DIRECTOR GENERAL

TECHNICAL COMMITTEE

DEPUTY DIRECTORS GENERAL

ADMINISTRATION AND FINANCIAL COMMITTEE

RESEARCH SECTIONS AND CENTERS

Agronomy Crop Physiology
Botany Plant Pathology
Cotton Breeding
Entomology
Horticulture
Plant Breeding
Soil Science
Statistics Agricultural Economics
Forest Research 3
Range Pasture 3
Fisheries Marine Biology 3
Food Processing Center 3
Wild Life Research Unit 3

RESEARCH STATIONS

REGIONAL

SUB-STATIONS

Gazira
Hudeiba
Kenana
Kadugli
Yambio

Guneid
Khashm El Girba
Masut
Sennar
Shambat
Soba
Gum Arabic Research 3
[El Obeid]
Fisheries Marine Biology 3 [EE]
Shagra, Port
Sudan, Wadi Halfa
Food Processing Centre 3 [Khartoum]
Forestry 3 [Soba]
Range Pasture 3
[Ghabzaa Gawazat]
Wild Life 3
[Khartoum]

RESEARCH SERVICES

Library
Documentation
Publications
Information
Training
Conferences
Foreign Relations
Agricultural Shows
Museums
Equipment Maintenance

ADMINISTRATION AND FINANCE

Finance Accounts
Personnel
Stores
Maintenance (Building)
Public Relations
Social Services
General Administration
(Field Transport)

1 The ARC is under the Ministry of Agriculture, Food and Natural Resources
2 Also referred to as "BOARD OF MANAGEMENT"
3 Transferred to the ARC in 1975

World Bank – 18269
SUDAN
AGRICULTURE RESEARCH PROJECT
PROPOSED STRUCTURE FOR THE AGRICULTURAL RESEARCH CORPORATION

MINISTER OF AGRICULTURE, FOOD, AND NATURAL RESOURCES

AGRICULTURAL RESEARCH CORPORATION

BOARD OF MANAGEMENT

TECHNICAL COMMITTEE

DIRECTOR--GENERAL

ADMINISTRATIVE AND FINANCE COMMITTEE

DEPUTY DIRECTORS--GENERAL (3)

Research Support Services

Administrative Services

Integrated Area Development Research Programs

Research Support Services

Administrative Services

Integrated Area Development Research Programs

CROP PRODUCTION RESEARCH DIVISION

ANIMAL PRODUCTION RESEARCH DIVISION

SOILS, WATER, AND ENGINEERING RESEARCH DIVISION

NATURAL RESOURCES RESEARCH DIVISION

SOCIOECONOMIC RESEARCH DIVISION

PROCESSING RESEARCH DIVISION

Cereal Crops

Large Ruminants

Soil and Water Management

Forestry

Food Research Center

Non-Cereal Food Crops

Small Ruminants and Poultry

Agricultural Engineering

Range, Pasture, and Fodder

Cotton Technology Center

Fiber Crops

Animal Health

Production Systems

Game and Wildlife

Marketing Studies

Crop Protection

Fisheries and Marine Biology

Planning and Evaluation Unit and possibly Training and Extension Unit under the Project would support development of this section

Social Studies

Plant Introduction and Special Crops

1/ Planning and Evaluation Unit and possibly Training and Extension Unit under the Project would support development of this section

2/ In close association or including the Project Support Unit

World Bank – 18379
### SUDAN

**AGRICULTURAL RESEARCH PROJECT**

Crops Research to be Conducted at the Proposed ARC Research Stations

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<th>Kenaf</th>
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<th>Grain Legumes</th>
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1/ Research Stations in the Area of the Agricultural Research Project

2/ National Coordination by a Research Station situated within the Project Area

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World Bank — 18266
SUDAN
AGRICULTURAL RESEARCH PROJECT
ECOLOGICAL ZONES
AGRICULTURAL RESEARCH PROJECT

NOMADIC MOVEMENT

Research Areas Boundary
HAMAR
Locality Covering Region
Rami, Semban
Rabi (Cold) Season
Dry Season (Hot) Season
Lui (Wet) Season
Dry Season
Rain Season
Rainy Season
NOMADIC Tribes which Own Cattle, Crops, and Cattle
Circling Railway
Rivers
Lakes
International Boundaries

MAP LEGEND

1. Northern
2. Southern
3. Eastern
4. Western
5. Darfur
6. Kordofan
7. Equatoria
8. Central African Empire
9. Republic of Zaire
10. Republic of Egypt
11. Kenya
12. Uganda
13. Libya
14. Arab Republic of Egypt
15. Republic of Sudan
16. Zaire
17. Congo (Kinshasa)
18. Angola
19. Mozambique
20. Tanzania
21. Burundi
22. Rwanda
23. Democratic Republic of the Congo
24. Zambia
25. Malawi
26. Namibia
27. Botswana
28. South Africa
29. Zimbabwe
30. Swaziland
31. Lesotho
32. Djibouti
33. Somalia
34. Ethiopia
35. Eritrea
36. Sudan
37. Chad
38. Cameroon
39. Nigeria
40. Benin
41. Togo
42. Ivory Coast
43. Ghana
44. Liberia
45. Sierra Leone
46. Guinea
47. Mali
48. Burkina Faso
49. Niger
50. Nigeria
51. Chad
52. Cameroon
53. Equatorial Guinea
54. Gabon
55. Congo (Kinshasa)
56. Angola
57. Zambia
58. Zimbabwe
59. Mozambique
60. South Africa
61. Botswana
62. Namibia
63. Lesotho
64. Swaziland
65. Malawi
66. Tanzania
67. Burundi
68. Rwanda
69. Democratic Republic of the Congo
AGRICULTURAL RESEARCH PROJECT
Main Transportation Network

[Map of Sudan and surrounding regions showing transportation networks and infrastructure.]