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LAKE CHAD AGRICULTURAL DEVELOPMENT AND FARMER TRAINING PROJECT

Submitted to: United States Agency for International Development/N'Djamena (USAID/N'Djamena)

Submitted by: American ORT Federation
International Cooperation Department

September, 1986

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This project paper reflects all changes suggested by USAID/Chad as of this date:

September, 1986

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ACRONYMS AND ABBREVIATIONS

Acronym	French	English or English Equivalent
A.I.D.		Agency for International Development
B.I.E.P	Bureau Interministeriel des Etudes et Programmes	Interministerial Studies Bureau
C.A.R.E.		Cooperative for American Relief Everywhere
C.B.L.T.	Commission du Bassin du Lac Tchad	Lake Chad Basin Commission
CEFOD	Centre d'Etudes de Formation pour l'organisation du developpement	Center for Development Organization Training
CESAO	Centre d'Etudes Economique et Sociale de l'Afrique de l'ouest	West African Center for Economic and Social Studies
CHEAM	Centre des Hautes Etudes Administratives	Center for Advanced Administrative Studies
CTT	Cooperative de Transporteurs Tchadienne	Chadian Transporters Cooperative
FAC	Fonds d'Aide de Cooperation	Aid and Cooperation Fund
FAO		Food and Agricultural Organization
FED	Fonds Europeen de Developpement	European Development Fund
GMT	Grands Moulins du Tchad	Chadian Large Mills
GOC		Government of Chad
INSH	Institut National des Sciences Humaines	National Social Science Institute
MEADR	Ministere d'Etat a l'Agriculture et au Developpement Rural	Ministry of Agriculture and Rural Development
MCC		Mennonite Central Committe
NGO		Non-Governmental Organization

ONC	Office National des Cereales	National Cereals Office
ONDR	Office National de Developpement Rural	National Rural Development Office
ORSTROM	Office de la Recherche Scientifique et Technique d'Outre-Mer	Overseas Scientific and Technical Research Office
ORT		Organization for Rehabilitation through Training
PCV		Peace Corps Volunteer
PVO		Private Voluntary Organization
PVO-DIP		PVO-Development Initiatives Project
REDSO		Regional Economic Development Services Office
SECADEV	Secours Catholique au Developpement	Emergency Catholic Relief Organization
SODELAC	Societe de Developpement du Lac	Lake Development Corporation
UNDP		United Nations Development Program
USAID		United States Agency for International Development
VITA		Volunteers in Technical Assistance
WFP		World Food Program

Chadian and French Terms used

Terms	English Definition
Chef de Canton	Government appointed administrative position.
Chef de Sous-Agence	The local head of an agency. In this paper, the local representative of SODELAC who supervises agents in the cantons of the Ngouri Sub-Prefecture.
corde	A traditional unit of measurement which varies around 60 meters.
daba	A traditional short-handled hoe, manufactured locally and used extensively in the Sahelian zone in Chad.
fonio	Finger millet.
korro	A traditional unit of volume measurement (based on the size of a dried gourd cut in two). For grains a korro is approximately equal to 2.5 kilograms.
Mai	A traditional village chief.
polder	A low-lying, enclosed area subject to periodic flooding, and used for agricultural production.
shaduf	A traditional water-lifting device used in the Sahel. A pole is balanced on a fulcrum with a counterweight on one end and a rope attached to a bowl at the other. The end of the pole with the rope and bowl is placed over a dug well. A worker pulls the rope down lowering the bowl down to the water level of the well and jerks the rope to permit the bowl to fill with water. The worker then allows the water filled bowl to come up the well, due to the counterweight, by releasing the rope.
wadi	A term used in Chad to describe seasonal streams and the oases in some areas around Lake Chad. These oases were formerly polders which are no longer inundated by Lake Chad.

I. SUMMARY PROJECT DESCRIPTION

A. Private Voluntary Organization (PVO) Applicant: American ORT Federation, 817 Broadway, New York, NY 10003. (Mailing address: ORT Technical Corporation, 2025 "I" Street, N.W., Suite 320, Washington, D.C. 20006.)

B. Government of Chad (GOC) Implementing Agency: Societe de Developpement du Lac (SODELAC)

C. Summary Financial Plan

AGENCY	Year 1	Year 2	Year 3	Total
AID	1,190,366	774,841	627,568	2,592,775
ORT	222,355	192,432	188,710	603,497
SUBTOTAL	1,412,721	967,273	816,278	3,196,272
GOC	107,196	16,402	16,402	140,000
PEACE CORPS	25,000	50,000	50,000	125,000
TOTAL	1,544,917	1,033,675	882,680	3,461,272

D. Project Goal

The goal of this project is to increase the amount and dependability of food production in Chad.

E. Project Purpose

There are two purposes to the project:

1) To increase wadi food production in the Ngouri Sub-Prefecture, while maintaining or improving soil fertility.
2) To identify models for increased wadi food production which will be replicable in similar conditions (e.g., other wadis, dry polders, environs of Lake Fitri).

F. Project Background

ORT first began its involvement in Chad in 1972 with a USAID funded survey of the education sector. This was followed by a World Bank funded training program (1975-1978) for the Ministry of Public Works road maintenance and road equipment personnel. A follow-on project was funded by AID to continue and expand this training program, but unfortunately, the civil strife of 1979-1980 forced the departure of the ORT team. With the return of political stability, ORT has been interested in re-establishing its program in Chad. The type of rural-based, small-farmer, self-sustaining food production activities which the PVO Development Initiatives Project (PVO-DIP) supports fits in with ORT's development philosophy and expertise. For these

reasons, ORT submitted to AID in February 1986 a concept paper for development of a sub-project within the PVO-DIP (677-0051).

The concept paper discussed three potential areas for project sites:

1) the northern Chari-Baguirmi or Karal region,
2) the Lac Prefecture, and
3) the southern Kanem.

The activities described in the concept paper revolved around helping small farmers expand their agricultural production through improved dry riverbed wadi, oasis wadi and polder irrigation. The concept paper was approved, and with a grant from AID to partially fund the costs of undertaking a design effort, ORT sent a five-person team to Chad in April-May 1986.

Prior to visiting prospective sites, the ORT team consulted with the GOC, AID, and Non-Governmental Organizations (NGO's) working in Chad. In discussions with the Ministry of Plan and Ministry of Agriculture and Rural Development (Ministere d'Etat a l'Agriculture et au Developpement Rural or MEADR) two concerns were repeated:

1) The need to design a project which can be self-sustaining,
2) The need to avoid duplicating the efforts of other NGO's (i.e., not developing a program similar to that of another NGO in the same geographic area).

Since the PVO Secours Catholique au Developpement (SECADEV) currently has a small farmers program in the region south of Lake Chad and the European Development Fund (Fonds Europeen de Developpement or FED) is planning to develop thirty irrigated perimeters from N'Djamena up to the Lake, the Chari-Baguirmi area was dropped from consideration. Similarly, since the PVO Cooperative for American Relief Everywhere (CARE) has an irrigated wadi project in the Kanem, this area was dropped from consideration. In the Lac Prefecture, the United Nations Development Program (UNDP) has begun an ambitious road, health and agricultural program. The agricultural program, however, stresses large-scale polder development in the Bol Sub-Prefecture. For this reason, with the agreement of the Ministry of Plan, the Ministry of Agriculture and Rural Development and USAID, the Ngouri Sub-Prefecture was chosen as a possible project area for investigation. Of the other areas suggested by the GOC (Goz-Beida, Am-Timan, Lake Iro and Lake Fitri) the design team, in consultation with the GOC and AID, chose Lake Fitri as a second possible project area.

The project design team, along with representatives of SODELAC, the National Office of Rural Development (Office National de Developpement Rural or ONDR), the Ministry of Plan and USAID visited both the Lake Fitri and Ngouri Sub-Prefectures during the period April 22 to May 2, 1986, to ascertain project possibilities. This document is a result of those site visits and discussions with GOC, AID and NGO's in N'Djamena.

G. Summary Project Description

This three-year development project will enable wadi farmers in the Ngouri Sub-Prefecture to expand their production by increasing the number of hectares under cultivation, as well as per hectare yield. This will be accomplished by:

1. introducing an improved pumping system for irrigation;
2. improving the traditional agricultural practices;
3. improving SODELAC's extension capabilities; and
4. providing agriculture credit.

The project will also identify one or more replicable models for small-farmer irrigation in wadis or similar areas. To this end, careful compilation of baseline data and of improvements in yields due to adoption of various agricultural packages will be a priority throughout the project life. Testing of various pumping systems -- their water output, social acceptability, ease of local manufacture, ease and cost of maintenance, and economic viability will be studied. From the beginning of the project, on-site practical tests will take place to help determine the most suitable pumping technology to employ. Simultaneously, as these tests on various human, animal, or motor powered pumps are taking place, improved agricultural techniques will be introduced to increase agricultural production of the current shaduf system. By year two, the project will be prepared to push toward wider adoption of the chosen improved pumping system(s). ORT envisions that the project will work in five wadis the first year, ten wadis in

year two and ten more in year three. By the end of the project, a sizeable amount of data will have been collected and experience gained on improved wadi agriculture. This knowledge will be used to identify one or more technical packages which can be employed in the hundreds of wadis in the region and in other areas, such as Lake Fitri, where similar conditions exist.

Maintenance of the environmental equilibrium in the wadis is of fundamental importance for the long term viability of the project. Therefore, the environmental effects of project interventions will be carefully monitored through careful compilation of water recharge and salinization data. Salinization control methods will be employed to help increase yields and protect the wadis from increased salinization which may occur from increased irrigation. Furthermore, the project's agro-forestry interventions will help stabilize the dunes around the wadis and create windbreaks, thus protecting the wadis.

The approach of the project will be to work with area farmers to find solutions to their agricultural problems in the wadis. Self-help philosophy will be emphasized, with farmers having to contribute in one form or another towards all interventions. This approach will help assure the long term sustainability of the project benefits.

The expatriate technical assistance team will consist of an Agronomist (33 months), a Rural Works Engineer (30 months), a Pump Specialist (18 months), and an Administrative Officer (36

months). The counterpart agency will be SODELAC, whose agents will play a central role in teaching area farmers improved farming techniques. It is also planned that six Peace Corps Volunteers (PCV's) will participate in the project, providing technical assistance in forestry, well construction, pump technology and health.

H. Summary Findings

The project is sociologically, technically and economically viable. It is also administratively and logistically feasible.

1. Sociological Findings

The project design team consulted with local and traditional leaders of the proposed project area, as well as with individual farmers. As discussed in the social soundness analysis, project interventions are of a scale not likely to cause major social upheaval, and the interventions proposed respond to the desires of the local population.

2. Technical Findings

The technical viability of the project revolves around teaching improved farming techniques, introducing an improved water lifting device, and controlling the salinization of the wadis. The intermediate-level techniques and technologies to be introduced have been proven effective in other developing countries.

3. Economic Findings

The isolation of the project area poses problems for food-production marketing beyond local use. The project design team determined that the current high transportation costs make it uncertain whether markets beyond the project area could be counted on to absorb excess production. The local market, however, should be strong enough to absorb the increase in agricultural production beyond subsistence. Major accomplishments will include: helping to bring the population of the project area up to and above a level of self-sustaining subsistence, satisfying the local market, and identifying one (or more) replicable wadi irrigation schemes. Thus, while the per-hectare and per-direct beneficiary cost of the project is high, the particularities of the project area, the pilot nature of the project, the effort to find a replicable model, and initial start-up costs explain and justify the project cost.

4. Administrative Findings

Again due to the isolated nature of the project area, administrative and logistical problems are posed for project implementation. Adequate resources, however, are budgeted towards addessing these problems. ORT is confident that with proper planning these problems can be overcome.

I. Project Issues

Three issues became evident during the project design effort: 1) the limited project timeframe, 2) health issues, and 3) the potential and lack of information regarding the Lake Fitri area.

1. Limited Project Timeframe

The project's three-year timeframe is very short, especially since much of the first year of the project will be spent setting up the Ngouri office, workshop and nursery; collecting baseline data; and introducing and testing improved pumps. Thus, significant increases in agricultural production cannot be expected until year two of the project at the earliest. Additionally, the major agroforestry benefits will not be evident within the timespan of the project. Due in part to these considerations, ORT views the project as a pilot activity which, once proved successful, will be extended and expanded.

2. Health Issues

The health issue was a focus of much discussion during the project design. Improved health care is a major perceived and real need of the population within the project area. Furthermore, the consensus of the design team members is that poor health directly affects agricultural production, due to lower productivity and missed work days. Additionally, any

irrigated agricultural project raises concerns regarding an increase in the prevalence of water-borne diseases. To address these concerns, the design team has built in a health survey, and funds to help offset any negative health effects brought on by the project.

3. Lake Fitri

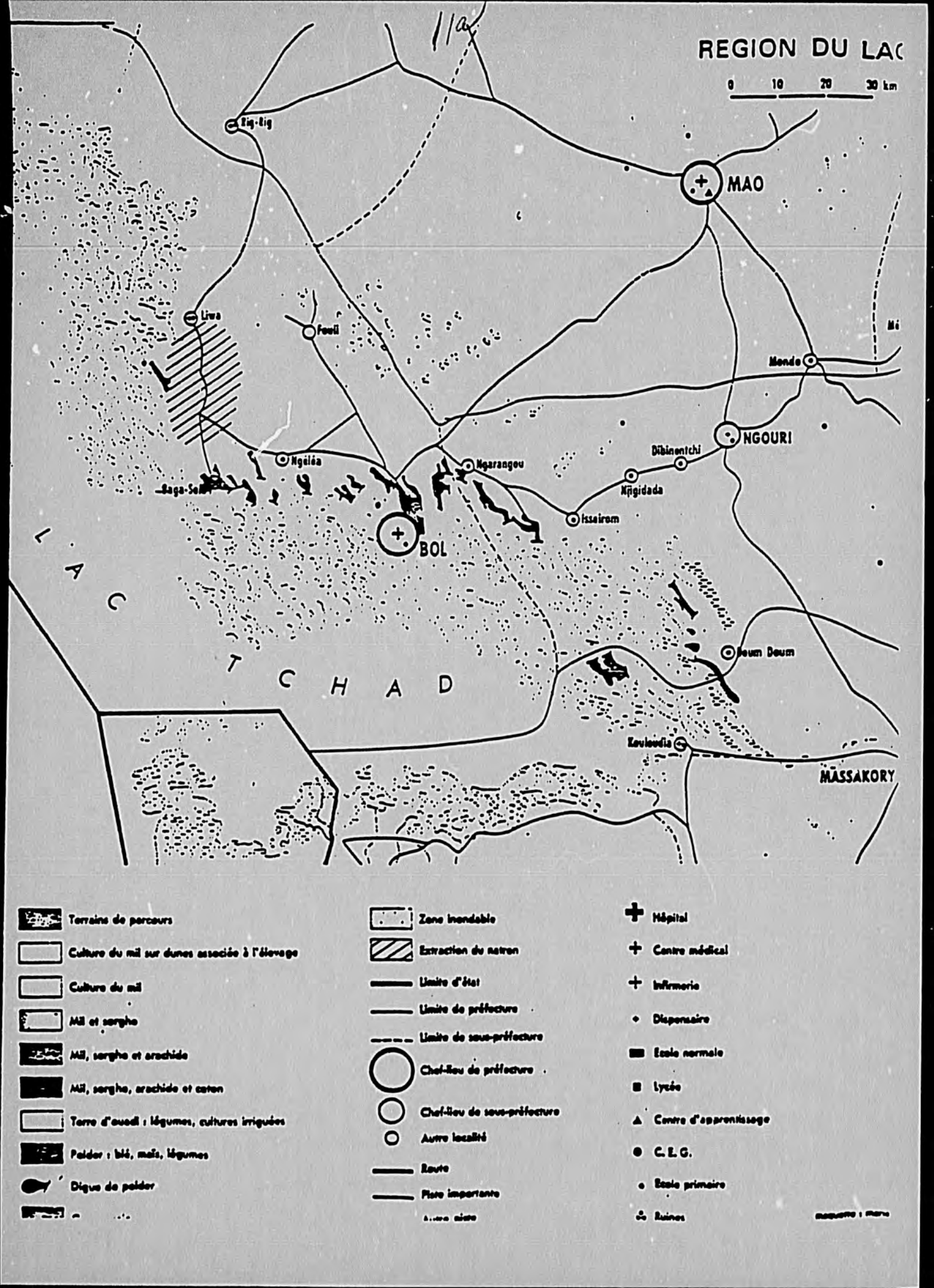
The design team's visit to Lake Fitri, and efforts to obtain information on that area, brought to light how little is known about the lake and its agricultural potential. Following the visit, the team felt that the area had some agricultural potential but that more information was required before any intervention could be planned. It is for this reason that the original project proposal included a studies component which would have permitted compilation of the necessary information on Lake Fitri, its population and its agricultural system. Unfortunately as a result of subsequent budget reductions, the study has been postponed pending securing financing from another source.

I. Project Waivers

The PVO Development Initiatives Project (677-0051) has a blanket source and origin waiver, permitting the purchase of vehicles, motorcycles, and spare parts from AID Geographic Code 935 Countries.

K. ORT Design Team Members

Dan Gerber	-	Team Leader
Ellen Brown	-	Anthropologist
Greg Kruse	-	Economist
Firmin Mansis	-	Agronomist
Huan Truong	-	Irrigation Specialist


REGION DU LAC
0 10 20 30 km
Zig-Zig
MAO
Liwa
Feouli
Mondo
NGOURI
Dibinentchi
Ngigidada
Ngaléa
Ngarangou
Isseirom
Saga-Sel
BOL
LAC TCHAD
Baum Baum
Kouloudia
MASSAKORY
Terrains de parcours
Culture du mil sur dunes associée à l'élevage
Culture du mil
Mil et sorgho
Mil, sorgho et arachide
Mil, sorgho, arachide et coton
Terre d'oued : légumes, cultures irriguées
Polder : blé, maïs, légumes
Digue de polder
Zone inondable
Extraction du natron
Limite d'état
Limite de préfecture
Limite de sous-préfecture
Chef-lieu de préfecture
Chef-lieu de sous-préfecture
Autre localité
Route
Piste importante
Hôpital
Centre médical
Infirmerie
Dispensaire
Ecole normale
Lycée
Centre d'apprentissage
C.E.G.
Ecole primaire
Ruines

II. PROJECT RATIONALE AND DETAILED DESCRIPTION

A. Project Rationale

The GOC 1986-1988 Interim Development Plan features four principal objectives:

1. Guarantee the population's basic needs, even if drought returns or persists.
2. Rapidly correct the persistent consequences of the drought.
3. Increase production on a lasting basis.
4. Provide for an equitable distribution of income.

Chad's Interim Development Plan notes that the country has substantial untapped resources upon which national development can be based. Foremost among these resources is good agricultural land, of which 5,635,000 hectares are potentially suitable for irrigation (Project de Plan Interimaire 1986-1988, p. 31.) Irrigated agricultural projects are thus among the GOC's top development priorities.

The GOC's objectives coincide with AID's policy in Chad of devoting the largest percentage of its assistance to food production. The purpose of the PVO-DIP is to assist small farmers in the Sahelian zone to increase their food production, and to support associated private sector activities. One means of doing so described in the PVO-DIP paper is to "demonstrate approaches to developing small farmer and private sector food

production systems which successor long-term projects can adopt." Thus, ORT has developed a project based on both the GOC Development Plan and the goals and objectives of the PVO-DIP, aimed at assisting wadi farmers in the Ngouri Sub-Prefecture of the Lac increase their agricultural production while, at the same time, carefully preparing for the possible replication of the project in other zones including Lake Fitri.

The Ngouri Sub-Prefecture has a threefold agricultural system: rainfed millet grown on dunes, recessional polder, and irrigated wadi agriculture. The project design team has chosen to concentrate on working with the wadi system because it is the most secure. Rainfed agriculture in the Ngouri area has now failed for several years in a row. Even last year when much of the country had a good harvest there was practically no harvest in this area. The lake level is the key variable in the polder system. With the lake varying greatly from year to year, there is always the possibility that the irrigation schemes will not work, if water does not reach the polders (as has happened to the large SODELAC projects begun before the civil war) or that crops will be flooded and destroyed if the lake suddenly rises (as happened last year with the polder corn crop in the Ngouri area). Thus, of the three agricultural systems practiced, wadi agriculture is the most reliable, since

it does not directly depend on the rains or on the level of the lake.

Unfortunately, the current wadi irrigation system, which uses shadufs, is not efficient. The farmers in the Ngouri area, as well as administration officials and traditional leaders repeatedly mentioned to the design team that what is needed is an improved means of lifting water from wadis. With such a system available, crop production would increase and many farmers would probably return to irrigated wadi farming which they have abandoned due to its low yields and difficulty of irrigation by shaduf. Of those who have abandoned the wadi system, some have taken to polder agriculture. The polder system, however, has two inconveniences:

1) the need for farmers to leave their homes to work in the polders; and
2) the unhealthy environment in the polders including a high rate of water-borne diseases from stagnant water, no permanent dwellings, no facilities, and no available clean drinking water. The project team was told that many farmers would prefer staying in their villages and farming wadis rather than going down to the polders.

In a 1959 report on the agricultural potential of wadis in the Kanem and Lac area, the agricultural engineer noted the following regarding wadis in the Ngouri canton:

"One must nevertheless mention that all the wadis of this canton were cultivated before the water table dropped. They [actually most] were abandoned around 40 years ago. The water table is currently close to 5 meters. It would certainly be interesting to experiment in these wadis with water lifting devices (other than the shaduf) which would permit lifting water at 5 meters with sufficient discharge: chain and bucket pump, animal-powered pump." (Prospection Agricole des "Quadis" du District de Mao et Etude de Leur Possibilite de Mise en Valeur, J. Girard, Janvier 1959 translated.)

There are two important factors to note. First, nearly thirty years ago the need to find a better water lifting device to improve wadi agriculture was already seen as a need. Secondly, the depth of the water table has not changed significantly over the past 65 years, despite a number of years of drought, indicating that the water table in this canton, at least, is relatively stable.*

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* In the neighboring canton of Dibinetchi the Girard report indicated that the water table in 1959 was at between 3.5 and 5 meters, also similar to what is found today. However, in the neighboring canton of Diguedada the water table has lowered from 0.5 to 2.0 meters in 1959 to 4 meters today. A possible explanation for this difference is that the water tables in the three cantons are influenced in varying degrees by the Lake Chad water level. The Girard study also noted that the Diguedada canton had excellent wadi development possibilities and that the wadi farmers in Dibinetchi were the best farmers in what is today the Lac and Kanem Prefectures. The Project envisions working in wadis in all three cantons.

The rationale behind the chosen project design also involves the need to make the project viable without long-term outside assistance. This sustainability is clearly the policy of the GOC and AID, and is also a basic philosophy of ORT. The project, therefore, will introduce only improved systems which are economically self-sustaining and which can be maintained and run by the local population, and will emphasize training farmers themselves. Nevertheless, the GOC's agricultural agents already in place must not be forgotten, since they have a key role in project implementation. These agents will be given additional training to improve their agricultural extension capabilities. They will also be provided with horses to permit them to reach more area farmers. SODELAC, which will take over the project facilities at the end of the project, should be able to continue some of the project programs (farmer extension, teaching improved agricultural practices, and agroforestry interventions) within the scope of their current small operating budget. Other project interventions will be maintained by Chadian entrepreneurs and the local farmers themselves.

B. PROJECT OBJECTIVES

1. Sector Goal

The sector goal of this project is to increase the amount and dependability of food production in Chad.

2. Project Purpose

The project has two purposes. The first purpose is to increase wadi food production in the Ngouri Sub-Prefecture, while maintaining or improving soil fertility. The second purpose is to identify models for increased wadi food production which will be replicable in similar conditions (i.e., other wadis, dry polders, and Lake Fitri).

Greater wadi food production in the Ngouri Sub-Prefecture will be made possible by increasing the yields currently obtained, and by increasing the number of hectares under cultivation. Wadi yields are expected to rise from the current 600-700 kg/ha for wheat and corn to 2,000 kg/ha by the end of the project. Irrigated millet yields should also rise substantially, from 600-700 kg/ha to 1,000 kg/ha. Vegetable production is expected to increase by at least 40% from current yields. The project will also permit more wadi hectares to be put into cultivation. Within the project area, some wadis already have 75% or more of their surface area being cultivated, while others have been abandoned due to the difficulty of lifting water by shaduf. Depending on which

twenty-five wadis are included in the project, between 100 and 200 additional hectares will come under cultivation during the initial three years of the project. It is estimated that the total cultivated area directly affected by the project will be 600 hectares by year seven after project start-up.

Besides increasing agricultural and production, the project will also be certain to maintain or improve soil fertility, maintaining the environmental equilibrium through water management and agro-forestry management techniques.

3. Project Outputs

There are eight outputs identified for the project. These are discussed below.

a) Improved Waterlifting Technologies Introduced, Tested and Adopted

The central problem with irrigated wadi agriculture, as currently practised, is that the traditional shaduf does not have a sufficient discharge. What is needed is an improved waterlifting device that is economically sustainable, ecologically benign, technically feasible and socially acceptable. At least two types of pumps appear to meet these criteria - the rower pump and treadle pump. The project will introduce these known technologies to the Ngouri area, test their relative adaptability to the local situation, and then proceed to promote their adoption by the local farmers. The

introduction of these pumps will likely necessitate the installation of improved wells - either traditional or tube-wells. For this reason, the project team will gather detailed information regarding water yields of the traditional wells during the initial stages of the project and will train one or more crews in the installation of tubewells.

b) Improved Farming Techniques Introduced and Adopted

The second most limiting factor in the traditional irrigated wadi agricultural system is the lack of use of improved farming techniques. The following are just some of the changes which might be affected to improve yields:

- adoption of a long handle hoe over the traditional daba would permit deeper tillage and better soil preparation.
- use of organic farming techniques such as mulching and composting would help decrease the rate of evaporation and increase soil fertility.
- adoption of recommended cropping dates.
- use of the right amount of seed per hectare (the per hectare rate of wheat is half of what is normally recommended).

The project Agronomist and SODELAC extension agents will introduce improved farming techniques to wadi farmers, permitting them to obtain better crop yields.

c) Improved Farmer Extension Services Available

The area farmers are currently provided extension services by SODELAC. In most cantons, SODELAC has one agent, but due to inadequate staffing and limited resources, some agents must currently serve two cantons. The agents have trouble visiting area farmers, since they do not all have means of transportation. The project will improve the agents' mobility by providing horses and a feed/health care allowance for each horse. The agents will undergo on-the-job-training from the project's Agronomist, Rural Works Engineer and Pump Specialist. Some agents will also be given 5-8 week third-country training.

d) Methodology of Salinization Control Established

One criterion for wadi site selection will be a low saline content of the groundwater, as this content varies from wadi to wadi. The project will closely monitor salinity levels in project wadis, to verify whether project interventions are increasing salinity. Within a closed ecological system such as the wadi, salts cannot be easily flushed out of the system. However, by improving the efficiency of the traditional salinity control methods (i.e., scraping off the top layer of salinized soils and putting areas to fallow), the project will be able to mitigate the salinity problem. (The efficiency of the traditional system may be improved through introduction of better tools and through monitoring of the salinization rate

of soils to help determine when they should be put in fallow). Also, the use of improved irrigation techniques may help control salinization. By sufficiently increasing the quantity of water used, salts will be leached down below root level.

e) Agro-Forestry Program Established:

(i) to help stabilize dunes;

(ii) to create windbreaks;

(iii) to augment fruit tree stands;

(iv) to make available more trees for planting in the area, thus increasing fuel and construction resources.

Most wadis in the project area are being encroached upon by advancing dunes. The agro-forestry intervention will help stabilize dunes and create windbreaks which will help protect wadis. In some cases, these actions should help recover parts of wadis that have been put out of cultivation due to deterioration of the ecological system. Fruit trees will also be made available to wadi growers, some of whom already grow dates and limes. Over the long-term, the forestry component, by bringing more trees to the area, will assist local residents meet their firewood and construction demands.

f) Pump Maintenance Training Given to Farmers, and Local Pump Manufacturer(s) Established

Farmers will be trained in the maintenance of whatever pumps are introduced to the project area. The project will finance the building of a workshop in Ngouri where training in pump maintenance can take place. In N'Djamena, ORT will work with the American PVO, Volunteers in Technical Assistance (VITA) to identify entrepreneurs whose workshops have the potential to manufacture appropriate pumps, and who are interested in taking on this product line. VITA will make credit available to qualified entrepreneurs to buy initial materials and tools for construction. ORT's Pump Specialist will give extensive on-site training to the entrepreneurs in construction of the pumps.

g) Credit Program Established for Equipment Manufacture and for Agricultural Production

Working in conjunction with VITA, ORT will establish a credit program to enable entrepreneurs to obtain the necessary tools and supplies to manufacture pumps. Depending on the need, credit will also be made available for purchase of pumps and wells by area farmers. Other related activities may also be considered for credit (e.g., credit to a merchant wanting to purchase a truck to transport produce to market).

h) Health Impact of Wadi Irrigated Agriculture Monitored

One potential negative effect of improved irrigation is that the increased amount of water made available may increase the prevalence of water-borne diseases. For this reason, the design team proposes to monitor the health impact of the project. Should any negative impact be identified, money is allocated in the budget to find a way to rectify the problem (e.g., construction and establishment of village pharmacies to make malarial suppressant drugs more available).

C. Project Components

The project will have two overlapping yet distinct phases. The first phase, encompassing approximately the first twelve months of the project, will involve establishment of the operational bases for project activities, baseline data collection, testing of techniques and technologies, and establishing the capabilities to begin the dissemination phase (Phase Two) of the project. The second phase of the project will involve extending to area farmers the technical packages identified and developed in Phase One. A discussion of each phase is presented below.

1. Phase One

a) Collection of Baseline Data

There have been a substantial number of studies done on the Lake Chad area. Unfortunately, during the civil strife of the last decade, many documents were lost and are no longer available in Chad. One of the project's first activities will be to obtain copies of relevant documents from the Office de la Recherche Scientifique et Technique d'Outre-Mer (ORSTROM), the World Bank, the Lake Chad Basin Commission, Commission du Bassin du Lac Tchad or CBLT) and others, and to establish a small library in Ngouri. At project's end, the documents will be turned over to SODELAC.

Most studies made in the past, however, have focused on polders or water pumping directly from the lake. Little work has been done on wadis. The project will proceed to conduct baseline studies on wadis and people in the project zone. These studies will serve two purposes:

(i) to gain a better understanding of the wadi system so as to better be able to implement the project; and

(ii) to establish baseline data serving as a point of reference to gauge the value of project interventions. Baseline data on health, social, economic, and technical factors will be gathered.

b) Manufacture and Testing of Pumps

A key Phase One activity will be the identification of at least one privately owned workshop in N'Djamena which will manufacture pumps. To facilitate construction of pumps and accelerate testing, several prototype pumps will be procured to use as models for the N'Djamena based manufacturers and to test in the initial five wadis. Information gained on user acceptance and pump performance will help suggest modifications in pump design, and determine which models are chosen for Phase Two dissemination.

Testing will be done in each of the wadis, with farmers chosen by the village chief. The farmers involved will have to be willing to follow the technical advice of the ORT team, and to give their time to project technicians to discuss all aspects of the experiments. For their willingness to experiment with the prototype pump, and to be questioned at length regarding all aspects of their farming operation, the farmers will have free use of the pump for one year. At the end of the period, each farmer will be given an option to buy a new pump at cost, keep the prototype at cost-minus-depreciation, or simply return the pump.

c) Adoption of Improved Agricultural Techniques

The Project Agronomist will be able to begin immediately dissemination of information on some improved

agricultural techniques (e.g., the recommended quantity of seed per hectare). Other interventions, like adoption of a long-handled hoe, will take more time, since local blacksmiths will have to be found to construct the hoes. As with the prototype pumps, the project technicians will arrange for certain farmers to experiment with the improved techniques, while other farmers, as a control, continue in the traditional manner.

d) Collection of Well Recharge Data, and Establishment of Tubewell Installation Capability

The Rural Works Engineer will carefully compile well recharge and yield data during Phase One. This data will help determine the best type of pump to use in the wadis. The local capability to install tubewells will be developed by the Rural Works Engineer and the two well construction PCV's as they install tubewells in each of the five Phase One wadis.

e) Monitoring of Salinization

This activity will start as soon as the soil and water testing equipment has been obtained. The Rural Works Engineer will make a survey of area wadis, and the level of salinization will be one of the prime technical criteria for wadi site

selection. Monitoring will continue throughout both phases of the project.

f) Establishment of Credit System

Credit will be made available during Phase One, enabling qualified entrepreneurs to purchase the tools and equipment necessary for setting up workshops to construct pumps. The project team will identify three to four entrepreneurs who already have workshops, to train in the manufacture of pumps.

Entrepreneurs who successfully complete the training program will be given a certificate to that effect. The project will then place orders guaranteeing purchase of a certain number of pumps made to rigid specifications. The Pump Specialist will continue advising the entrepreneurs through the end of his tour. The credit will be given through the VITA program, following the same criteria currently employed in its N'Djamena program.

2. Phase Two

a) Dissemination of Pumps to Wadis

Based on the lessons learned in Phase One, the project team will choose the one or two most appropriate pump models for dissemination. The pumps may be partially subsidized at first, to encourage their adoption. This subsidy, however, will be phased out by the end of the project. At first it will

probably be necessary for the project to handle transport of pumps to Ngouri and sale of pumps to area farmers. By the end of the project, a Ngouri-based merchant willing to handle these tasks will have been identified.

b) Improvement of Well Construction Capabilities

Introduction of an improved well will necessitate better well construction capabilities. There are two options: either to deepen and improve existing wells or to introduce tubewells. The Rural Works Engineer working with the two Peace Corps Volunteers may wish to experiment with improving traditional wells (deepening them and lining the lower part with bricks). The advantage of this option is that it involves less effort since it does not introduce a new technology. Unfortunately, merely deepening wells may not sufficiently increase water yields. Whether traditional well improvement is attempted or not, the Rural Works Engineer will undoubtedly wish to establish tubewell construction capabilities. Local entrepreneurs who are interested in providing tubewell installation services will be identified. The entrepreneurs will purchase the necessary equipment (with a VITA loan, if needed) and hire teams of 3 or 4 to install the tubewells. Training will be provided by the PCVs working under the direction of the Rural Works Engineer. At first the project will subsidize the cost of materials for well construction, but the farmer purchasing the pump and the tubewell will have to

pay for the labor. By the end of the project, all subsidies will be removed.

c) Finalization of Credit Component

VITA will help ORT operate a credit program within the Ngouri office which will enable local farmers to purchase pumps. Credit criteria and the interest rate are still to be negotiated, guided in part by VITA's experience with its on-going credit programs.

d) Pump Maintenance Training

The SODELAC extension agents will be taught pump maintenance, permitting them to extend this knowledge to area farmers who purchase the pumps. Local blacksmiths will also be given simple training in the repair of pumps (replacement of gaskets, repair of pedals, etc.)

e) Initiation of Agro-Forestry Program

The agro-forestry program will become a major project activity, starting in the second year. The two Peace Corps Foresters are expected to arrive twelve months into the project and will be responsible for setting up the nursery and beginning an active forestry program in collaboration with either SODELAC or the Ministry of Water and Forest. Prior to the establishment of the Ngouri nursery, the project team will be able to obtain seedlings from the GOC Water and Forest

Nursery in Bol. The reasons for not starting the agro-forestry program until the second year are to permit the phasing-in of project activities and to avoid overburdening the logistical capabilities of the project staff.

f) Continued Dissemination of Improved Agricultural Techniques

This activity, begun in Phase One, will be extended to the twenty additional wadis brought into the project during years two and three. The techniques found to be the most useful and most readily adopted during Phase One will be those given the most attention.

g) Salinization Control

The salinization monitoring, begun during Phase One, will be continued throughout the project. Should salinization increase in project wadis, interventions such as removal of the top layer of salinized soil and fallow rotation of wadi plots will be initiated. The project does not envision being able to bring new salinization control techniques to bear, but rather will choose to ameliorate traditional techniques.

h) Monitoring of Health Effects

Baseline data on the prevalence of water-borne diseases in the wadis will be obtained in Phase One. During Phase Two,

there will be a follow-up evaluation of the prevalence of diseases in the wadis, to ascertain if the project has contributed towards increasing the incidence of disease. If the study indicates negative effects, the project will begin a program to counter the problems (e.g., establishing village pharmacies).

D. PVO Inputs to be Financed by AID

1. Technical Services

a) Agronomist (33 months)

The Agronomist will be responsible for improving farmer extension services by helping area farmers directly and by training SODELAC agents. (See Annex F for detailed job description).

b) Rural Works Engineer (30 months)

Working with the Pump Specialist, the Rural Works Engineer will be responsible for introducing and testing improved water-lifting devices. He will be charged with improving existing wells or introducing tubewells suitable for the improved pump which the Pump Specialist chooses. The Rural Works Engineer will also be responsible for establishing the methodology of salinization control. (Please see Annex F for detailed job description).

c) Pump Specialist (18 months)

The Pump Specialist's primary responsibility will be to test and introduce prototype improved pumps suitable for the project area, which will be manufactured in private workshops in N'Djamena. The Pump Specialist will train local entrepreneurs in the construction of pumps, taking particular care to monitor quality control. In conjunction with the Rural Works Engineer, the Pump Specialist will give pump maintenance training to local farmers. (Please see Annex F for detailed job description).

d) Administrative Officer (36 months)

The Administrative Officer, who will be the Chief of Party, will be responsible for overseeing all administrative and logistical aspects of the project and serving as liaison between the Ngouri based team, GOC officials, AID, Peace Corps and ORT/Washington. Major responsibilities include: monthly reporting to ORT/Washington and quarterly reporting to GOC, AID and Peace Corps regarding project progress, problems and suggested solutions; accounting of all in-country expenses; arranging for all logistical needs of the project and project technicians; overseeing and arranging for construction of the Ngouri office and housing compound; and providing the administrative backstopping and support for the Peace Corps Volunteers associated with the project. (Please see Annex F for detailed job description).

e) Short-Term Personnel (17 man/months)

The project has budgeted for the following short-term experts to assist project personnel: Data Collection Consultant; Communications Expert; Health Specialist; Forester; Social Scientist; Maintenance Trainer; Environmental/ Soils or Marketing Expert and Specialists for Lake Fitri Studies. (Please refer to job descriptions in Annex F).

f) Peace Corps Volunteers (12.5 man/years)

The project will use the services of six Peace Corps volunteers, working in the fields of well construction, forestry, pump technology and health. The locations where volunteers will live depend partially on the wadis chosen for project implementation. Possible assignments are N'Djamena (Pump Technology volunteer); Ngouri (two Forestry volunteers and Health volunteer); Djbinintehi (Well Construction volunteer); and Njigidada (Well Construction volunteer). (Please refer to job descriptions in Annex F.)

g) VITA Credit

VITA will provide technical assistance to start up a credit program in Ngouri. N'Djamena entrepreneurs may also obtain loans from VITA, enabling them to purchase the supplies and equipment necessary to construct irrigation pumps.

2. Participant Training

a) In-Country

Project personnel will train SODELAC in improved farming techniques, and pump and well technologies. Peace Corps Volunteers will train crews in tubewell installation. In N'Djamena, the Pump Specialist will train local entrepreneurs in the construction and assembly of pumps.

b) In Other Countries

The Centre d'Etudes Economiques et Sociales de l'Afrique de l'Ouest (CESAO) in Senegal has a five-week Rural Community Organization course which would be valuable for SODELAC extension agents participating in the project. The program includes training in agricultural technology, farm management, establishing budgets, using credit and measuring agricultural profit. ORT has also budgeted money for tubewell and pump training in Bangladesh.

3. Special Studies/Research

a) Pre-Implementation and Ongoing Studies

In order to define better the potential benefit to the farm family from participation in the project, a baseline study of the farm family and its existing production practices and 'income' earning activities and opportunities will be undertaken by the Social Scientist and Agronomist. This study will have the following purposes:

i) Provide essential data regarding the activities of the farm family throughout the year, analyzing not only agricultural activities, but all 'income' generating activities which may be in conflict with modifications of the production system proposed by the Agronomist.

ii) Provide baseline data for the conditions of production, the production groups and level of farm family well-being in the project area before the project intervention. This activity will deepen the present understanding of the farming system, covering dune, wadi, and polder agriculture.

iii) Deepen current understanding of market conditions and factors bearing on market conditions, to clarify the potential for commercialization of project production, and begin the task of identifying interesting market opportunities and marketing contacts. Included in this task is a survey of regional markets, transport systems, and storage facilities available to the project. Also, an initial effort will be made to select those crops or food products with the greatest commercial potential, in local, regional, national, and export markets.

iv) Provide a comprehensive survey of potential project sites and "control" sites, and identify the owners, abandoned parcels and reasons for abandonment. Point out the relative socio-economic merits of each.

v) Provide a general census of the region, not in detail, but sufficient to characterize the various population centers by relative size and importance, and their respective production activities and problems.

vi) Provide a general understanding of health problems in villages, wadis and polders.

vii) Determine the metric equivalents of the traditional weights and measures in use in agriculture and markets. This activity will make later comparison of project output with non-project output possible.

viii) Evaluate the feasibility of assisting private individuals or firms through credit and managerial training to provide essential inputs and services to the project area.

(See Annex O for a more detailed outline.)

4. Commodities

Commodities financed by the project will include the necessary tools and equipment to construct and assemble pumps, tubewell installation equipment and supplies, forestry supplies and housing and office supplies and furnishings. Soil and water testing equipment will also be purchased. (See Annex D.)

5. Construction

The SODELAC office and residence in Ngouri is in a total state of disrepair. The residence will be repaired, and an additional house built on the compound to house the two expatriate technicians assigned to Ngouri. The office will need to be completely rebuilt and expanded.

A nursery for the forestry program will be constructed in Ngouri. A small warehouse and office will be needed, as well as a wall around the nursery to protect the seedlings.

6. Contingency/Inflation

The budget has a 10% contingency line-item, to cover unexpected costs and inflation over the life of the project.

E. PVO Inputs

ORT will finance approximately 20% of the total project costs. The overall budget of 4 million dollars reflects the total cost of the project, including ORT's contribution. (See Annex T.)

F. Other Inputs

1. GOC

SODELAC will be ORT's counterpart agency for project implementation. SODELAC is a government parastatal responsible for rural development activities and agricultural extension in the Lac Prefecture (in the other 13 prefectures in Chad ONDR is the responsible GOC agency). The SODELAC office in N'Djamena is headed by its General Director, who reports directly to the Direction of the MEADR. The major field office is in Bol, the capital of the Lac Prefecture, and is headed by SODELAC's Director of Production. Each of the Prefecture's cantons is supposed to have one extension agent, but due to funding problems, some extension agents cover two cantons. These agents report to their Chef de zone, who in turn reports to the Chef du Sous Agence located in each of the two Sub-Prefectures.

SODELAC has had little program support since the civil war, when the large and unsuccessful World Bank-financed polder projects came to an end. With the advent of the Italian-financed UNDP project, SODELAC will be able to restore some of its N'Djamena and Bol-based activities. The ORT project in Ngouri will give the field agents useful work and support them by providing transportation and training. Once the project ends, it is unlikely that SODELAC will be able to continue its project related extension work at the same level of effort without further outside assistance. Nevertheless, SODELAC, as it has shown during the last few years, should be able to continue at least basic extension services to a portion of the

rural population. The project design has taken these factors into consideration, emphasizing the role of private enterprises and individual farmers in project sustainability.

During the project, SODELAC will make five of its agents and its Chef de Sous Agence directly available to the project. Furthermore, SODELAC will provide rent-free use of its residence and office compound in Ngouri. SODELAC may also make available to the project the technical services of other staff, such as land surveyors, depending on specific needs and availability.

The Bureau Interministerial des Etudes et Programmes (BIEP) may also assist in the Lake Fitri studies, providing personnel to assist in the studies.

2. Peace Corps

Under terms of the ORT/Peace Corps agreement, Peace Corps will assume the costs of:

a) recruiting and selecting volunteers;

b) medical processing;

c) security clearances;

d) transportation to and from Chad;

e) emergency travel outside of Chad;

f) stipends;

g) readjustment allowance.

III. COST ESTIMATES AND FINANCIAL PLAN (AID and ORT only)

A. Summary Cost Estimate	Year 1	Year 2	Year 3	Total
1. Expatriate Technical Assistance	175500	195563	171635	542698
2. International Travel and Transport	50772	21400	28772	100944
3. Local travel	17500	12400	10000	39900
4. Housing	43200	32400	21600	97200
5. Local hire personnel	57000	59850	62845	179695
6. Construction	125000	35000	0	160000
7. Training costs	86600	23000	18000	127600
8. Vehicles, equipment, supplies and furnishings	388688	105980	90250	584918
9. Home office backstopping	115840	121632	127714	365186
10. Overhead	51872	56514	54323	162709
11. Short-term consultants	65200	66250	10000	141450
12. Evaluation	0	19600	19600	39200
13. Other direct costs	69120	58200	55000	182320
14. Peace Corps	44376	38753	38753	121882
15. Health component	0	30000	30000	60000
16. Subtotal	1290668	876542	738492	2905702
17. Contingency (10%)	129067	87654	73849	290570
18. Total	1419735	964196	812341	3196272

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B. Financial Plan

The Washington office of ORT will maintain continuous contact with the field office in N'Djamena, and will assure that all financial reports are submitted in a timely manner to USAID/N'Djamena. While all original receipts for field expenditures will be held in ORT's London accounting office, copies of all receipts will be kept by the Administrative Officer in Chad and sent to the Project Coordinator in Washington. The Controller of the American ORT Federation will be charged with all payroll matters, and will sign off on financial reports to USAID. He will have direct accountability to the Home Office Project Coordinator.

ORT's financial management practices and its ability to conduct internal audits can be corroborated by AID's Office of Private Voluntary Cooperation with which ORT is registered as a PVO. Annual audits are published each August. Technical Assistance billings for 1984 totalled $10,828,468. The current life-of-project budgets for technical assistance programs in Africa alone total $60,515,354.

ORT proposes that the financing of the AID portion of the project be handled via establishment of a letter of credit. Funds from this account will be moved to the N'Djamena field office via wire transfer. Since no banking facilities exist in Ngouri (none exist in Chad outside of N'Djamena), there will be extra precautions taken to secure the overland delivery of cash

to Ngouri and security of the cash in Ngouri. The budget provides for high quality safes and guards for the offices in both N'Djamena and Ngouri.

C. Cost Estimates of Other Inputs to the Project

1. GOC

The GOC will contribute the land in Ngouri where the office, housing and workshop will be built. The current residence in Ngouri, which is in need of major repairs, will also be given rent-free to ORT for the life of the project. SODELAC will also contribute the time of its extension personnel in the field, and time of its administrative staff in Bol and N'Djamena for project monitoring. Estimates of contributions are detailed in chart I:

2. Peace Corps

The Peace Corps will assume the costs of volunteer recruitment and selection, medical processing, obtaining security clearances, transportation to and from country of assignment, emergency travel external to country of assignment, stipends and readjustment allowances. The Peace Corps estimates these costs as $10,000 per year per volunteer. The estimated cost for this project is, therefore, ($10,000 x 12.5 volunteer years) $125,000.

Chart 1:
GOC Estimated
Contribution

(a) PERSONNEL post	% of time	Monthly Salary	Months	CFA	$US
(i) DG of SODELAC	20%	100,000 CFA	36	720,000	2,057
(ii) Dir. of Production	30%	80,000	36	864,000	2,469
(iii) Chef de Sous Agence	100%	40,000	36	1,440,000	4,114
(iv) Agents (4)	100%	25,000	36	3,600,000	10,286
(v) MEADR Counterpart	100%	60,000	36	2,160,000	6,171
Subtotal				8,784,000	25,097
(b) Social Security				878,400	2,510
(c) Ndj and Bol SODELAC Office Backstopping		97,220	36	3,500,000	10,000
(d) Evaluation				837,550	2,393
(e) Use of Ngouri Facilities (land, buildings)		972,220	36	35,000,000	100,000
TOTAL				490,000,000	140,000

IV. Implementation Plan

A. Implementation Responsibilities

1. ORT

ORT will take all responsibility for the recruitment and fielding of the expatriate project staff and the major technical inputs of the project. ORT's Administrative Officer will assure the logistical and administrative support needed by the project technicians. ORT will also establish the necessary infrastructure to support the Peace Corps Volunteers associated with the project, including maintaining the necessary records, and providing administrative backstopping, orientation, and technical guidance for the PCV's.

2. GOC

The GOC will be responsible for providing competent extension agents in the Ngouri area to serve in project implementation. Furthermore, the GOC will assure prompt delivery of the necessary exonerations and paperwork for the clearing of duty-free purchases of project vehicles and equipment.

3. AID

AID will have no implementation responsibilities.

4. Peace Corps

Peace Corps will be responsible for the prompt recruitment and placement of qualified volunteers, as determined in joint negotiations with ORT.

5. VITA

VITA will be responsible for the establishment of a sound credit program in N'Djamena and Ngouri. It will monitor the loan program and assure responsible management.

B. Collaboration with Other Donors

1. United Nations Development Program (UNDP)

The Italian-financed UNDP program in the Lac Prefecture will involve road building, health, and agricultural development. The primary focus of the agricultural program is on large irrigated polders in the Bol Sub-Prefecture. Depending on funding available, there may be some future UNDP intervention in the wadis in the Ngouri Sub-Prefecture. ORT is prepared to cooperate with UNDP's eventual efforts in the Ngouri Sub-Prefecture, sharing information and other resources.

2. Africare

Africare has proposed an extension of their Abeche Rural Development Project under financing of the PVO-DIP, which

will, among other actions, test and promote adoption of improved pumps. ORT hopes to work in collaboration with Africare in sharing information regarding design and adaptability of various pumps. The wadis in the Quaddai region which Africare will be working in are dry river beds as opposed to the oasis wadis of the Lac Prefecture. Nevertheless, there are similarities in pump requirements and a sharing of information is likely to benefit both programs. Information gained by Africare in its forestry component will also be of great use to ORT's agro-forestry effort. The assistance given by Africare personnel to the ORT design team suggests an excellent potential for a collaborative effort.

3. CARE

CARE has proposed a project under the PVO-DIP to help small farmer irrigation in the Kanem and Chari-Baguirmi. If a collaborative relationship can be established between CARE and ORT, both PVOs may benefit, especially since the CARE project will also be testing improved pumps in settings similar to that of the Ngouri Sub-Prefecture.

4. MCC (Mennonite Central Committee)

MCC is planning to test the Rower pump in Chad. ORT will

collaborate with the MCC sharing information regarding the adaptability and design of this human powered pump.

5. VITA

Since the project will rely on the private sector for inputs and marketing services, sustainability will be improved by establishment of a credit program to assist businessmen who are prepared to provide essential inputs and marketing services. VITA has already established a small-business credit program in N'Djamena, evaluating the commercial viability of potential manufacturing or service enterprises, assisting entrepreneurs in planning and financial management, and administering loans.

VITA is also undertaking agricultural production credit activities in the N'Djamena area. The growing interest in small scale irrigation projects, particularly for vegetable production, which has a high value per unit of land and applied water, has brought several irrigated perimeters into the VITA portfolio. This experience may be very useful for evaluating the commercial viability of the potential use of motor pumps in the project area.

As discussed earlier, AID intends for VITA to administer both a loan program for N'Djamena-based manufacturers of pumps and for Ngouri-based farmers. VITA's experience in appropriate technology will also provide the project technicians with a tremendous potential resource.

C. Procurement Plan

1. Authorized Source of Procurement

The PVO-DIP has already received a source-and-origin 636 (i) waiver permitting the procurement of vehicles and spare parts manufactured outside the U.S. This waiver is necessary, due to the lack of service facilities and spare parts for U.S. manufactured vehicles in Chad. The project will purchase Japanese or European manufactured vehicles (five 4-wheel drive cars or pick-ups and one truck).

Detailed in the Illustrative Commodity and Equipment Section (Annex D), are eight lists of commodities to be procured. Of these eight, three will require procurement of most of their items from the U.S. (soil testing equipment, prototype pumps, and shop equipment) and five lists will contain mostly items to be procured locally (pump materials, tubewell construction equipment and supplies, forestry supplies, household furnishings, and office equipment and furnishings).

2. Responsibility for Procurement

All in-country procurement will be the responsibility of the Administrative Officer and his staff. They will assure that ORT and AID procurement procedures are followed and will be responsible for obtaining bids, filing the necessary papers for exonerations of duty-free items and in-country shipping of

materials to Ngouri. Prior to leaving for post, the Administrative Officer will receive an orientation regarding ORT's procurement procedures.

Procurement of items from the U.S. will be overseen by the Project Coordinator in Washington, working with ORT's Procurement Department.

3. ORT's Procurement Procedures

ORT's procurement activities date back to the 1920's. ORT presently maintains procurement offices in London and Washington, with the bulk of procurement for AID-funded projects implemented by the Washington office.

Procurement Department personnel have had extensive experience in product-identification, packing and shipping and have access to a supplier network in the United States and nine other countries worldwide. They hold to a policy of obtaining the best prices coupled with reliable delivery, and, most importantly, speed of dispatch.

The ORT Procurement Department functions as a controller of budgets, and provides monthly expenditure reports to field project managers and funding agencies.

Procurement for AID funded projects takes into account the following:

a) utilization of US flag carriers unless a waiver is received;

b) enforcement of AID source-and-origin requirements, as prescribed in standard provisions applying to US grantees and contractors. ORT maintains in its files all AID and Federal Regulations concerning procurement.

V. Monitoring Plan

A. PVO Project Management

1. In-Country

ORT will establish two in-country offices in Chad - one in N'Djamena and one in Ngouri. The N'Djamena office will be staffed by the Administrative Officer, and a local-hire administrative assistant, bookkeeper and secretary. The N'Djamena office will be responsible for liaison with the field technicians, Peace Corps Volunteers, USAID, Peace Corps Washington, the Chadian Government, other donors, and ORT's home office. Customs clearance, banking, financial and narrative reporting, procurement and logistics will be major responsibilities of the N'Djamena office. The Administrative Officer will also spend much of his time up-country in the Ngouri office - particularly during the start-up phase. Other responsibilities of the Administrative Officer will be to assure that progress towards meeting the overall project purposes is on schedule, to identify solutions to problems which arise during project implementation, and to assist in data compilation and analysis.

The Ngouri office will be headed by one of the two expatriate technicians, who will be named Deputy Chief-of-

Party and who will be assisted by an administrative assistant and a secretary. The Deputy Chief-of-Party, however, is not expected to devote more than 10% of his time to administrative matters, as most of these duties will be responsibility of the N'Djamena-based Administrative Officer and Ngouri-based administrative assistant. The office will have work space for the expatriate technicians, the local-hire surveyor, the SODELAC, the MEADR counterpart and the various short-term consultants. The Ngouri and N'Djamena offices will be linked by short wave radio.

2. Home Office

Home office support will be structured to maximize input from various organizational resources, taking full advantage of ORT's broad and practical experience in the areas of project management, agricultural development and training.

The following section presents the organizational resources available to the project, and outlines their anticipated utilization.

The International Cooperation Department

This department is responsible for developing, coordinating, and implementing all technical assistance projects undertaken by ORT. It has its offices in Washington,

London and Geneva. Backstopping responsibility for projects is divided among these offices, depending upon staff capabilities, the sector involved, the client and the donor agency. Each office brings together a team of administrators and project coordinators who are training/technical specialists in disciplines covering the main fields of ORT technical assistance.

Washington Office

All backstopping activities for this project will be coordinated through the Washington office, where a Project Coordinator will be assisted by a full-time secretary. The Project Coordinator will: (1) coordinate and monitor all activities related to expatriate personnel, including orientation, logistical support and recruitment of long and short-term consultants; (2) oversee evaluation planning and execution; (3) establish and coordinate the internal reporting procedures; (4) assure systematic and timely information-sharing among all ORT departments involved in the project; (5) monitor project expenditures and program outputs; (6) coordinate the inputs of all organizational resources utilized by the project; (7) maintain continuous contact with the field office in N'Djamena and make periodic field visits; (8) assure

that all program reports are submitted in a timely manner to the GOC and USAID/N'Djamena; and (9) maintain contact with AID Washington as required.

The Director of the Washington office will provide overall management supervision for this project.

The bulk of procurement for AID-funded projects is implemented by the Washington procurement department. Between 1980 and 1986 alone ORT has provided more than $5,000,000 worth of commodities for AID-funded projects. This office will also monitor all procurement expenditures, and secure all U.S. procurement.

London Office

The London office houses an interdisciplinary team of specialists/trainers, several of whom--an agriculturalist, a training specialist, and an engineer--will be assigned on a part-time basis to provide assistance to the project in the areas of agricultural extension, training, and equipment production/maintenance.

New York Office

The Controller of the American ORT Federation, located in the New York office, will be responsible for all matters

related to payroll and financial accountability to AID. He will control management of the Federal Reserve Letter of Credit, and will sign the Financial Status and Cash Transaction Reports submitted to AID/Washington and USAID/N'Djamena.

B. AID Liaison

The Administrative Officer will keep USAID/Chad informed of project progress and problems, and of any proposed changes in program activities. By having a full-time administrator assigned to the project, ORT will be able to assure prompt and accurate financial and narrative reporting to USAID and the GOC. The ORT Administrative Officer will be available to the USAID Project Manager and USAID/Chad Project Development Officer responsible for implementation of the PVO Development Initiatives Project (677-0051).

C. GOC Project Management

The project will be implemented in close collaboration with the GOC. This collaboration began during the design of the project, when the active support of SODELAC, ONDR, the Ministry of Plan, the Ministry of Agriculture and Rural Development and the regional administrative officials was sought and obtained.

For example, the SODELAC for the Ngouri Sub-Prefecture accompanied the design team throughout its trip to the Lac Prefecture, and contributed to the project design. The NGO Coordinator for the Ministry of Plan also contributed to the project design, emphasizing the need to coordinate NGO activities (avoiding duplication of efforts) and to plan self-sustaining activities. These contributions, as well as the support and guidance given by the Minister and the Secretary of State for Agriculture and Rural Development, as well as the SODELAC officials in Bol and N'Djamena towards the design of the project are all positive signs. To help assure that this relationship continues, ORT envisions the following:

- ORT and SODELAC will submit joint quarterly reports to the Ministry of Agriculture and Rural Development, the Ministry of Plan and the Sub-Prefect of Ngouri.
- The SODELAC will act as the Deputy Chief-of-Party's counterpart.
- The Administrative Officer will report directly to the General Director of SODELAC:
- The SODELAC agents assigned to each canton in the project area will participate in project activities, and will benefit from third-country and on-the-job training.
- The SODELAC will submit quarterly progress reports to ORT regarding activities directly related to the project.

- Regular meetings between SODELAC and ORT will permit project progress to be monitored, and any potential problems to be discussed and solutions proposed.

D. Reporting Responsibilities

As mentioned above, the Administrative Officer will be responsible for compiling the quarterly narrative reports based on input from the project technicians. These reports will be submitted to USAID and the interested GOC agencies. SODELAC will also submit quarterly progress reports to ORT. Financial reports will be submitted through the ORT Washington office.

Narrative quarterly reports will follow a format agreed upon by AID, the GOC and ORT, detailing project progress, perceived problems and suggested solutions. Narrative reports will be submitted to AID within 30 days of the end of each reporting period, and within 45 days to the GOC (extra time is required for translation).

VI. SUMMARY ANALYSES

A. Summary Technical Analysis

1. Soil and Water Management Practices:

The project design team identified several constraints to agricultural production in the wadis, which can be relieved with inputs of appropriate equipment, technical assistance and extension. These constraints fall into the following categories:

a) poor tillage;

b) inefficient irrigation basin size;

c) inefficient water-lifting devices;

d) inefficient water distribution and scheduling techniques;

e) low-yielding traditional wells;

f) salinity build-up due to lack of drainage;

g) low capacity of human-powered water-lifting devices.

These constraints and proposed interventions are discussed below.

Poor tillage:

Traditional farmers use the daba, or short-handle hoe to prepare land before irrigation. The handle of the daba is only forty or fifty centimeters long and it is held with one hand. The user must bend over at the waist. This traditional method

permits tillage to a maximum depth of a few centimeters in the soils in question, and work progresses at a very slow rate.

Introduction of long-handled hoes with broader and heavier blades permits use of both arms and back muscles. In addition to working faster, the farmer is able to till the soil to a much greater depth. Studies have shown that this greater depth of tillage results in yield increases of seven to twenty-four percent.

The project will introduce the long-handled hoe into the region. Local blacksmiths will be trained to build the new hoes with local materials. Project personnel will also work directly with participant farmers in the use of the new tools. This change will require patience, and perhaps some form of innovative incentive, since farmers are accustomed to the old system and must spend a certain amount of time learning the feel of the larger, more efficient hoe.

Improved Irrigation Basin Size:

The traditional shaduf irrigation systems use small, level basins, about one meter square, which are filled from adjacent small canals or furrows. It is estimated that about 25% of a given field is taken up by the small dikes separating the basins. If basins are enlarged to two meters square, the land taken up by dikes is halved. This allows more dense cropping

Dune bordering one side of this dry polder is typical of the dunes bordering most polders and wadis in the Ngouri Sub-Prefecture.

Land preparation using daba in an Ngouri Sub-Prefecture polder.

and higher yield on a given plot. However, it is important to assure that the larger basins are constructed level. Micro relief in basins causes non-uniform water application and loss of efficiency. It is also important to increase the irrigation stream size to the largest practical with human-powered lifting, to assure water spreading across the larger basin in a reasonable time. The lag time between water first entering a basin and spreading to its extremities also causes non-uniform application and resulting inefficiency, particularly on light and sandy soils.

The Rural Works Engineer will develop guidelines to determine the optimum basin size as a function of soil type and stream size (flow rate). The guidelines must be simple enough to be adopted by farmers with the aid of extension agents.

Improved Water Lifting Devices:

Traditional irrigation uses shadufs to lift water from shallow-dug wells. The net capacity of a shaduf, not counting rests, with a typical lift of four meters, is something less than one liter per second, or thirty watts of water work. In contrast, a healthy man can produce about 100 watts of net work output for 15 to 30 minutes, using the major muscles of the body. Thus, to lift water with the shaduf, which uses the arm

muscles, is much less efficient than with the treadle pump, which uses leg muscles.

Some pumps have been developed specifically for manual irrigation from shallow wells. The twin-treadle pump uses both legs, each acting on separate cylinders for uniform flow. This pump is designed for lifts between two and six meters, and delivers around 75 watts of water work in this range (about two liters per second at four meters lift). The Mennonite Central Committee (MCC) Rower pump uses the arm and back muscles in a rowing-type action. The capacity of the Rower pump is less than the treadle pump, but it is simpler and cheaper. A good description and performance data of these pumps is given in Human and Animal-Powered Water Lifting Devices by Intermediate Technology Publications (See Annex P). Plans for these pumps will be obtained and modified to fit local materials and technology. Prototypes will be built and tested. One or more small workshops will be contracted to set up small-scale production, with project team providing technical advice in efficient manufacture and quality control. The Rural Works Engineer will also work with extension agents in installation and use of the pump or pumps selected for widespread use.

Improved Wells:

The traditional dug wells used for irrigation typically yield one liter per second or less. This may be adequate for a shaduf, but is not sufficient for improved pumps. Further, the

shallow wells are constantly caving in, requiring a large labor input to re-dig them.

Shallow tubewells are far superior to dug wells from the standpoint of both yield and durability.

The "sludger" method of drilling tubewells is eminently applicable in the wadi areas. This technique, described in "Small Wells Manual," USAID, 1969, uses a minimum of hand tools and manual labor. A good crew can install two or three tubewells per day.

Casing and screen will be made with locally available PVC pipe. The pipe is slotted with a hack saw and small circular saw to make screen. If slits cannot be cut sufficiently narrow, larger slits are cut and the screen is covered with a sock sewn from synthetic material, to prevent entrance of sand. These improved wells and the improved pumps complement each other.

The Rural Works Engineer and Peace Corps Volunteers will introduce and perfect the "sludger" method for installing tubewells in the wadis. Wells and screen will be designed to match the conditions of the pumps being used and aquifers in question. The Pump Specialist will also work with project shop personnel to set up a pipe-slotting operation to make screen.

Improved Water Scheduling and Distribution:

Most farmers were observed to irrigate with frequent, but too-light applications. The result is that water never penetrates deep into the root zone, evaporating quickly off the soil surface. This practice wastes water, reduce(s) yield, and accelerates salinity problems by leaving a salt crust on the soil surface.

Good water scheduling techniques (applying the required amount (depth) of water to a crop at the right time) can greatly increase or optimize crop production per unit of manpower input to lift water. Scheduling can also minimize salinity problems and leeching of nutrients below the crop root zone.

The Rural Works Engineer will develop measurement and scheduling techniques that are effective and simple enough to be extended to participant farmers. Schedules will take into account crop type and growth stage, climate, and soil characteristics.

Salinity Monitoring and Control:

Many wadis have existing and potential problems with salinity. The classical technique of controlling or reclaiming saline soils is over-irrigation, to leach salts from the root zone. This technique cannot be applied in the wadis, due to

internal surface drainage and very low groundwater gradients. In other words, there are no areas lower than the wadis to where they can be drained (without costly pumping).

The traditional methods of salinity control and land reclamation also include scraping salt off the soil surface where excessive amounts have collected, and hauling it away, and putting areas that have become salinized into fallow, allowing normal rainfall to leech out the salts.

The salinity-control strategy proposed by the project design team has three inter-related components:

a) Identify wadis with low potential for salinity problems, by testing groundwater. Development activity will be concentrated in the most favorable areas;

b) Monitor groundwater levels, gradients and salinity in project areas with shallow tubewells or piezometers. Annual changes in water level and salinity can be used to anticipate and avoid future problems from overuse;

c) Develop and implement criteria for minimum well spacing, to avoid overuse of groundwater, and salinity from intense irrigation.

The Rural Works Engineer will test water at potential sites as a preliminary measure to selection. Once sites are chosen, water levels and salinity will be monitored in a grid of shallow test wells or piezometers. The Engineer will develop

criteria for optimum or minimum well spacing, from the standpoint of available water, and the area of land that can be irrigated from a project well/pump system, including fallow expansion room. Spacing wells too closely builds in poverty if plot sizes are too small to expand.

Motor Pumps:

There may be some potential for pumping groundwater with small gasoline or diesel suction pumps. The Rural Works Engineer and Agronomist must first investigate feasibility from the standpoint of appropriate pumps, wells and economics. If this technology proves to be feasible, the Rural Works Engineer will introduce the optimum technical package (pump and well).

2. Agronomic Analysis

a. Constraints to Agricultural Development

i) Climatic Constraints

The wadis are situated along the Ngouri - Dibinentchi - Diguedada axis east of Lake Chad. Access is via unpaved sandy roads, which are difficult to drive through in the dry season.

- Rainfall

There is a decline in the current rainfall compared to the normal pattern of 300 mm/year in the

area. It varies from 160 to 200 mm/year on average, sharply dropping to 80 mm in 1984. It is also erratic and unevenly distributed.

- Wind and Evaporation Pattern

The evaporation pattern is governed by the harmattan and rainy seasons. The harmattan, a hot and dry wind, blows from November to March/April, with a prevalence of shifting winds. The highest speeds are reached in the morning and around noon. These winds result in the movement of sand around the polders and wadis.

Evapo-transpiration measurement in Bol was 7.37 mm/day from March to May.

ii) Physical Constraints

- Water Supply in the Wadis

Groundwater is the most secure source of water, although the water table in some areas is gradually dropping. The water table is currently 4 meters deep.

There is debate whether the ground water is primarily fossil water supplemented by a recharge from rainfall, or is primarily recharged by Lake Chad.

- Salinity of the Groundwater

The groundwater is salty. The level of electric conductivity and the types of salt could not be determined during the design mission because of lack of a means to measure and analyze salinity.

- Salinization of Soils

This is caused by the groundwater, first as a result of the evaporation of the subsurface water, and currently, due to irrigation activities. The volume of water drawn with the shaduf is very small, with high evaporation levels, and the salt remains on the surface of the soil.

iii) Constraints of Farming Methods.

The primary constraint is the method of watering the land -- currently the shaduf. Its use entails a grueling effort. The user merely seeks to wet the soil, instead of providing the crops with adequate amounts of water.

During the period when there was abundant rainfall and a very high water table (0.5 to 1 m deep), the soil was permanently wet, it was sufficient to dig a hole for the plant to grow, as is the case under recession farming. Despite the drop in the level of the water table and the need to irrigate,

there have been few improvements in the farming system.

The water drawn into the 1 m^2 ridges is immediately drained into adjacent ridges and evaporation dries up the soil shortly thereafter.

Outdated farming methods are also used in preparation and planting techniques, which are similar to the extension farming systems of the dunes and polders.

Building ridges around the 1m^2 plots (done primarily because of inadequate water) results in the loss of 35 to 40% of the available arable land.

iv) Extension Problems

The great mixture of crop varieties observed is due to the way seeds are acquired. The farmer either uses his own seeds (which is often difficult, due to the low levels of production), buys from the local market, or obtains the seeds from the extension service. The seeds bought from other areas by international organizations are usually not adapted to local conditions, and are often of poor quality.

There is no system for supplying pesticides.

b) Factors Favorable to the Development of the Wadis

Some favorable factors should be taken into consideration in seeking solutions to the problems encountered.

i) Wadi crops are integrated in an ancient farming system, to which the farmer is very attached. The people are open to technical solutions which could alleviate the grueling effort involved in using the shaduf.

ii) The farmers have acquired experience in irrigated farming, and have shown some adaptability in the combination of crops grown, with a view to coping with the harsh environmental conditions. Thus, farmers have abandoned crops that require a lot of water (corn), and replaced them with less demanding ones such as sorghum and finger millet.

iii) The wadis are bottom-lands formerly covered by the waters of Lake Chad. The soils are rich in humus.

iv) The farmers are already aware of the effects of manure. The latter is provided by establishing shifting corrals on the dune farms after harvests, and in the wadis by applying goat manure, which farmers believe can reduce salinity.

v) The natural vegetation has many useful species such as the hy phaena thebaica (dum - palm), whose trunk is used for construction (shaduf and houses), the leaves woven and used for fence construction, and the fruits eaten; the date palm, whose dates are highly appreciated; the acacia seyal, used for fuelwood; salvadorapersica, a creeping plant whose leaves are used as a spice; and other species such as eucalyptus or Parbuisonia which grow well in the area, and can be used as windbreaks.

The villagers grow guava, citrus and date palm fruit in wadis.

c) Proposed Technical Solution

The proposed solutions are as follows:

i) Improved water lifting device: replacement of the shaduf with a more efficient water lifting device, which can be repaired locally is necessary. One pump suggested is the USAID Universal Treadle pump. It has a nominal flow of 7.2 m^3/h (compared with 3.6 m^3/h for the shaduf), and would help overcome the major constraint - shortage of water.

A motor-pump was not chosen at this time, for the reasons given earlier (problems of spare parts, maintenance and profitability).

ii) Land Preparation Technique: the higher water flow to be provided by the USAID Universal Treadle pump will require readjustment of the size of the plots, the dikes, and the type of well. These changes will be taught to farmers adopting the new pump technology.

iii) Irrigation Techniques: the farmer will be taught how to irrigate the plots correctly. He should allow the water to infiltrate, in order to water the plant better and push the salt to greater depths (below the level reached by the roots) thereby reducing soil salinization.

iv) Farming Techniques: Emphasis will be put on:

- deep plowing of the soil in order to aerate it, and have a soft layer of soil to facilitate water percolation and the drainage of salt. This technique will require introducing a plowing tool that is more efficient than the local hoe.
- increasing the quantity of seeds per hectare, especially for wheat, whose current amount (70 to 100 kg/ha) should be increased to 200 kg/ha or more.

- extending information regarding the timely planting of seeds.
- extending information, along with the introduction of the new pump, regarding each crop's watering needs. The output results based on the quantity of water used for irrigation will be the best method of obtaining data.
- the possibility of producing seeds locally should be explored before introducing other improved varieties. Seeds currently used should be selected and cleaned right on the farms.
- improved use of organic matter is proposed (especially intercropping with nitrogen fixing plants or cropped separately, and use of manure).

The field trials of the various farming methods proposed is the best way of introducing these methods to the farmers, and increasing the likelihood of their subsequent adoption.

v) Agro-forestry Activities.

Agro-forestry activities will help protect the wadis and crops from strong winds, stop the shifting of sand around the wadis, grow fruits which meet people's needs, and in the long-term, increase the availability of wood for construction and fuel needs.

In the case of windbreaks, eucalyptus and/or parkinsonian will be planted, serving also as a living fence.

For dune fixation, salvadoria persica is proposed.

Fruit cultivation can be improved with the planting of citrus, guava, and date palm trees.

Reforestation activities will be carried out planting utility trees, especially the hyphaena thebaica, Balanites, zyziphus, and the acacia seyal.

d) Expected Results

i) Improvement of the irrigation system will lead to increased yield for wadi agriculture and will enable the cultivation of currently abandoned wadis.

ii) Crop yields can be increased from the current average of 600 - 700 kg/ha to 2,000 kg/ha for corn and wheat, and 1000 kg/ha for finger millet.

iii) The extension service will be improved as a result of the training of four SODELAC agents.

iv) Soil salinization created by current farming methods will be controlled by the increasing amount of water available and introducing improved farming methods.

v) The physical environment of the wadis will be preserved through the reforestation activities.

B. Summary Financial Analysis

1. Recurrent Costs associated with project implementation

The project will make use of certain existing GOC resources, such as:

- Office space and housing compound in Ngouri, rehabilitated at project expense;
- Counterpart personnel, drawn from SODELAC's existing personnel in the Ngouri Sub-Prefecture, and provided with transportation at project expense.

No new investment or new recurrent cost burden will be imposed upon the GOC during or after project implementation.

2. Implications for continuation/replication

The basic premise of project design is to create a self-sufficient, sustainable agricultural system which is not dependent upon government finances, resources, or direction. The private sector will be relied upon to provide all inputs and marketing services.

Technical assistance will be directed primarily to exploring, together with farmers, possibilities for system improvements through introduction of new practices and technologies. GOC counterpart personnel will broaden their knowledge in the course of working with project personnel, and should remain in the region to continue to provide extension services to farmers as before.

Development of local industry, such as pump manufacture and repair workshops, and improved hand tools manufactured by local artisans, will ensure the continued availability of project innovations.

C. Summary Economic Analysis

The following is an outline of the basic economic circumstances in the project region. For a more complete discussion of the issues raised, see Annex J.

Physical Nature of the Production Problem

While the Lac Prefecture is considered one of the most favored regions of the Sahelian Zone, agriculture has been in serious trouble in the Ngouri Sub-Prefecture for the past several years. Despite the presence of the lake water resource, the farming population is still basically dependent on rainfall patterns for successful farming. Two of the three agrosystems of the area have suffered severe failure during the past several years:

1) Rainfed millet cultivated on the dunes has produced almost no harvest in some villages for three years now. Rainfall has been as low as 80mm, and in higher rainfall years (still less than 300mm) the rains have been poorly distributed in space and time.
2) The corn crop produced in the polders has become increasingly difficult to cultivate, first as the lake

continued to recede relative to its historical levels, and farmers were obliged to travel up to 25 or 35 kilometers to reach the recession zone, and second, after the rains of 1985 caused an abrupt rise in the lake level, flooding thousands of hectares of corn, and entirely destroying the crop.

2. Consequences of the Physical Change

There are two major consequences of this situation for the project proposed:

1) A need exists for modification of the present system to increase the reliability of food production in the project area.

2) Failure of the subsistence cereal crops, as during the past several years, can severely limit the farming population's ability to participate in the project.

The wadi system was chosen as the zone of intervention because it offers the best possibility of mastery of the limiting water resource. Increasing food production in the wadis will be accomplished by:

- Intensification of production - more output per unit land.
- Extension of production - increasing the area a farmer can manage.

3. Economic Benefits

1) The marginal benefit to improving the shaduf irrigated agriculture system is more substantial than one might expect,

since the shaduf is not capable of delivering an adequate quantity of water to the basic food grain crops produced in the wadi. The project design team's estimate of the incremental benefit that can be realistically achieved per unit of land farmed is presented below.

2) Increasing the area a wadi farmer can farm, by increasing his ability to lift and apply water, and manage salinity problems, is a more straightforward gain.

3) A benefit of improving the productivity of wadi agriculture will be an increase in the total number of farmers working in the wadis. The 1959 Girard study indicates that the wadis in the Ngouri area had been abandoned 40 years previously because of the increasing difficulty of water lifting. Conversations with farmers in NDjiguidada indicated that farming in the wadis was declining there, also because of the increasing difficulty of water lifting.

4) Another form of benefit which farmers will derive from the project will be an increase in available land resulting from improved salinity management. Land currently under cultivation will remain productive longer, and areas now increasingly salinized may be reclaimable.

In economic terms, the benefit to increasing the number of persons farming in the wadis must be offset by the production those farmers would have achieved elsewhere - in this case in the polders. The team feels that because of the hardship of annual migration to the polders and islands, and because of the

severe health problems encountered there, a potential exists to increase the number of wadi farmers in the area by drawing in people who would otherwise have made this migration.

It may be that people will still prefer to farm in the polders in the hot season, when the wadi is least productive, but will increase their efforts in the wadis in the rainy and cold seasons, in response to project innovations.

The benefits realized by farmers participating in the project will fall into three categories:

- Increased food supply for the family
- Improved security of food supply for the family
- Increased production for sale on local and regional markets.

4. Economic Constraints

a. Infrastructure

The basic constraint to development in the Lac Prefecture is the extremely poor (in fact, practically non-existent) infrastructure of the area. Transport is very costly (the highest official rate in the country), and limited to a few vehicles per week. The lake is no longer navigable (once, agricultural products like wheat went directly from Bol to N'Djamena by lake). This results in a very high cost of inputs (seed, fuel, etc.) and high marketing costs to take product(s) out of the region into more lucrative markets.

b. Communication

Communication systems are likewise practically non-existent, with SODELAC and foreign donor project personnel having the only links with the capital. Parts or repair services not available locally must be sought by travelling to the capital, a costly and time-consuming process.

c. Markets

The consequences of this situation for the project are to:

- Rely only upon local and regional markets outlets until other possibilities have been thoroughly investigated,
- Avoid costly systems requiring inputs not available locally, and outreach to other regional markets to sustain cashflow until reasonable conditions of supply and product transport are verified.

It is difficult to forsee at this time what future market opportunities this production will enjoy. There is an extremely complex market and regional economic dynamic underway at present in the entire Lake Chad and N'Djamena area, due to numerous donor activities, and the continuing uncertainty of climatic and political conditions.

The conditions and donor activities creating the most uncertainty are the following (see Annex K for further discussion):

- Italian Financed UNDP road project,

- Italian Financed UNDP production project (Bol Sub-Prefecture polders and wadis),
- FED irrigated perimeter projects in Chari-Baguirmi,
- Africare and CARE irrigated perimeter projects in Chari-Baguirmi,
- Possibility of resuming normal trading relations with Nigeria,
- Possibility of resumption of more normal level of Lake Chad, opening the lake to navigation out of Bol to N'Djamena and Nigeria.

As in any marketing situation, success will require an intimate knowledge of conditions in the marketplace and within the marketing system, personal contacts, and intelligent, informed decision making. While a period of study may provide an indication of feasibility, and a useful starting place for a marketing effort, marketing is an on-going process requiring steady effort, a natural talent, and imagination. The best marketing resources available to the project are the farmers themselves, and the middlemen and transporters who serve the region. The project's market development strategy will have to evolve over time, and will ultimately be determined by:

- Willingness of project farmers to undertake joint marketing activities;
- Need for more sophisticated level of marketing effort than the farmers themselves can provide; and
- Evolution of regional economic circumstances. These circumstances will be influenced by numerous donor

projects planned or underway, particularly with regard to the following variables:

- Demographic trends in the area;
- Crop production increases in the area;
- Infrastructure improvements in the area;
- Demographic and agricultural changes in the N'Djamena area; and
- International opportunities as influenced by infrastructural developments and political changes.

Replicability, Unit Cost and Return

One of the most important results of the project will be to develop replicable models of improved wadi agriculture. Careful on-going monitoring will be an important and relatively costly component of the project, to insure effective evaluation of the alternatives introduced, and determination of the relative benefits of various systems.

A successful pilot project should demonstrate upon completion that the objective is attainable, or that certain specific methods have been found to be the most effective for the purpose. Given this fact, the economic viability of a pilot project is based not upon the productivity of pilot project activities relative to pilot project cost, but rather upon the actual economic viability of the system the pilot project has developed.

Accordingly, the cost per hectare and per farm family of a pilot project is high, since the cost of experimentation and careful analysis is high. For this project, estimated costs of intervention per person, per family, and per hectare of land developed are:

	(US$)
Estimated Total Project Cost	4,054,525
Estimated Ngouri Production Cost (See Annex I)	2,797,622
Estimated Total Hectares Improved or Put Into Production during project life	300
Estimated hectares improved or put into production during four years after project completion	300
Estimated Farm Families per Wadi Hectare	4
Total Families, project life plus four years	2,400
Average Number of Persons per Family	5
Total Persons	12,000
PROJECT PRODUCTION INVESTMENT PER PERSON	232
OF ABOVE, ON ANNUAL BASIS	77
PROJECT PRODUCTION INVESTMENT PER FAMILY	1,157
OF ABOVE, ON ANNUAL BASIS	386
PROJECT PRODUCTION INVESTMENT PER HECTARE	4,663

Two observations are relevant:

Agricultural investments typically require a number of years to attain profitability, depending upon the level of investment, land and water resources required, and the length of the production cycle (livestock is slow, vegetables are

fast). A three year horizon is not generally sufficient to evaluate the economic return to an investment in agriculture. The true economic value of pilot project activities will only begin to be felt only after the three year "investment" period is over, and the models developed are introduced elsewhere.

For this reason, it is suggested that the standard economic criteria of viability are applicable at final evaluation of the pilot project, but not at the pilot project feasibility level.

The standard criterion of project viability is the Rate of Return. A rate of return is not an absolute measure, but rather is intended to compare an investment activity with other similar investments of equal risk. What is the real return to investment in subsistence agriculture in Chad? Historically the risks are very high, and the rewards have been very low - famine leaves no room for argument on that score. The project area is in need of an improved production system which will increase people's ability to manage scarce resources and reduce the risk of annual variation in food supply. This pilot project intends to demonstrate the possibility of investment in the subsistence agriculture sector. The feasibility of undertaking the project should be evaluated in the light of the need we are seeking to address, and the feasibility of alternative investments available to meet that need.

The wadi system appears to be, for both technical and economic reasons, the only viable candidate for investment in improved agricultural systems in the region. In numerous discussions with government officials, donor personnel, and other experts, one fact emerged repeatedly: No one knows how to manage a sustainable agricultural system in the wadis, hence the need for a pilot project.

The approach adopted in a pilot project, with the objective of evaluating the marginal advantages of increasing levels of technology, investment, and operating expense, must be evolutionary. A series of possibilities must be explored, not necessarily in strict sequence, but definitely representing a continuum of possible levels of technology. In order to evaluate the marginal advantage achieved by each increment of additional human effort, capital input, or operating expense, a careful system of monitoring of project element effects upon the people, their productivity, and their natural resources must be instituted. Outlines for the development of a baseline database, and of a monitoring system , are presented in Sections VII A and II D 3 and Annexes P and R.

To examine the potential feasibility of two levels of intervention, illustrative production budgets presenting simplified models of the existing agricultural system, a system employing a human powered hand pump, and a system employing a

motor powered pump are presented in Annex I. The high level of uncertainty surrounding economic circumstances in the Ngouri area, particularly product markets as described in detail in Annex J, is reflected in the range of variation in assumptions and consequences presented.

The bulk of the analysis is placed upon examination of the potential returns to farmers participating in the project, because this return is ultimately the only meaningful criterion of project feasibility and success.

The basic conclusions to emerge from the study are:

1) A hand powered pump costing as much as 70,000 FCFA which can provide adequate water to wadi crops (which the shaduf cannot) appears to be a very attractive investment. The price used for the pump in the analysis is a prototype price, derived from a pump which CARE Chad had made. The production price will normally be less. The margin of safety for recovery of the hand pump investment is very large in the example.

2) Only very high value crops can justify the expense of a motor-powered pump. The greatest expense is not investment, but operations. On fairly conservative financial and operating assumptions, the margin of benefit appears small relative to the level of risk entailed by the

investment. The many economic factors constraining production of high value crops are discussed in detail in Annex K. They are, briefly:

Limited local markets,

Competition in regional markets from Bol,

Competition in N'Djamena markets from other, closer, irrigated-perimeter projects.

Upon initial examination, the value of water in production appears to barely cover the cost of operating a motor pump. The details may appear more favorable, however, after some experience in the field, and in the marketplace.

3) The economic return, calculated by valuing the irrigation labor time saved at the current wage rate for agricultural field labor in the region, clearly favors the hand pump. A value of 500 FCFA per day is placed upon free time, because this is the value placed upon labor in agriculture in the region, and in certain areas it is apparently not difficult to find such work if one so desires. It is not necessary to estimate a shadow wage rate, since a real opportunity exists for productive employment in agriculture, labor, not land, being the scarce resource in the area. A look at the time spent lifting water in the traditional shaduf system will quickly show why this is so.

4) There is a substantial risk of loss associated with the motor pump operation. The cost of operating the pump, primarily fuel and oil, is a critical factor. Every effort must be made to reduce this cost to a minimum.

D. Summary Social Soundness Analysis

1. Project Feasibility

The Lake Chad Agricultural Development and Farmer Training Project appears to be feasible within the wider socio-cultural context and within that of the Kanembou, who will be the prime beneficiaries of the project, since they own and occupy the project wadi sites. Reasons for feasibility, possible risks the project runs, and steps that can be taken to avoid these risks are discussed below:

The project appears feasible because it offers solutions to major problems which the people in the project area want to solve, namely availability of sufficient food and water. Because of inadequate rainfall over the last few years, they have been unable to grow enough rainfed millet to be self-sufficient. In order to supplement this crop, they have turned to growing cereals, or cash crops in wadis and/or polders, permitting them to buy cereals. While wadis are located near the villages which own them, irrigation which shadufs is fatiguing. Many older people lack the strength to

older people lack the strength to cultivate with the shaduf and cannot supplement their cereals this way. Polders are often easier to cultivate, but since they lie along the shore of Lake Chad they are frequently distant from the farmers' villages. Some people have given up trying to cultivate enough to provide food or income, and go instead to the capital city during the dry season, to earn money. They return to their villages when the rain comes, and plant rainfed millet. The distances people must travel, however, and the inconvenience and distress of being far from home make these last two solutions untenable in the long run. If the rains continue to fail, people will, eventually, decide to move permanently to the polders or to the city. Since the Kanembou have a strong attachment to their ancestral villages and lands. Cultivating in the wadis near their homes would be a preferred solution. The Kanembou in the project area have, therefore, great interest in finding ways to lessen the burden of wadi irrigation and to increase the yields of their supplemental crops.

Project feasibility is enhanced by the fact it will not seek to shift the emphasis people put on traditional rainfed millet cultivation, or to change the values they attach to their agricultural activities. Rather, by modifying agricultural techniques in ways requiring little change in time

invested, the farmer should be able to increase his yield in the wadis, and reduce the amount used in water extraction, the hardest part of wadi cultivation.

The project will not require people to organize themselves into new types of social groups, such as farmer or village cooperatives. Because people will not have to learn new social behaviour in addition to new farming techniques, project feasibility will be enhanced. Setting up repair workshops for pumps will however, require some modification of the traditional master-apprentice relationship, since these workshops will involve larger numbers of people exercising more responsibility than is common in traditional artisanal ventures in Chad. The limited number of small entrepreneurs who set up these workshops will, however, do so by choice, and will therefore probably be self- motivated to learn the new social and managerial skills necessary to running a small business.

Beneficiaries will have continuous input into project decisions. Constant monitoring of the participants' opinions, objections, and experiences will allow the project team to expand, modify or reject the new techniques. The project is not a "package deal". It is designed to find which of many different techniques can be put together into an acceptable system for increasing food production.

Previous projects in the Lake Prefecture have had some problems regarding jurisdiction over the land involved, with the result that the farmers, who feel great respect for their traditional chiefs, were not whole-hearted participants. This project will benefit from having the weight of both traditional and modern authorities behind it.

One risk the project runs is continued bad rainfall. Despite increased crop yields resulting from the new techniques, the total agricultural production in the area could then be insufficient to support area population. Since the project cannot control nature, it is possible that a continued decline in rainfed, millet production could not support the population in the project area.

Another risk is that, despite all its efforts, some project interventions could necessitate changes in behaviour and values that some project participants will be unwilling to make. Frequent monitoring of participants' reactions and the flexibility to respond by modifying the project activities have been built into the project, and should lessen this risk.

By involving the traditional land-owning authorities, the project also runs the risk of land-tenure problems. The chiefs may demand excessive traditional payments once production rises. They may reassign land to people who pay them well or

may appropriate land for themselves. To avoid such problems, baseline studies will survey not only the number of wadis, plot size, etc. but also ownership, so that people cannot be ousted from their fields. Monitoring yield and how it is used will also help check this problem. Further, the project will be working with the traditional parcels, requiring very little if any reassignment of land. People will, however, be free to sell or acquire rights to parcels already owned. If former owners see the value of their former land increase, they may wish to reclaim it. It is therefore important that the Mai and SODELAC confirm each project farmer in the ownership of his land.

2. Project Participation

The purpose of the project is to increase food production, especially by resolving the problem of difficult water extraction. The local population has expressed interest in solving this problem and a willingness to experiment with possible solutions. Farmers who are already working almost full time just to produce sufficient food cannot, however, invest more labor or time in project activities. The project will, therefore, not demand large amounts of additional time/labor/money.

The project team will recognize that, although there is a learning curve, the amount of time and energy required at the beginning to master some innovations may be too great, whatever the eventual savings in effort. But once savings to the original participants become visible, others may be tempted by the increased yield or decreased labor the project offers. The farmers' judgements about such investments are basic to the selection of replicable models.

3. Beneficiaries

Project beneficiaries are deprived but able Chadian farmers and entrepreneurs. Small farmers in the project area have been working hard in wadis or polders, planting their millet seed in the dunes year after year, waiting for the rains to bring them an adequate harvest, with sufficient food to meet nutritional needs and to commercialize.

A number of beneficiaries belong to a disadvantaged group, the Haddad. The project will help improve the standard of living of Haddad farmers and blacksmiths.

Small entrepreneurs, who undertake tool production and pump repair, will also benefit.

Women participate less than the men in the traditional agricultural sector, but they will benefit directly from

lessened labor in shaduf cultivation and from increased food, and indirectly from increased family income. (Please refer to Annex L - Section on Social Consequences, Benefit Incidence, Equity).

4. Project Replicability

One of the two purposes of the project is to find models which can be replicated in other parts of Chad suffering from the same problems as the project area. These places may be found in other wadis in the Lac and Kanem Prefectures and also in dry polders. Another area which may be suitable for project replication is Lake Fitri, where vegetable gardeners are irrigating using only a well bucket and enamel basins or watering cans. They would benefit from intermediate level technology and inexpensive methods of water extraction and from improved agricultural practices. These techniques may also be usable in dry river beds in Batha, Ouaddai and Biltine. A successful project could, eventually be replicated throughout a number of areas in Sahelian Chad. (Please refer to Annex L for the complete Social Soundness Analysis).

E. Summary Environmental Analysis

1. The Project Site

The project site displays a unique physical environment. The project is situated in an area of sand dunes that have gradually encroached from the northeast into Lake Chad, under the force of the Northeast Harmattan wind. Associated inter-dunal depressions contain fine silty loams, originally deposited by Lake Chad. It is in these depressions, ranging in area from a few hectares to 50 or 60, that project activities will take place. Windbreaks and other forestation will be introduced on the adjacent dunes. There are approximately 300 such sites in the Ngouri Sub-Prefecture, of which only 25 are presently cultivated.

The depresssions, or polders, nearer the lake, are still subject to occasional flooding in high rainfall years. Their groundwater table is quite superficial -- 2 meters or less. Eastward, towards Ngouri, the depressions are not subject to lake flooding. Here they are termed wadis. The wadi water tables are generally at lower levels, down to 4 meters, or more, beyond which it becomes too laborious to pump water with the traditional shaduf. The water tables have been receding over time from 2 meters to 4 meters below the surface in the canton of Djiguidada.

Girard's reconnaissance survey on the wadis in the area in 1959 found considerable differences among the wadis that he surveyed along the axis of the road between Ngouri and present day Isseirom (Girard, 1959). He reported that many had been completely abandoned because of salinization, many were partially ruined, and others had salt crusts and effloresences. Clusters of salinized wadis were found in the vicinity of Njigidada and Dibinentchi. A few small wadis were flooded, being occupied by saline lakes. Nevertheless a few hectares of wheat were observed in unflooded portions. Some were considered too dry to cultivate; others near Dibinentchi had been cultivated but were abandoned 30 years previous due to lowering of the water table.

Now the wadis are planted in wheat during the cool dry season, and maize during the rainy and hot dry seasons. In lower rainfall years, millet replaces maize.

Also notable is the fact that no fertilizers are applied, and no leguminous crops rotated with the cereals. The rainfed millet fields on the dunes receive manure from livestock corralled there during the dry season, but manuring of wadi soils is not mentioned. One has to conclude that nitrogen is being supplied by free-living, N-fixing organisms in the soil, i.e. bacteria and perhaps algae, and crop growth and yields may have reached an equilibrium with available soil nitrogen from this source. Nitrogen, then, will become a limiting factor to

increased production, and will have to be furnished in some form, when production is intensified by greater water use.

The pattern of salinization observed by Girard does not reveal a gradient of increased salinization towards Lake Chad. It is rather patchy, with clusters of salinized wadis near the main settlements. An obvious conclusion would be that these wadis had abundant groundwater. Many years of cultivation, however, resulted in salinization. Where groundwater is within 2 meters of the surface, salinization by upward capillary movement and evaporation also occurs.

In conclusion there is a long history of occupation, wadi cultivation, and of coping with salinization and fluctuating water tables in the region.

2. Environmental and related health aspects

a) Water-related diseases.

The project will increase water use, so as to leach salts from the soils, as well as to provide adequate moisture for crops. However, increased water use will not create a flooded or permanently wet environment needed by mosquitoes or the *Bullinus* snail, intermediate hosts of Schistosomiasis. Flooded places, if they occur due to high rainfall will most certainly become saline and unsuitable for mosquitoes. There is no foreseeable risk of malaria or schistosomiasis from the

project. Settlements are reported to have tube wells sunk by Peace Corps volunteers, so that potable water need not come from wells in the wadis. These low risks, notwithstanding, project activities will include baseline health surveys and treatment, if necessary.

Recommendation. The baseline studies of health conditions and status should attempt to distinguish both the incidence of water related diseases, and the nature and places of exposure.

b) Pesticides

No pesticide use is planned for the project. Birds and termite damage are the main problems reported by the area's farmers. More frequent and more abundant irrigation could control the termites. Birds are driven off by boys.

Increased production can be expected to attract pests, however. Elsewhere in Chad pesticides have been used, including the highly toxic parathion.

Recommendation. The project agronomist should seek assistance from S&T's Office of Agriculture and/or the REDSO/WA environmental officer, should it become imperative to use chemical pest control. He should be prepared to guide farmers in the project area to safe and ecologically sound methods of pest control, should they seek to use pesticides on their own initiative.

c) Salinization

A major assumption is that the project will correct salinity build-up by providing more water and increasing depth of cultivation - reducing or eliminating salt accumulation in the root zone or the surface.

Since the wadis are a closed, internally drained system, salt charged groundwater remains in the system. The groundwater, however, is not a closed hydrological system, being fed by rain falling on the wadis, or seeping into the dunes and hence into the regional water table.

Because the water table has receded during recent decades, we can assume that there is little fresh water input to the wadis. Also, any contribution from Lake Chad to the regional groundwater resource must be saltier than during higher rainfall years. The project's proposed irrigation practices would redilute salts already accumulated at the surface as well as those tending to accumulate from on-going irrigation, and transfer them in solution to lower soil horizons, and eventually back into the groundwater.

Project soils are medium to fine textured, hence leaching would have to be deep (up to two meters) in order to avoid reverse movement back into the root zone. Ultimately, downward percolating water will reach the groundwater.

Over time the wadi's groundwater can only get more saline if there is no dilution from inflowing rainwater percolating

downward from neighboring dunes. One cannot even speculate how long it might take to create groundwater too salty for irrigation, since the sub-surface hyrdology is not known.

Recommendation. Minimum leaching requirements should be established with controlled field trials. Pump irrigation experience in similar, closed basin environments, e.g. Nevada, Utah, some places in Arizona, in the "basin and range" country between the Rocky Mountains and the Sierra Nevadas, should be reviewed for possible lessons.

d) Sustainability of soil fertility

Nitrogen will certainly become a limiting factor to crop production, especially if two crops per year of maize are to be attempted.

A sustainable maize yield of 2000 kg/ha would require at least 50 kg/ha of nitrogen and perhaps 5 kg of phosphorus. A low input solution to the provision of nitrogen would be inter-cropping or rotations with fodder legumes or edible legumes, e.g. cowpeas. Phosphorus needs will also need to be satisfied, eventually, perhaps with acidulated phosphate rock from Niger.

Recommendation. N-fixing crops should be included in the cropping schemes to be tried out. These could be perennials (trees) used as field boundaries as well as annual crops. The economics of phosphate fertilizers use should be analyzed.

e) Agroforestry

The use of *Acacia albida* as a complementary tree crop in grain cultivation is well known in the Sahelo-sudanian zone. This species should be accorded priority for millet fields on the dunes. Agroforestry trials with *Atriplex* should be made on saltier soils. It accumulates salts, and is liked as a forage by sheep. It could help to remove salts from the wadi areas. Eucalyptus are notoriously heavy water users and their use as windbreaks at the edge of cultivated areas could depress the water table locally.

Tree tenure and use rights aspects should be reviewed before encouraging planting. Nurseries sites must be chosen with care, to ensure good water quality.

3. Concluding Remarks

The proposed project will revive and make productive irrigated cultivation of long abandoned wadis. No adverse health impacts are forseeable. Soil fertility will have to be sustained under increased output, ideally with low-input means, such as N-fixing rotation crops and locally obtainable phosphate rock.

The project would make possible added, if not always sustainable, production, in places that have been abandoned. With careful water management, perhaps later with the use of minimal water, the wadis could be cultivated for many years.

VII. EVALUATION

A. Monitoring

The Administrative Officer will keep ORT/Washington informed via monthly progress reports regarding any delays, changes in the implementation schedule and progress of the project technicians. The quarterly progress reports drafted by the technicians will detail accomplishments towards meeting project outputs and purposes and detail the proposed work plan for the next quarter. The yearly site visit by the ORT/ Washington Project Coordinator will also help ORT evaluate project progress.

One of the most important aspects of the project will be to evaluate the technical interventions, especially due to the pilot nature of the project and the need of the technicians to test and choose among various approaches and techniques. The project technicians need to determine the viability of the water pumping technologies introduced, the value of the various agronomic and agro-forestry technical interventions, and the most effective means of salinization control.

Sociological and economic criteria for project success are also extremely important, and issues of satisfaction with the productivity of interventions and the cost/benefit for individual farmers must be constantly monitored. (Please see Annex R - Sociological and Economic Evaluation Criteria).

B. Formative Evaluation

A mid-term evaluation will be scheduled for approximately eighteen months after commencement of project activities, during Phase Two. The mid-term evaluation will, therefore, concentrate on evaluating project success in accomplishing the following Phase One activities:

- establishment of a viable base for operations in Ngouri and N'Djamena;
- collection of an adequate quantity and quality of baseline data (technical, economic, and social);
- prototype testing and manufacture of pumps;
- adoption of various improved agricultural techniques by local farmers.

The evaluation will also gauge progress towards meeting overall project purposes and outputs.

Based on the conclusions drawn, the mid-term evaluation will recommend any changes, required to improve project implementation, and will give a preliminary indication of whether this pilot project should be expanded and extended. A more detailed evaluation plan will be submitted to AID within two months of the scheduled evaluation, as issues identified by the project technicians become clearly defined. Two outside evaluators will be recruited by ORT, and approved by AID and the GOC. The evaluation team will be completed by representatives of USAID/Chad, SODELAC and ORT. The evaluation is expected to take three weeks.

C. Summative Evaluation

A final evaluation will be scheduled three or four months prior to the completion date of the project completion date. Project output indicators will be used as benchmarks for this final evaluation. The primary purpose of this evaluation will be to determine whether the pilot project was successful enough to be expanded and extended. Analysis of opportunities and possible problems for replication will be made in the evaluation, and shared with the GOC and donor community.

Two outside evaluators will be recruited by ORT and approved by AID and the GOC. The evaluation team will be completed by representatives of USAID/Chad, SODELAC and ORT. The evaluation is expected to take three weeks.

VIII. NEGOTIATING STATUS

ORT submitted a draft of the project proposal to USAID/ N'Djamena on May 20, 1986. Final modifications to the proposal were made by ORT in Washington during the latter part of May and June. The formal project proposal is scheduled to be submitted to USAID/N'Djamena by the end of June, with the formal AID review taking place immediately thereafter. A cost proposal and cooperative agreement will then be negotiated with USAID's Regional Economic Development Services Office (REDSO) during July-August 1986. ORT is prepared to open its N'Djamena office in September 1986. ORT will also begin preparing for establishment of the Ngouri office and housing compound prior to the execution of the Cooperative Agreement, now estimated as October 1, 1986.

A formal country agreement between ORT and the GOC is currently being negotiated. ORT has submitted a proposed country agreement to the Ministry of Foreign Affairs and Cooperation, and expects to sign the agreement with the GOC by the end of July 1986. Several GOC agencies have actively participated in the design team effort: SODELAC, the Ministry of Plan, and the Ministry of Agriculture and Rural Development, and have given support to the concept of the project as discussed in meetings. A formal project agreement will be signed with the GOC stating the project's purpose and describing the project's components, outputs and end-of-project status. Also, the project roles and contributions of SODELAC and ORT will be discussed.

ANNEXES:

A. Logical Framework

B. Project Agreement with the GOC

C. Detailed Cost Estimate

D. Illustrative Commodity and Equipment List

E. Initial Environmental Examination

F. Position Descriptions

G. Agronomic Analysis

H. Rural Works Analysis

I. Crop Budgets

J. Transportation and Markets

K. Social Soundness Analysis

L. Administrative Analysis

M. Third Country Participant Training Schedule

N. Project Implementation Schedule

O. Information on the Rower and Treadle Pumps

P. Socio-Economic Baseline Data

Q. Remarks on Lake Fitri

R. Sociological and Economic Evaluation Criteria

S. Maps

T. Detailed Cost-Sharing Worksheet and Research-versus-Production Worksheet

ANNEX A

LOGICAL FRAMEWORK

NARRATIVE SUMMARY	OBJECTIVELY VERIFIABLE INDICATORS (AND TARGETS)	MEANS OF VERIFICATION	IMPORTANT ASSUMPTIONS
Program or Sector Goal: To increase the amount and dependability of food production in Chad	Increase in total food over a three year period.	1) GOC and FAO agricultural data. 2) Independent USAID analysis of data.	1) Rainfall during project lifetime will approximate average rainfall of past 20 years. 2) Local population not disrupted by civil strife.
Project Purpose 1) To increase wadi food production in Ngouri Sub-Prefecture while maintaining or improving soil fertility. 2) To identify models for increased wadi food production which will be replicable in similar conditions (i.e., other wadis, dry polders, Lake Fitri).	E.O.P.S. 1) Per ha. project wadi yields increased: a) wheat and corn from 600-700 kg/ha to 2,000 kg/ha b) irrigated millet from 600-700 kg/ha to 1,000 kg/ha. c) vegetables a minimum 40% increase from the current level. 2) Between 100 to 200 additional ha in wadis cultivated. 3) Environmental equilibrium maintained in project wadis through agro-forestry and water management interventions. 4) At least one replicable model for improved, self-sustaining and economically viable wadi agriculture is identified.	1) Baseline production data compared to ongoing project production data. 2) Test soil at project sites over full range of fertility criteria. 3) Project reports and evaluations.	1) People in project area do not leave for lack of staple rainfed cereal crops

OUTPUTS

1) Improved water lifting technologies introduced, tested and adopted.	. At least two technologies tested. . At least one technology accepted by . 25% of farmers in project sites by . end of project.	Project reports.	
2) Improved farming techniques introduced and adopted.	50% of farmers in project wadis using one or more of following: . improved irrigation techniques; . improved tools and implements; . crop protection techniques; . organic farming; . better utilization of seed per ha; . better cropping and rotation . schemes; . more efficient water doses.	Project reports.	
3) Improved farmer extentension services available.	. Four SODELAC agents undergo on-the-job and third-country training. . SODELAC agents and project staff reach 1,000 area farmers.	SODELAC and project reports.	SODELAC agents available to participate in project.
4) Methodology of salinization control established.	. Production maintained or increased despite continued or increased water use. . Level of salinization not increased at project sites.	On-site inspection. On-going program of soil test results compared to base-line data.	Salinization can be controlled at a cost and means of control acceptable to farmers.

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OUTPUTS

5) Agro-forestry program established to: a) help stabilize dunes; b) create windbreaks; c) augment fruit tree stands; d) make available more trees for planting in area, thus increasing fuel and construction resources.	. Trees are planted as windbreaks and on dunes at least at 20 of 25 project wadi sites. . Increased number of fruit trees planted at least 20 to 25 wadi sites. . Establishment of Ngouri nursery.	- On-site inspection.	- Lack of rainfall does not impose overwhelming burden on farmers to keep trees alive.
6) Pump maintenance training given to farmers and pump manufacturing training given to entrepreneurs.	. On-the-job training for maintenance of pumps given to area farmers. . At least one N'Djamena entrepreneur manufacturing pumps.	- On-site inspection.	
7) Credit program established for equipment manufacture and purchase and for agricultural production.	. VITA develops credit module for project. . X number of loans made. 50% loans repaid.	- VITA and ORT reports.	VITA, ORT and USAID agree on joint effort.
8) Health impact of wadi irrigated agriculture monitored.	Incidence of water related diseases monitored at 25 wadi sites.	On-site health surveys.	PCV or local health workers available to assist short-term project health consultant.

INPUTS	VERIFIABLE INDICATOR	MEANS OF VERIFICATION	ASSUMPTIONS
Technical assistance for: 1) Production and marketing 2) Water and salinity control and farm site planning. 3) Water lifting. 4) Agroforestry. 5) Social organization 6) Credit and Financial Management 7) Maintenance training 8) Health Surveys.	1) ORT team in place: a) Agronomist (33m) b) Rural Works Engineer (30m) c) Administrative officer (36m) d) Pump expert (18m) 2) Peace Corps Volunteers Foresters (2) 24m each Health 18m Pump Mechanic/Trainer 24m Tubewell Diggers (2) 30m each 3) Short-term ORT: Marketing specialist Health specialist Sociologist Maintenance trainer Environmental/soils expert Evaluators Forester 4) ORT local hire: Administrative Assistants (36m) Bookkeeper (36m) Secretaries (36m) Drivers (36m) Guards (36m) 5) GOC personnel: a) 4 SODELAC agents (36m each) b) 1 MEADR counterpart (36m) 6) VITA Credit	Project reports and records; observation	1) Peace Corps volunteers can be recruited. 2) SODELAC agents available to participate in project.

INPUTS	VERIFIABLE INDICATOR	MEANS OF VERIFICATION	ASSUMPTIONS
	7) Equipment: Support equipment: a) Vehicles b) Office equipment and furnishings c) Water lifting devices d) Office supplies e) Housing furnishings f) Pump materials g) Tubewell construction equipment and supplies h) Forestry supplies i) Shop equipment.		

ANNEX B: PROJECT AGREEMENT WITH THE GOVERNMENT OF CHAD

LAKE CHAD Agricultural Production and Farmer Training Project
Agreement Between
the Government of Chad (GOC), Represented by the Ministry of Plan and
the American ORT Federation (ORT)

This agreement sets out the conditions and obligations between the GOC and ORT regarding the implementation of the Lake Chad Agricultural Production and Farmers Training Project, hereinafter referred to as the Project. This project agreement will be subject to all the rights and stipulations agreed to in the Country Protocol executed by the GOC and ORT on _____1986.

ARTICLE I

Description of Project

A. Project Purpose

The project will take place in the Ngouri Sub-Prefecture of the Lac Prefecture. The two purposes of the project are:

1) To increase wadi food production on the Ngouri Sub-Prefecture while maintaining or improving soil fertility.

2) To identify models for increased wadi food production which could be replicable in similar conditions.

B. Project Components

The project will have two overlapping, yet distinct phases. The first phase which will encompass approximately the first twelve months of the project, will involve establishment of the operations bases for project activities, baseline data collection, testing of techniques and technologies, and establishment of capabilities to begin the dissemination phase (Phase Two) of the project. The second phase of the project will involve extending to area farmers technical packages identified and developed in Phase One. These efforts will involve: dissemination of improved human-powered pumps to wadi farmers; tubewell installation capabilities; an agricultural

credit program to enable farmers to purchase pumps and wells; pump maintenance training; an agroforestry program; dissemination of improved agricultural techniques to area farmers; salinization control of project wadis and monitoring of the effects of project interventions on local health conditions.

C. Project Objectives

The following is a list of the main project objectives:

1) Improved water lifting technologies introduced, tested, and adopted.

2) Improved farming techniques introduced and adopted.

3) Improved farmer extension services available.

4) Improved Methodology of salinization control established.

5) The agro-forestry program will seek to
   a) stabilize dunes;
   b) create windbreaks;
   c) augment fruit tree stands;
   d) make available more trees for planting in the area.

6) Pump maintenance training given to farmers and a local workshop established.

7) Credit program established for equipment manufacture and purchase and for agricultural production.

8) Health impact of wadi irrigated agriculture monitored.

D. End of Project Status

By the end of the project, the following should have been accomplished:

1) Increased per hectare wadi yields for the estimated 300 hectares in the 25 project wadis in wheat, corn, millet and vegetables.

2) An additional 100 to 200 wadi hectares put into cultivation.

3) Environmental equilibrium maintained in project wadis through agroforestry and water management interventions.

4) At least one replicable model for improved, self-sustaining and economincally viable wadi agriculture identified.

II. Implementation Responsibilities

A. O.R.T.

ORT will take all responsibility for the recruitment and fielding of the expatriate project staff and the major technical inputs of the project. ORT's Administrative Officer will assure the logistical and administrative support needed by the project technicians. ORT will also establish the necessary infrastructure to support the Peace Corps Volunteers (PVC's) associated with the project. This will include maintaining the necessary records and providing administrative backstopping orientation, and technical guidance for the PCV's.

B. GOC

The GOC will provide ORT with all assistance, rights, benefits, exemptions or exhonerations as provided by the Protocol between GOC and ORT.

Further to said Protocol the GOC will assure prompt delivery of the necessary exonerations and paperwork necessary for clearing duty-free purchases of project vehicles, equipment, supplies and the personal effects of the ORT technicians and the PCV's. To facilitate communications between Ngouri and N'Djamena, the GOC will permit ORT to establish a radio hook-up between the two localities. No taxes or operator fees will be charged by the GOC for establishment or use of this radio system.

The GOC agrees that SODELAC, (Societe de Developpement du Lac), will permit ORT to use rent-free to the extent ORT deems necessary, SODELAC's office and residence compound in Ngouri during the life of ORT's project (ORT will rebuild, expand and refurbish the office and residence compound). The project team will work with the SODELAC agents assigned to the project area and the Chef de Sous Agence, who is currently stationed in Koulodia but is expected to move to Ngouri. The ORT personnel will give on-the-job training to the SODELAC agents and provide the agents with opportunities to obtain short (5-8 weeks) third country training. In addition ORT will provide horses to the agents, to permit them to reach more farmers. SODELAC will provide the project with agents, use of the Ngouri housing and office facilities other than in the existing office and

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residence compound and special manpower e.g. surveyors and their equipment.

The GOC will also provide the services of its Bureau Interministeriel des Etudes to assist ORT in its data collection activities in the Ngouri area. The GOC will provide a counterpart from the Ministry of Agriculture and Rural Development to follow the project and assist in project implementation.

C. Peace Corps

The project will benefit from the services of six Peace Corps volunteers working in the fields of well construction, forestry, pump technology and health. The locations where volunteers will live depend partially on which wadis are chosen for project implementation. Possible assignments are: N'Djamena (Pump Technology volunteer); Ngouri (Forestry and Health volunteers); Djbinintehi (Well Construction volunteer) and Njigidada (Well Construction volunteer).

The Peace Corps Volunteers will have all rights and privileges accorded them by the existing agreement between the GOC and Peace Corps.

D. VITA

VITA will be responsible for the establishment of a sound credit program in N'Djamena and Ngouri. They will monitor and assure the responsible management of the credit program.

III. Reporting

Quarterly Reports will be submitted by ORT to USAID, SODELAC, the Ministry of Agriculture and Rural Development, the Ministry of Plan and the Sub-Prefect of Ngouri. The Administrative Officer will be responsible for compiling the quarterly narrative reports, based on input from the project technicians.

Narrative quarterly reports will follow a format agreed upon by AID, the GOC and ORT, detailing project progress, perceived problems and suggested solutions. Narrative reports will be submitted to AID within 30 days of the end of each reporting period and within 45 days to the GOC (the extra time for submission to the GOC is necessary for translation). The SODELAC Chef de Sous-Agence will submit quarterly progress reports to ORT regarding activities directly related to the

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project, within 30 days of the end of each reporting period. The reports will detail project progress, perceived problems and suggested solutions.

IV. Financing

The summary estimated financial plan is presented below:

AGENCY	Year 1	Year 2	Year 3	Total
AID*	1,190,366	774,841	627,568	2,592,775
ORT	222,355	192,432	188,710	603,497
SUBTOTAL	1,412,721	967,273	816,278	3,196,272
GOC**	107,196	16,402	16,402	140,000
PEACE CORPS	25,000	50,000	50,000	125,000
TOTAL	1,544,917	1,033,675	882,680	3,461,272

*ORT will be responsible for all handling and accounting of AID funds earmarked for this project.

**This is an estimate of GOC in-kind contributions.

V. Conditions to ORT's Performance Precedent

This agreement will take effect upon the signing of a Cooperative Agreement between O.R.T. and USAID to fund the project. The Peace Corps and VITA components of the project will take effect upon signing of agreements between ORT and these organizations. ORT's ongoing performance hereunder is contigent upon continuing performance of USAID, Peace Corps and Vita.

For the American ORT Federation

_____

Title
Title
Date_____

For the Governmemt of Chad

_____

Date_____

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ANNEX C. DETAILED COST ESTIMATE

1. Expatriate Technical Assistance

Position	Year 1	Year 2	Year 3	Total
a) Agronomist (33 months-Ngouri)				
Base salary of $30,000/year	22500	31500	33075	87075
Fringe Benefits (15% base salary)	6750	9450	9923	26123
Education allowance	9000	12000	12000	33000
b) Rural Works Engineer (30 months-Ngouri)				
Base salary of $35,000/year	17500	36750	38588	92838
Fringe benefits (15% base salary)	5250	11025	11051	27326
Education allowance	6000	12000	12000	30000
c) Administrative Officer (36 months-N'Djamena)				
Base salary of $30,000/year	30000	31500	33075	94575
Fringe benefits (15% base salary)	9000	9450	9923	28373
Education allowance	12000	12000	12000	36000
d) Pump Specialist (18 months-N'Djamena)				
Base salary of $35,000/year	35000	18375		53375
Fringe benefits (15% base salary)	10500	5513		16013
Education allowance	12000	6000		18000
	175500	195563	171635	542698

2. International Travel and Transport

Expense	Year 1	Year 2	Year 3	Total
a) To/from post				
(i) Airfare to post $1,500 tkt x 4/ each technician	24000	0	0	24000
Airfare from post $1,500 tkt x 4/ each technician	0	6000	18000	24000
(ii) Unaccompanied baggage - 660 lbs/ family at $2.49/lb., $1643/family	6572	0	6572	13144
(iii) Excess baggage 22 lbs.	800	0	800	1600
b) R & R: $1000/rt x 4/ each technician	16000	12000	0	28000
c) Inspection Trips: (DC-NDJ-DC)				
(i) Airfare $2,500	2500	2500	2500	7500
(ii) Per Diem 10 days x $90	900	900	900	2700
	50772	21400	28772	100944

3. Local Travel

Expense	Year 1	Year 2	Year 3	Total
a) 2 Air Charters - NDJ-Massakory (or Bol) per year - 200,000 FCFA/hr x 3.5 hrs.	4000	4000	4000	12000
b) Air Charter - Ndj-Ati (year 2) 200,000 FCFA/hr x 4	0	2400	0	2400
c) SODELAC Agents' and Peace Corps Vols.' horses and feed, 10 x $750/horse = $7500 $600/horse/yr feed = $6000	13500	6000	6000	25500
	17500	12400	10000	39900

4. Housing

Expense	Year 1	Year 2	Year 3	Total
a) Rent N'Djamena $1000/month Administrative Officer	12000	12000	12000	36000
b) Rent N'Djamena Pump Specialist	12000	6000	0	18000
c) Utilities N'Djamena $800/month	19200	14400	9600	43200
	43200	32400	21600	97200

5. Local Hire Personnel*

	Position	Year 1	Year 2	Year 3	Total
a)	Administrative Assistant (NDJ)	5000	5250	5513	15763
b)	Administrative Assistant (Ngouri)	5000	5250	5513	15763
c)	Bookkeeper (NDJ)	3000	3150	3308	9458
d)	Security Guards (NDJ) $1000 x 6	6000	6300	6615	18915
e)	Security Guards (Ngouri) $1000 x 6	6000	6300	6615	18915
f)	Secretary (NDJ)	4000	4200	4410	12610
g)	Secretary (Ngouri)	4000	4200	4410	12610
h)	Surveyor (Ngouri)	5000	5250	5513	15763
i)	Shop Supervisor (Ngouri)	4000	4200	4410	12610
j)	Drivers/Mechanics $2500 x 6	15000	15750	16538	47288
		57000	59850	62845	179695

*Note--Salaries include mandatory GOC Social Security Employer Contribution

6. CONSTRUCTION

Project	Year 1	Year 2	Year 3	Total
a) SODELAC Ngouri Office	40000	0	0	40000
b) Ngouri Warehouse and Workshop (SODELAC Compound)	15000	0	0	15000
c) Ngouri Nursery including well	0	35000	0	35000
d) Housing Ngouri (2 units) (SODELAC Compound)	60000	0	0	60000
e) Well for Office/Housing Compound	10000	0	0	10000
	125000	35000	0	160000

7. TRAINING COSTS

Expenditure

	Year 1	Year 2	Year 3	Total
a) Equipment: audio-visual equipment VCR and camera $1,700/unit x 2	3400	0	0	3400
b) Materials for local farmer training	10000	15000	10000	35000
c) Development of training materials	20000	0	0	20000
d) Publication of training materials	3000	3000	3000	9000
e) Recurrent farmer training costs	5000	5000	5000	15000
f) Participant training in Senegal for SODELAC agents				
(i) Airfare (Ndj-Dakar-Ndj) $1820/rt x 10= $18200				
(ii) Per diem - $20/day x 40 x10 = $8000				
(iii) Registration fee, briefing papers $400 x 10 = $4000	30200	0	0	30200
g) Pump and tube well training for 1 SODELAC agent, 1 village leader or entrepreneur and pump specialist to Pakistan				
(i) Airfare: NDJ-Dacca-Ndj: $3000 x 3				
(ii) Per diem: $75 x 20 days x 3				
(iii) Briefing papers, local Bangladesh travel, etc: $500 x 3 = $1500	15000	0	0	15000
	86600	23000	18000	127600

8. Vehicles, Equipment, Furnishings and Supplies

Purchase	Year 1	Year 2	Year 3	Total
a) Five 4 wheel drive Toyoto landcruisers 3 pick-ups @ $20,000 2 station wagons @ $22,500	105000	0	0	105000
b) Toyoto 5 ton truck	45000	0	0	45000
c) Vehicle operations, spare parts, insurance and maintenance	75250	75250	75250	225750
d) Prototype pumps and motor pumps	10000	0	0	10000
e) Pump materials	5000	8000	8000	21000
f) Shop equipment N'Djamena	5000	2000	0	7000
g) Workshop equipment Ngouri	3000	3000	0	6000
h) Tube well construction equipment & supplies	4000	3000	2000	9000
i) Soil testing equipment	12500	0	0	12500
j) Forestry supplies	5000	10000	5000	20000
k) Electric generators (3)	4750	0	0	4750
l) Household furnishings 4 units @ $12500	50000	0	0	50000
m) Office equipment and furnishings (desks, typewriters, tables, calculators, photocopiers, radio hook-up for N'Djamena and Ngouri)	50000	0	0	50000
n) Procurement services	14188	4730		18918
	388688	105980	90250	584918

9. Home Office Backstopping

These costs reflect ORT's administrative and technical support costs expressed as a percentage of home office staff time allocated to the project as follows:

	Year 1 Salary	% of Time	Base Back-stopping	Fringe Back-stopping	Year 1	Year 2	Year 3	TOTAL
a) Project Coordinator	40000	100%	40000	8800	48800	51240	53802	153842
b) Director	66000	20%	13200	2904	16104	16909	17755	50768
c) Secretary	18000	100%	18000	3960	21960	23058	24211	69229
d) Controller	44000	10%	4400	968	5368	5630	5918	16922
e) Bookkeeper	21630	25%	5408	1190	6598	6928	7274	20800
f) Training Specialist*	30000	20%	6000	1560	7560	7938	8335	23833
g) Equipment Specialist*	25000	20%	5000	1300	6300	6615	6946	19861
h) Agriculturalist*	25000	10%	2500	650	3150	3308	3473	9931
					115840	121632	127714	365186

U.S. Fringe = 22%
London Fringe = 26%

10. Overhead

	Year 1	Year 2	Year 3	Total
Year 1: 26% x $105000 = $27300 26% x $94508 = $24572	51872	0	0	51872
Year 2: 26% x $118125 = $30713 26% x $99233 = $25801	0	56514	0	56514
Year 3: 26% x $104738 = $27232 26% x 104195 = $27901	0	0	54323	54323
	51872	56514	54323	162709

11. Short Term Consultants

Consultant				
a) Paris data collection consultant (i) Fee: $200/day x 18 days = $3600	3600	0	0	3600
b) Communications expert (i) Fee: $200/day x 26 days = $5200 (ii) Per diem: $90/day x 30 days = $2700 (iii) Airfare: $2500 RT = $2500	10400	0	0	10400

c) Health Specialist (2 trips) (i) Fee: $200/day x 26 days = $5200 (ii) Per diem: $90/day x 30 days = $2700 (iii) Airfare: $2500 RT = $2500	10400	10400	0	20800
d) Forester (2 trips) (i) Fee: $200/day x 30 days = $7600 (ii) Per diem: $90/day x 45 days = $4050 (iii) Airfare: $2500 RT = $2500	14150	14150	0	28300
e) Social Scientist (2 trips) (i) Fee: $200/day x 30 days = $6000 (ii) Per diem: $90/day x 35 days = $3150 (iii) Airfare: $2500 RT = $2500	11650	11650	0	23300
f) Maintenance Trainer (i) Per diem: $90/day x 21 days = $1900 (ii) Airfare: $2625 RT = $2625	0	4525	0	4525
g) Environmental/Soils or Marketing Expert (i) Fee: $200/day x 26 days = $5200 (ii) Per diem: $90/day x 30 days = $2700 (iii) Airfare: $2625 RT = $2625	0	10525	0	10525
h) Local Hire or BIEP studies service, translation and data collection activities (includes 3 social scientist follow-up studies).	15000	15000	10000	40000
	65200	66250	10000	141450

12. Evaluation

		Year 1	Year 2	Year 3	Total
a. Year 2:					
Mid-term evaluator					
(i) Fee: $200/day x 25 workdays x 2 consultants)	= $10000				
(ii) Per diem: (10 days x $90 + 15 days x $60 x 2)	= $3600				
(iii) International Travel 2500 x 2	= $5000				
(iv) Final report preparation $200/day x 5	= $1000	0	19600	0	19600
b) Year 3:					
Final evaluation					
(i) Fee: ($200/day x 25 work days x 2 consultants)	= $10000				
(ii) Per diem: (10 days x $90 + 15 days x $60) x 2	= $3600				
(iii) International travel: 2500 x 2	=$5000				
(iv) Final report preparation: $200/day x 5	= $1000	0	0	19600	19600
		0	19600	19600	39200

13. Other Direct Costs

	Year 1	Year 2	Year 3	Total
a) Storage of household effects ($2,000/year x 4 = $8,000)	8000	7000	6000	21000
b) Communications (telex, cables, telephone couriers, reproduction)	12200	12200	12200	36600
c) Temporary housing allowance ($51/day x 30 days)	6120	0	0	6120
d) Pre/post medical exams ($200 x 4)	800	0	800	1600
e) Office utilities (2 offices)	18000	18000	18000	54000
f) Housing utilities (4 units)	24000	21000	18000	63000
	69120	58200	55000	182320

14. Peace Corps

		Year 1	Year 2	Year 3	Total
a) Training		80000	0	0	80000
b) Settling-in grant Living allowance Housing In-country travel Vacation pay Health care Job-related equipment	($10,000/year per volunteer)	25000	50000	50000	125000
		105000	50000	50000	205000

13. Other Direct Costs

	Year 1	Year 2	Year 3	Total
a) Storage of household effects ($2000/year x 4 = $8000)	8000	7000	6000	21000
b) Communications (telex, cables, telephone couriers, reproduction)	12200	12200	12200	36600
c) Temporary housing allowance ($51/day x 30 days)	6120	0	0	6120
d) Pre/post medical exams ($200 x 4)	800	0	800	1600
e) Office utilities (2 offices)	18000	18000	18000	54000
f) Housing utilities (4 units)	24000	21000	18000	63000
	69120	58200	55000	182320

14. Peace Corps

	Year 1	Year 2	Year 3	Total
a) Training	25000			25000
b) Settling-in grant Living allowance Housing In-country travel Vacation pay Health care Job-related equipment	19376	38753	38753	96882
	44376	38753	38753	121882

15. Health Component

	Year 1	Year 2	Year 3	Total
To be determined	0	30000	30000	60000

16. Subtotal

	1290668	876542	738492	2905702

17. Contingency/Inflation

10 percent of totals	129067	87654	73849	290570

18. TOTAL

	1419735	964196	812341	3196272

ANNEX D: Illustrative Commodity and Equipment List
(includes freight and shipping charges). $1 = 350

Item	Local or US Procurement	Unit Price	Quantity	Total Cost
1. Soil Testing Equipment				
a) Hach or La Motte Portable Soil test kits, A-7-A	U.S.	$240.00	4	$960
b) Hach or La Motte Portable Water test kits, 439-100 YSI-type Conductivity Models (included above)	U.S.	1700.00	4	6,800
c) Soil chemicals refill package A-131	U.S.	135.00	4	540
d) Pisometer-pressure Model #K-652	U.S.	127.00	4	508
e) Master pisometer K-650A	U.S.	905.00	1	905
		Subtotal FOB		9,713
	Option 1.	Air Freight N'Djamena		5,057
		Total CIF		14,770
	Option 2.	Ocean Freight Cameroon		2,782
		Total CIF		12,495
2. Prototypes Pumps/Motopumps				
a) Rower pump (MCC)	Bangladesh	$15*	6	$90
b) Treadle pump	Bangladesh	22	6	132
c) PVC tubewell	local	40*	12	480
d) Motopumps (gas)	local	750	6	4,500

* FOB price from IDE distributor.

MATERIALS LIST

UNIVERSAL MODEL TREADLE PUMP

PART	PIECES	MATERIAL	DIMENSION
PUMP BODY			
Pipe Tee	4	PVC	110 mm dia
Pipe Elbow	2	PVC	110 mm dia
Pipe Nipple	41	PVC	110 mm dia x 50 mm
Pipe Reducer	2	PVC	110 mm dia x 60 mm
Pipe Elbow	2	PVC	63 mm dia
Cylinders	2	PVC	100 mm dia x 360 mm
VALVES			
Valve Plate	4	Cast Metal	110 mm dia x 10 mm
Valve Flap	4	Rubber Sheet	95 mm dia x 3 mm
Valve Flap Screw	8	Brass	4 mm dia x 18 mm
Valve Flap Nut	8	Brass	4 mm
Metal Keeper	4	Aluminum/Brass	15 mm x 80 mm x 1 mm
PISTONS			
Rod	2	Cold Rolled Steel	12 mm dia x 440 mm
Piston Plates	4	Cast Metal	90 mm dia x 10 mm
Piston Cups	4	Leather/Neoprene	100 mm dia
Rivet	2	Aluminum/Copper	3 mm x 15 mm
Rope Tie	2	Hot Rolled Steel	25 mm x 100 mm 3 mm
Nuts	10	Steel	12 mm
Treadle Support	2	Steel Pipe	27 mm dia x 60 mm
PULLEY/FRAME			
Pulley	1	Hardwood	250 mm x 250 mm x 25
Pulley Axle	1	Cold Rolled Steel	12 mm dia x 110 mm
Washer/Spacer	2	Steel	12mm i.d.
Long Column	1	Hardwood	40 mm x 80 mm x 1.6 m
Short Column	1	Hardwood	40 mm x 80 mm x 090 m
Column Spacer	1	Hardwood	30 mm x 50 mm x 80 mm
Column/Cylinder Spacer	2	Hardwood	30 mm x 50 mm x 130 mm
Cylinder Side Clamp	4	Hardwood	20 mm x 50 mm x 390 mm
Cylinder End Clamp	4	Hardwood	20 mm x 50 mm x 110 mm
Wood Screws	8	Steel	4 mm x 40 mm
Column Spacer Bolt	1	Threaded Steel Rod	8 mm dia x 130 mm
Side Clamp Bolt	2	Threaded Steel Rod	8 mm dia x 170 mm
Nuts	6	Steel	8 mm
Flat Washers	6	Steel	8 mm
Journal Cover	2	Sheet Metal	40 mm x 40 mm x 1 mm
Journal Cover Nails	8	Steel	1.5 mm dia x 5 mm
Handle	1	Steel Pipe	21.3 mm dia x 400 mm
Rope	1	Braided Dacron	10 mm dia x 1 meter

B2

Item	Local or US Procurement	Unit Price	Quantity	Total Cost
5) Forestry Supplies				
a) Plastic potting bags	local	$0.05	30,000	$1,500
b) Watering cans	local	$25	20	500
c) Picks	local	$12	10	120
d) Hoes	local	$12	10	120
e) Shovels	local	$15	25	375
f) Pails	local	$8	15	120
g) Barrels	local	$15	25	375
h) Rope	local	$1.25/m	500 m	625
i) Motopumps	local	1,250	2	2,500
j) Wheelbarrows	local	$120	5	600
k) Seeds	local	$250	-	250
l) Fencing	local	$6,500	-	6,500
m) Miscellaneous	local	$5,000	-	5,000
				$18,585

6. Shop Equipment: Tools and Material				
Tools:				
Metal Saw	U.S.	10	4	40
Band Saw	U.S.	100	2	200
Saw Blade Sets	U.S.	30	6	180
Hand Saw	U.S.	20	4	80
Wrench Set	U.S.	65	2	130
Pliers	U.S.	2	10	20
Tool Chest	U.S.	175	2	350
Drill Set	U.S.	75	2	150
Drill Press	U.S.	600	1	600
Hand Drills	U.S.	50	3	150
Welding Stand	U.S.	100	2	200
Arc Welder	U.S.	400	1	400
Gas Welder	U.S.	450	1	450
Socket Set	U.S.	60	2	120
Torque Wrench	U.S.	100	2	200
Forge	U.S.	1,050	2	2,100
Anvil	U.S.	400	2	800
Vehicle Maintenance Tools	U.S.	2,000	1	2,000
Freight & Insurance		2,500	N/A	2,500
				$10,670

Item	Local or US Procurement	Unit Price	Quantity	Total Cost
(con't Shop Equipment)				
Material:				
Leather seals	local	5	10	50
Screens	local	2	10	20
Joint compound	local	1	5	20
Nuts, bolts	local	250	2 Lots	500
PVC pipe	local	1,300	1 Lot	1,300
Plastic parts	local	100	1 Lot	700
Paint	local	100	1 Lot	100
Check valves	U.S.	1,300	1 Lot	1,300
				$3,975

7. Household Furnishings

a) Refrigerators (Arthur Martin)	local	$800	5	4,000
b) Stoves	local	650	5	3,250
c) Generators	local	1,000	2	2,000
d) Air Conditioners	local	200	10	8,000
e) Overhead Fans	local	150	20	3,000
f) Portable Fans	local	100	4	400
g) Desks, 2 per house	local	250	8	4,000
h) Tables, 3 per house	local	150	12	1,800
i) Chairs	local	100	32	3,200
j) Sofa set	local	500	4	2,000
k) Dressers, 3 per house	local	400	12	4,800
l) Cabinets	local	150	16	2,400
m) Curtains	local	100	16	1,600
n) Ladder	local	150	4	600
o) Beds, 4 per house	local	250	16	4,000
p) Lamps	local	100	24	2,400
q) Miscellaneous	local	100	24	2,500
				$49,950

	Item	Local or US Procurement	Unit Price	Quantity	Total Cost
	8. Office Equipment and Furnishings				
a)	Safes (Nugue Brand)	local	$1,000	2	2,200
b)	Mimeograph Machine	local	1,250	1	1,250
c)	Personal Computer/Printer	U.S.	4,500	2	9,000
d)	Typewriters (Japy or Hermes)	local	850	5	4,250
e)	Photocopiers (Gestetner 2000)	local	2,500	2	5,000
f)	Telephones N'Djamena	local	300	3	900
g)	Calculators (Precisa 4100)	local	250	5	1,250
h)	Refrigerators	local	400	2	800
i)	Generator	local	1,000	1	1,000
j)	Air Conditioners	local	800	4	3,200
k)	Fans	local	100	4	400
l)	Desks	local	250	12	3,000
m)	Chairs	local	75	40	3,000
n)	Filing Cabinets	local	400	8	3,200
o)	Lamps	local	100	12	1,200
p)	Radio hook-up	U.S.	15,000	1	15,000
q)	Other				5,000
					$59,650

ANNEX E

Initial Environmental Examination

1. Introduction

The environmental and related soil and water resource management and health aspects of the proposed project are discussed here. A summary environmental impact table is attached to this narrative.

Observations and judgments made here are based upon project documentation, several references (see attached list), and an interview with the design team leader, Dan Gerber, on June 13, 1986, in Washington, D.C.

2. The Project

This three-year project will be funded out of a AID/Chad umbrella private sector grant (677-0051), which requires that grant applications include their own IEES's.

To recapitulate, the purposes of the project are, in summary:

* to increase wadi (local term for inter-dunal depressions) food production in Ngouri sub-prefecture, maintain or improve soil fertility, and identify models for increasing food production for diffusion to other wadis, or similar sites.

The outputs are to be:

* testing and application of improved water pumping devices
* improved farming tools and techniques
* improved extension services
* salinization control developed
* windbreaks and agroforestry species planted; nursery set up
* pump manufacturing and maintenance training provided
* credit program set up, through collaborative effort with local VITA credit project
* health baseline studies and surveillance accomplished

Of particular concern to this IEE are possible health hazards, salinization and other aspects of productivity of the soils under intensified production technologies envisioned. It is projected that corn and wheat yields can be more than doubled to 2000 kg/ha, while millet yields would increase from 600/700 to 1000 kg/ha.

3. The Project Site

The project site displays an unusual uniqueness of physical environment and landuses adapted to it. It is situated in an area of sand dunes that have encroached from the northeast into Lake Chad over thousands of years, under the force of the North-east Harmattan wind. Associated inter-dunal depressions contain fine silty loams, originally deposited by Lake Chad. It is in this depressions, ranging in area from a few hectares to 50 or 60 that project activities would take place. Windbreaks and other forestation would then be carried out on the adjacent dunes. There are approximately 300 such sites in the sub-prefecture, of which only 25 are cultivated at present in the Ngouri sub-prefecture.

The depression nearer the lake, locally referred to as polders, are still subject to occasional flooding in high rainfall years by the lake's salty water, as occurred in 19 Their groundwater table is quite superficial -- 2 meters or less. Eastward towards Ngouri, the depressions are not subject to lake flooding. Here they are termed wadis. Going Eastwards, the wadi water tables are generally at progressively lower levels, down to 4 meters, or more, beyond which it becomes too laborious to pump water with the traditional shaduf.

In general, the water tables have been receding over the past 25 years, from 2 meters to 4 meters below the surface in the canton of Djiguidada.

The depressions have been cultivated since many years ago. In 1959, Girard reported some wadis having been abandoned since before 1920, on account of salt build-up in the soils. It is probably safe to assume cultivation for over 100 years.

Girard's reconnaissance survey of the wadis in the area in 1959 found considerable differences among the wadis that he surveyed along the axis of the road between Ngouri and present day Isseirom (Girard, 1959).

He reported that many had been completely abandoned because of salinization, many were partially ruined, and others had salt crusts and effloresences. Clusters of salinized wadis were found in the vicinity of Njiguidada and Dibinentchi. A

few small wadis were flooded, being occupied by saline lakes. Nevertheless, a few hectares of wheat ("belles cultures") were observed on unflooded portions. Some were considered "too dry" to cultivate (water table too deep); others near Dibinentchi has been cultivated but were abandoned 30 years previous due to lowering of the water table, which in 1959 was at between 4 and 5 meters. He also observed that some were cultivated with greater attention and expertise than others.

Now the wadis are planted in maize during the rainy season, wheat during the cool dry season, and maize during the hot dry season. In lower rainfall years millet replaces maize. Yields of 600 to 700 kg/ha of all wheat and millet are reported (Annex G), but rainfed maize yields are 200 to 280 kg/ha.

One can conclude that continuous cultivation had one of two results: (1) lowering of the water table to depths too deep for pumping with the shaduf (over 3.0 meters), (2) salinization.

Also notable from standpoint of soil productivity is the fact that no fertilizers are applied, or leguminous crops rotated with the cereals. The rainfed millet fields on the dunes receive manure from livestock corralled there during the dry season, at night. But manuring of wadi soils is not mentioned. One has to conclude that nitrogen is being supplied by free-living, N-fixing organisms in the soil, i.e. bacteria and perhaps algae, and crop growth and yields may have reached an equilibrium with available soil nitrogen from this source.

Nitrogen, then, will become a limiting factor to increased production, and will have to be furnished in some form, when production is intensified by greater water use.

The pattern of salinization observed by Girard does not reveal a gradient of increased salinization towards Lake Chad (and coinciding with ever more superficial groundwater). It is rather parchy, with clusters of salinized wadis near the main settlements. An obvious conclusion would be that these wadis had abundant groundwater, permitting many years of cultivation resulting in salinization. However, where groundwater is within 2 meters of the surface, reported by Girard near Isseirom, salinization by upward capillary movement and evaporation also occurs.

Differences in soil drainage were observed by Girard, who recorded complaints that soils in an abandoned cluster of wadis were so permeable that the micro-basin flooding technique didn't work; water drained too rapidly into the sub-soil. (Wadis north of Dibinentchi).

In conclusion there is a long history of occupation, wadi cultivation, and of coping with salinization and fluctuating water tables in the region.

4. Environmental and related health aspects

a) Water related diseases.

The project proposes to increase water use, so as to leach salts from the soils, as well as to provide adequate quantities for crops. However, the increased use will not create a flooded or permanently wet environment needed by mosquitoes or the Bulinus snail intermediate hosts of Schistosomiasis. Flooded places, if they occur due to high rainfall will most certainly become saline and unsuitable for mosquitoes. There is no foreseeable risk of malaria or schistosomiasis from the project.

Settlements are reported to have tube wells sunk by Peace Corps volunteers, so that potable water need not come from wells in the wadis.

Notwithstanding these low risks the project activities will include baseline health surveys and treatment, if necessary.

Recommendation. The project baseline studies of health conditions and status should attempt to distinguish both the incidence of water related diseases, as well as the nature and places of exposure, including places such as the polders to which some residents migrate.

b) Pesticides

No pesticide use is planned for the project. Birds and termite damage are the main problems reported by the area's farmers. More frequent and more abundant irrigation could control the termites. Birds are driven off by boys.

Increased production can be expected to attract pests, however. Elsewhere in Chad pesticides have been used, including the highly toxic parathion.

Recommendation. The project agronomist should seek guidance and assistance from S&T's Office of Agriculture and/or the REDSO/WA environmental officer, should it become imperative to use chemical pest control. He should also be prepared to guide farmers in the project area to safe and ecologically sound methods of pest control, should they seek to use pesticides on their own initiative.

c. Salinization

A principal technical assumption is that the project will correct salinity build-up by providing more water and by increasing depth of cultivation (with an improved hoe), thereby facilitating leaching of salts downward, beyond the depth at which groundwater could flow upward into the root zone. Thus instead of the salts accumulating in the root zone or the surface, they would accumulate in the subsoil and at lesser concentrations than at the surface, since they would be in solution, and not subject to evaporation.

Since the wadis are closed, internally draining systems, salt charged groundwater cannot be conveyed elsewhere. It remains in the systems. The groundwater is, however, not a closed hydrological system, being fed by any rain that falls directly on the wadis or that seeps into the dunes and thence into the regional water table, eventually to add to the groundwater resource of the wadis.

Because the water table has receded during recent decades, we can assume that there is little fresh water input to the wadis. Also, any contribution from Lake Chad to the regional groundwater resource must be saltier than during higher rainfall years. The project's proposed irrigation practices would in essence redilute salts already accumulated at the surface as well as those tending to accumulate from on-going irrigation, and transfer them in solution to lower soil horizons, initially to depths of 2 meters or more, and eventually back into the groundwater.

Leaching to a depth of up to 2 meters is probably needed. According to FAO's 1975 Crop Water Requirements:

> "In the absence of impervious layers, the depth of groundwater below the root zone, at which the contribution to the moist root is reduced to less than 1 mm per day, may be taken at some 50 to 90 cm for coarse and heavy textured soils and about 120 to 200 cm for most medium textured soils." (p. 118).

The project's soils are medium to fine textured, hence leaching would have to be deep in order to avoid reverse movement back into the root zone. Ultimately, downward percolating water will reach the groundwater.

Over time the wadi's groundwater can only get more saline if there is no dilution from inflowing rainwater percolating downward from neighboring dunes. One cannot even speculate how long it might take to create groundwater too salty for irrigation, since the sub-surface hydrology is not known, either qualitatively or quantitatively. One cannot know to what extent downward percolating salt charged waters would be diluted in the groundwater reservoir.

One could envision, however, the possibiity of 5 to 10 years of intensified irrigated production, ending when groundwater becomes too salty and/or too deep to pump.

This scenario, which is a worst case one, can be compared to the present one of only 25 out 300 wadis being cultivated, the rest having been abandoned to salinization or die to excessive depth to groundwater (excessive for the shaduf technique, that is).

A possible outcome, which can be seen further north would be the limiting of production to the very salt tolerant date palms.

In essence, then, the project is not likely to solve forever the salinization problem, only displace it and delay it as a limitation on cultivation. The project would bring into production abandoned wadis, and if successful, make them quite productive for many years.

Recommendation. Minimum leaching requirements should be established with controlled field trials. Suggested layout is four adjacent basins separated by the usual band, each 3m x 3m, and three of which would receive different quantities of water. The fourth would be the control plot. Sites should be selected which are for representativeness. Pump-irrigation experience in similar, closed basin environments, e.g., Nevada, Utah, some places in Arizona, in the "basin and range" country between the Rocky Mountains and the Sierra Nevadas, should be reviewed for possible lessons.

d. Sustainability of soil fertility

Nitrogen will certainly become a limiting factor to crop production, especially if two crops per year of maize are attempted (rainfed and hot, dry season irrigated).

A sustainable maize yield of 2000 kg/ha would require at least 50 kg/ha of nitrogen and perhaps 5 kg of phosphorus. A low input solution to the provision of nitrogen would be inter-cropping or rotations with fodder legumes or edible

legumes, e.g. cowpeas. Phosphorus needs will also have to be satisfied, eventually if not right away, perhaps with acidulated phosphate rock from Niger.

Recommendation. N-fixing crops should be included in the cropping schemes to be tried out. These could be perennials (trees) used as field boundaries as well as annual crops. The economics of phosphate fertilizer use should be analyzed.

e. Agroforestry

A few comments and suggestions are offered.

The use of *Acadia albida* as a complementary tree crop in grain cultivation is well known in Chad as well as elsewhere in the Sahelo-sudanian zone. This species should be accorded priority for millet fields on the dunes. Agroforestry trials with *Atriplex* should be made on saltier soils. It accumulates salts, and is liked as a forage by sheep. It could help to remove salts from the wadi areas. Eucalyptus are notoriously heavy water users and their use as windbreaks at the edge of cultivated areas could depress the water table locally. Their cultivation should take this into account. Some Eucalyptus are more tolerant of salt than others, e.g. *E. microtheca*.

Tree tenure and use rights aspects should be reviewed before encouraging planting.

Nurseries sites must be chosen with care, expecially so as to ensure good water quality.

f. Ronier palm

The fabrication of pumps from materials other than the ronier palm will alleviate in some measure the pressure on existing stands, which are used for shaduf construction.

5. Concluding Remarks

The proposed project will revive and make more productive irrigated cultivation of wadis long abandoned due to salinization and dropping of water tables. No adverse health impacts are foreseeable. Soil fertility will have to be sustained under increased output, ideally with low-input means, such as N-fixing rotation crops and locally obtainable phosphate rock. (Obtainable in Niger).

Groundwater resource quality may not be sustainable, however, since the wadis are closed drainage systems, from which it would be too costly to pump out drain water.

Eventually after some years of cultivation, salts leached out of the surface horizons may render the groundwater too salty to use for irrigation of all but the most salt tolerant crops.

The project would, nevertheless, make possible added production, even if not sustainable, in places that have been abandoned. With careful water management, perhaps later with the use of minimal water, the wadis could be cultivated for many years.

Of particular concern to this IEE are possible health hazards, salinization and other aspects of productivity of the soils under intensified production technologies envisioned. It is projectd that corn and wheat yields can be more than doubled to 2000 kg/ha, while millet yields would increase from 600/700 to 1000 kg/ha.

REDSO/WCA has made the following negative determination with respect to the Initial Environmental Examination:

> "All components of this project are recommended for negative determination in concert with project commitments to monitor project impacts on salinization, waterlogging, groundwater drawdown, and water-related diseases incidences as described in the attached IEE. Any procurement or use of pesticides, or provision of credit to procure or use pesticides will require clearance from AID/W pursuant to 22 CFR 216.3(B) prior to disbursement of project funds for those purposes."

TABLE 1
ANNEX I - SUMMARY ENVIRONMENTAL IMPACT
IDENTIFICATION AND EVALUATION SHEET

COLUMN 1 LIST OF SELECTED CRITICAL ENVIRONMENTAL CONCERNS	COLUMN 2 PROGRAM/PROJECT COMPONENTS LIKELY TO CAUSE SIGNIFICANT CHANGES	COLUMN 3 ENVIRONMENTAL NATURE OF PROBABLE IMPACTS NEGATIVE (-) POSITIVE (+)
PROGRAM/PROJECT IMPACTS ON THE ENVIRONMENT		
Natural Environment		
1. Potential Major Effects on Existing Water Resources;		
a) Surface (Rivers, Lakes Reservoirs)	N.A.	
b) Underground (Aquifers)	Pumping and Irrigating	-
c) Estuary	N.A.	
d) Ocean	N.A.	
2. Potential Loss or Damage to Environmentally Sensitive Areas:		
a) Unique or Unstable Geologic Formations	N.A.	
b) Wetlands, Marshes, Flood Plain, and Estuaries	N.A.	
c) Acquifer Recharge Areas	N.A.	
d) Rare or Endangered Plant and Animal Species and Their Habitats	Alternative pump reduces pressure on ronier palm stands	+
e) Historical, Archaeological and Cultural Resources	N.A.	

NA - Not Applicable
U - Unlikely to be of Importance
P - Potentially of Importance
C - Critical

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3. Potential Significant Influence on Existing and/or Future Land Use Activities and Development Patterns Which May Affect:		
a) Wildlife Refuges	N.A.	
b) Prime Agricultural Lands	Irrigation and leaching restore lands	+
c) Valuable Natural Resources Forests, Wetlands, Minerals, etc.	N.A.	
d) Open Space/Recreation Lands	N.A.	
e) Ecological Balance of the Area/Region	indeterminate	
	production will help stabilize	+
4. Potential Significant Ecological Consequence from Introducing New or Different Techonological Systems in Conjunction with Community Infrastructure Services:		
a) Water Consumption versus Supply Limitations	pumping cold exhaust supply	-
b) Energy Requirements	N.A.	
c) Ambient Air Quality	N.A.	
d) Water Quality and Quantity	leaching could diminish quality	-
e) Change in Agricultural Practices & Use of Human Waste for Fertilizer	indeterminate	

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Human Environment		
1. Potential Social Disruption or Change to Traditional Customs and Socio-Cultural Conditions:		
a) Community Character & Cohesion	N.A.	
b) Social Organization	N.A.	
c) Institutional Structures	N.A.	
d) Life Styles and Cultural Traditions	N.A.	
e) Family Patterns & Values	N.A.	
f) Demographic or Social Profile	N.A.	
g) Level of Personal Safety & Convenience	N.A.	
2. Potential Significant Change to Established Housing Concepts & Practices:		
a) Building Materials	N.A.	
b) Construction Techniques	N.A.	
c) Housing Form & Styles	N.A.	
d) Interior Design of Structure	N.A.	
e) Spatial Relationships of Structure to Other Shelter Components (Courtyards, Cooking Area, Bath, etc.)	N.A.	

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Human Environment, (cont.)		
f) Population Density	N.A.	
g) Housing Location	N.A.	
3. Potential Significant Effect on Public Health and General Well-Being:		
a) Communicable Disease Control & Environmental Health Conditions	U.	
b) Displacement & Relocation of Population	N.A.	
c) Employment	N.A.	
d) Land Tenure and/or Stability of Human Settlement	N.A.	
LOCATIONAL FACTORS POTENTIALLY IMPACTING PROGRAM/PROJECT		
1. Presence of Significant Natural Hazards:		
a) Seismic Disturbances	N.A.	
b) Flooding	N.A. or U.	
c) Droughts	P.	
d) Tornadoes, Hurricanes	N.A.	
e) Landslides, Rock Slides, or Unstable Slope Conditions	N.A.	
f) Fires	N.A.	

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Presence of Significant Natural Hazards, (cont.)		
g) Soil Stability - Shifting Sands, Expanding Clay, Erosion, etc.	N.A.	
2. Existence of Major Environmental Health Problems:		
a) Water Quality/Supply	P.	-
b) Climate & Ambient Air Quality	N.A.	
c) Exposure to Communicable Diseases	N.A.	
d) Man-Made Nuisances - Noise, Odor, Toxic Materials, etc.	N.A.	
3. Availability & Capacity of Basic Community Infrastructure & Services		
a) Transportation - Accessibility to Jobs, Services, etc.	P.	+
b) Water Supply & Distribution	P.	+
c) Sewage Collection, Treatment & Disposal	N.A.	+
d) Health Care	P.	
e) Solid Waste Disposal	N.A.	

NA - Not Applicable
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4. Urban/Regional Growth & Land Use Coordinations: a) Strains on the capacity of existing natural systems (food production, water supply, etc.) or man-made systems (public transport, electrical supply, schools, etc.) due to Prevailing Physical Growth Pattern of Urban Center(s) Anticipated to be Possible HG Sites	N.A.	
b) Identifiable Important Environmental Resources Threatened by the Process of Urbanization - Rare or Endangered Plant & Wildlife Habitats - Wetlands - Agricultural Lands - Flood Plains - Forests - Historic, Archaeologic & Culturally Significant Sites - Unique Natural Areas - Scarce or Critical Raw Materials	N.A.	

NA - Not Applicable
U - Unlikely to be of Importance
P - Potentially of Importance
C - Critical

Annex F. Position Descriptions

1. Long-Term Technical Assistance

a. Administrative Officer (36 months)

The Administrative Officer will serve as Chief of Party and will be responsible for overseeing all administrative and logistical aspects of the Lake Chad Agricultural Production and Farmer Training Project. He will serve as liaison between the Ngouri-based team, GOC officials, AID, Peace Corps and ORT Washington. The Administrative Officer will be the spokesperson for ORT in Chad, representing ORT to the GOC, AID and other international donors and NGO's. The Administrative Officer will assure the smooth functioning of the ORT N'Djamena office and give assistance to the Deputy Chief of Party in administration of the regional office in Ngouri. The Deputy Chief of Party (either the Agronomist or Rural Works Engineer) will represent ORT to local GOC officials in Ngouri.

The Administrative Officer will be responsible for recruitment of all local-hire personnel. He will also be charged with establishing and operating a system for accounting of all in-country expenses. The Administrative Officer will serve as de facto Peace Corps Representative, responsible for orientation and supervision of the PCV's assigned to the project.

One of the first tasks of the Administrative Officer will be to arrange for and supervise the construction of the Ngouri housing and office compound. This and other duties involved with supervising the administrative aspects of the Ngouri office will necessitate frequent travel to Ngouri.

Logistical responsibilities of the Administrative Officer include: processing all necessary paper work for the duty-free importation of project equipment and materials, in-country purchasing of equipment and materials, arranging for in-country shipping, procurement and inventory record-keeping, negotiating leases for the N'Djamena office and housing, and establishment of a vehicle and office operations and maintenance system.

Another major duty of the Administrative Officer will be reporting to ORT headquarters on a monthly basis, and to the GOC, AID, Peace Corps, and VITA on a quarterly basis regarding project progress, problems and suggested solutions. The Administrative Officer will answer directly to the Washington based Project Coordinator and will carry out such tasks as may be requested by the Project Coordinator.

The Administrative Officer should have a minimum of three years previous work experience in Africa and should speak French fluently. Previous experience in Chad or Central Africa is highly desirable. Experience in logistics and administration of development projects and good writing and organizational skills are required. Previous construction or construction supervision experience is highly desirable. The Administrative Officer must be able to live in a difficult environment and have good cross-cultural and personal relations skills.

b. Pump Specialist (18 months)

The Pump Specialist will be responsible for the manufacture, testing and introduction of improved water lifting devices. The Pump Specialist will review the appropriateness of various models (twin treadle, MCC Rower, animal traction powered, etc.) and will select two or more for prototype testing and manufacture. Manufacturing of the pumps and certain tubewell parts will take place in private workshops in N'Djamena. The Pump Specialist, with assistance from the Administrative Officer and, as appropriate, the VITA Director will identify one or more private workshop owners willing and able to have their workshop upgraded to produce the improved pump product line. The Pump Specialist will give hands-on training to the workshop owners and staff in the quality production of the improved water lifting devices, and make the necessary arrangements for their full scale production following field testing of the prototype models.

Field testing will take place in the Ngouri Sub-Prefecture, at the wadi sites. The Pump Specialist will work in conjunction with the Rural Works Engineer in the field tests, traveling periodically to Ngouri. The Pump Specialist will arrange for accurate record keeping of pump testing and will use the results to modify and improve production. Technical supervison of the Pump Technology PCV is another duty of the Pump Specialist. Prior to his departure, the Pump Specialist will establish a system of pump use data collection which can be continued after his departure. Working with the Rural Works Engineer and PCV's, the Pump Specialist will also train area farmers and, as appropriate, entrepreneurs or blacksmiths in the maintenance and repair of the improved pumps.

The Pump Specialist must have previous experience constructing human-powered pumps. An engineering degree in mechanics and previous production and applied experience are required. The candidate must be committed to collaborating with local farmers and entrepreneurs in identifying the most appropriate pumps for use in the project area.

Previous work experience in Africa is highly desirable. Good French language ability is required. The Pump Specialist must be able to live in a difficult environment and have good communications and cross-cultural skills.

c. Rural Works Engineer (30 months)

The Rural Works Engineer will be responsible for upgrading the traditional irrigation system in the selected project wadis. He will have to work in collaboration with the Agronomist and short-term Sociologist in the selection of project sites; with the Agronomist in soil and water testing of wadis and in designing of the irrigated perimeters; and with the Pump Specialist in field testing of the improved pump. Working with the two PCV Well Diggers and SODELAC agents, he will train local people (one or more local entrepreneurs' crews) in installation of tubewells and possibly the upgrading of traditional wells for use with the improved pumps. The Rural Works Engineer will oversee all phases of these construction activities and will train local farmers in routine pump and well maintenance and operation, water scheduling and management.

The Rural Works Engineer will also supervise salinity data collection activities and advise area farmers on how to manage the salinity problem. The Rural Works Engineer will also arrange for local blacksmiths to produce a long handled hoe and will arrange to test this hoe with area farmers. The Rural Works Engineer, in collaboration with the Agronomist, will investigate the feasibility of using small gasoline-powered pumps for irrigation in the project .

The Rural Works Engineer should be a qualified Civil or Rural Works Engineer with previous experience in Africa. He must speak French and have the willingness and ability to learn basic Kanemou, the local language. Knowledge of tubewells is required.

Since the Rural Works Engineer will live in Ngouri, the candidate must be willing and able to live in a remote and isolated area with few modern distractions. Excellent communications and cross cultural skills are required.

d. Agronomist (33 months)

The Agronomist will be responsible for the introduction of improved farming techniques to local wadi farmers. He will improve farmer extension services by helping area farmers directly and by training SODELAC agents in improved farming methods. One key responsibility of the Agronomist is to keep accurate records on crop yields in both the control wadis and

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in the project wadis, to help determine the usefulness and profitability of project interventions. Data collection will also involve monitoring the number of beneficiaries, recording the total area cultivated, yields and crop production.

The Agronomist will also set up experimental plots within the project wadis to test seed varieties, farming methods and organic fertilizer methods. The Agronomist will supervise the technical activities of the two Peace Corps Foresters and help establish a SODELAC nursery in Ngouri and a reforestation program in and around the project wadis.

The Agronomist should have advanced training in an agricultural discipline and be familiar with the farming systems of the Sahel. Previous experience in Africa is required. The Agronomist must speak French and have the willingness and ability to learn basic Kanemou, the local language.

Since the Agronomist will live in Ngouri, the candidate must be willing and able to live in a remote and isolated area with few modern distractions. Excellent communications and cross-cultural skills are required.

2. Short-Term Consultants

a. Data Collection Specialist

This consultant will be charged with obtaining copies of all relevant documents regarding the peoples, the cultures, the agricultural systems, the economic systems, and physical characteristics of Lake Chad and Lake Fitri. Also documents on human powered pumps and previous development projects in the Lake Chad region will be obtained. Copies of some of the documents can only be obtained at OSTROM in Paris. Other documents will be obtained from the World Bank, AID, the Intermediate Technology Group and other agencies. The Data Collection Specialist will compile a full anotated listing of the documents obtained.

b. Communications Expert

The Communications Expert will be responsible for installing the single side band short wave radio hook up between Ngouri and N'Djamena. The Administrative Officer will obtain information from AID/N'Djamena regarding the recommended equipment and forward this information to ORT/Washington, who will procure the equipment. Upon receipt in the field of the equipment, the Communications Expert will travel to N'Djamena and Ngouri to set up the system.

c. Health Specialist

In collaboration with the Ministry of Public Health, a survey will be done in the project area to determine the baseline health conditions prior to project interventions. A second survey to follow a year later, will determine the health effects of project interventions. The Health Specialist may be someone from the Ministry of Public Health, from an agency already working in Chad, or an outside expert depending on the availability of qualified in-country staff. The primary purpose of the health survey is to determine what effects project interventions have, especially in regard to water-borne diseases. If negative effects are found to result from project interventions, the Health Specialist will make specific recommendations to address the problems.

d. Forester

Two trips have been budgeted for a forestry consultant. The first trip is scheduled to take place during the first year of the project. The Forester will prepare a report detailing specific recommendations regarding the establishment of the forestry component. This information will provide the basic work plan for the Peace Corps Foresters, who are expected to arrive at the beginning of the second year of the project. A second trip has been budgeted to provide the PCV's with an opportunity to call upon outside technical assistance to overcome specific problems that may develop during project implementation.

e. Social Scientist

The Social Scientist will gather socio-economic and anthropologial baseline data, and other information he or ORT feels is necessary for a thorough understanding of project conditions and evolution.

The Social Scientist's data-gathering techniques will include observation, interviews with Lac Prefecture and local officials and authorities, as well as interviews with local beneficiaries and control groups. He will analyze and make recommendations with respect to facilitating management or adapting project activities. He will supervise a locally hired Social Scientist (either a B.I.E.P. employee or independent consultant) developing with him schedules suitable for discovering baseline data and carrying out monitoring activities. He will direct the local consultant in the administration of schedules and interviews so that this work may continue when the expatriate Social Scientist is absent. He will aid the local Social Scientist in analyzing his data and be responsible for an adequate analysis of the material.

f. Maintenance Trainer

A Maintenance Trainer consultancy will provide pump and tubewell maintenance training to local farmers and SODELAC extension agents. The exact maintenance training needs will be determined by the long-term technical team, based on the technology used and observations regarding current use.

g. Environmental/Soils or Market Specialist

Funds have been budgeted for the services of either an Environmental/Soils or Marketing Specialist to help project technicians overcome specific technical problems.

h. Lake Fitri Studies

Two trips each for three consultants have been allocated in the budget to study the Lake Fitri area. The specialists (a Social Scientist, Agriculturist, and Marketing Specialist) will be responsible for gathering baseline data on the Lake Fitri area and making specific recommendations regarding the potential development of this zone. The Specialists will also determine the appropriateness for replicability of the agricultural technical packages developed for the Ngouri area for the lake Fitri area.

3. Peace Corps Volunteers

a. Foresters (24 months each)

The PCV Foresters will work under the direction of the Agronomist, and will be charged with establishing a forestry program to help stabilize dunes and create windbreaks around project wadis, increase fruit tree stands in the project area, and make more trees available for planting in the project area. One main activity will be working in conjunction with the counterpart SODELAC agents to establish a nursery that meets the needs of the population. This will entail not only supervising construction of the nursery, but also providing planning and management assistance to SODELAC to enable the nursery to function smoothly and to eventually operate independently when outside assistance is withdrawn.

The Foresters must establish a collaborative relationship with the wadi farmers, permitting them to understand the farmers' needs and enabling them to enlist the farmers' efforts in promoting reforestation.

The PCV Foresters should have degrees in Forestry, and speak French and (following training) Kanembou. Housing will be provided to the volunteers in the town of Ngouri. The houses will be of mudbrick, with no electricity or running water. Furnishings, including a gas stove and kerosene refrigerator, will be provided to the PCVs. The Foresters will be provided horses, as will their SODELAC counterparts, to enable them to visit area wadis. The volunteers will have the logistical services of ORT at their disposal, to obtain needed project inputs, and will be working in a structured and adequately-funded project supported by the local population and GOC.

b. Well Diggers (30 months each)

The Well Diggers will work under the technical guidance of the Rural Works Engineer. They will be responsible for heading and training crews to install tubewells in the project wadis. They will also train area farmers in the maintenance of the tubewells and help the Rural Works Engineer in the data collection activities. The Well Diggers' counterparts will be the SODELAC agents and the PCVs will train the agents in tubewell installation. The Well Diggers will help the Pump Specialist, who will generally be in N'Djamena, gauge user acceptance of the improved pumps and suggestions for modifications and improvements.

The Well Diggers must have mechanical training or experience, and will undergo a thorough tubewell construction training program. They must speak French and (following training) Kanembou. Housing will be provided in one of several villages in the project area (perhaps Djbinintechi or Njigidada) depending on which wadis are selected for project implementation. The houses will be constructed of mudbrick, with no electricity or running water. Furnishings, including a gas stove and kerosene refrigerator will be provided. The Well Diggers will be provided horses for transportation to wadis and have use of a truck when necessary for project activities.

The Volunteers will have the logistical services of ORT at their disposal, to obtain needed project inputs, and will be working in a structured and adequately-funded project supported by the local population and GOC.

c. Pump Technology Volunteer (18 months)

The Pump Technology Volunteer will assist the Pump Specialist in his tasks of training one or more entrepreneurs in N'Djamena in the manufacture of one or more models of human

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powered irrigation pumps. The PCV will assist in data collection on user acceptance of the various pumps and as such will occasionally travel to the Ngouri Sub-Prefecture. As needed, the PCV will give management assistance to the pump producing entrepreneurs to enable them to make the improved pumps a profitable product line. The PCV is expected to overlap with the Pump Specialist for 12 months and will then take over the responsibilities of the Pump Specialist after his departure.

The Pump Technology Volunteer should have a degree in engineering or previous mechanical experience and must be committed to establishing a dialogue and collaborating with lcoal farmers and entrepreneurs in identifying the most appropriate pumps for use in the project area. The PCV must speak French and have the ability and desire to learn basic Kanembou. Housing will be provided in N'Djamena. A motorcycle will be provided for transportation.

d. Health Volunteer (24 months)

The Health PCV will be stationed in Ngouri, Djbinintechi or Njigidada. He will help implement the recommendations of the Health Specialist regarding controlling negative health effects resulting from increased irrigation. While the specific job description for the Health PCV will have to await the recommendations of the Health Specialist, the job will necessarily entail extending preventive health care information regarding water-borne diseases and continued data collection on the incidence of disease.

The Health PCV should have a background in health care and/or a college degree, and speak French. The PCV will learn Kanembou, the local language of the people in the area. The PCV will be provided with a mudbrick house with neither electricity or running water, but will be given furnishings including a small kerosene refrigerator and gas stove. A horse will be provided for transportation.

ANNEX G: AGRONOMIC ANALYSIS

I. PROJECT SETTING

A. Physical Setting and Conditions

1. Geographic Location

The project wadis are located on the north-east shores of Lake Chad in the Ngouri Sub-Prefecture, along the Ngouri-Dibinentchi-Djiguidada axis. Access to the area from N'Djamena is via sandy unpaved roads, which are difficult to drive through in the dry season.

2. Relief

The project area is part of a sandy dune plateau with many low lands, wadis, which were submerged for some extended period by Lake Chad. These lowlands have a north-west to south-east orientation. One can observe that the dunes and lowlands are parallel. The dunes are 15 to 20 meters high near Ngouri. The cross-sectional view of the lowlands is dissymmetric and this can be seen in the field, i.e. the dune is steeper on the windward side.

3. Climate

a. Rainfall Patterns

The wadis in the Ngouri area are situated in the 350 mm Saheb-Saharan isohyet. The southern border extends from N'Djamena to south of Abeche, and covers 11% of the national territory.

Average monthly rainfall recorded over a 32 year period in Bol is as follows:

J	F	M	A	M	J	J	A	S	O	N	D	TOTAL
0.0	0.0	0.0	0.4	6.0	9.7	61.0	167.4	45.6	6.9	0.0	0.0	297.0mm

Rainfall for Ngouri in the last two years was only 80 mm in 1984 and 156.7 mm in 15 days in 1985.

The area has a normal average rainfall of 300 mm, which is very erratic and unevenly distributed in both time and space.

Cheverry already pointed out in 1966 that "the average annual rainfall over a 29 year period was 292 mm with fluctuations from one year to another - the extremes noted were 46 and 300 mm, respectively. In general the rains are not abundant but intense. For example, intense rainfalls of more than 60 mm occur once every three years. The intensity is very pronounced during the early part of the rainy season (210mm/hour), and then tapers off after 5 to 10 mm. It is unevenly distributed in space as well: 18 rainfalls occurred in the Bol Berim and Bol Guini polders, and figures obtained ranged from 219 to 365 mm." (translation).

b. Temperature

No data is available for the area under study. However, data obtained from Bol provides a good indication of the area's general temperature pattern (See Table 1 and Figure 1). The temperature varies a lot reaching 40°C in the rainy season. The data available is insufficient to allow an assessment of the impact on crops.

c. Evaporation and Evapo-transpiration

This factor is of paramount importance in the area because it has a direct impact on the water, soil and plants. Evaporation measurements (with the Colorado tray) as well as potential evapo-transpiration measurements with an evapo-transpirometer set on a watered lawn) in Bol Guini and Bol Matafo (over a 6 year period, SCET-INTER, 1972) provides the following data:

	J	F	M	A	M	J	J	A	S	O	N	D	TOTAL
EP/Month -Polder	211	224	302	305	285	257	246	208	204	273	264	225	3003
EPT/MONTH	144	142	208	228	227	195	181	148	151	199	179	146	2148

One can roughly estimate the amount of water evaporated during the three season, as follows:

Rainy Season (June-Sept.): Average Evapo-transpiration during 4 months:
Evapo-transpiration = 169 mm/month
i.e. 5.63 mm/day

Cool Dry Season (Nov.-Feb.): Evapotranspiration = 133 mm/month
i.e. 5.10 mm/day

Hot dry Season (March-May): Av. Evapotranspiration = 221 mm/month
i.e. 7.37 mm/day.

These data are important because of their impact on irrigation operations in the wadis.

d. Wind Patterns

The annual wind pattern is governed by the harmattan and rainy seasons in the following ways:

- during the harmattan season the wind blows in a north-easterly direction from November to March/April,

- during the rainy season, the wind blows in a south-westerly direction from May to September.

Day-time winds are the most common (SCET-INTER.)

Speed of 2m/s during 3500 hrs (80% of total daylight)
Speed of 4m/s during 2500 hrs (56% of total daylight)
Speed of 6m/s during 850 hrs (20% of total daylight)

The highest speeds are reached in the morning and around noon. The harmattan which is hot, dry and strong in the area, has dessicating effects on crops and the environment.

e. Insolation

No data was found for this climatic factor which is important for the growth of useful plants. However, it was observed during the trip that it is not a limiting factor.

4. Soils

The numerous studies carried out all agree that the area around the lake is a massive erg, an extension of the desert to the northn whose lowlands were submerged by encroachments of the lake. This provides an explanation for the textures of the area's soils. There are two major types of soil:

-dune soils, which are sandy and dry; and
-the lowland soils made up of lake alluvium

a. Types of Soils

-Dune Soils: these have the following profiles 0 to 15 cm.: grayish brown sandy layer, gradually turning reddish brown; 15 to 90 cm: brownish red layer turning to beige from 90 to 120 cm. (beige sand).

They are very porous and lack organic matter and minerals. However, the farms are manured during the grazing period in the dry season. These nutrients are reached at the beginning of the rainy season.

-Lowland Soils (wadi): In examining their profile (from the wells), one sees several deposits:

-0 to 10 cm: has a light soil with a pseudo-sandy texture which when wet forms a hard crust that can be easily detached from the bottom layer. It is probably a mixture of clay and fine polyhedric silt.

-20 to 100/200 cm fissured clay

-below 200 cm begins a marl layer.

b) Hydric Pattern of the wadi Soils

Hydric capacity: No pedological studies were found which indicated the soils' useful hydric capacity.

-Hydromorphy and Natural Drainage

Nobody mentioned a problem of water logging in the rainy season, even when heavy rains fell. Likewise, an inspection of recently irrigated perimeters showed no problems of water-logging.

Mr. Girard's 1959 report (Survey of wadi agriculture and it's development prospects in the Mao district) noted the fact that the wadis which were flooded in 1956 only dried up in 1959 and that many wadis were still flooded in January 1959, i.e. four months after the rainy season (subdistrict of Djiguidada). However, it should be pointed out that at that time the watertable was at the most 2 meters deep in this district's wadis. Currently the watertable is 4 meters deep.

It would therefore seem that the extreme shallowness of the watertable was the main cause of the soil's hyromorphy.

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Permeability: from the observation of the rate of water percolation into the irrigated soil, permeability is good. The sandy silt-clay structure of the soil enables one to predict that permeability is not less than 3 cm/hour. No data is available for the area.

c) Salinity Problems

Most of the wadis visited were either partially or entirely covered with salt. This salinization is not caused by the soil itself, but rather because the sub-surface water is salty.

d) Ground Water

Currently, the watertable is 3.5 to 4 meters deep. The presence of this groundwater, which is the only source of water for irrigation, is important.

i) Its origin: many questions remain unanswered on this issue despite the numerous studies conducted.

This important question about how the water table is recharged should be answered through a regular monitoring of its level. The simultaneous drop in the levels of the lake, rainfall in the area, and wadi water table further complicate matters.

ii) Salinity of the Groundwater: Salinity of groundwater is common in semi-arid areas. Evaporation is the main cause of salinity increases. Evaporation occurs on both the waters of the lake and the surface of wadi soils where the water table is very close to the surface.

Measurements taken from the lake and polders (SCET-INTER.), show that conductivity increases the further one gets away from the lake. On the north-eastern part of the lake (the proposed site of the project) conductivity measurements in 1966-68 ranged from 300 to 350 in the polders near Ngarangou and Iseirom, and 600 to 700 in Kouloudia in the east. One is very much tempted to say that the salinization of the water table of Ngouri's wadis is due to the waters of the lake (consequently, the watertable is recharged by the lake).

One thing is certain: the salinization of wadi soils is caused by the salt in the groundwater. This salinity was very high when the water table was very shallow (less than 2 meters deep), with water rising through capillaries, coupled with the high rate of evaporation. This explains the high proportion of "natron" (Sodium carbonate) wadis during that period. The drop

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in the water table (currently 4 meters) has stopped and reversed this action which SCET-INTER shows through the following chemical phenomenon:

-When the water table was very shallow and contained sodium bicarbonate, the chemical reactions of reduction enriched the soils with sodium carbonate and sulfite.

-When the water table drops, the surface soils are drained thus facilitating the reoxidation of sulfite; the presence of calcium sulfite at such a shallow level facilitated the formation of sodium carbonate. A drained soil which has some limestone in it will thus loose its sodium carbonate which is replaced by Na and Ca. The presence of a marly layer in all the soils of the wadis visited, provides these soils, which are rich in clay and silt, good physical properties (good sweating, good absorption of rain water and ease of farming), and microbic activity (because of sufficient Ph), which allow it to quickly decompose organic matter.

The current salinization of wadi soils is caused by irrigation with the shaduf (a system which is described later on) whose major drawback is the small amount of water lifted: the water is neither lifted quickly enough nor is it in sufficient quantities to allow for a good flushing of the soil. This drawback, together with the high rate of evaporation, accelerates the salinization of the soil surface (the crust mentioned under the pedology section).

Traditional Methods used to reduce salinity:

-In some northern wadis (near Mao) some farmers scrape away the crusted surface layer which they bury in a deep hole. This enables them to continue farming their plots of land.

The subdivision of the perimeters into smaller plots separated by 15 cm dikes helps avoid salinization during the cropping season. Indeed, the dikes retain the salt at the high mark attained by the irrigation water. This system does not seem to be efficient because the same soil is re-used the following cropping season, with an increased level of salinization.

e. Fertility of Wadi Soils

The wadi is a closed system which, unlike certain polders, no longer gets alluvial deposits from the lake. Instead, it is overcultivated and further depleted by the erosion of run-off water. Obviously, it's fertility has declined. Unfortunately, the results of the pedological analysis of wadi soils could not be obtained.

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f. Vegetative Cover

i) Sandy Dunes

The predominant tree and shrub species are as follows: Belamites aegyptiaca, Commiphora Africana, Acacia senegalensis, ziziphus mauritania, and the Hyphaena Thebaica (down plam). There are thick bushes of callotropis procera in the crop fields of the dunes and villages.

Grass Cover: There was little or none (due to the dry season). However, one could still see some cyperus and aristidea.

ii) Uncultivated and Salt-free wadis: These have most dune species in addition to which there are: Boscia Senegalensis, Salvadora persica and Hypheanea thebaica. Grasses include Cynoden dactylon, imperata cylindrica and some cyperacia.

The exploitation of these species, trees and shrubs in particular, is very intensive in the area - the fruits of the Balamites aegyptiaca are highly appreciated for food and sometimes for making soap.

- The sap of the callotropis is used as a poison for the tip of arrows/spears and the fiber of this species is used in making fishing nets.

- The fruits of the ziziphus mauritania are edible.

- The trunk of the hyphaena thebaica (down palm) is used in the construction of shadufs and houses. It's leaves are used in building fences. Its fruit is edible.

- The different species of acacia are either used to produce tannin or as fuelwood (acacia seyal).

- Salvadora persica, a very useful creeping species whose leaves cover the dune and thus stabilize the sand. It is also used for making spices. Some planting operations will satisfy villagers' needs (the salvadora persica can be used to stabilize the dunes around the wadis which are threatened by sand encroachment).
- Hyphaena Thebaica for construction purposes.
- Balanites aeyptiaca for its fruit.
- Acacia Seyal for fuelwood.

In some of the wadis visited, the villagers had planted citrus trees (already bearing fruits) and papaw which are growing. There are also date palms which form a thick windbreak along sides of the wadis.

5. Conclusions of the Environmental Analysis

It should be pointed out that there are a very limited number of publications to reference because few studies have been conducted for the wadis in the Ngouri area. The analysis was based on a few outdated studies and on observations in the field.

a. Constraints on Agricultural Development in the Area

i) Water: Lack of water is a significant constraint for both dryland and irrigated farming in the wadis. In dryland farming rainfall is unpredictable and uncontrollable. In the wadis the constraint is posed in terms of the quantity and quality of water.

ii) Soils: As in the case of water, there is insufficient data of the content and characteristics of soil in the area. Salinity is a real constraint to the utilization of these soils.

iii) Climate: Evapo-transpiration is a constraint for both vegetation and the environment. Wind patterns are included under this factor.

iv) Location of the Area: The lack of good roads is an impediment to any development initiative in the area.

b. Favorable Factors

- the texture and structure of wadi soils is good for agriculture;
- the climate facilitates the growth of diversified crops;
- the vegetation is adapted to local environmental conditions and is very useful to both the people and the environment.

c. Actions to be taken

a) There is the need for preliminary studies on soils and water resources in the wadis and a need to set up a system for monitoring these resources.

b) A study needs to be taken to evaluate appropriate techniques for dealing and monitoring the soil salinization problem.

c) Project interventions are needed to protect the environment and crops from the dessicating effects of the wind (evapotranpiration) by:

- planting windbreaks around the wadis; and
- dune stabilization around the wadis (tree planting).

d) Given the inaccessibility of the area, the project should design methods which are financially and technically within the reach of farmers.

B. Institutional Framework

This section is mostly taken from the report titled "Assessment of Dryland and Irrigated Farming in Chad" (September 1984) - CILSS, as well as interviews the team had with agricultural officials at all levels.

1. Extension Service System

The farmers of the wadis in the Ngouri area are provided extension services by SODELAC (Agency for the Development of the Lake Chad region).

SODELAC's headquarters is in N'Djamena.

The Agricultural Production and Extension Unit is based in Bol. It is headed by a divisional chief stationed in Bol, and the unit is sub-divided into two:

-Sub-Unit of Bol
-Sub-Unit of Doum-Doum which includes the wadis of the Ngouri area. It is headed by an active agent who knows the physical and social environment. The sub-unit of Doum-Doum is divided into four zones. The zone covering the wadis of the Ngouri area consists of Ngouri, Dibinentchi and Djiguidada and is supervised by a zonal chief stationed in Dibinentchi.

The agents provide extension advice, and the distribition of seeds and collection of seed debts.

2. Organization of Farmers

There is no farmer organization. Agents have recently started setting up farmer groups in preparation for the

installation of motorpumps which will soon be given by SODELAC to a few villages.

3. Production Structures in the Field

a. Training of Farmers and SODELAC Agents

i) SODELAC has no farmer training unit.
ii) Training of Agents

This is provided by two schools: the CFTA (Training Center for Agricultural Technicians) in Doyaba, which trains work supervisors and extension agents over a three year period; the CETA (Agricultural Vocational Training Center) in Ba-ILL, which trains middle-level agricultural and extension agents. Candidates are recruited from holders of the CEPE (Junior High School diploma) or 10th graders. It's four year training program at the end of which they earn a BEA (agricultural training diploma).

Both centers are currently facing operational problems.

b. Agricultural Research

Research on cereals is supposed to be conducted at the national level by the Department of Agronomic Research which is presently focusing on the southern part of the country; and around Lake Chad by SODELAC at the Bol Matafo Station, which no longer operates. Cotton research in the south is the only component being actively pursued.

c. Inputs Supply

i) Fertilizer is not applied on cereal crops around Lake Chad. It is felt that the soils of the polders and wadis are adequately rich.

Funding for fertilizer procurement in Chad depends on the cotton production network:

-Cottonchad does the procurement;
-Distribution to users (farmers and various firms) is done by ONDR (National Office for Rural Development). In fact, the major users are the southern farmers of the cottonbelt who are provided extension service by ONDR within the framework of increased productivity operations (using fertilizer and animal traction). Cotton, rice, peanuts and sorghum are the principal crops that benefit from such operations in the south.

ii) Seeds

The procurement of seeds is done by various international organizations from those farmers with surpluses, and the seeds are then given to extension services for distribution.

Reimbursement of seed is in-kind with a 25% surcharge so as to enable the distributing agencies to build their own stocks. This rate is hardly attained by farmers in the areas visited. In fact, there is no national seed program. However, there are some projects such as "The Cereals Seed Production Program in the Sahelian Zone" (FAO/UNDP, FENU and WFP), which operates an irrigated seed farm in Gasse and a dryland farm in Massenya. Some of the other objectives of this program include: reconstitution of the seed bank of local varieties, the multiplication of these varieties, an experiment at improving local varieties, and testing new varieties.

iii) Perticides

There is no pesticide supply system. In case of major outbreaks of insect attacks, authorities distribute small quantities of pesticides which, in most cases, have lost their efficiency.

iv) Animal Traction

The southern part of the country is the only area where animal-plowing is being developed. There is no plowing in the Sahelian zone. Interviews with the farmers of Am-Ndjamena (in the Lake Fitri zone) show that the introduction of this farming technique would be warmly welcomed and people are looking forward to it.

v) Farm Credit

There is no national farm credit system and each agricultural development agency organizes its own farm credit system. ONDR is the only agency which has a well established system of its own in the south. VITA, has a credit program in the Chari-Baguirmi Prefecture.

4. Post-Harvest Structures

With the exception of cotton, which is covered by an official price policy and an organized marketing network, the other crops are sold freely on the market. Prices fluctuate, depending on the season and place.

The most active system is that of traditional merchants who are gradually concentrating on the south. Such a system does not exist in the region around Lake Chad and farmers sell directly at weekly markets. The ONC (National Marketing Agency) was established to stabilize producer and consumer prices.

5. Conclusions of Institutional Analysis

This sector faces many problems due to the lack of resources in all the areas discussed above.

Actions to be taken

a) Help the farmer to draw from the productive potential of local seed varieties which are well adapted to the environment, by using simple farming techniques. At the same time, have farmers test improved varieties which are adapted to the local environment.

b) While the area studied is ideal for the proliferation of pests, the use of pesticides is problematic. First, the area is hard to reach. Second, an input structure does not already exist. Third, there are potential risks to water and health through improper use. Nevertheless, pesticides should be considered for use due to the potential pest problem. Thus, preliminary studies have to be done to assess the risks of pollution (types of products to be used, the penetration of such pesticides into the area's soils and their toxicity and the economic viability of pesticide use).

c) Training farmers at the technical (farming methods and tool maintenance), operational, and farm management levels is needed. Also extension agents of the agricultural agency operating in the area should receive additional training. This training will focus on the techniques employed in the project.

d) Encouragement should be given to local or national private concerns to take on project activities (e.g. the manufacture of pumps).

II: ANALYSIS OF TRADITIONAL FARMING SYSTEM

A. Farming

There are three types of farming in the zone:

dryland farming on the dunes (this is the main activity),
wadi farming (this is a supplementary farming activity), and
polder farming (undertaking this activity is a sign of the degradation of farming conditions in the wadis).

1. Dune Farming

It is estimated that the average family size in the area has five members of which three are active members.

In dune farming, the average family has a 1.5 ha plot. Millet is cultivated in monoculture and it is a local variety with a 70 to 90 day maturing cycle.

After the harvest (in September), the farmer sets up a cattle corral in his farm in order for the cattle to spread manure on the plot.

Soil preparation is done in April-May. Clearing of weeds is done with a hoe and by burning.

Seed planting is primarily dry seeding done in May or in early June prior to the first rains. Normal seed planting is done between June 15 and July 15. Erratic rains often result in replanting. Seeds are planted in "hills"[1] set in rows with a 100 x 80 spacing, and 6 to 8 grains are planted in each hole. Ten to fifteen kg of seeds are planted per hectare with seed planting taking 1 to 2 days.

The first weeding and thinning leaves 4 to 5 plants per hill and is done two weeks after seed planting.

The second weeding depends on the rate at which the weeds grow.

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[1]The agronomic term "hill" means planting a group of seeds at a relatively wide spacing. The term does not imply that a mound is formed on which sowing is carried out.

The major damages to crop are caused by:
-birds (quelea quelea),
-earhead caterpillars,
-downy mildew,
-striza and chibras.

Children protect the farms from birds. Farmers have no means of controlling insects.

The harvest occurs 70 to 80 days after planting, when the grains are still green in order to minimize the damage done by birds. The earheads are cut one by one with a knife. The harvested crop is dried on the farm in an elevated granary covered with thorny branches. Trashing and winnowing is done by a team of women. During storage the sitophitus sp is the only insect that causes some damage. The grains are stored in a hole inside the hut.

2. Wadi Farming

According to our survey an average family has a 0.25 to 0.30 ha plot. In 1959, Girard surveyed all the wadis of Ngouri, Dibinantchi, and Djiguidada. There were about a hundred wadis in each district. Wheat, corn, and vegetables were cultivated in them. They faced the problems of salinity and flooding.

The same author pointed out that in 1954 only corn and millet could be cultivated in the rainy season in the wadis around the village of Ngouri, because the water table had dropped to 5 feet (in 1959). These wadis were cultivated up to around 1920 (according to Girard), when they were abandoned due to the drop of the watertable. More wadis in Djiguidada and Dibinentchi are still being farmed.

Types of Crops Grown in the Wadis

There have been changes over the last 3 decades regarding the types of crops grown. When the watertable was shallow and rainfall was abundant: wheat was grown in the cool dry season, corn was grown in the rainy season, and corn was also grown in the hot dry season. Vegetables were grown all year round: okra, pepper, watermelon, and cassava. Water was lifted using the shaduf, but under less arduous conditions, as the water table was shallow.

With the drawdown of the water table and scanty rainfall, the types of crops grown have changed:
- in the rainy seasons sorghum and/or finger millet, and vegetables,
- in the cool dry seasons wheat and vegetables, and
- in the hot dry season finger millet.

The farmers have therefore switched to crops which require less water (sorghum, and finger millet) and shorter maturing dates.

However, it should be pointed out that there is a decline in the cultivation of hot dry season crops, the reason being that farmers prefer to move to wet polders in order to grow corn under recession farming on plots that are at times as big as 1.5 to 2 hectares. This trend was noted in all the villages visited by the team.

-Soil Preparation in the wadis consists of:
-clearing the farm if there are weeds.
-superficial tillage by hoe to build the small 15 cm dikes dividing the plot into smallet plots whose size is about 1m by 1m. The small dikes are sometimes emptied in order to dig canals. Seed planting is done in hills arranged in rows. Wheat is planted between the hills within a row at a spacing of 15 cm. Spacing between rows is 20 cm. For corn spacing is 70 by 30 cm.

Seeding rate for wheat is 4 to 6 seeds per hill and for corn 3 to 4 grains per hill, which is later thinned to 2 to 3 plants per hill.

Quantity of seeds per hectare for wheat is 70 to 100 kg/ha., for corn is 20 to 25 kg/ha., and for finger millet is 10 kg/ha. There are several varieties including foreign wheat varieties such as "Pendjame", "Dambata", "Zinati bouterille" and "Florence aurore."

For corn local varieties with a yellow kernel, with a 70 to 80 day maturing date are available. Foreign varieties used are mostly Nigerian:
- big and white kernels, with a 120 day maturing date.
- big and dark-red kernels, with a 120 day maturing date.

Currently, farmers are ending up with a mixture of varieties.

Irrigation in the Wadis

In the first year, the farmer constructs his shaduf and digs a well. The shaduf is made from the trunk of the *hyphaena thebaica* (doum palm) and a woven container with a 5 to 10 liter capacity.

Most wells are dug by professional well-diggers and the sides are levelled.

It is estimated that it takes 5 days to make the shaduf and dig a well.

For an area of 25 acres, the farmer uses 2 or 3 shadufs because the well often dries up after lifting water from it for an hour and to shorten the distance over which the water flows in the dikes.

The farmer builds dikes starting the edge of the well. These are initially elevated and descend a slope on the sides of the plot (i.e. using gravity irrigation). Main dikes are also built. The subdivision on the perimeters into small subplots (1 meter by 1 meter) results in the loss of 35 to 40 percent of the area of the plot. Small plots are used because:

- The square subplots provide for a better control of the water which is released in small quantities;

- The subplots also reduce the salinity of the water. The salty top layer of the soil is used to build the small dikes and subplots thereby cleaning the interior of the small subplots. The small subplots also retain the salt contained in the irrigation water (capillary phenomenon noted at the watermark level on the sides of the subplots). It is men who lift the water from the well, while children or spouses pour it either into the dikes of subplots. In general, the water flows from one subplot to the next. The water flows quickly into the subplot and as soon as it reaches about 10 cm. the small dike is opened to allow the water to flow to the next subplot. In fact, each subplot merely gets a small amount of water during each irrigation.

SODELAC estimates the volume of water as follows:

- shaduf: 1 l/s = 60 l/mn = 3,600 l/h or 3.6 m^3
- average daily irrigation = 6 hours, i.e. 3.6m^3 x 6 = 21.6 m^3. On average, 4 days irrigation is needed for a 25 ares plot.
- volume of water for 0.24 ha. 21.6 m^3 x 4 = 86.4 m^3 per irrigation.

<u>Wheat</u>: 15 irrigations, i.e. 1,296 m^3/25 ares or 5,184 m^3/ha. with irrigation done once every 5 to 7 days.

<u>Corn</u>: (short maturing variety): 10 irrigations, (i.e. 86.4 m^3 x 10 = 864 m^3/areas or 3,456 m^3/ha) with irrigation done once every 5 to 6 days.

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Thus, the farmer has to work non-stop 60 days in the case of wheat, and 50 days for corn.

From what the team saw, the farmer tries to run the water through as many subplots as possible. Furthermore, the work is so hard that many farmers cannot sustain the necessary effort and they prefer to cultivate the polders. Corn grown under recession farming in the polders is planted from March 15 onwards.

3. Crop Yields

SODELAC's 1984/85 cropping season report gives the following yields:

	DJIGUIDADA	DIBINENTCHI	NGOURY	TOTAL PREFECTURE
Dune Millet				
. Number of farmers	8,300	3,650	5,000	16,950
. Ha planted	2,500	6,400	3,200	12,100
. Yield kg/ha	100 K/ha	378	400	
Wadi Rainfed Corn				
. Number of wadis cultivated	10	13	-	23 wadis
. Number of farmers	370	460	-	830
. Ha planted	240	360	-	600 ha
. Estimated yield kg/ha	208	282	-	
Dry Season Crop				
. Number of wadis	10	13	2	25 wadis
Ha Planted				
. Wheat	70 ha	120 ha	-	190 ha
. Corn	15	42	-	57
. Finger Miller	-	12	-	12
. Other Crops	13	9	10	32
Total Ha	84 T	145 T	-	229 T
Output				
. Wheat	84 T	145 T	-	229 T
. Corn	-	-	-	-
. Finger Miller	-	9.5 T	-	p.5 T
Yields				
. Wheat	0.833	0.828	-	
. Corn	-		-	
. Finger Miller	-	1.263	-	

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The above figures are for the 1984/85 cropping season, which had a poor rainfall. However, wadi farming does not depend on rainfall.

The team noted the following:

a) There is little farming done in the wadis. Out of about 300 wadis in the Sub-Prefecture on Ngouri, only 23 wadis are farmed totalling 600 ha in the rainy season (i.e. 26 ha/wadi). In the cool dry season 25 wadis are farmed for an area of 291 ha (i.e. 11.64 ha/wadi).

The farmers of Ngouri village have abandoned most wadis. The Sub-Prefect confirmed this and he estimated that only 5 percent of Ngouri farmers cultivate the wadis. This abandonment was already noted by Girard in 1959. Many people go to N'Djamena, while others head for the polders where they do recession farming. It should be pointed out that these figures were estimates made by SODELAC agents - there was no survey.

b) The yield for rainfed corn grown in wadis where it was also irrigated, was only 208 to 282 kg/ha.

The yield for wheat given in the above table were the same in both Djiguidada and Dibinentchi - 0.830 ton/ha (rain factor is irrelevant). Finger millet (fonio) had a yield of 1.263 ton/ha in Dibinentchi. The estimated yields are different from those given by the farmers interviewed by the team:

-Wheat: 600 to 700 kg/ha
-Finger Millet: 500 to 600 kg/ha.

The figures are also different from those recorded in SODELAC's technical data files purportedly obtained from traditional wadi farming using the shaduf:

-wheat, using traditional farming methods: 2 to 2.5 tons/ha.
-wheat, using modern irrigation methods: 2.5 to 4 tons/ha.

Yields for recession corn as reported by the SODELAC extension service are:

1.5 to 2.5 tons/ha for the local variety, and 2 to 3 tons/ha for the foreign variety.

Yields for dune millet were very poor in Djiguidada. But it should be noted that the average yield is 400 kg/ha.

B. Live Stock

Livestock was a flourishing activity in the project area in the past but the recent drought has decimated the big animals. Goat rearing is still a major activity and each family has at least fifteen goats, donkeys, camels and horses. A noteworthy point is the fact that these people realized very early the need to manure their dune farms by corralling their herds on them throughout the dry season.

C. Conclusions on the Traditional Systems

1. Dune farming is risky and cannot be controlled.

2. The low rate of farmer participation in the cultivation of the wadis has reached a point for concern. The gruelling work involved in using the shaduf is the primary reason for the abandonment of the wadis.

3. The intensity of farming in the wadi far exceeds the farming methods used.

4. Shortage of water is the main obstacle to the cultivation of the wadis. It is the only factor which is likely to change or improve current farming methods, and at the same time the rate of wadi farming.

III: ANALYSIS OF PROPOSED TECHNICAL SOLUTIONS

The study of the current environmental, institutional and farming systems has led to the definition of a certain number of actions to be undertaken by the project:

A. Agroforestry

This component will consist of the following activities:

- Planting windbreaks
- Planting trees and/or shrubs for dune stabilization.
- Planting trees which meet people's real needs, notably those that produce fruit, and wood by-products (for construction and fuel wood).

1. Windbreaks

The ideal windbreak should be oriented perpendicular to the predominant winds, especially the hot and dessicating winds of

the hot dry season (harmattan winds). It should be high and the plants close to each other, but without preventing the free calculation of air.

A good windbreak will reduce wind speeds for about 20 times its height. The trees should also meet other real needs of the population.

The wadis lie in a northwest-southeast orientation and they are often more than 1 km. long, and big wadis are 200 to 300 meters wide. The windbreak should be planted along the side facing the direction of the wind (northeast). With a tall windbreak (10 to 20 meters high), the entire wadi is protected and it may be unnecessary to plant other rows inside the wadi. If this is deemed necesssary, the additional rows should be planted obliquely to the wadi's longitudinal axis. Species which could be used as windbreaks include:

- Parkinsonia occuleata: Because it can grow tall and its wood can be used for construction, this species could be tested in the wadis. It adapts well in areas where the soil moisture or water table is high, and its roots can also develop deep down in search of water. However, the species should be somewhat salt-resistant.

2. Dune Stabilization

The species should stabilize the sand around the wadis, especially the side from which the predominant winds blow. This protection should be provided over a certain distance close to the edge of the dunes.

The species suggested are:

- Salvadora persica which is found growing wildly in the area. Its branches and leaves spread far from its base, thus covering the soil over a wide area. This species has other uses because the local people use the tender branches and leaves to make vegetable salt which has good healing properties.

Aristida species can also be combined with Salvadora.

3. Aboriculture

This activity is spreading in the wadis. Lime trees and guavas bearing fruits were seen by the team in the wadis visited. Banana trees are occasionally tried but the strong winds and perhaps salinity do not allow them to grow properly. The team was informed that in some wadis on the northern part

of the lake (toward Mao), a whole variety of fruit trees were growing very well (lime, orange, mango trees, ets.).

The date palm grows very well in the wadis and the improvement of its yield would be worthwhile. The fruit can be well preserved if they are dried.

Several local species are used by the local population: Zizyphus, tamarindus and blanites aegyptiaca.

4. Planting Trees for Fuelwood and Construction

A lot of wood is used in the area either for construction (houses and shadufs) or for fuelwood.

The species used locally for construction is mostly the doum palm (hyphaena thebaica). Its leaves are woven and used for fencing around homes.

The species used as windbreaks (eucalyptus and parkinsonia) also produce poles which are used for construction.

It may also be worthwhile to develop the acacia seyal whose red wood is used for fuelwood. This could assure the replacement of this species currently harvested for fuelwood.

5. Implementation of Proposed Activities

For the local species, the conditions are ideal because seeds are available locally and these plants grow wildly. The exotic species also grow well in the region.

In year one seedlings provided by the forestry service unit in Bol should be used for a pilot reinforcement activity in a wadi. However, the seedlings should be provided at the beginning of the rainy season so as to assure their natural establishment and subsequent growth. At the same time, the project will examine the possibility of setting up a nursery in Ngouri. Adequate planning to take care of planted trees needs special attention. Many reforestation projects fail as a result of neglecting this aspect.

The first condition for success is that the trees planted meet real needs of the population. In most cases, people fail to take care of the plants which they do not themselves perceive to need.

It may be necessary to propose an incentive system (Food for Work) in collaboration with CARE or WFP. The potential for an incentive system will be determined during project implementation.

B. Solutions to the Problem of Soil Salinity

The ultimate solution to soil salinity problems depends on the availability of sufficient water to flush the soil. As was pointed out in tha analysis of the farming system the shaduf does not solve the problem. Instead, it worsens the problem because of its small draw. The solution should consist of looking for more efficient ways of lifting water and improving the traditional system of salinization control.

In the agronomic field the solutions proposed are:

1. Deep plowing of the soil beyond the depth reached by the crops' roots in order to facilitate the flushing of salt during irrigation. This will also aerate the soil.

The shaduf irrigated farming method (small quantities of water and quick flow of the water from one catchment basin to another) and the superficial tillage of the surface soil lead to salt sedimentation at shallow depths - sometimes less than 10 cm deep.

2. Provide sufficient quantities of water to meet the needs of irrigated crops. The solutions proposed are intended for the technical packages outlined below.

C. Improvement of Technical Packages

The improvements mainly cover:

- Soil preparation,
- appropriate seeding rate and plant spacing,
- intercropping of leguminous plants with cereal crops, and
- the irrigation system.

The implementation of these improvements depends entirely on the farmer. Under the traditional system in which water is a permanent constraint, he was able to choose techniques that minimized his risks.

If the water constraint is removed, the farmer will be willing to adopt solutions which might increase his yield. With the shaduf system, these improved methods will hardly, if at all, increase current yields, because the water constraint is overriding.

1. Plan for Implementing the Technical Packages

a) Type of Cropping Proposed

Essentially, the crops to be grown will be based on the dietary habits of the population and on what farmers themselves believe will find a market. Cereal crops will be the major crop grown because the farmers' priority is to be self-sufficient in food. The most profitable cash crops might be vegetables. Too great a production of vegetables, however, can not be absorbed by the local markets. A typical plot may thus look as follows (25 ares):

Rainy Season - Corn (20 ares) intercropped with cowpeas (5 ares)
Cool Dry Season - Wheat (15ares), onions (5 ares) and other vegetables (5 ares)
Hot Dry Season - Finger millet (millingui) (20 ares) and vegetables (5 ares).

b) Soil Preparation

The intercropping plan outlined above assumes that sufficient water supply is secured. The pumping system installed should provide sufficient flow and facilitate the farmer's work. The introduction of a pump which has a greater capacity than the shaduf would require improvements in land preparation. These improvements are:

- alterations of the dikes, and
- larger sub-plots which would allow for a slower flow of the water, thus avoiding the quick entry and exit of the water in the subplots.

The amount of irrigation will take the following into consideration:
- the watering needs of the plant
- evapo-transpiration
- drainage water, and
- losses in the dikes.

As an illustration, here is an estimate of the watering requirements of the proposed crops:
- o Wheat: 5000 to 6000 m^3/ha,
- o Corn: 6000 to 8000 m^3/ha,
- o Finger millet: about 300 m^3/ha.

The farmers will be trained to adhere to watering schedules, and the areas to be irrigated at any given time. Already, the farmers have substantial experience in irrigation.

c) Seeding Rate Per Hectare

The first major change will be wheat for which the team proposes increasing the seeding rate to about 200 kg/ha (instead of the current rate of 70 to 100 kg/ha) and broadcasting the seeds. The broadcasting of finger millet will also be experimented.

d) Organic Matter

The following organic matter should be tried:
- Animal manure (farmers already apply manure on dune farms),
- Crop residues (this will raise the problem of appropriate tools),
- Green plants (Cowpeas will be quickly introduced and will be intercropped with corn. It could even be grown in monoculture).

c) Crop Protection

This component will be approached with care for various reasons:
- accidental poisoning of people,
- pollution of the water table through wells, and
- availability of products.

Phytosanitary problems in the wadis should first be identified. The past problems reported to the team were termites and birds. The best method of dealing with termites is frequent submersion.

2. Recommended Method of Introducing the Improved Technical Packages:

Volunteer model farmers' plots will be used to introduce the techniques and their farms will also be used for demonstrations. The trials will be made in each of the wadis selected by the project team.

3. Expected Yields

Using the same local varieties as currently used expected yields are:

	Average Yield Per Ha (in Kgs)			Production on 25 Ares		
	Current	Expected	Increase	Current	Expected	Increase
Corn	600 to 700	2000	1350	162.5	500	337.5
Wheat	600 to 700	2000	1000	162.5	500	337.5
Finger Millet	500 to 600	1000	450	147.5	250	112.5
				462.5	1250	787.5

CHAPTER IV: RESOURCES AND ADDITIONAL ACTIONS

A. Technical Staffing Requirements

1. Long-term Staff

a) Project management should be entrusted to an agronomist with a background in agro-forestry. He should also have a minimum experience of five years in irrigation projects. It is desirable that he have experince in managing farm credit activitied, applied research and agricultural extension. Prior assurances should be sought to endure that this person knows the working/living conditions in the proposed project area. (See annex F for detailed job description).

b) He will be backed by an implementing team made up of: agricultural advisor and the Peace Corps foresters.

- (Preferably, the agricultute advisor should be a Chadian - SODELAC's Chef de Sous Agence already assigned to the project area.)

2. Short Term Consultants

At the beginning of the project a Pedologist may be called upon to make soil and water analysis, make farming recommendations and prepare monitoring procedures.

B. Training of Agents

By the end of the first year of the project, the Chadian agricultural advisor and agents will have received on the job training and should be given an opportunity to get third-country training in an African country with similar conditions.

C. Baseline Studies

For a better understanding of the project area, the following baseline studies should be conducted prior to commencement of project activities:

1) Soil Studies focusing on:
   - physical and chemical properties
   - permeability
   - suitability for irrigation
   - farming suitability and potential for agro-forestry.

2) Groundwater Studies focusing on:
   - depth of the watertable
   - flow
   - water analysis.

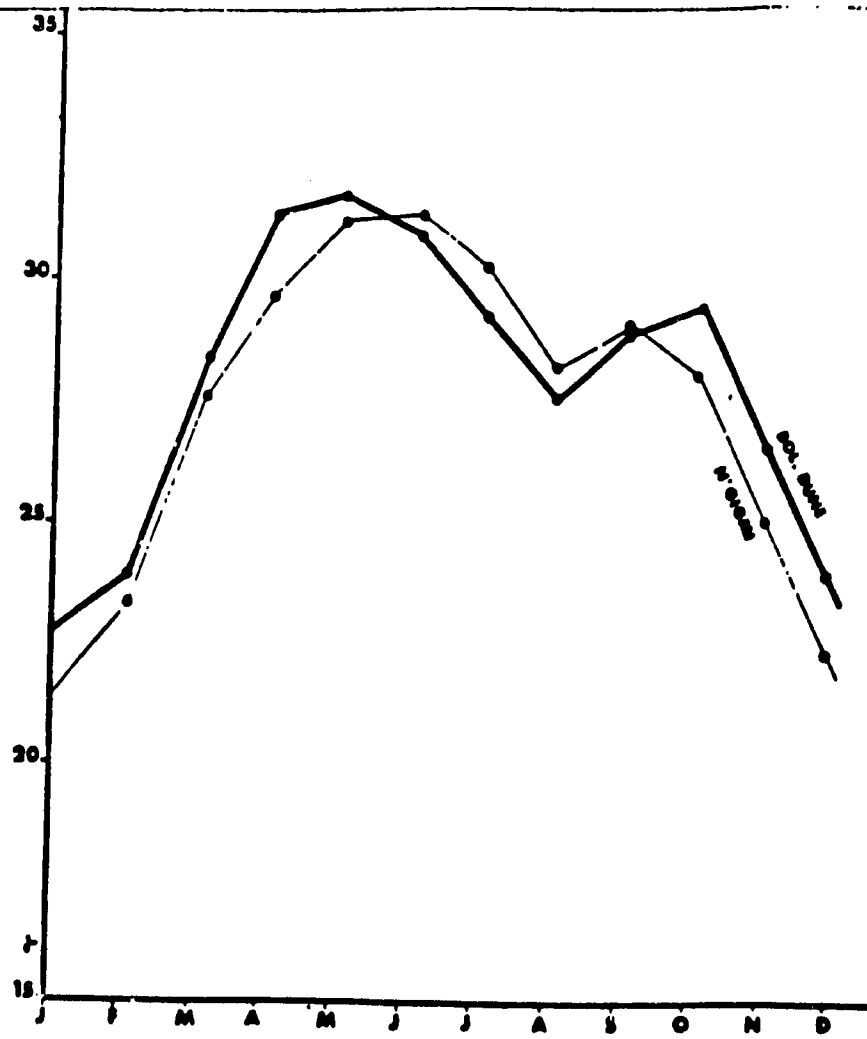
3) Agro-pedological Survey of the project site's wadis

4) Measuring the area of the cultivated wadis

5) Studying wadi production systems and land tenure
   - production unit
   - distribution of plots/population
   - allocation of wadis among villages
   - traditional plot preparation gross and net area
   - cropping schedules in the wadis
   - yields for all wadi crops
   - farming methods used and their rationale.

Tableau 1 . Températures mensuelles moyennes et absolues à Bol-dune (Bouquet, 1974)

BOL-dune (23 ans)	Températures moyennes			Températures absolues	
	minima	maxima	moyennes	minima	maxima
Janvier	13,9	31,1	22,4	5,0	38,2
Février	16,4	33,2	24,3	10,0	42,2
Mars	21,7	36,9	28,7	11,9	44,0
Avril	25,2	39,2	32,2	16,5	46,0
Mai	26,5	38,6	32,5	20,0	44,0
Juin	26,9	36,0	31,5	19,6	43,0
Juillet	25,9	33,4	29,6	19,0	42,0
Août	24,6	30,8	27,7	18,0	39,0
Septembre	25,1	33,1	29,1	19,5	41,0
Octobre	23,3	36,4	23,7	17,0	41,9
Novembre	18,9	35,5	27,2	6,5	40,0
Décembre	14,6	31,6	23,1	4,4	39,2



—LA TEMPÉRATURE MOYENNE MENSUELLE SUR LES RIVES DU LAC TCHAD.

Tableau 2 : Calendrier cultural wadi et dunes

	NOV	DEC	JANV.	FEV.	MARS	AVR.	MAI	JUIN	JUILLET	AOUT	SEPT.	OCT.	Total cycle
1. BLE - saison froide + Legumes													120j
2. Mil liqui (fonio) Saison chaude + Legumes													45-50j
3. Maïs - Pluies + Haricot + divers													90-100j
4. Mil dunes - Pluies													70-80j

ANNEX H. Rural Works Analysis

1. Agricultural Practices: Land Preparation

Observations during the field trip indicated farmers in the project area do not prepare soil correctly.

There was no land preparation for recessional cultivation.

For wadis (or in wet polders) farmers used the daba to prepare their land: soil is slightly scratched to 5cm under the top soil. This operation explains the very low yield in the area, i.e. 300 kg/ha for sorghum.

Several tests indicated that yields can be 25% higher in correctly prepared land, mostly for corn, which is very sensitive to the physical conditions of soil.

By introducing the long-handled hoe and teaching farmers to till deeper (15cm/20cm) with the new tool, the production might be increased by 20%-25% for corn.

Farmers can adopt some of the following suggestions:

a. Start preparing the fields right after the rainy season, while soil is still wet. This possibility depends on the timing of the rainfed crop.

b. During the dry season, prepare the fields after an initial wetting of the soils by irrigation .

More demonstration tests will be undertaken during Phase One to help determine the quantity of water needed for irrigation prior to soil preparation.

2. Measurement of the yield of Shallow Wells

Conversations with farmers in the project area indicated that in some areas the level of the water table has lowered by 1m. every five years. CARE/Chad found, in Kanem, a 3m. lowering of the water table in the last 20 years.

These facts stress the need for careful planning in using limited water resources.

The measurement of the yield of the shallow wells is a most urgent study to be performed. This operation should be conducted prior to the determination of the selected wadis, and then be extended to every sample well in each wadi under cultivation, to gather data and to advise farmers on water use.

The basic procedures for testing the yield from wells is to lower the standard water level by pumping, and observing the time taken for the water to recover its level. The quantity of water removed from the well by pumping will be the same as the quantity required to replace it. This quantity, divided by the time of recovery will give an approximate figure for the yield, sufficiently accurate for most purposes. The yield of many wells varies with the season of the year.

The quantity of water extracted during the test can be measured in containers outside the well, or, in the case of a hand-dug well with a regular cross-section, by multiplying the area of the cross-section by the change in water level. If, for example, the water level is lowered 2m in a circular well 1.3m in diameter, the volume of water removed will be: $M/4 \times (1.3)^2 \times 2 = 2.65m^3$.

If it takes 4 hours for this water level to recover, the yield of the well is $2.65/A = 0.663m^3/h$ or $663/3600 = 0.181/s$.

This well would yield 0.181/s continuously for 24 hours a day. If it was intended to be used for irrigation, drawing water for 10 hours a day, water could be extracted at a higher rate, depending upon the storage capacity of the well. Suppose there is no water left when the level is lowered by 2m at the end of the day, and during the night the water level rises 2m. The total amount of water which can be extracted in 10 daytime hours will be the yield in 10 hours plus the storage volume, and this amounts to: $10 \times 0.663 + 2.65 = 8.28m^3$. This is equivalent to a yield of $0.828m^3/h$ or 0.231/s during this time.

References: FAO - Small Hydraulic Structures - Irrigation and Drainage Paper 26/2, FAO, Italy, 1975.

Small Scale Irrigation, Peter Stern, I.T.P. 1984.

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3. Water Lifting Efficiencies

An evaluation of the efficiency of three water lifting systems is made below:

1. the traditional system using the shaduf;

2. an improved system using the USAID universal treadle pump; and

3. a motor pump.

The evaluation is based on a typical plot with the following assumptions:

- area to be irrigated: 0.25 hectares

- crop: tomato in dry season

- gross irrigation requirement: 8,500m^3/ha or 2,125m^3/0.25 acres

- duration of irrigation requirement: 130 days

- water need is assumed to be the same during the cycle, then, daily gross water requirement is 2,125 - 130 = 16.35m^3/day

- Brief descriptions of the three systems follow:

  a. The shaduf can draw out 60^l/min, and the output is 3.6m^3 x 0.65 = 2.34m^3/hour; (0.65 is factored rate to account for rest periods while working).

  b. The universal treadle pump can draw out 2^l/s at 4m head, and its output may be estimated at 7.2m^3 x 0.65 = 4.68m^3/hour;

  c. The motor pump (a model available in Chad) has a maximum output of 20m^3hr at 14m total head and is powered by a 3-5 HP gasoline engine. The motor pump will be operated at low speed, corresponding to an output of 12m^3/hr during the test, consuming around 0.61 of gasoline per hour according to the theoretical consumption of gasoline by HP developed by hour.

d. Costs

The shaduf costs 1000 CFA, and can be used for two years. The cost per year is 500 CFA.

The universal treadle pump costs 70,000 PCFA and is supposed to be written off after 3 years.

The motor pump costs 400,000 FCFA (local duty-free price) including accessories, and is supposed to be written off after 5 years or 6,000 hours, with maintenance and repair costs estimated at 50% of the intitial cost during this period.

Table of Cost Comparison (Straight-line Depreciation is Applied):

No.	Description	Shaduf	AID/Universal Treadle pump	Motorpump
1	Time needed for irrigation hr/day	7 hours	3h 30 mins	1h 20 mins
2	Operating costs/m^3	N.A.	N.A.	24 FCFA
3	Depreciation cost	negligible	6.5 FCFA	6.66 FCFA
4	Maintenance/repair costs/m^3	N.A.	-	3.33 FCFA
	Total costs/m^3	N.A.	6.5 FCFA	33.99 F or 34 FCFA

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Comments

a. The farmer using the shaduf must pump 130 days, 7 hours a day. He is exhausted and usually does not provide the required amount of water. The lack of adequate water is the underlying reason for the very low yield in the wadis, e.g.: 300 kg/ha for sorgho.

b. The universal treadle pump's user must pump 130 days, 3.3 hours a day, or pump 7 hours every two days.

He might have time to provide better care (soil preparation etc.) and is able to provide the required amount of water. He will obtain a better production than the one pumping with the shaduf.

c. The farmer using the motorpump needs only 177 hours for pumping during the cyle of production, he may then use the (130-22) 108 days for other activities.

This important gain in time is subject to the availability of water from the wells. He may have to pump daily, or once every two or three days depending on the yield of the well. He also must work ten to twelve days to improve the soil preparation by using the improved hoe. (We know that a man using an improved hoe for tilling needs 40 days to till one ha of land - ISRA-SENEGAL/CASAMANCE).

With a well prepared land provided with the right amount of water, he can expect to get a much higher yield.

The operation costs him 34 FCFA x 2,215 = 72,250 FCFA for watering, including depreciation but he is assured to have a good crop; he has enough time to grow more crops if land and water are available. He can also try selling out pumping services to neighbors, making profits from pumping services.

Since his pump is calculated to be used 1,000 hrs/year, and since with his 3 crops/year he will not use more than 530 hrs/year, he may then offer 470 hours of pumping services to other farmers during the year.

He might use the figures in the table to estimate the unit price to be charged to the customer, for example, $1m^3$ provided can be charged 34 FCFA x 1.4 = 47 FCFA.

To be economically justifiable, the motorpump must not be under used.

d. Special observations while testing motorpump.

(i) A small motor pump of 3 to 5 HP is capable of providing from 5 to 10 times more water/hr compared to the shaduf. This increase in the discharged flow requires an adequate conveyance system (canal, slope, etc.) to avoid losses, seepage during the distribution. The actual system (basin irrigation) set up for shaduf should be improved. The technical guidance for modifications will be provided by the Rural Works Engineer of the project.

(ii) The traditional system of basin irrigation with unlined earth canals is retained because farmers can easily rebuild and maintain this system.

(iii) Some improvements to increase the capacity of stockage of the wells might be necessary and will be recommended in time by the Rural Works Engineer of the project, after examining data from field studies.

Finally, the technician must present for evalution a more complete economic survey on the effects of different systems of pumping. Lack of reliable current data and of time were limiting factors to achieve this during the design effort.

4. Water requirements - Standard for Irrigation Water - Tolerance of Crops to Salinity.

a. Water requirements - irrigation water requirements are estimated based on the following assumptions:

(i) The useful rainfall for plant-growing is 50% of the average rainfall.

(ii) Groundwater can provide 100% of water requirement in wadis.

(iii) The efficiency is 0.6, taking into account losses by infiltration in the fields and in the distribution system.

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b. Standards for Irrigation Water
(TDS = Total Dissoled Solids)

Quality of Water	Crops suited	Conductivity	TDS mg/l	Boron ppm
Good	All crops	50 - 500	D-600	0 - 0.5
Moderate	injurious to sensitive crops	500 - 2200	600 - 2000	0.5 - 2
Poor to Unsuitable	Harmful to most crops	Over 2200	Over 2000	Over 2

Small-scale Irrigation - Peter Stern

The quantity of salt in a sample of water can be determined by boiling the sample dry and weighing the solid residue which is left. This gives the Total Dissolved Solids (TDS), expressed in parts per million (ppm) by weight, equivalent to milligrams per litre (mg/l). Salinity is also indicated by the electrical conductivity of a solution.

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c. Relative Tolerance of Crops to Salinity

High Tolerance	Medium Tolerance	Low Tolerance
Barley	Alfafa	Citrus
Cotton	Cantaloup	Cloves
Date palm	Figs, grapes	Field beans
Grasses	Maize, oats	Green beans
Rape	Olive, peppers	Soft fruits
Spinach	Potatoes, rice	
	Sorgho, wheat	
	vegetables	

FAO - Irrigation and Drainage Paper 24

FAO - Crop Water Requirements - 1977

The above table may help farmers selecting crops suitable to their land. The project will help in the determination of the degree of salinity of individual wadis.

5. Salinization and Waterlogging

During our field trip, we observed causes of salinization in both abandoned wadis and in parts of wadis under cultivation.

a. In abandoned wadis, salinization occurred most commonly in low-lying areas where groundwater, often quite heavily charged with salts in solution, lies near the surface and is subject to intense evaporation, leaving the salts in the surface layers of the soils.

b. On partly salted wadis, salinity seems to be produced by irrigating with water containing dissolved salts, and where there is a high water table. Salts are therefore deposited in the surface soil layers. This phenomenon is largely due to the small quantity of water drawn down by the shaduf, allowing more evaporation in the conveyance system.

c. Waterlogging occurs when the upper layer is shallow, reasonably permeable, lying over a very dense impermeable clay. As surplus water cannot drain easily through the underlying impermeable clay, the top soil may remain waterlogged.

ANNEX I: ILLUSTRATIVE CROP BUDGET COMPARISON OVER ONE FULL CROPPING SEASON

The budgets which follow give an indication of crop yields and human labor time for irrigation from shaduf, human powered hand pump, and water pumps.

Yields are improved primarily by providing sufficient water to the areas cultivated, and also by increasing the density of planting. Since both the hand pump and the motor pump are, in principle, capable of supplying sufficient water to the crop, no improvement in yield is assumed from use of the motor pump.

Corn is substituted for fonio in the rainy season because it is the preferred food grain in the region, and because it is higher yielding, given adequate irrigation, than fonio. Almost no maize is produced in the wadis now, because it is not possible to irrigate it adequately with the shaduf.

Onions in the cold season represent all increased vegetable production all year long. The increase in revenue from onion production, therefore, really represents an improved cash flow spread almost evenly across the year from all minor crops cultivated in the wadi.

'Onion' statistics are omitted from the totals in the summary tables to make the changes in the basic food production system more evident. But all cropping activities are included in all other calculations.

ASSUMPTIONS

Farm Family of 5 persons,
of which 3 active

Crop yields & sowing density (kg/ha)

Crops	Trad'l yield	seed	Improved yield	seed	H2O req. m3/ha.
Millet on dunes	300	10	300	10	-
Fonio in rainy season	600	10	NA	NA	NA
Fonio in dry season	500	10	1000	15	2000
Wheat in cool season	1200	100	2000	200	5000
Corn in rainy season	NA	NA	2500	30	8000
Onions in cool season	15000	NA	25000	NA	3000

Water Pumping System	m3/hr	cost	life	m3 per m-day
Shaduf	2	3,500	3 yrs.	14
Piston Pump	4.68	70,000	3 yrs.	32.76
Motor Pump	10	400,000	10,000 hrs	70

Irrigation system efficiency 65%
No impact on life of well from different water lifting system.
Labor time: Adult labor time is estimated; bird protection by children.

Average working day in wadi	7 hrs.
Current wage for day labor (opportunity cost)	500 FCFA
Annual grain requirement per person (as per WFP)	125 kgs
Average annual rainfall	300 mm

Crop price	per korro		per kg (1 korro = 2.5 kgs)	
	low	high	low	high
Millet	100	250	40	100
Fonio	100	250	40	100
Wheat	100	250	40	100
Corn	100	250	40	100
Onions (per sack) (70 kg. sack)	6000	10000	86	143

Crop price ranges are derived from conversations with farmers and merchants at the markets of Dibinentchi and Isseirom, and from discussions with SODELAC agents. No time series data is available.

Gasoline prices

Gasoline at N'Djamena		250	FCFA/litre
Official transport cost per litre		29.45	
Gasoline at Ngouri today	400	279	Best price

Traditional Production System - Annual Cycle of Cereals + Onions
Shaduf

Season	Crop	Hectares	Labor (man-days) General	Irrigate	Applied H20 m3	Total Yield
Rainy	Millet	1.5	15	0	0	450
Rainy	Fonio	0.15	15	20	70	30
Cold	Wheat	0.15	27	104	365	180
Cold	Onions	0.15	NA	86	300	1500 *
Hot	Fonio	0.15	15	40	140	75
CEREAL CROP TOTALS		2	72	164	575	795 *

* Onions are included for illustration of the role of vegetable crops but are not included in the totals.

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Total cereal production	795
less 15% for seed + losses	119
Available cereal supply	676
supply per person	135

which is the subsistence ration calculated for the Sahalian Zone.

Total applied water per year (inc. onions)	875 m3
for argument, say	1000 m3
Annual depreciation on shaduf	1167 FCFA
cost per m3 delivered	1.2 FCFA/m3

Onions, the most important cash crop in the region, are used as a proxy for all commercialized vegetable production. Other vegetables will also be grown in all seasons.

Alternative Production System - Annual Cycle of Cereals + Onions

Season	Crop	Hectares	Human powered Piston Pump Labor (man-days) General	#Irrigate	Applied H2) m3	Total Yield
Rainy	Millet	1.5	15	0	0	450
Rainy	Maize	0.15	30	35	750	375
Cold	Wheat	0.15	27	35	750	300
Cold	Onions	0.10	NA	14	300	2500 *
Hot	Fonio	0.15	15	14	300	150
CEREAL CROP TOTALS		2	87	85	1800	1275 *

* Onions are included for illustration of the role of vegetable crops but are not included in the totals.

Irrigation labor time is adjusted by irrigation system efficiency.

Total cereal production		1275
less seed requirement		52
less storage losses @	10%	133
Available cereal supply		1091
less Family Subsistence requirement		675
Surplus Available for sale		416 kgs
Estimated value	Highest	41,558 FCFA
	Lowest	16,623 FCFA

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Annual Net Benefit Calculation	Highest	Lowest
Cereal Revenue	41,558	16,623
Onion incremental revenue	142,857	85,714
TOTAL NET REVENUE GAIN	184,415	102,337
Labor time saved 136 m-days	68,190	68,190
TOTAL ECONOMIC SAVINGS	68,190	68,190
ANNUAL NET ECONOMIC BENEFIT	252,605	170,528
ANNUAL NET CASHFLOW	184,415	102,337

The cost of the pump (70,000 FCFA) is recovered in the first year.

Total pumped water per year	3231 m3
Annual depreciation of pump	23,333 FCFA
cost per m3 of water delivered	7.2 FCFA/m3

Alternate Production System - Annual Cycle of Cereals + Onions
Motor Powered Pump

The production system is assumed to be the same for either the human powered or the motor powered pump. No increase in area farmed is assumed. The only changes for each crop are the cost of applied water, and the labor time required to irrigate.

Cost of Water:		
Pump cost	400,000 FCFA	
Useful life	10,000 hrs	
Hourly depreciation	40 FCFA	
Output	10 m3/hr	(FCFA/m3)
Unit cost of depreciation		4
Unit cost of maintenance & repair (50% of cost)		2
Fuel consumption	1 l./hr	
Fuel price	400 FCFA/l.	
Unit cost of fuel		40
Unit cost of lubricant (20% of fuel cost)		8
Total Unit Cost of Operations		54
Variable Unit Cost		50
Fixed Unit Cost		4

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Season	Crop	Hectares	Labor (man-days) General	#Irrigate	Applied H20 m3	Total Yield	Cost of Water #
Rainy	Millet	1.5	15	0	0	450	0
Rainy	Maize	0.15	30	16	750	375	62,308
Cold	Wheat	0.15	27	16	750	300	62,308
Cold	Onions*	0.10	NA	7	300	2500	24,923
Hot	Fonio	0.15	15	7	300	150	24,923
TOTALS		2	87	40	1800	1275	174,462

* Onions are included for illustration of the role of vegetable crops but are not included in the totals.
\# Cost and labor time are adjusted by the irrigation system efficiency factor.

Crop production is assumed equivalent to production achieved with the human powered piston pump. No additional inputs have been applied, and water application is adequate with both systems.

Annual Net Benefit Calculation	Highest	Lowest
Current price of gasoline at Ngouri		
Cereal Revenue	41,558	16,623
Onion incremental revenue	142,857	85,714
TOTAL NET REVENUE GAIN	184,415	102,337
Incremental Expenses (inc. dep.)	174,462	174,462
TOTAL INCREMENTAL EXPENSES	174,462	174,462
Labor Time Saved 189 m-days	94500	94500
TOTAL ECONOMIC SAVINGS	94500	94500
ANNUAL NET ECONOMIC BENEFIT	104,453	22,376
ANNUAL NET FINANCIAL BENEFIT	9,953	(72,124)
plus depreciation	12,923	12,923
ANNUAL NET CASHFLOW	22,876	(59,201)

Each pump is capable of serving two hectares. The average family in this calculation farms 25 ares. Therefore, eight families can benefit from one pump.

	Highest	Lowest
ANNUAL NET CASHFLOW	183,009	(473,609)

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Annual Net Benefit Calculation	Highest	Lowest
Best possible price of gasoline at Ngouri		
Cereal Revenue	41,558	16,623
Onion incremental revenue	142,857	85,714
TOTAL NET REVENUE GAIN	184,415	102,337
Incremental Expenses (inc. dep.)	127,551	127,551
TOTAL INCREMENTAL EXPENSES	127,551	127,551
Labor Time Saved 189 m-days	94,500	94,500
TOTAL ECONOMIC SAVINGS	94,500	94,500
ANNUAL NET ECONOMIC BENEFIT	151,364	69,287
ANNUAL NET FINANCIAL BENEFIT	56,864	(25,213)
plus depreciation	12,923	12,923
ANNUAL NET CASHFLOW	69,787	(12,290)

Each pump is capable of serving two hectares. The average family in this calculation farms 25 ares. Therefore, eight families can benefit from one pump.

	Highest	Lowest
ANNUAL NET CASHFLOW PER PUMP	558,296	(98,323)

Two way analysis of variation in fuel price and consumption

BEST CROP PRICES

		Fuel cost FCFA/L.			
	+E191	280	400		
Fuel cons. L./hr	0.5	989,409	803,317	Mean:	632,733
	1	555,194	183,009		

WORST CROP PRICES

		Fuel cost FCFA/L.			
	+G191	280	400	Mean:	120,042
Fuel cons. L./hr	0.5	332,791	146,698		
	1	(101,425)	(473,609)		

AVERAGE CROP PRICES

		Fuel cost FCFA/L.			
	+E191	280	400		
Fuel cons. L./hr	0.5	661,100	475,008	Mean:	304,423
	1	226,885	(145,300)		

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Assume for the sake of argument, since we have no statistical distributions to work with, that the means represent a reasonable average of the true cost of operating the pump (i.e., somewhere in the middle of the range of values one can imagine, given current fuel prices, and the manufacturer's data on the pump and operating conditions). It seems reasonable that farmers with the capacity to generate a fairly reliable surplus will be less likely than average to sell their crops at the worst possible prices. If they can wait only 30 to 60 days to sell, they can expect a substantial improvement in price received. Assume, therefore, that the probability of sale at harvest time is 25%, that of sale at the best price is 25%, and the probability of sale at a price of 175 FCFA per korro (the average price) is 50%. The expected annual cashflow to a pump becomes:

Probability	Value	Product
0.25	120,042	30,011
0.5	304,423	152,212
0.25	632,733	158,183
EXPECTED VALUE		340,405

While this is admittedly a facile argument, it does give some indication of the potential earnings from a motor-pump per year. The major risk factor which has been ignored is the technical risk of crop failure due to pests, disease, etc.

This value should be compared with the cost of the pump, recovered over three years (assuming two hectares are served, a three year life is normal).

Cost of pump	400,000 FCFA
Interest rate	12%
Life	3 yrs
Capital recovery factor	0.416348
Annual recovery cost	166,540
Annual expected cashflow	340,405
less recovery cost	166,540
Annual net cashflow	173,866
Per farmer net cashflow	21,733

Compared with an annual per capita income of US$ 82.00, or 28,700 FCFA, this represents a substantial sum. This argument is not intended to make exaggerated claims for the potential benefit to the introduction of gasoline powered pumps into the

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Ngouri area. It is one line of reasoning, which ignores many very important technical and social problems, which indicated that the technology is worth trying in the field.

The critical point to note from the economic and commercial point of view is that cashflow is dependent upon the sale of high value crops. Food grains alone cannot justify the expense of operating the pump. As discussed in Annex K the potential for widespread increases in production of high value crops is constrained by many factors.

An alternative to remaining in the wadi in the hot season, where we have assumed that the only productive activity is cultivation of fonio, is for farmers to take their families and go down to the polders. This is an attractive proposition, even if they have farmed the wadi in both the rainy and the cold season, because a family of three active farmers could probably produce more than 1500 kgs of maize in a recession crop in a good year. The team did not have the time to investigate first-hand production conditions and living conditions in the polders, but from numerous conversations, the following points were revealed.

1) If the rainfed millet crop fails, under current production conditions people must either go to the polders or migrate out of the area, e.g. to N'Djamena. Only about 5% of the population of the immediate Ngouri area remain to work in the wadis at present. Comparison of the production possibility estimated for the hot season wadi, versus the 1500+ kgs of maize from the polder will immediately show the current situation. Nonetheless, some people do remain in the wadis, even in bad years.

2) Production in the polders is very risky also, much more so than production in the wadis. The polder may remain dry if the lake fails to rise. Many polders have not seen water for more than ten years now, and are slowly becoming wadis themselves. If the lake rises early, the corn crop may be flooded out. Over 10,000 hectares of maize were lost in this way in 1985.

3) Health conditions in the polders are very bad. People complain about constant illness, lack of potable water (lake water is often used), the death of children every year from water-borne illness and other diseases (a measles epidemic claimed 80 children last year), malaria and bilharzia, etc.

4) It seems reasonable to assume that there is some likelihood that some fraction of the population which currently makes the annual trek to the polders would prefer to stay and farm the wadis, if only a better system of water lifting were available. The basic complaint about wadi agriculture is not that it is not productive, on the contrary, it is recognized as very productive. The difficulty of working long days lifting water is simply more than people can stand.

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ANNEX J: TRANSPORTATION AND MARKETS

1. Transportation

The lack of serviceable roads is a major constraint to development in the Lac Prefecture. Transportation rates are the highest in the country south of the Saharan Zone. The lack of reliable transport at reasonable cost makes marketing agricultural products and procurement of inputs prohibitively expensive. It results in a generally depressed level of commerce, which impedes resource development and the accumulations of capital. The Ngouri area is an isolated area, with important consequences for project design, as discussed below.

The Cooperatif Tchadien des Transporteurs (CTT), will serve any area at the official rate. The official rate for transport of agricultural products (excluding food aid) in the Lac Prefecture is 117.80 FCFA per ton-kilometer. Ngouri is roughly 250 kilometers from N'Djamena by way of Massaguet and Massakoury. This results in the following illustrative costs of transport between Ngouri and N'Djamena:

	(FCFA)
Rent 5 ton truck (round trip)	294,500
One ton of grain (one way)	29,450
One sack of grain (one way)	2,945

Taking 10,000 FCFA as a rough value for a sack of grain in the N'Djamena market, this represents roughly 30% of the value of the grain. Taking 15% to 30% as a nomal range of marketing margin, it is clear that a substantial price differential is required to make grain trade into or out of the Ngouri area commercially attractive.

In fact, a transporter interviewed at the market at Dibinentchi said he had never hauled grain, although he managed four of the fifteen trucks which serve the area. Interestingly enough, he would haul onions for 1500 CFA per sack, which is a considerable discount off the going rate. Onion sacks apparently weigh in at about 70 kg., which converts to about 85 CFA per ton-kilometer. Onions and jujubes are the only agricultural products which he admitted to hauling regularly and in quantity.

When questioned about rates, he offered, after some discussion, to provide a 5 ton truck round trip to N'Djamena for 350,000 CFA, but said he would load 6 tons on it, which would make the rate almost exactly the same as the official rate.

The Sous-Prefet at Ngouri informed us that 15 trucks serve the area regularly. Of these, 10 carry 5 to 6 tons, and 5 are heavier 10 or 12 ton vehicles. The general impression of very limited transport service notwithstanding, the private sector in Chad would almost certainly respond to an opportunity for profit. If a product exists that is worth hauling, the merchants and transportors will find a way to haul it.

A corollary to this is that if a farmer has the ability to produce more than he can consume, he will produce something that the market will reward him for. Markets take place once a week, and although there is no official market news service in Chad, marketing is virtually everyone's business, and market news is probably sufficiently current to allow farmers to make reasonably good decisions. Attempting to introduce an artificial marketing system, such as the SODELAC vegetable marketing effort in the late '70's, can do more harm than good, as people learn to produce goods for which no real commercial market exists. Potatoes and cabbages, eggplant and squash are apparently in great surplus around Bol, as market gardeners continue to produce these crops for which they no longer can find an outlet.

2. Markets

The project must consider both input markets and as product markets. The basic project premise of sustainability requires that the private sector provide all essential marketing services for inputs and products. The GOC is not in a position to commit additional resources to these activities, and the farmers participating in the project would be poorly served if they were left reliant upon government services.

The experience of vegetable growers in the Bol region is an example of what can happen in similar circumstances. Some of these people are still producing cabbages and potatoes and other "exotic" vegetables just as they did, very profitably, when SODELAC was providing transport and marketing services to N'Djamena. Transport out of Bol is almost non-existent at present, however, and there is a gross surplus of these products.

(i) INPUT MARKETS

Wadi farmers in the Ngouri area are served primarily by the traditional market system for their production input needs. Inputs purchased on local markets include:

Seed - a premium is paid at sowing time for seed grain, which is recognized by its origin in the field of a farmer who had a very good yield, or by its visible qualities. Prices quoted were:

Wheat	1,000 cfa/Korro
Corn	400 cfa/Korro
Millet	1,000 to 1,500 cfa/Korro

These prices represent roughly a 60% premium over the highest reported prices paid during the year for these food grains, and are almost four times the normal seasonal high prices.

In recent years, due to a succession of crop failures, seed provided by FAO was brought in and distributed by SODELAC, with very poor results. The seed was not suited to the conditions of the region, being a long cycle variety of millet. The local short cycle varieties are still in short supply. Superior varieties from among the local lines have not been selected and multiplied systematically, and with continuing recurrent drought, some of the best genetic material is at risk of disappearing altogether.

Vegetable seed is available from SODELAC and in N'Djamena at reasonable prices (300 - 500 cfa/ package). Onion farmers conserve seed, and probably so do all growers of traditional vegetable crops. Garlic seed is apparently unavailable, although this is a very high value crop.

Hand tools - local blacksmiths make a variety of very serviceable tools according to traditional design:

hand hoe @ 400 - 500 cfa (polder hoes are more costly than dune hoes),

sickles (none seen at this time of year),

Needles for sewing up grain sacs,

fish hooks, arrow points, knives, all razor-sharp.

A hand hoe might last one to three years, depending upon the use and the user. Clearly, the capital required to go into farming is very modest.

The shaduf is apparently usually made by its user, requiring only the purchase of a water basket. Two days of work for two men are apparently sufficient to install a shaduf. Add another day for selecting, cutting, and hauling poles and cross-members, and at the going rate for wage labor of 500 cfa/day, a shaduf will cost roughly 3,500 cfa. With a useful life reported at two to three years, this also represents a very modest investment. A well is the work of two days for two men, and might last five to ten years, depending upon the aquifer.

The two people we met who were using or had used motor pumps were able to purchase gasoline and oil locally, at a price which clearly reflects the cost of transport, and perhaps

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also the lack of demand. There are no mobylettes, no motorcycles, only government or donor vehicles, and apparently no mills or small engines of any kind which function regularly as part of the local economy. Prices quoted in a wadi next to Ngouri were:

Gas	400 cfa/liter
Diesel	325 cfa/liter
Oil	1250 cfa/liter

The current retail price of gasoline in N'Djamena is about 225 CFA per liter. The official transport rate for petroleum products would add about 30 FCFA per liter to this for the 250 kilometers to Ngouri. Both individuals interviewed who owned and operated motor pumps had suffered from the high cost of fuel and oil, and unavailability of parts and service. One man had sent to Nigeria for replacement parts, and the other had gone to Massakoury in search of a mechanic.

The lack of an input market infrastructure is a severe constraint to the introduction of more sophisticated systems. Lack of demand will effectively prevent any businessman from investing in inventory that he cannot turn over. All persons familiar with mechanical services and repair in Chad agreed that parts were a real problem, even for the fleets of food aid trucks. This would indicate that there are other factors inhibiting businessmen from investing in inventory also, such as a fear that events similar to those of the late seventies will again force them to flee the country, leaving their assets behind.

The numerous donor projects intent upon developing irrigated perimeters along the Chari and elsewhere in Chad may improve the situation for motor pumps as the number in service increases dramatically.

It is not in the best interest of sustainability for the project to attempt to provide input marketing services. Means must be found to provide all necessary inputs through the private sector. A credit program might be appropriate for stimulating interest in certain needed items or services, but commericial viability remains the acid test.

Two specific services which were considered were the local manufacture of hand pumps, and repair and service of motor pumps. These elements should be addressed by the pre-implementation study. A further possiblity for consideration is the provision of some form of direct marketing service by arrangement with a transporter. This, too, will require further detailed study to evaluate the feasibility of the idea, and identify individuals or firms who might provide the service.

To address the question of world market impact on project items in detail is beyond the scope of this effort. Two inputs which are necessarily imported are petroleum products and PVC pipe for local manufacture of pumps. The current world market situation for petroleum products would seem to indicate that prices will remain low and relatively stable for the duration of the project. Saudi Arabia is bringing on-line a vast industrial complex which will manufacture plastics from natural gas. This should have the same effect on prices of this input in the world market.

Inflation effects upon the project have been ignored in the production economics analysis. This is consistent with standard practice, which assumes that all input and product prices will inflate to roughly the same degree, thus cancelling out their effects. Inflation is more of a concern in a financial analysis, where it is to the advantage of the debtor, who repays his debt more easily, as his margin inflates also. But no systematic financial analysis is possible at this point, due to the high degree of uncertainty surrounding project output and product prices.

(ii) PRODUCT MARKETS

Data Availability

Official statistics are severely lacking for the Lac Prefecture. Those statistics which are available are often doubtful, because they are generated by rules of thumb and rough estimation rather than systematic observation. This situacion is unavoidable to the extent that the government agents in the area lack the resources to carry out detailed surveys or data gathering activities. Agents are generally without any means of transportation, while their area of responsibility extends over hundereds of square kilometers of very difficult terrain.

Population statistics as such are non-existent. The last census was in 1968, and figures have been developed by simple extrapolation based upon an assumed rate of population growth ever since. Estimates of the population in the Lac Prefecture encountered in the literature range from 144,000 to 250,000. Even the sedentary populations are highly mobile in response to the severe conditions of recent years, making an estimation of the effective working and consuming population in any given area still more difficult.

Production statistics are also dubious, although they are often estimated from known quantities, such as tons of seed distributed. This can also lead to various sorts of error, but there is a current basis for the statistics generated. The FAO

Food Assessment Reports indicate, as quoted in Basic Agricultural Information for Chad, USAID/ADO, Nov. 1985, that food grain production in the Lac Prefecture has varied between 4,500 and 33,330 tons since 1980. Using the 144,000 population figure for the region, this translates into between 31 and 231 kg/person per year. The subsistence cereal ration for the Sahalian Zone is estimated at 135 kg/per person per year. The importance of in and out migration in the Lac Prefecture is evident.

Food Production and Market Size

Persons contacted were generally in agreement that the area has been a grain deficit region for the last several years. Even in good years, localized rain shadows can cause severe hardship for some parts of the population. The son of the Chef de Canton of Ngouri reported that an area 7 kilometers wide and 15 kilometers long had had absolutely no millet harvest last year, while other areas had a modest harvest. The SODELAC agent at Isseirom reported that hunger was a severe problem in the islands at present, and that promised food aid was not received. It is felt that that these are not isolated incidents, and that even in good years, there will be elements of the population who will be forced to migrate down to the very unhealthy conditions of the islands (which the design team did not see) to survive.

Market statistics are non-existent for the region. While ONDR has a program of collecting the mercuriales du marche (market price surveys), SODELAC apparently does not. The range of prices used in the production analysis in section VI.C. were gleaned from numerous conversations with people in the markets and government officials, and from observations of current market prices in the area. These are very rough estimates, but there is no time series data available. In general, food grains sell for between 100 FCFA (at harvest time and for a few weeks thereafter) and 250 FCFA (in April-May). There are periods when the price goes much higher, but for the purpose of estimating returns to the project participants, these figures were selected as being conservative and justifiable.

Estimates of the quantities of grain traded are also not available. It was interesting, if futile, to attempt to estimate the number of persons and quantity and value of products passing through the markets at Dibinentchi and Isseirom. People come and go, goods are displayed and hidden in back rooms, and some of the most important transactions take place in courtyards far removed from the marketplace.

Digression on Weights and Measures

A further complication is the system of weights and measures employed in the marketplace. The basic units of sale are:

the spoonful,
the shotglass full (pony),
the 70g. canful,
the glassful,
the small heap,
the large heap,
the Korro - a specific bowl, which holds perhaps 1.5 L., heaping full - said to contain roughly 2.5kg of grain
the Sackful - by definition, 40 korros. The MASI Grain Marketing Study reported that a sack may be 45 korros on purchase and 40 upon sale, but this was not observed by the team.

Sacks are also reported to hold 100 kg of grain, 70 kg of onions, 60 kg of dried gumbo, etc. And small sacks of 50 kg of rice are also sold. This makes calculation of the value of production from a farmer's field difficult in the case of grain, and practically impossible in the case of vegetables.

Farmers' fields are measured by the corde, a traditional measure which varies around 60 meters. This, too, makes calculation of productivity from existing cultural practices difficult to evaluate, since it is a rare farmer who has any notion of how many ares he is farming. Furthermore, in the wadi systems, which employ small one-meter-square basins for irrigation, the land area lost to irrigation system structures can be very large, relative to a more extensive, efficient system of water application, and farmers fields vary considerably in layout.

One would expect a food deficit area to show grain prices based on the central market plus transportation and marketing margin, and a food grain surplus region to show prices based on the central market less marketing margin and transport. A young man who manages four of the perhaps fifteen trucks which serve the market at Dibinentchi informed us that he never hauls grain out of the area. His vehicles are a 5, a 6, and two 12 ton trucks. This can be taken to mean that there is no significant commerce in cereals out of the area. Wheat and corn, the principle grains produced in the area, are not particularly high value crops on the N'Djamena market. The complex regional dynamic, discussed in detail below, makes forecasting grain prices, especially in the absence of any hard data, a difficult task. It would not be surprising to find prices falling over the next few years, if:

the Italian road goes all the way to Massaguet,
the Italian polder project is successful in substantially increasing grain production,
the region does not suffer another severe drought and period of falling lake levels.

The Office National Cerealier (ONC) is charged with trying to stabilize food grain prices throughout the country. This is a difficult task, and the program has never really gotten off the ground, although a number of recent commitments have been made by European donors to sustain it. In principle, the ONC will intervene whenever a grain surplus exists, buying to stabilise the farmer price and create a store for later resale. The financial resources required to undertake and sustain such a program, which might require the ability to purchase perhaps 20 per cent of the national grain crop and result in very substantial operating expenses, are not likely to be available in the forseeable future.

The basic marketing assumption of the project, as discussed below, is reliance upon local markets. The production analysis in section VI.C. suggests the following scenario, if 300 hectares are brought into production in the wadis over the life of the project:

Basic production unit size	25	ares
Total production units	1000	
Surplus grain production per unit	416	kg
Total surplus grain production	499,200	kg
or	499	tonnes
Population of Lac Prefecture	144,000	persons
Grain requirement per person	135	kgs
Total grain requirement	19440	tons
Average annual production last 3 yr	23060	tons
Average annual surplus last 3 yrs	3620	tons
Project production as percent of surplus	14%	

This is fairly significant percentage of the total marketable surplus in the region. But this is the maximum the project hopes to achieve in its lifetime, and will not be realized until the last year. At that time, the transportation situation will, hopefully, have improved, making distribution to other regional markets, such as Mao, Massakoury, and Massaguet easier and less expensive. Informed sources report that people have been coming to the Lac region to buy grain from the Kanem and the Batha from time immemorial. The possiblity of grain prices going sky high again is not discussed, because this does not present a marketing problem.

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Vegetable markets are much more complex than grain markets for many reasons. Perishability of product, inelastic demand, high quantity of production from a relatively small plot of land, low capital requirement for entry, highly seasonal production, large variation in quality and perceptions of quality, etc. are factors which make vegetable marketing a highly specialized and competitive business in the developed world. There is a considerable variety of vegetable products available on the local markets in the Lac Prefecture. These could be grouped into two categories for purposes of commercialization: those which will stand shipping and those which will not. The condition of the roads in the area, and limited access to transportation services (there were no commercial vehicles at the market at Isseirom) make the requirements for shippability fairly rigorous. Major items produced in the region in each category are:

Shippable:
- Onions - the main commercialized crop at present,
- Dried gumbo - an important commodity of trade,
- Dried tomatoes - less so,
- Piment - grows everywhere,
- Garlic - almost none produced for lack of seed or sets, but very high value,
- Potatoes - seed also a serious constraint, many technical production problems, and
- Manioc - demand unknown; ITTA at Ibadan has some highly productive varieties.

Not shippable:
- Fresh tomatoes,
- Fresh gumbo - might ship, but grows everywhere,
- Melons and Watermelons,
- Lemons - might ship, but sold in very small lots,
- Eggplant - white eggplant might ship,
- Mangoes - poor quality, and
- Guavas - poor quality.

Not seen, except in a few private gardens:
- Beets - would ship, and
- Lettuce - difficult to ship.

Not seen at all:
- Cabbage,
- Green peppers, and
- Carrots.

The importance of basing commercialization on local markets is even greater for vegetables than for grains, because of the competition in Bol, and the hundreds of hectares of irrigated perimeters planned for the N'Djamena area, as discussed below. Thus, shippability is a moot point.

In the production analysis in section VI.C., onions were used as a proxy for all vegetable production. Vegetable cropping patterns are too complex to permit an estimate of an "average" vegetable plot in a wadi. The area devoted to grains and onions was selected based on the observation that of 25 ares in production, roughly 15 would be devoted to grains (fonio) and 10 to vegetables year round. This means that 20 ares of vegetable production did not enter into the calculation (rainy and hot season production). The relatively small area devoted to vegetables and their high food and market value lead farmers to apply adequate quantities of water even with the shaduf. This results in a fairly decent yield under current production conditions. The analysis assumes that the value of incremental production is captured in the value of incremental onion production in the one season. This is a conservative assumption.

The rainy season fonio crop was replaced by a rainy season maize crop in the improved water lifting system analysis because maize is the preferred food in the region, and is not cultivated in the wadi only because it is very demanding of water.

Estimating the value of vegetables marketed in the region is another difficult task. Many farmers cannot say how much they earn from their onions, because they harvest a little at a time, replanting as they go, and at the end of the season, have no idea what quantity of onions they have produced or what they earned from them. Other vegetables and spices face the same problem.

However, walking about the rural markets, one could generalize as follows:

	Small Mkt		Lg Mkt	
Seller based estimate	high	low	high	low
Number of vegetable sellers	250	150	1000	750
Ave. value of vege. per seller	3000	2000	4000	3000
Ave. Value of Sales gross	750,000	300,000	4,000,000	2,250,000

	Small Mkt		Lg Mkt	
Buyer based estimate	high	low	high	low
Number vege. buyers	2000	1500	8000	6000
Ave. value of purchase	500	300	700	500
Ave. Value of Purchases	1,000,000	450,000	5,600,000	3,000,000

These numbers are highly speculative, and are useful only to the extent that they seem plausible, and it helps to put some numbers to the question at hand. The production analysis valued onion production as follows:

	high	low
Estimated incremental value	142,900	85,700
Number of project parcels	1000	1000
Total project incremental value	142900000	85700000

There are at least four main markets in the project area, the markets at Dibinentchi (the largest in the Lac Prefecture), NDjiguidada, Isseirom, and Ngouri. Someone from the farm family will go to market at least once a week.

Number of market days/yr	52	52
Value per market day	2,748,077	1,648,077
Value per market day	687,019	412,019

	Small Mkt		Lg Mkt	
	high	low	high	low
High est. % of Mkt value	20%	46%	4%	7%
Low est. % of Mkt value	12%	27%	2%	4%

(This shows the "value per market" as percentage of average estimated value of markets above.)

The large variation in estimates is the natural result of lack of data. These are highly approximative estimates, but are the best that can be done under the circumstances. Pre-implementation studies can further examine the market potential for various crops. It should be remembered that a variety of crops will in fact make up the market basket of project output of vegetables.

Also, other less obvious cash benefits will accrue to project participants to the extent project personnel can diversify their activities. Fruits have a very high market potential, being very much in demand (one lemon goes for 10 to 15 f, a guava for 15 to 25, mangoes for up to 50) and in very short supply. However, this is not a market which can be exploited by a three year project. Garlic offers high potential earnings (1000 to over 1500 f/korro in Ati), if a source of seed or sets can be found, and it can grow in local conditions.

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Ngouri was once a local center of chicken production, birds selling for as little as 200 f., and being shipped out regularly to N'Djamena. The drought drastically reduced the flock in the last two years. People are familiar with chicken raising, and it is an activity that integrates extremely well with market gardening, as chicken manure is one of the richest natural sources of nitrogen. Together with a program of composting, this activity could have multiple benefits at the production level, and provide an additional source of income.

3. General Remarks On Commercialization And The Regional Dynamic

The basic philosophy of sustainability requires that the project not provide services, but rather create or stimulate institutions which can provide services. The model(s) of wadi development which result from project activities will only be viable to the extent that they integrate into the larger economy of Chad. Certain elements must be brought in from outside the farming community. Depending upon the level of integration achieved, fuel and oil, pump parts, vegetable seed, or other inputs may be required. If this proves impractical, there will still be a need for some elements of the water lifting system which cannot be manufactured locally, and for flow of products onto regional markets as the project's innovations spread and production increases.

These are natural economic processes. The private sector in Chad is very active, and capable of seizing opportunity. Project interventions at the level of marketing will be directed at stimulating awareness of such possiblities, and assisting willing entrepreneurs to make the most of them. Thus a credit program for inputs to the farming system, whether establishment of a local hand pump manufacturing operation, or assistance in inventory financing for a parts house in the capital, might be envisaged. Direct marketing links might be stimulated by financing a local transporter on the basis of a contract to haul produce to regional markets. These are all possibilities, which will have to be explored by project staff.

Similarly, farmer decision making will not be undercut by project staff perceptions of what is "profitable" or not. The best informed people in the marketplace are those who have been there all their lives, and their decisions should be respected. It is entirely appropriate to educate farmers as to the financial requirements of new production systems by requiring their financial participation, but they are more likely to succeed in meeting their commitments if they are allowed to meet them in their own way. Similarly, attempts to introduce new crops or make people aware of new market

opportunities are entirely appropriate, but project participants are the best judge of their ability to bear risk, and must commit themselves without reservation if they are to put themselves effectively to the task of changing the circumstances of their lives.

Regional Dynamic

A number of very significant projects are currently underway or planned in Lac and Chari-Baguirmi Prefectures which will probably have an effect upon the project area. Additionally, political and climatic factors are at work which can also create or destroy opportunity in the area.

The Italian financed UNDP project is about to invest between US$35 and US$50 million in the Lac Prefecture, mostly in the construction of a road and in several agricultural projects in the Bol Sub-Prefecture. Project funds are obligated through the end of 1987. The project elements are still being defined, but they were described briefly to us as follows:

A road, either from Ngouri to Bol, or from Massaguet to Liwa and beyond, depending on funding. Not paved, the GOC is to provide maintenance.

Deep wells to provide water for the road work, hence along the road, later to be converted to village wells.

Development of nine polders around Bol. Barrages with gates, to avoid the present problem of having to break and remake the barrage to allow salt leaching lake water in periodically. Tube wells within the polders to guarantee water even if the lake level falls.

A 30 to 50 hectare seed farm at Matofo near Bol to provide food grain seed to the project. Perhaps our project can do some seed multiplication for them.

Storage facilities in the Bol Sub-Prefecture.

Some experimental work in wadis in the Bol Sub-Prefecture.

This project will clearly have an enormous impact on the region for at least the duration of the project (thru 1987), if only because of the amount of money being spent. A road from Ngouri to Bol will be good for Bol, because this is the worst stretch of road in the Lac Prefecture at present, but it will not help Ngouri much. A road to Massaguet thru Massakoury, and a spur to Mao would be very useful, if the funding comes through.

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ANNEX K. Social Soundness Analyis

1. Methodology

The project design team, consisting of a team leader (administrator and political scientist), an agicultural economist and financial analyst, an agronomist, a rural works and irrigation engineer, and a cultural and social anthropologist spent one month in Chad. During the two weeks, the team visited potential sites, the social anthropologist held meetings with the chiefs and notables of ten villages. She also conducted lengthy interviews with fourteen farmers male and female, at the project sites in order to determine their perceived needs. She held discussions with local government and extension agency officials and traditional authorities in the project areas. In meetings with the Minister of Agriculture and Rural Development and the Ministry of Plan, as well as with ONDR and SODELAC (extension agencies), the team ascertained the policy, needs and desires of the Chadian government and their view of the farmer's needs. The team also consulted with representatives of the UN, various countries' aid programs and NGOs, to learn from their experience and knowledge. Secondary sources and files were also utilized.

2. Socio-Cultural Context

(i) Wider social, economic and political environment

The population of the Lac Prefecture is 158,000, with a density of 7.1 people/km2.

The Lac Prefecture, which borders Lake Chad, is part of greater geographical and social Kanem. It has felt the comings and goings of different groups over many centuries, and has as much ethnic diversity as present-day Kanem. Though the inland regions of the Prefecture have historical attachments to Kanem to the north, the region directly bordering the Lake was often politically independent, and itself a stronghold for bold cattle raiders who plundered their neighbors. The geography of the Lake and Kanem Prefectures, which formed a single administrative unit until 1962, consists of a relief of polders and wadis dotted among the sand dunes.

Like the rest of Kanem and Chad, the Lac Prefecture has undergone extensive drought, livestock losses, poor rainfed crop harvests and much travail and social displacement. Parts

of the area around Ngouri, the selected project area, are reported not to have had a millet harvest for at least three years. Despite their suffering and much movement of surrounding populations, many of the inhabitants have remained in the region, trying to supplement their staple, rainfed millet, with production in the wadis and polders. The GOC recognizes the need for food self-sufficiency and has requested, starting with a 1985 Geneva Conference, that development efforts be undertaken in order to achieve this goal.

The Lac Prefecture was hard-hit during the four year Sahelian drought, for a numnber of reasons. The area's staple crop, penicillum millet, is dependent on rainfall, which was far too low for adequate harvests. With lower rainfall the level of Lake Chad dropped, leaving many polders, whose produce is used to supplement the millet crop, high and dry. Likewise, fish production fell. And much of the livestock, used to fertilize the fields, died. In addition, large numbers of displaced people moved through the project area on their way to the lake, where they hoped to find water, forage, or cultivable fields. While most of the displaced persons have left the project area, either returning home or moving closer towards the lake, this is all that has changed after 1984. The plentiful rainfall which gave Chad an adequate harvest overall in 1985 did not reach this region. With the drought, shallow-water fish disappeared and cattle died. Fish, milk and butter had been a large component of people's diet in the region. Fishermen, herders and farmers have all turned increasingly to cereal cultivation to replace these items. Many farmers have been forced to commute considerable distances from their villages -- 25-35 km. -- to grow cereals in polders to supplement what little rainfed millet they have harvested. Many families have migrated together to the lake to cultivate, and many men have gone to the capital city, Ndjamena.

(ii) Ethnic Overview, Compatibility of Project and Society

That part of the Prefecture's population on the edge of the lake, on islands and in the polders, is mostly Kouri and Boudouma cattle herders and farmers. The inland area, where the target wadis are located, is inhabited for the most part by Kanembou, who through their long history of connections with rising and falling Empires maintain traditional hierarchical government structures. For the last eight centuries they have been Muslims, although not strict ones.

The language spoken most frequently in the project area is Kanembou. Some men speak French or Arabic, the lingua franca

in most of northern Chad, but those who work in the region will have to make an effort to learn some of the local languages in order to reach most farmers and women.

The Kanembou are divided into a number of clans claiming kinship with one another. Some areas are predominantly inhabited by one clan but in the target area around Ngouri, none is dominant (Bouquet, 1974, Les iles et rives du Lac Tchad, p.42). The homogeneous character of each village is particularly striking (Ibid, p. 39). Many villages in the Ngouri area are inhabited by the Kadjidi and Darkoa clans, special groups believed to be descended from the same mother as other Kanembou clans but from a different father. In fact these clans are Haddad, a subordinate caste of ironworkers, potters, tanners, weavers, etc. A disadvantaged group, the Haddad are looked down upon, and it is considered proper for them to carry out the most difficult tasks such as carrying water. The Haddad are also often cultivators. Other Kanembou prefer to put more emphasis on cattle-keeping than the Haddad, who are considered poor but also very hard-working.

The Kanembou are part of the Empire of Bornou, historically dependent on Bornou and its representative, the Alifa Mao, the Sultan of Mao, who holds authority over his chiefs, the Mai. Since colonial times the Mai have been reconfirmed in their traditional power by being named chefs de canton.

Officially the state is the owner of the land. Traditionally the Mai is the "owner" of the land, and organizes and controls its population. He is aided in his job by the Mara Blai, the chef de terre, chef de village, and the Nguiguim Blai, the liaison between the village chiefs and the chef de canton. These titles hold for most of social Kanem but vary in some areas, though the offices remain the same). The chef de terre has the right to assign fields to the initial settlers of a new village. Henceforth, he may once again reassign. He may also expropriate land. In return for access to land the population owes him customary payments, for example, a percentage of their crops if they harvest more than a certain amount. Given their traditional power, authority and influence, it is difficult to undertake agricultural action without these officials' support.

Until 1979 the Lac Prefecture was a region favored by the GOC and various donors, who poured significant amounts of money into polder development. Projects failed for environmental, technical and social reasons. (This project will try to avoid the mistakes and pitfalls of earlier projects by conducting a

preimplementation study of previous projects for "lessons learned"). Today the IBRD can no longer see putting money into intensive polder development or reclamation. Wadis, on the other hand, were not the object of GOC/donor intervention before the onset of civil disturbances.

Whether or not the Lac was favored in the past, the present situation is very difficult. Kanem and the Lac Prefectures are food-deficit areas. Since 1983 CARE/Chad has been working with wadis in Kanem, but they face problems different from ORT. They have been resettling displaced persons, including many nomads, in wadis, and teaching them to use traditional irrigation systems. The ORT project area has few displaced persons. The problems ORT faces are helping the people in Ngouri Sub-Prefecture reach food self-sufficiency and developing a package of appropriate technology, a way of introducing it and of training farmers and mechanics.

(iii) Traditional Economy of the Project Area

The people in the Lac Prefecture carry out a complex range of economic activities: rainfed dune agriculture, irrigated wadi and polder production, recession agriculture in the polders, herding, fishing and trading. The Kouri are primarily cattle herders and farmers, keepers of the prize Kouri cattle. The Kouri cultivate millet, wheat and corn on the islands where they live, and on the recession slopes of the lake, or sometimes in polders.

The Boudouma are herders and farmers, like the Kouri. In recent years they had turned to fishing more than herding; with the drought they have become even more dependent on farming. Other nomadic groups, such as the MBororo, Arabs and Gorans (an Arabic word meaning non-Arab nomads), such as the Kreda, also traverse the region with their herds but this is not their home range.

The Kanembou are sedentary cattlekeepers. They do not move their cattle over long distances, but pasture them around the village and stable them in their fields of stubble at night so their dung can fertilize the soil. The small ruminants they also keep have become a much more important source of milk since the drought destroyed so many milk cows. The mainstay of the economy is agriculture. But a family's wealth and standing is measured more by its cattle rather than its granaries.

For the Kanembou agriculture in the dunes, wadis and polders is tightly linked. Primary is the production of rainfed pennicillum millet in the dunes. Supplementing it may be wheat, corn, beans and vegetables grown in irrigated wadis or in polders. The intensity of wadi or polders cultivation, meant to supplement rainfed agriculture, depends greatly on the size of the millet harvest. But at present, wadi cultivation cannot completely replace rainfed agriculture, nor can less than very intensive polder production. Therefore, a family's primary investment of interest, time and labor is in rainfed millet.

The nuclear or polygynous Kanembou family is the production unit. In the millet fields husband and wife, and older (15 or more) children prepare, sow, weed, and harvest while the younger children look after the animals and, when the grain is ripe, stand guard during the day to chase away birds and other animals. The average size of rainfed fields is 1.5 ha. In the wadis the division of labor is somewhat different. Only younger men usually cultivate with a shaduf; their young children (eight or more) help by running about shifting water from one irrigation channel to another. Wives many come to help with the shaduf once their household duties are out of the way. The size of a wadi parcel depends on what a man inherited, but parcels seem to run between 0.25 and 0.30 acres. The amount of land in a parcel a man can actually keep under cultivation depends on a number of factors. Areas of the parcel are rotated in and out of cultivation to limit salinization. The area being cultivated at any one time depends on the depth of the water table, the man's strength and interest, the number of family members he has to help him and has to feed, how much cash he needs and whether he has other fields in polders.

Who works in the polders depends on the family composition and how far away the polders are. A family of only husband and wife, or one with older children, may pack up and, taking their animals with them, go for several weeks or a month at a time to their polders if they are far away. A man with young children or with polders not too distant may go himself, spending a shorter time before coming back to stay with his family for a bit.

Whether a family works fields in a polder depends in part on where the polders are located, their need for cereals to supplement their millet crop or to earn cash, whether they have a wadi parcel and, if so, the difficulty of exploiting it. In a humid or dammed polder, a man can grow a much more extensive grain crop than he could in a wadi. On the other hand, the inconvenience of travelling long distances and the chances of

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illness with stagnant water and mosquitoes everywhere, are deterrents.

The availability of labor depends greatly on the mix of different types of agriculture a family employs. It is certainly possible to be busy every minute. The typical crop calendar is detailed in Annex G.

In recent years as the drought worsened, many people were forced to turn more and more to wadi, or especially, polder cultivation. Many people abandoned their villages for great lengths of time in order to cultivate in the polders. The people at present in villages and cultivating in wadis are therefore fewer than was formerly the case. When the 1986 rainy season begins many will return to their villages, as they did in 1985. Numbers of those who have gone to N'Djamena will also return to their homes in order to plant their millet. Whether they stay will depend on the rains. If they fail, as they did in 1985, many will probably leave again. People have strong attachments to their traditional villages, which they are reluctant to leave permanently. For a village to reach a communal decision to move closer to a polder, and to abandon its traditional lands and wadis, to which it has ancient and strong attachments, is very complicated indeed. It is difficult to foretell at what point the strains imposed by poor harvests and the harshness of wadi cultivation will push people to leave their homes permanently.

Fishing and trading are dry season activities, secondary to a Kanembou's millet harvest. Fishing, of course, must wait until the lake has receded somewhat after the rains. Trading in the past often involved cattle. Men also trade sugar or grain, produced during the rainy season or grown in wadis or polders throughout the year, and onions, grown in wadis in the dry season. Trading can be long distance, to Nigeria, Niger, the Cameroons; to Ndjamena; or to the local markets of the Lac and Kanem. Women market only small quantities of vegetables or grains. A number of people market their produce or engage in trade at a low level in order to get cash to cover their basic needs for tea and sugar, clothes and taxes. The cash to pay these minimum expenses is as basic to their economy as is the need for food, and should be considered as part of subsistence. Produce from wadis or polders is often used to meet these demands while rainfed millet is used for food supplies. With the decrease in rainfed harvests, the burden of food provision has shifted to the wadis/polders where either cereals must be grown, or other products which can be sold for cash to buy cereals. Families have been caught in a crunch

between their need for food, and irreducible cash demands; as a result interest in increasing production, especially in wadis or dry polders, is very high.

The farmers' economic situation also helps to explain why this project has been designed as it has. Very few farmers are able to make any sort of major monetary investment in increasing their yield. Many cultivators have neither the money to invest nor the annual income to keep up credit payments. They would be unable to continue using any expensive technological changes much beyond the lifetime of the project, unless the changes could guarantee not only that they would reach self-sufficiency but obtain considerable discretionary income. Therefore more of the project is designed to use low-cost technological and agricultural changes requiring small initial and continuing monetary investments. For those who have access to larger sums of money through trade or other activities, the VITA credit and financial management component is intended to help them to invest and to continue managing more expensive technologies.

2. Feasibility

In the past, SODELAC had problems in the polder projects because they tried to cut out the Mai, claiming the state owned the land and that SODELAC had the right to distribute it because the state was improving the land. This project will try to work with traditional landholdings, and avoid such problems. The project has the support of both SODELAC and the strong traditional chiefs. The two Chefs de Canton in the Ngouri area agreed to lend their support. Since the land within the project wadis has been traditionally held for generations, and is not new land being brought into production, the problem of distribution should be lessened.

The Mai are men of influence and their cooperation and interest will probably enhance the spread effect of the project. There is, however, a potential that difficulties may arise by working with the traditional authorities: customary payments and sharecropping. In the past, some writers claim, the traditional authorities were extortionate. It was hard to judge how people viewed customary payments during the short time alloted for the survey. The project implementers will need to monitor this closely. They can always refuse to include sharecropping wadis as project targets.

The project also intends to work with traditional decision-making groups and traditional systems of land tenure. In the area of Ngouri all land within the wadis is traditionally owned by someone, even though it may not currently be

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exploited. Ideally, the inhabitants of one village own a whole wadi, or more than one wadi. In reality, because some wadis are big and some villages are small, more than one village may own land in the same wadi. Also, not all villages own a wadi. Whatever the case, the ownership of each parcel of land within the wadi is well known. Ownership passes from father to son; sometimes the parcel is sub-divided among brothers; at other times one son may be interested in wadi cultivation, so he receives the entirety. No one, however, owns more than one plot in the same wadi.

Parcels may go out of cultivation for many reasons: problems of salinity, lowering of the water table, the owner having grown too old for heavy labor, or lacking sufficient family members to help him irrigate, or finding it just too hard. Eventually the family may transfer these parcels to a son or other relative who expresses interest in cultivating there. Other parcels were removed from production because their owners leave the village. Once it becomes clear they will not be returning, the Mai may reassign the field to other villages, or to newcomers who request a field.

This flexibility in assigning land ownership probably ensures that all the land in the target wadis will be exploited, since unused parcels will be reassigned. In the Canton of Ndjiguidada some wadis are, the Chef de Canton says, unowned. Extension of the project into this area will have to be preceded by resolution of any problems of land ownership; these wadis will, however, bring land never yet exploited into production.

Although the traditional government structure is strongly hierarchical, decision-making and implementation at the local and village level is very democratic. Once a village has agreed that it is interested in being included in the project, the team will consult with the Mai, who may announce to the villagers that they are going to be included in the project. But in the traditional way, it is for the villagers, not the Mai, to decide on how the project will be implemented. Only after considerable discussion will the villagers reach a consensus on who should try out the innovations and how, should the innovations fail, the villagers will sustain the experimenters until the next harvest. This decision is then communicated to the Mai.

This habit of village discussion, evaluation and consensus-making bodes well for the ORT project as currently conceived. The project will try a number of technical and agronomic changes, and monitor the farmers' reactions to them. As the

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men of one village said to the anthropologist, "We can't tell you whether we think a donkey pump is a good idea because we have never seen one. But if you let us use one, then we will learn about it and we can decide if we think it is worthwhile or not." The project intends to use this process of evaluation and consensus to introduce innovations, rather than imposing a new cooperative organization. Past experience in the area with cooperatives has been poor. SODELAC introduced farmer cooperatives into their polder projects, but they did not last (Ibid, p. 103.) The League of the Red Cross and Red Crescent has recently had little luck getting village cooperatives to function.

If the farmers themselves decide to band together to invest in technology too expensive for an individual the credit and financial agreement arm in the project, administered by VITA, will help the farmers obtain credit and make sure they understand the implications of their investment. But the impetus to form cooperatives must come from the farmers themselves; it will not be imposed by the project.

On the other hand, the ORT project will train local blacksmiths or mechanics in the repair of simple pumps, necessitating the organization and repairshops. The advice and counsel of the VITA credit and financial management arm will facilitate this new way of organizing.

4. Host Country Commitment

One of the country's main priorities, stated in its interim three-year plan, is food self-sufficiency, the object of this project. Both the Ministries of Agriculture and Rural Development and Plan, those which would be most directly concerned with the implementation of the ORT project, stated their desire for a project in the region now proposed, Ngouri Sub-Prefecture.

At the national level, the Secretary of State for the Ministry of Agriculture and Rural Development has been kept fully apprised of the project's evolution and he is awaiting the project proposal with interest. The Ministry of Plan sent a high level representative with the team for site visits, and has been part of the design process. SODELAC, too, has expressed considerable interest and willingness to cooperate. It assigned an agent full-time to assist the design team and itself contributed to the project design. The head of BIEP has said that his Bureau would be willing to undertake studies necessary.

The regional authorities in the Lake Prefecture were very pleased with the project, saying that the project fit their own concepts of what needed to be done for the zone. The regional SODELAC authorities are committed to the project and have signaled their willingness to assign their agents and infrastructure to the project.

5. Collaboration

GOC colloboration is an integral part of the project. SODELAC agents, who have been functioning at a restrained level since 1979, will receive training and materials so that they can fully cooperate with the project team.

6. Problem Identification, Beneficiary Participation

In interviews, village notables and farmers were invited to identify their major problems and possible solutions. Two needs were mentioned over and over: food and water. Half the people interviewed stated the need for food to nourish the family and even to have the strength to work was their biggest problem. Lack of water concerned an equal number. The inextricably intertwined nature of their agricultural system is emphasized by their comments about water. One third of those who mentioned water meant rainfall, without which there would be no cereal; one third referred more specifically to the difficulty of irrigation either in wadis or polders, irrigation on which they were dependent to supplement their inadequate rainfed crops. The remaining third referred to lack of water in the wells in wadis, polders and villages for people to drink or irrigate with.

When asked if they had any ideas about how to resolve these problems some people discussed trying to increase their yield by cultivating in a wadi or polder where water was more dependable than rainfall is. Most said they had no ideas themselves, but that if ORT came up with a project to help lessen the problems, they would be more than willing to try.

People in the project area definitely feel they have a problem and are willing to try out possible ways to overcome their difficulties. Moreover, the people who are working at present in the wadis are the people most willing to work hard; working with a shaduf is punishing labor and only the energetic and motivated are willing to do it. Informant after informant attributed the abandonment of wadi fields solely to the

difficulty of operating a shaduf out of a well more than 3m. deep. One owner of a wadi parcel who abandoned it to work in polders, said he would give up walking many kilometers and spending considerable time away from his family in the company of only mosquitoes if it were not so hard to work the shaduf. If somehow he could increase his output he would definitely prefer to work in a wadi.

The local farmers have themselves identified their major incentive to participate in the project--increased yield/ reduced labor--which, since they are no longer self-sufficient in food production, is a major incitement. It must be recognized, however, that if the very bad rainfall of the last few years continuous, there is always the possibility that increased production in the wadis will not be sufficient to offset the drop in millet harvested, nor to retain people in their villages and wadis. Farmers consider rainfed millet to be the mainstay of the economy, and if they cannot produce enough they may either move to the polders in an attempt to grow sufficient staple crops or abandon farming altogether and migrate to the capital or elsewhere. Farmers will probably continue to consider increased yield/decreased labor in the wadis as a sufficient incentive as long as they can produce what they judge to be a minimally sufficient crop of rainfed millet.

7. Social Consequences, Benefit Incidence, Equity

(i) Participator/Beneficiary Profile

80% of population are cultivators (Enquete Agricole Bol., p. 10). Only 12.3%, mostly men, had other work in addition to agriculture (Ibid, p. 15).

The initial beneficiaries of the project will be the owners of parcels in the project wadis who are cultivating at the time the project begins, or who wish to be included. From the project survey, it appears that these farmers are for the most part young men, who have enough strength to work the shaduf, with some children old enough to run about opening and closing the earthen dikes controlling the flow of water. They, plus the wife/mother constitute the typical working group in the wadis. The average size of such a working group, judging from the people surveyed, is 3.5. On some days the wives help their husbands with the shaduf, joining them after they have finished their housework and cooking, but their attendance is irregular because they may go to market or have too much to do with the children and small animals and housework. Both will directly benefit from any technical changes which would lighten the irrigation work load.

The income from wadi produce belongs to the man. Officially his wife receives no part of the harvest of income, but any increase in output which goes towards food self-sufficiency will indirectly benefit the wife and family. If the produce generates more cash income, the wife and family may or may not also benefit indirectly. The wife does most of the small-scale marketing of vegetables in weekly markets. While officially the money she makes belongs to her husband, informants said she usually used it to buy necessities for the family, such as sugar and tea, spices and sauce ingredients, and soap. Any small change left over she usually keeps for herself.

From observations in markets, it appears to the anthropologists that men, more often than women, commercialized large quantities of cereal or onions, the two most common cash crops grown in wadis. This income belongs to them just as the vegetable produce does. One man interviewed said he intended to spend the profits of his surplus on clothing for his family, another that he hoped to buy a milk-goat for his wife so she could give their children milk. While men can spend their income on things which do not benefit their wives, such as bridewealth, or a horse, or a trip to Mecca, these men spoke of other expenses which could benefit the family as a whole.

The wadi farmers interviewed all "owned" their parcels, even though some farmers had fathers still living. While this question of inheritance versus transfer inter vivos poses an interesting anthropological question, it is unlikely to affect the project unless elderly fathers suddenly start laying claim to the produce grown by their sons. No one questioned about this seemed to think it likely.

Most of wadi farmers have no or very little western education, though most have attended Koranic school. One farmer interviewed, however, was primary school teacher working in his wadi to supplement his income. He was planting cereal grains, as well as vegetables of many different sorts, and was trying to teach his neighbors in the wadi to like them. This sort of farmer would clearly help the spread effect of the project.

Some other wadi farmers interviewed, although uneducated, had also had contact with the wider world. One had been a merchant who bought cattle locally and sold them in Nigeria,

using the profits to buy goods to sell in N'Djamena and local markets. When Nigeria devalued the naira, he lost so much he could no longer continue in the business, so he bought two small motorpumps in Nigeria and brought them back so he could cultivate in the wadis in order to feed his sixteen children, something he could never do with rainfed agriculture alone. He lacked the knowledge, however, to deal with the recurrent costs of gasoline, oil and maintenance. He was, therefore, thinking of taking the drastic step of selling his second pump, which he had had the foresight to buy as a replacement should the other break down, in order to have enough money to buy gas, etc., to operate his pump through until the next harvest. This sort of farmer could benefit from the training in pump maintenance and the credit and financial management aspects of the project. Although most others are illiterate in French, some, having been to Koranic schools, may be able to do simple sums and notations in Arabic. They, too, could benefit from the same training should they choose more advanced irrigation technologies. As the project is designed, only those who feel the need will have to take on the cultural baggage of credit, financial planning and management. Anyone involved in the project may do so, and they will receive training to help them understand the full implications of their actions.

As the project continues, and others learn of the changes possible in alleviating labor and increasing yield, it is hoped that other owners of fields in the project wadis will join. Owners who are too old, or who lack the desire or ability to exploit their fields can, the chef de canton/Mai of Ndjiguidada claimed, without difficulty transfer their land to another interested kinsman. Should people who do not own plots be interested, the Mai has the right to reassign to them land of families who have died out or to expropriate land of migrants from the village who show no sign of returning. The project's efforts to control salinization may also be able to bring some parcels back into productivity. There is, therefore, the potential that all the plots in a wadi could be exploited and that some present non-owners could receive fields and thus benefit from the increased production at the project sites.

Since the wadis are limited in size, there is also a limit on the parcels and the number of people who can directly benefit from project wadi improvement. Some villagers may be unable to obtain fields, and while this may present some problem of equity, it has always been the case that some people own wadi fields and others do not, so that this is not a new form of inequity introduced by the project. In the canton of Ndjiguidada, which neighbors Ngouri, there are approximately 140 presently unowned wadis whose land could be assigned to

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interested parties. When the anthropologist queried some village leaders about ownership of fields and problems of equity one replied "In this village we are all brothers; if one of us benefits we all do." He is correct that benefits from increased production would pass through the extended family to more than the farmer himself.

The project should also improve the lot of a number of traditionally disadvantaged people, the Haddad, for Darkoa and Kadjidi Haddad constitute a substantial population in the Ngouri wadi area and a large part of the farming population; they are admired by people who know the Lac Prefecture as being hard workers who do not shun working the shaduf. Haddad are also the local blacksmiths, and so some will be included in the project either as manufacturers of improved hoes and other tools, or as repairers of simple pumps. Thus, some Haddad should directly benefit from both the agricultural and equipment aspects of the project.

While in other parts of Chad it is possible to find people who have had experience as automobile or motorcycle mechanics, much of the Lac Prefecture is so sandy that few automobiles and practically no motorbikes can navigate the dunes. It is therefore unlikely that the project will be able to find blacksmiths/ mechanics who have already had appropriate technical experience.

Given the traditional economic and agricultural systems of the area, in which a woman has no control over land or the income from crops she helps to produce, women will directly benefit less than the men involved in the project. As has been noted, easing the work involved in irrigation will lessen a woman's labor when helping her husband in the wadi. Increased family income also indirectly benefits her. Since women are, to a large extent, excluded from the agricultural sector, it is difficult, however, to include directly them in a project intended to increase the output of traditional agriculture. Women should nevertheless benefit directly from the health component of the project.

Potential for negative impact of the project lies in the inclusion of the traditional chiefs and "owners of the land" in the project's implementation. Experience in the polder projects of the 1970's was that allowing the chiefs joint control with SODELAC, over distribution of polder lands only encouraged them to return to earlier tactics of feudal exaction of traditional payments from their peasant subjects (Bouquet, 1974, p. 100-1). While several people questioned about this possible impact laughed bitterly at the idea that they had

produced enough even to consider a customary payment to their traditional chiefs, increased production does increase the chances that this may be demanded. In the past, traditional chiefs also employed sharecroppers, who received only half the produce they grew in the authorities' wadis. The social scientist on the project and the people in the field must follow all this carefully, and be ready to mention any signs of high-handedness to local GOC authorities. This risk of extortion, however, appears to be well worth taking, since the traditional chiefs still maintain considerable control over their land and their subjects. Any attempts to mobilize the common farmers or to interfere with land distribution would appear destined to fail, (Ibid, p. 54, and private communications), or at a minimum destined to generate distracting and distressing controversy between the implementing agencies, ORT and SODELAC, the traditional authorities and the farmers.

(ii) Extent of Participation

As has been discussed above, local farmers and authorities were asked to identify their needs and problems and possible solutions or ideas for improvement. They were also asked how they would go about decision-making and resolving inequities. All the interested GOC agencies have been consulted and involved throughout the project design and have expressed their interest in the present project.

The allocation of time within the agricultural calendar is likely to affect the extent of participation in the project. The present agricultural calendar, for someone who works hard, is already heavily charged. The most likely times for a farmer to be free are in January-February and July. These would be the optimal times for farmers to invest the additional time and labor which some innovations may require. However, many of the innovations are intended to reduce the amount of labor or time the farmer must invest. Indeed, if wadi production can become a sufficient supplement to rainfed agriculture it may increase the amount of time available, by relieving some farmers of the necessity of traveling long distances to the polders. (Note: "There has probably been a net reduction in labor availability due to the time required to travel to recessional lands, despite reductions in labor requirements for rainfed crops and herding." (Weaver et al., 1985, p. A-4). Thus the project cultivator should find that he has more free time and labor at some times of the agricultural year than he does under the traditional system, which he may choose to invest in changes in order to increase yield. Why different farmers decide to do so or not must be closely monitored in order for decisions about new innovations to be made.

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In general, no innovations are intended to conflict with the farmer's primary interest, rainfed millet cultivation. The exception is one means of improving yield within the traditional wadi system of farming: better soil preparation. The team agronomist suggests that working the wadi soil more thoroughly, down to a depth of 40-60 cm. rather than today's 10 cm., just before the rainy season, would allow the rain to penetrate farther, aerate better, wash more salts out of the soil, and be retained longer than with the present practice. This considerable effort would have to be furnished just at the end of April and in May, at the time when most people are preparing their millet fields in the dunes. This is also currently the time for Ramadan, when people's productivity drops because of fasting requirements and nighttime festivities. Project implementors should recognize that it is unlikely, therefore, that this technique for improving yield will be widely employed. They will, however, use many other ways of increasing yield.

Beneficiary participation has been built directly into the implementation and monitoring of the project. Various participants in the project will themselves use and test different sorts of agronomic practices and irrigation and salinization control technologies. The project will begin with simple, inexpensive changes. Different participants will implement various changes, and will be able to evaluate their own efforts and yields and those of farmers in neighboring parcels and other project wadis. The local project staff and study groups will continuously gather information about yields, labor inputs and beneficiary reactions. The social scientist has been scheduled to arrive after the beneficiaries have had time to judge each major change in the traditional system and the yield from it. The social scientist will intensively monitor beneficiaries' ideas, suggestions and reactions and analyze them in conjunction with the data collected as an ongoing procedure. These sociological findings, plus the technical, agronomic and economic results will determine which innovations are introduced into the project wadis, which changes are continued and which are dropped out.

Baseline studies must also be undertaken at the beginning of the project. These studies will help select project wadis and control wadis. Control wadis are necessary to determine what events external to or beyond project control may affect the success or failure of project innovations. This baseline data, plus the data from the ongoing monitoring, will provide the basis for a sociological and technical understanding of the participants' decisions about the value and utility of project innovations.

8. Spread Effect

(i) Within the project area

Village leaders in the project area have said that decisions about who is to experiment with new agricultural techniques and technology, as well as judgments about their effectiveness will be reached in village meetings, where everyone has a voice. Thus, villagers not engaged directly in the project will stay aware of project interventions.

In each project wadi, farmers will try out several different techniques and technologies at the same time. They will thus be able to compare and decide for themselves about the value of the different components. These wadis will also serve as demonstration wadis where non-participants from other villages will be able to observe the different methods at work and judge for themselves the results. The SODELAC and ORT agents will carry out extension in the area, perhaps arranging transport for groups of interested farmers to visit the project wadis.

(ii) Beyond the project area

One purpose of the project is to develop models which will be replicable in other places. A number of wadis can be found elsewhere, in most of the cantons of the Lac Prefecture as well as in neighboring Kanem, where an estimated 130 wadis are exploitable (personal communication, CARE/Chad). The models will not, however, be useful only in wadis. There are three kinds of polders along the edge of Lake Chad, humid, dammed, and dry. At present the dry polders are either exploited by shaduf or abandoned for the same reasons as the wadis. Either the water is too difficult to extract or the ground has become too saline because it has not been flushed. The models developed in the wadis to facilitate water removal and control salinization will therefore be applicable to dry polders.

There are three scenarios for the future of the polders: (a) most optimistically, rainfall will increase and the lake level will rise, rendering some dry and dammed polders humid, (b) the lake will remain the same, and the models can be applied to a large number of dry polders, (c) rainfall will continue to decline and the lake level will continue to fall, turning some humid and dammed polders into dry polders, thus increasing the number of spots where the models of wadi irrigation will be applicable. Developing useful models of wadi irrigation is therefore a conservative strategy, and one which foresees spreading the model to other areas.

Nor would the models be confined to polders and wadis alone. In the Batha Prefecture, Lake Fitri, fed by the river Batha, presents a number of geographical and technical similarities to the Lac Prefecture. At present some farmers are using the lake for irrigation but at a very low level, drawing water in a small bucket and watering the garden plants from an enamel basin or watering can. The GOC has expressed considerable interest in increasing the agricultural viability of Lake Fitri; certainly even a small improvement in water removal technology would be a major step.

The project has been designed to remain within the financial and technical means of local farmers and mechanics, in order to reduce the chances that progress will collapse once the project ends. A long lifespan for changes brought about by a project is one good way of increasing a project's spread effect.

9. Social Soundness Analysis: Agroforestry

For technical reasons the ORT project proposes planting three kinds of trees at each project wadi. First, fruit trees, which since they require considerable water, will be planted around the edge of the wadi itself; the fruit trees will slow evapo-transpiration, increase the nutritional elements and variety in the local diet, and provide income to those who sell the fruit. Second, on the sides of the wadis, since sand is creeping in to engulf the wadis, trees will be planted which are particularly able to stabilize the sand. Third, at the top of the wadi and the dunes beyond, trees will be planted which will stabilize the dunes, serve as windbreaks to protect the wadi and village, and provide poles and firewood.

Because the rules of land and tree ownership change according to the kind of land involved, the beneficiaries of agroforestry activities in these three zones will be different. Their spontaneous interest in agroforestry will also vary. These differences must be clearly understood in designing agroforestry activities.

LAND OWNERSHIP: The whole village, as personified in the chef de terre, owns a wadi; though the village as a whole owns it, however, some villagers do not own, that is to say, have the right to exploit and to pass to their offspring, parcels in the wadi and other do. Those without parcels are, however, potential parcel-holders because their village owns the wadi; should a parcel be abandoned a villager can petition the chef de terre to grant it to him. All villagers can dig wells in the wadi for water for themselves and their animals.

Land in and around one's house, referred to in the local French as a concession, belongs to the family head. The dunes surrounding the village belong to the village as a whole, as does an area of communal pasture beyond the fields. Each field belongs to the person who cleared it, so long as he uses it. Farmers do not usually make their fields on the sides of a wadi because a heavy rain may wash out a crop planted on the slopes.

TREE OWNERSHIP: Fruit trees which are planted by someone on his land belong to that person. Thus a man could plant a mango tree in his concession and later move, but the tree would belong to him. Likewise, he may plant fruit trees in his wadi parcel and later give that parcel to another, yet the trees would continue to belong to him. Trees which sprout naturally in the wadi belong to the person who owns the parcel on which they grow. On the other hand, trees which are planted by individuals in a public place, e.g. the town square, belong to the public and can be used by anyone. When the anthropologist inquired of these matters, most people thought the idea of someone planting trees in a public spot was crazy, since the product would not be his.

Trees in the bush may be used by anyone. People who need poles or cord simply take them when they locate the appropriate material. Several informants said that cutting a new field in the bush around an exploitable tree does not bring the tree under the farmer's control. Rather, the tree stays public property. This matter must be examined further in baseline studies since it is unclear whether the public can gain access to the tree if they must cross a privately-owned field.

BENEFICIARIES: Only parcel owners can plant trees in the wadis themselves. Any villager can, however, plant fruit trees in and around his concession and benefit from the fruit crop. Everyone who discussed fruit trees with the anthropologist was most interested in planting some and attributed their inaction to the difficulty of getting seedlings. Several people had gone to the tree nursery at Bol, the Prefecture capital, to buy seedlings. A project nursery can, therefore, predict considerable interest in fruit trees and expect individuals to pay for the plants. The nursery should grow not only fruit trees such as limes, lemons, oranges, grapefruit, and mangoes but locally popular fruits like jujubes and tamarinds which have considerable commercial value.

The utility of planting trees which will take several years to mature before providing poles and firewood, both of which can still be found in the bush, albeit with some trouble, may be less clear to the villagers. The agroforester can try to explain the trees' utility, the importance of windbreaks and dune fixation which will protect the village's water supply at the bottom of the wadi. There is the risk that the villagers will consider dune fixation the affair of wadi parcel holders, since they will be the main short-term beneficiaries, rather than thinking of the whole village as the long-run beneficiary. As the humorousness of the idea of planting trees in public spots suggests, individuals may be unwilling to plant and care for trees in the bush which will be for the use of anyone. Busy wadi farmers may also not have time to undertake a significant effort of reforestation in the first years of the project, especially since all the villagers will benefit from reforestation in the end.

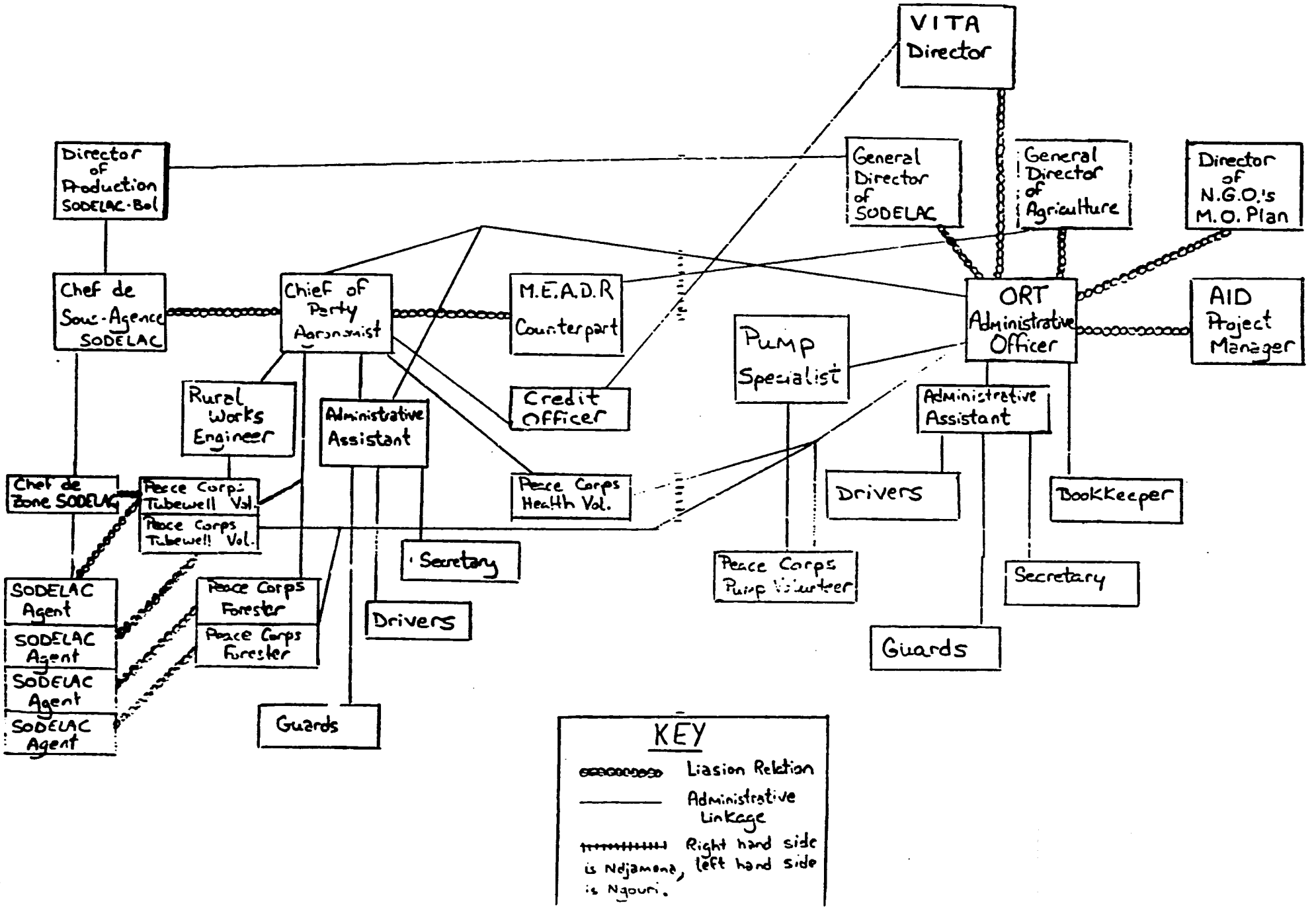
If it becomes necessary to motivate the villagers to plant and maintain trees in a reforestation project activity, the anthropologist suggests using Food for Work in a traditional Kanembou way. The custom of inviting the village to come aid in cultivating one's field was frequently used before the drought of the 1980's. The host would send word to specific people but also generally announce that on a certain day he would hold a farming party. During the day the people would clear, plant, weed or whatever, to accompanying music, then retire to partake of a feast provided by the host to thank them and "to meet their needs (satisfaire leurs besoins)". The ORT project could undertake, perhaps with the cooperation of WFP or CARE who could supply the food, to reforest each wadi through FFW (Food for Work) cooked on site. ORT would do the proper accounting and assure that the workers received their (cooked) food at the end of the day. ORT or the village should also provide a number of sheep/goats to supplement the FFW and make a proper feast. The whole village would be invited to the farming/reforestation party and would receive their FFW in the form of traditional and expected payment. Some women, as is customary, would do the cooking in return for their share of the feast. In the same way, using FFW to provide traditional feasts, the villagers could be asked from time to time to water the trees and otherwise ensure their survival.

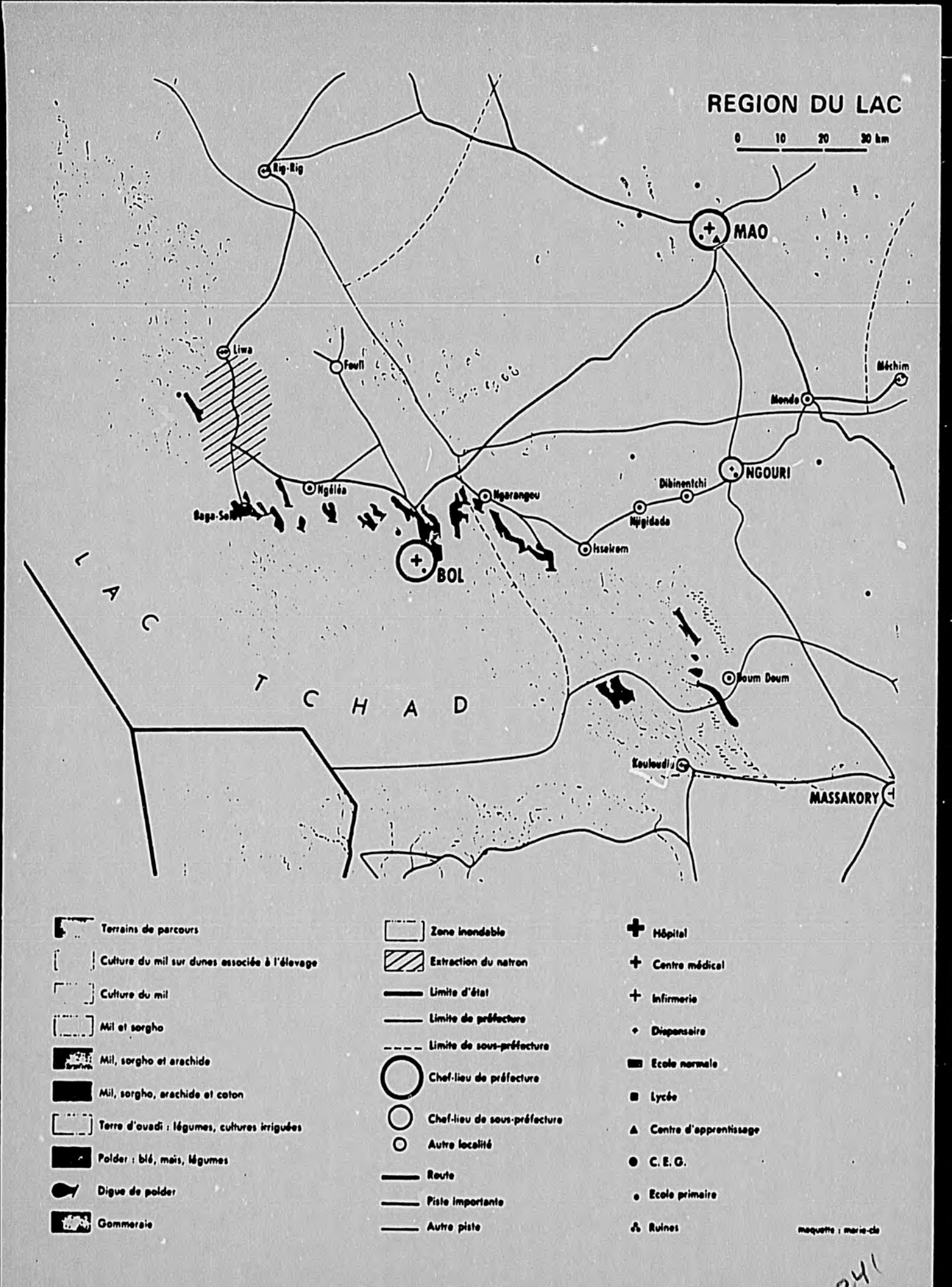
Several matters must be resolved by the Anthropologist during the baseline studies before such FFW for reforestation could be even considered. Who the host should be will depend on how the villagers will view ownership of the project trees. Should the host be the village chief, or the chef de terre in

this guise rather than that of the village chief, the chef de canton or another authority, the Peace Corps Forester or Project Agronomist, or someone else? This decision must be made by considering how ownership will affect the villagers' access to the trees for firewood, cord, poles, etc. Polewood trees may need to be kept apart from other trees, since they are a potentially valuable resource. If they are planted along with other sorts of FFW trees, their exploitation in the future may lead to disagreements and misunderstandings among the villagers. The Anthropologist should undertake discussions with the villagers and local authorities to determine their views and ideas about this.

ANNEX L. Administrative Analysis

The following organigrams represent the administrative set-up of the proposed ORT project in Chad and its relationships with other agencies (SODELAC, MEADR, Peace Corps, VITA , and USAID). The Deputy Chief of Party in Ngouri is responsible for overseeing technical aspects of the program, and is the official spokesperson for ORT in Ngouri. Either the Rural Works Engineer or Agronomist will be the Deputy Chief of Party in Ngouri, depending on the qualifications of the individual technicians recruited (in the organigram it was arbitrarily assumed the Deputy Chief of Party would be the Agronomist). The ORT Administrative Officer will be the Chief of Party, and will be the official spokesperson for ORT in N'Djamena. He will also be the official liaison with AID, VITA, MEADR, and SODELAC headquarters in N'Djamena. Another role for the Administrative Officer is to be the de facto Peace Corps Representative, responsible for orientation of volunteers, keeping all pertinent Peace Corps records, monitoring the volunteer's work, and being responsible for evacuation, termination and other functions as necessary and consistent with the ORT-Peace Corps agreement and Peace Corps Manual and Handbook.


VITA Director
Director of Production SODELAC-Bol
General Director of SODELAC
General Director of Agriculture
Director of N.G.O.'s M.O. Plan
Chef de Sous-Agence SODELAC
Chief of Party Agronomist
M.E.A.D.R Counterpart
ORT Administrative Officer
AID Project Manager
Pump Specialist
Rural Works Engineer
Administrative Assistant
Credit Officer
Administrative Assistant
Chef de Zone SODELAC
Peace Corps Tubewell Vol.
Peace Corps Tubewell Vol.
Peace Corps Health Vol.
Drivers
Bookkeeper
Secretary
Peace Corps Pump Volunteer
Secretary
SODELAC Agent
SODELAC Agent
SODELAC Agent
SODELAC Agent
Peace Corps Forester
Peace Corps Forester
Drivers
Guards
Guards
KEY
Liasion Relation
Administrative Linkage
Right hand side is Ndjamena, left hand side is Ngouri.


REGION DU LAC
0 10 20 30 km
Rig-Rig
MAO
Liwa
Feuli
Méchim
Mondo
NGOURI
Dibinentchi
Ngéléa
Ngarangou
Ngigidada
Baga-Sola
Isseirem
BOL
LAC TCHAD
Doum Doum
Kouloudia
MASSAKORY
Terrains de parcours
Culture du mil sur dunes associée à l'élevage
Culture du mil
Mil et sorgho
Mil, sorgho et arachide
Mil, sorgho, arachide et coton
Terre d'ouadi : légumes, cultures irriguées
Polder : blé, maïs, légumes
Digue de polder
Gommeraie
Zone inondable
Extraction du natron
Limite d'état
Limite de préfecture
Limite de sous-préfecture
Chef-lieu de préfecture
Chef-lieu de sous-préfecture
Autre localité
Route
Piste importante
Autre piste
Hôpital
Centre médical
Infirmerie
Dispensaire
Ecole normale
Lycée
Centre d'apprentissage
C. E. G.
Ecole primaire
Ruines
maquette : marie-cle

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ANNEX M. Third Country Participant Training Schedule

1. Bambey Training

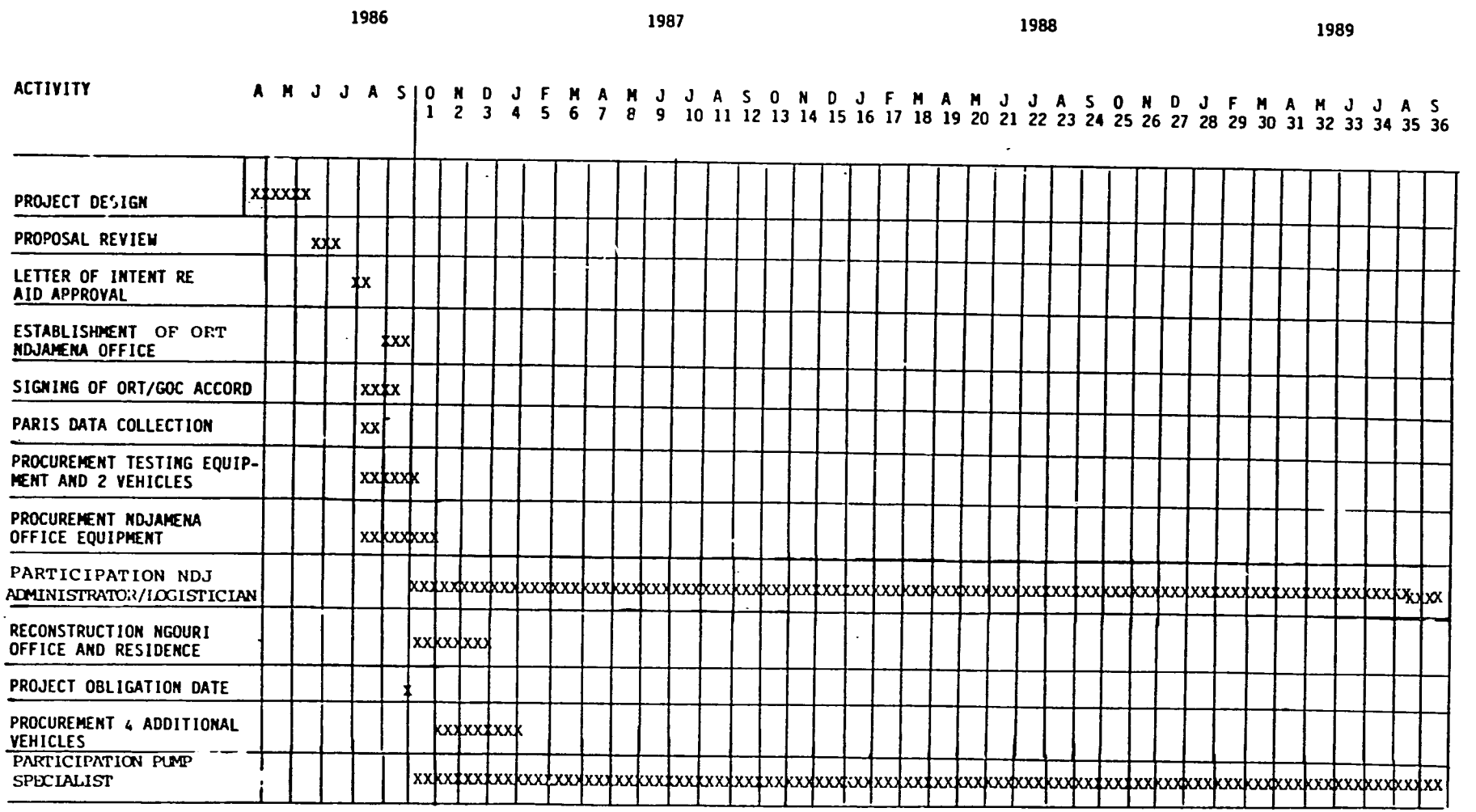
During Year One, ORT intends to have the 10 of the SODELAC agents working in the project area attend a five-week rural community organization course at the Agriculture and Rural Development Training School at Bambey, Senegal. ORT is currently providing technical assistance and trainers to the school and can help assure a training program tailored to the SODELAC needs. Eligible participants should have five years of experience or one year of experience and an Agent Technique degree. This course trains participants in the management of agricultural projects: measuring agricultural profit, using credit, establishing budgets, and agricultural technology and farm management. Active participant involvement through role playing, case studies, group interaction, and site vists is emphasized in the program. Since dates for the program vary each year, the exact timing of the participant training is not presently known.

2. Bangladesh Training

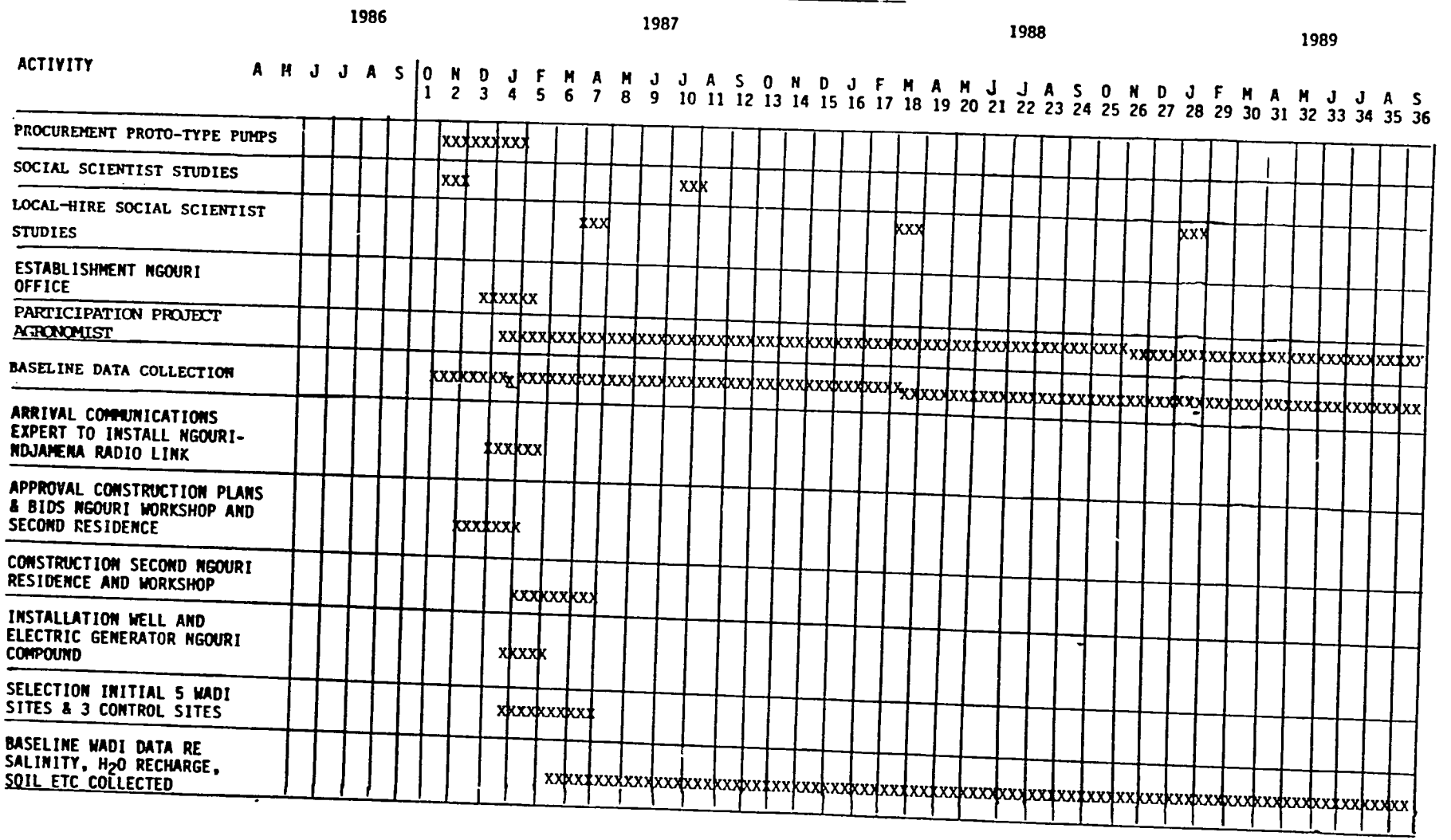
During Year One of the project, the Pump Specialist, a SODELAC agent and either a village leader or a local pump manufacturer will travel to Bangladesh to see first-hand the pump and tubewell technology employed extensively in that country. This trip will enable the participants to gather information on pump construction, utilization, and maintenance. The details of this trip have not yet been arranged.

ANNEX N

PROJECT IMPLEMENTATION SCHEDULE



PROJECT IMPLEMENTATION SCHEDULE



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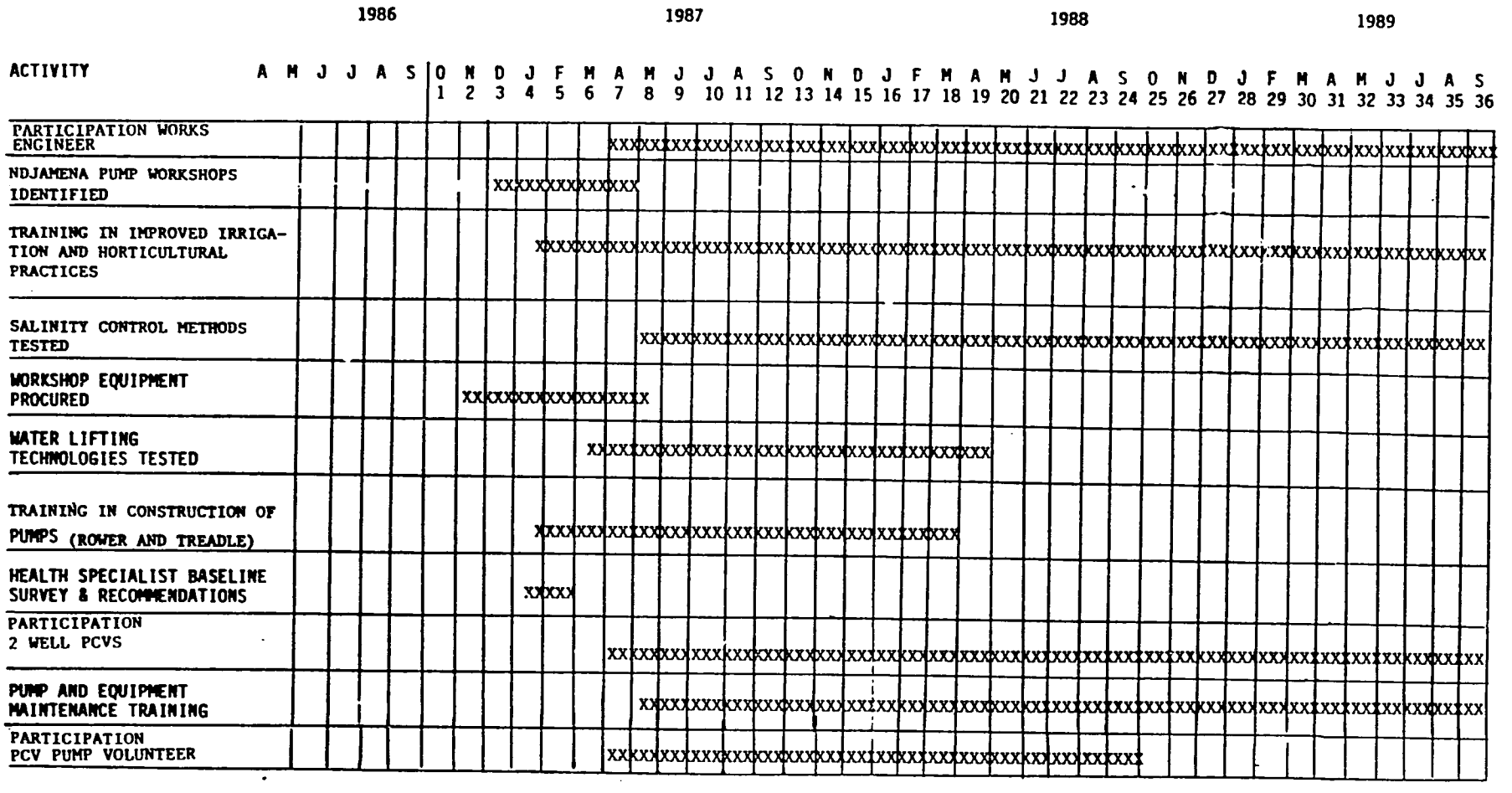
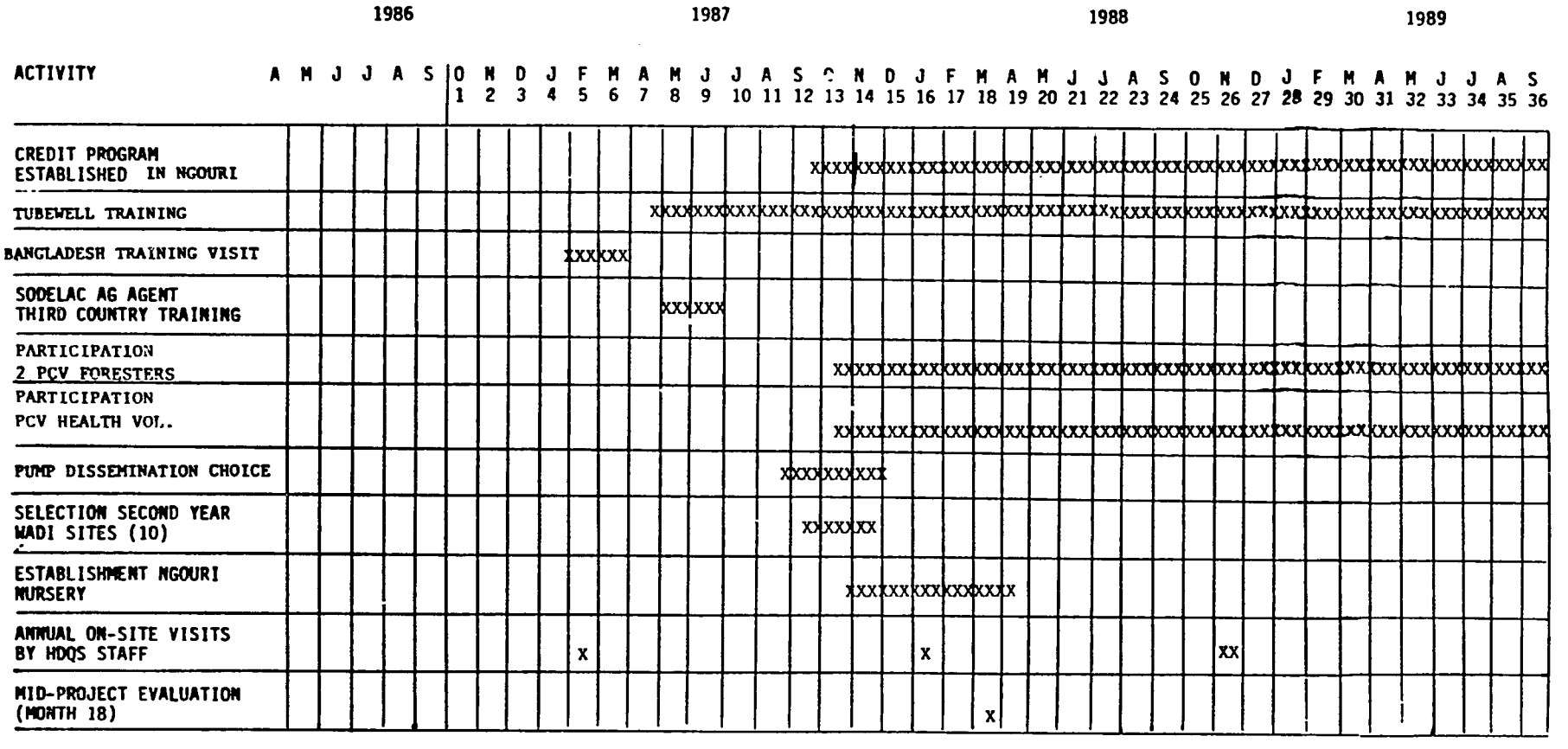
PROJECT IMPLEMENTATION SCHEDULE



PROJECT IMPLEMENTATION SCHEDULE



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PROJECT IMPLEMENTATION SCHEDULE

ACTIVITY	1986						1987												1988												1989									
	A	M	J	J	A	S	O 1	N 2	D 3	J 4	F 5	M 6	A 7	M 8	J 9	J 10	A 11	S 12	O 13	N 14	D 15	J 16	F 17	M 18	A 19	M 20	J 21	J 22	A 23	S 24	O 25	N 26	D 27	J 28	F 29	M 30	A 31	M 32	J 33	J 34	A 35	S 36
LAKE FITRI STUDIES											X	XX																X	XXX													
HEALTH SPECIALIST FOLLOW-UP STUDY																			XX	XXX																						
SELECTION THIRD YEAR WADI SITES (10)																											XX	XXXXX	XX													
END OF PROJECT EVALUATION (MONTH 33)																																							XX			

ANNEX O: INFORMATION ON THE TREADLE AND ROWER PUMPS

1. The Rower Pump

a. Information from "Human and Animal-Powered Water-Lifting Devices," W.K. Kennedy and T.A. Rogers, Intermediate Technology Publications, 1985.

The concept of cheap, manually-operated tube-well pumps designed to irrigate small plots of land has become one of the focal points of irrigation development in Bangladesh in recent years. This emphasis has taken place in order to make water more accessible to small farmers, to make the poor rather than the wealthy receive the benefits, and to generate employment among the landless. From this scenario, the Mennonite Central Committee with the assistance of the Mirpur Agricultural Workshop and Training School directed its efforts at developing a pump envisaged by George Klassen, an MCC engineer (37).

The Rower pump (Figure 30) is a reciprocating-action piston pump whose PVC cylinder is inclined at an angle of 30° to the horizontal. A unique feature of this pump is that it is fitted with a surge chamber at the pump suction. This absorbs the impact of the accelerating and decelerating column of water within the tube-well pipe and so provides a steadier upward flow of water. This in turn enables the operator to make easier and quicker strokes. It has been found that a man can pump 50% more water in a given time using a pump with a surge chamber fitted. The ease of operation is remarkable - the addition of the surge chamber enables children (who would otherwise be too small to operate a conventional hand pump) to pump water quite easily.

Figure 20 shows the increased discharge obtained with the use of a surge chamber on both the Rower pump and the UNICEF New No. 6 pump (37, 31). (The Consumers' Association have also carried out laboratory tests on surge chambers for the World Bank.) Note that the use of a surge chamber could also be considered on other conventional hand pumps - especially to enhance the discharge for small-scale irrigation requirements.

The results of field tests carried out with the Rower pump by the Mennonite Central Committee indicate a prohibitive labor cost for the mannual irrigation methods which rest or fall on the question of labour costs. Where labour costs have to be taken into account (and where these are relatively high) then the case for manual irrigation becomes less favourable.

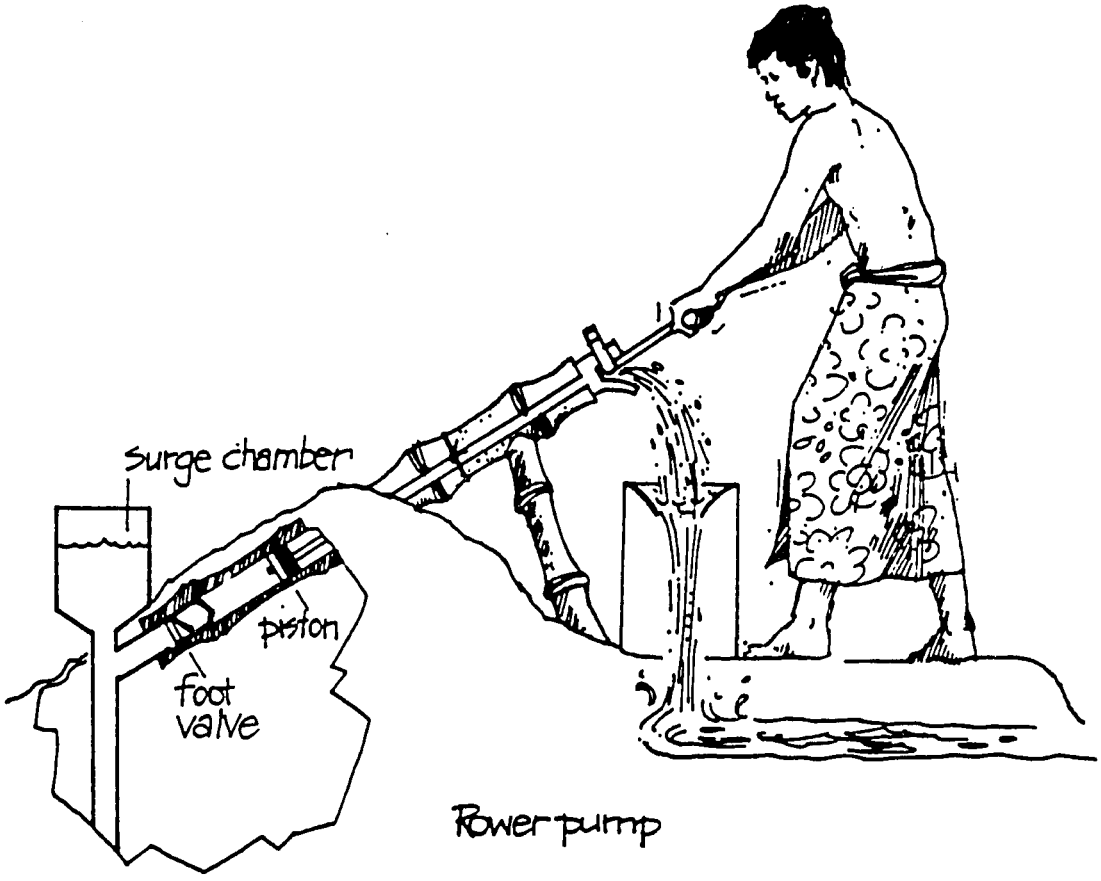
Rower pump developments

In 1981, the Mennonite Central Committee (MCC) and the Mirpur Agricultural Workshop and Training School (MAWTS) conducted an experiment comparing three manually-operated irrigation pumps: the 2" Rower pump, the treadle pump manufactured and marketed by Ranpur-Dinajpur Rehabilitation Services (RDRS) and the new No. 6 Bangladesh pump. It was found that the Rower pump continued to operate usefully at lower static water levels (down to 8.5m) than the other pumps tested. Naturally in irrigation pumping situations the tubewell requires to have aquifer conditions which do not significantly restrict water inflow to the well.

Since 1980 the Mennonite Central Committee have established a marketing effort geared to the sale and distribution of the Rower pump. For the 1980-81 season total sales were 415 pumps. During the 1981-82 season, 650 pumps were sold and installed in three districts, with a further 150 pumps distributed by MAWTS in three other districts. The sales target for the 1982-83 season was 1000 pumps.

The MCC consider that their experience in introducing the Rower pump for tubewell irrigation constitutes a test of the principles generally involved in the introduction of new technology. The MCC initiative in irrigation development involved a package of three new constituents - the Rower pump, PVC tubewell and filter. This was a situation which required special efforts since without proper field training and installation there would be a danger of rejection of the whole package even if only one constituent failed.

Training was an important aspect in introducing the new technology. It was essential to provide good examples and'hands-on' experience during the training period. Field testing is also essential for product development. MCC did extensive field testing, while maintaining close communication with the users. This led to improvements and simplifications being made to the original design.



Power pump

When the Rower pump was first introduced it was installed above ground. However, recently more and more Rower pumps have been partly buried in the ground with only the discharge pipe exposed. This has the advantages of keeping the lift to the absolute minimum, eliminating the danger of knocking or damaging the surge chamber, and reducing the risk of theft or vandalism.

The Rower pump is vulnerable to damage if the pump handle strikes the end of the pipe. The latest design consists of a flanged steel insert to eliminate damage of this kind.

The Rower pump is now also manufactured by a UK company (SWS Filtration Ltd.) Two operating options are suggested: a standing position or a sitting one. The standing position is recommended for household (domestic supply) operation. The sitting position is recommended if the pump is to be used for irrigation. (As mentioned already the pump may be completely buried in the soil, leaving only the outlet above ground level.)

The SWS Rower pump has a maximum effective suction lift of up to 3.7m. Within this range an output of up to 1.5 litres per second is claimed (achieved by an 'average healthy man'). This is a 'water watts' output of 55W which suggests a manual input which could not be sustained for lengthy periods. Women and children would be expected to pump less water, but even a child pumping slowly can operate the pump and produce more water than that obtained from most other hand pumps.

b. Information from "Rural Water Supply Handpumps Project," Saul Arlosoroff et al., World Bank Technical Paper Number 29.

The Rower is a direct action handpump developed for low-lift irrigation applications in Bangladesh.

Following is a related report about the Rower pump. These were written by the Mirpur Agricultural Workshop and Training School (MAWTS) and the Mennonite Central Committee.

This report is reproduced here because the Rower is a widely used example of a new generation of direct action handpumps which offer many advantages based on their village level operation and maintainance (VLOM) characteristics including simple maintenance, low cost, and local manufacture. The general advantages and technical analysis of direct action handpumps are discussed in Annex A. The laboratory tests of the Rower pump are discussed in the Handpumps Project Management Report No. 3 and are summarized in Chapter 6 of this Report.

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THE ROWER PUMP

1. DESCRIPTION

The Rower pump is a manually operated reciprocating pump with a 2 inch nominal diameter PVC pipe as the pump cylinder. The piston inside the cylinder is operated by pulling and pushing directly on a T-handle at the end of the piston rod. The pump is installed at an inclined angle of 30° from the horizontal to the well in the ground through a "Y" connector piece. Moving the "T" shape handle in a rowing motion the farmer/operator thrusts the piston back and forth in the cylinder and draws water out of the tube well by means of suction. Use of a suction chamber is made to compensate for the velocity variation produced by the water column traveling in the well pipe, which provides a steadier upward flow of water in the ground pipe enabling the operator to make easier and smoother strokes. Compared with the conventional metal body lever pumps a person can pump significantly more water in a given time with the Rower pump at a suction lift of 15 to 25 feet (5 to 8 meters). The output difference increases with the increased lift, however, at 20 feet lift the output is about 0.8 liters per second (12 GPM) depending on the acquifer condition. The pump is easy to install and operating comfort is remarkable. The pump is being used for small scale irrigation by the farmers for various types of crops. Several types of the Rower pump have been produced and tested for various lifting height and cylinder sizes. Another successful version is the 3 inch diameter Rower pump suitable for low lifting of surface water up to a lift of 10 feet (3 meters) giving an output of about 2 liters per second.

2. TYPES OF ROWER PUMPS

Types	Maximum Lift	Recommended Maximum Working Lift	Discharge at Recommended Lift	Suitability
Rower pump 2 inch	26 ft (7.9 m)	20 ft (6.1 m)	0.8 liters/sec 13 gal/min	Tube well
Rower pump 2.5 inch	18 ft (5.5 m)	12 ft (3.7m)	1.5 liters/sec 20 gal/min	Lifting water from dug well & tube well
Rower pump 3 inch	12 ft (3.7 m)	9 ft (2.7 m)	2.0 liters/sec 30 gal/min	Surface water lifting from pond, canal, river, etc.

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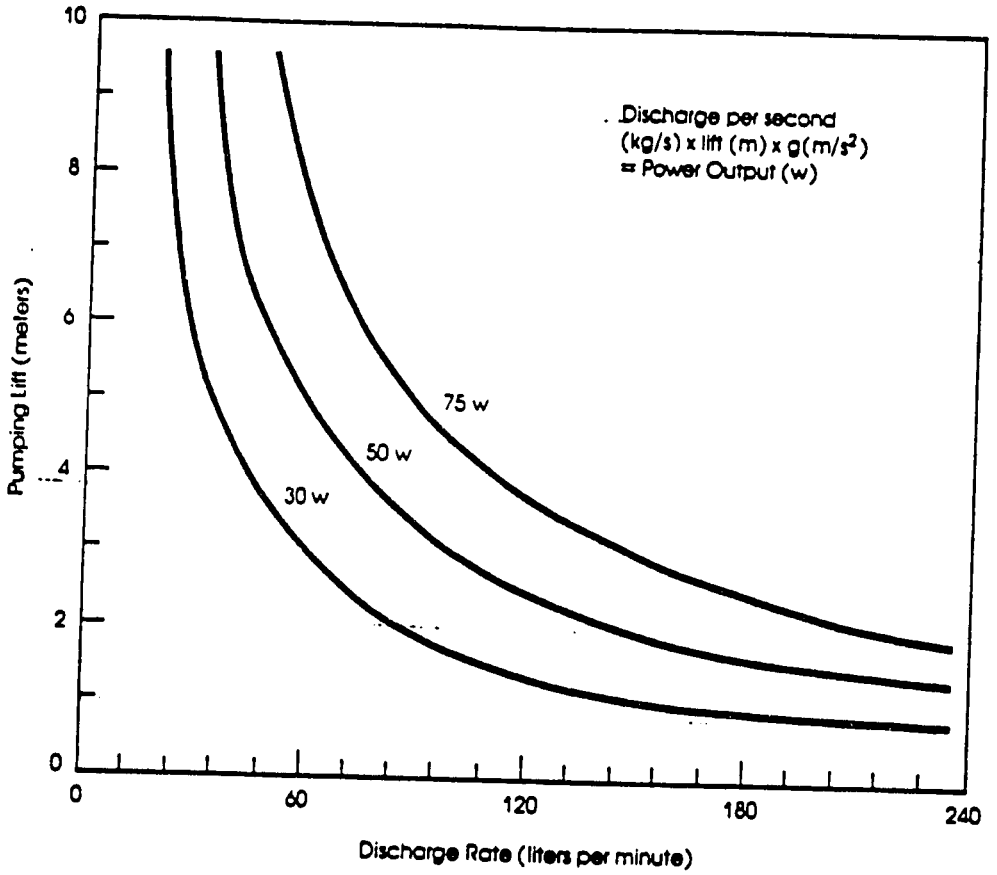
Figure B-1
Water Discharge Versus Depth



3. PERFORMANCE CHARACTERISTICS

During field trials carried out in various parts of Bangladesh, the performance of the two inch Rower pump has been found as indicated in the discharge graph shown for various power inputs by individuals while operating the pump. However, for an average healthy person operating the pump output over a period of eight hours of continuous operation in turn by two persons operating and resting is an indicated in the table:

2 Inch Rower Pump

Lift Height	Discharge
10 feet (3.0 m)	23.0 gpm (1.5 liters/sec)
15 feet (4.6 m)	20.0 gpm (1.3 liters/sec)
18 feet (5.5 m)	17.0 gpm (1.1 liters/sec)
20 feet (6.0 m)	12.5 gpm (0.8 liters/sec)

4. OPERATIONAL INSTRUCTION

4.1 Well

The well normally consists of 1-1/2 inch nominal diameter galvanized iron (G.I.) pipe or PVC pipe as found suitable, depth of the well would vary according to the ground condition from place to place. A screen/filter length of 12 feet (3.7 m) at the bottom of the well is generally recommended. In certain cases 6 foot (1.8 m) length may be sufficient. Fine sand condition would necessitate a gravel packing around the screen. Gravel packing must be well mixed and consist of required sand sizes. A cap is required at the bottom of the screen. The top end of well casing should be installed at a proper point so that the pump outlet will be 20 to 24 inches (51 to 61 cm) above the surface where the operator stands. This height assumes an adult operating the pump. For final placement of the well, pack the top of the casing pipe tightly, to prevent movement of the well during pumping action.

4.2 Installation of Pump

a) Inspect all the pump parts so that they function properly:

Foot valve seal should seat tightly inside the tapered end of the cylinder.

- Piston locking nut moderately tightened and lock ring correctly attached, assembly in correct order.

- Surge chamber collar properly sealed with rubber mounting coupler. Check coupling for required rigidity.

b) Installing pump cylinder to "Y" function piece:

- Use paint on the threads.

- Use pipe wrench to moderately tighten the cylinder to the junction "Y" piece.

- Turn the pump in the direction the farmer wishes to operate the pump.

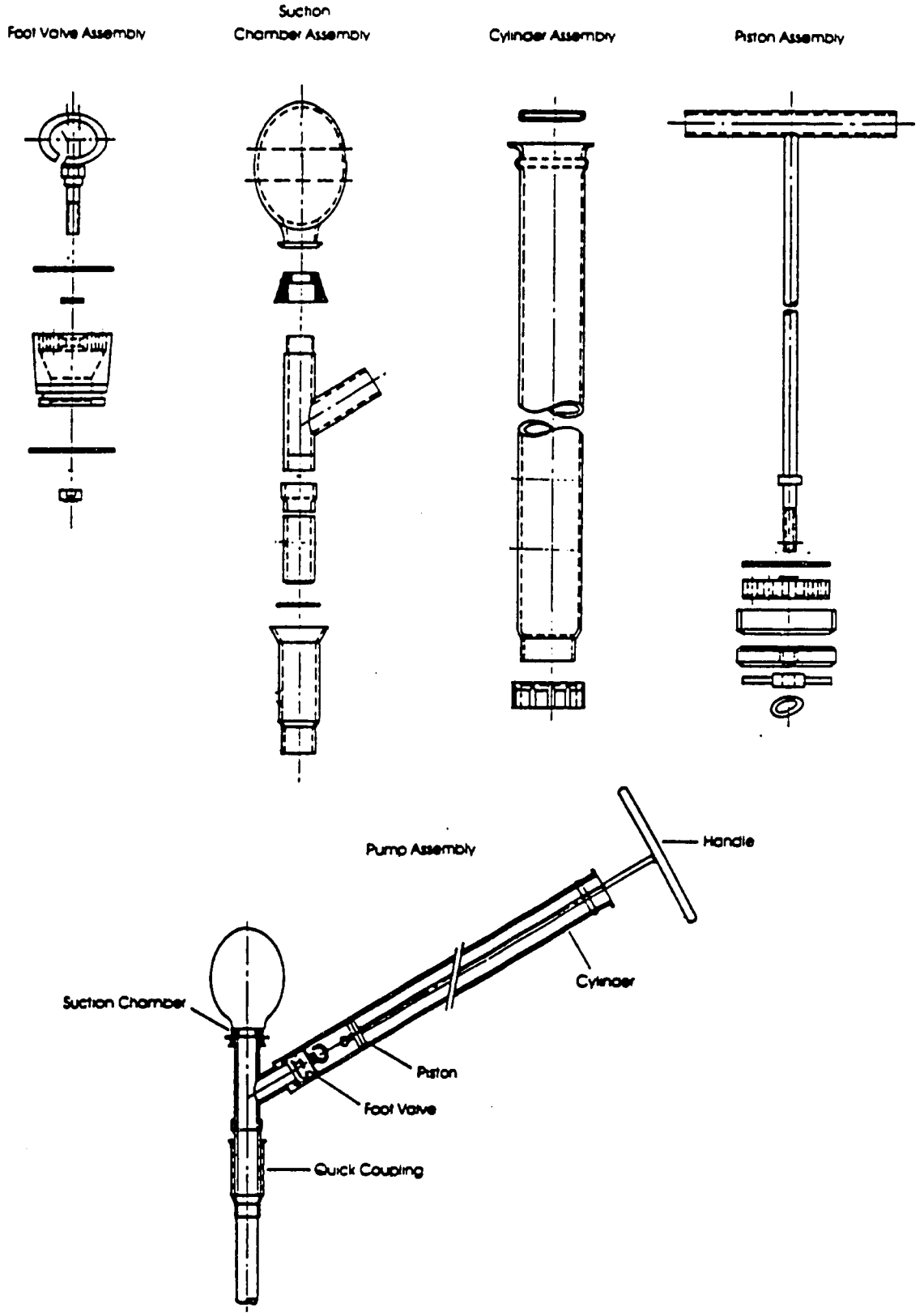
- Check the angle of the pump against the horizontal ground and the comfortable angle should be about 30°.

c) Support for the inclined pump cylinder:

- Split a bamboo and tie it around the outside of the PVC pipe for sunlight protection and for stable support. Also fashion a bamboo or branch of tree to act as a vertical support directly under the pump cylinder about 1 foot from the end of the delivery spout. With wire or rope fasten these together. For additional rigidity and stability the pump can be completely buried in an earth mound.

d) Make a proper receiving area for water to fall. Approximately 3 foot (1 m) diameter area with small dike around the perimeter. If the user wishes the water can be conveyed by various means found suitable for different areas. Effort should be made to prevent soil erosion around the pump specially at the delivery end.

Figure B-2
Sub-Assemblies of the Rower Pump



4.3 Developing the Well

In order to lengthen the useful life of the well and the pump and allow for easy operation of the pump the following procedures are recommended:

> Once the pump and well are completely installed begin to operate the pump, when water appears, stop and quickly remove the surge chamber from the pump allowing the water column to rush down into the well.
>
> Repeat this procedure two to three times. Next start pumping water from the well with Rower pump till all dirty water ceases to come out. When water appears clean remove the surve chamber as before, as many times as necessary, till no more dirty water is discharged from the well. This procedure may have to be repeated several times before the well is satisfactorily developed.

4.4 Tools Required for Installation of the Pump

Pipe wrench and hacksaw blade (if PVC well is used). For normal operation hardly any tools are required.

5. REPAIR AND MAINTENANCE

The merit of the Rower pump lies in the very simple design used for its manufacture. The pump during its normal operation hardly requires any maintenance, and the components are very simple and spares may be easily replaced without use of any tools. Simplified maintenance is an important feature of this pump. Access to both pistol and foot valve is quick and simple. They can be removed without dismantling the pump. The pistol with the leather cup seal in the cylinder can be easily removed by pulling out the piston rod. A rod with a hook at one end and a ring at the other is used to both draw out the foot valve and slide it back again. If the pump looses its prime then the foot valve seals and sealing of the suction chamber around the coupling rubber piece should be checked for leakage. Different rubber seals used in the pump can be made from ordinary inner tubes and replaced. Other maintenance points are:

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5.1 Leather Bucket

If the action of the piston becomes stiff usually it is found that the leather bucket has swollen and needs "shaving" to make it an easy slip fit.*

5.2 Rubber Piston Valve

If a replacement valve is required it must be tight fit around the piston rod, and cover all the holes in the aluminum plate.

5.3 Over Tightening of Locking Nut

Over tightening of the locking nut can result in cracking the aluminum plates. For this reason a washer is provided to facilitate tightening.

5.4 Bending of Piston Rod

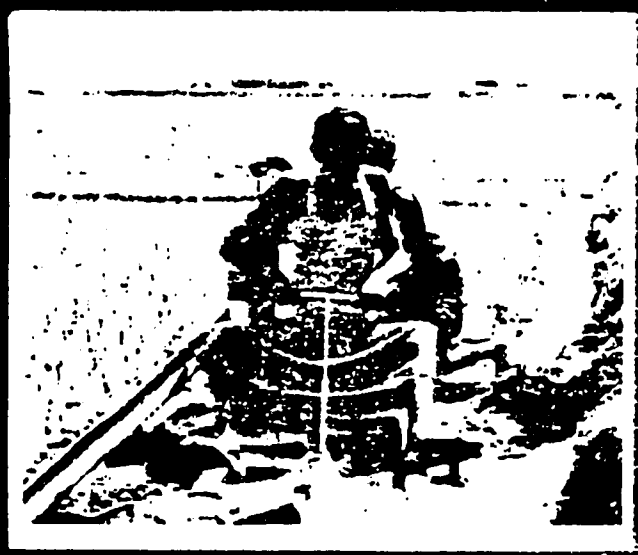
If the piston rod is bent, it will result in excessive wear of the piston guide or the leather bucket. This condition must be avoided.

---

* Editor's comment: This statement has been included here because it is part of the original document provided by the Mennonite Central Committee. However, elsewhere, with other types of pumps, it has been found that the practice of "shaving" oversized leather buckets (leather cup seals) has drastically shortened their working life. The outside of the leather is its strongest part, and once shaven the remainder deteriorates rapidly. It is therefore important to provide original leather buckets which are undersized and will not need shaving. Buckets with a diameter about 1/16 inch (about 1.5 mm) smaller than the inside diameter of the cylinder have been found to work well elsewhere, with different pumps.

c. Information from "Rower Pumps", International Development Enterprises, Pamphlet.

ROWER PUMPS



- *HIGH OUTPUT*
- *EASY OPERATION*
- *SIMPLE REPAIR*
- *LOW COST*

DESCRIPTION

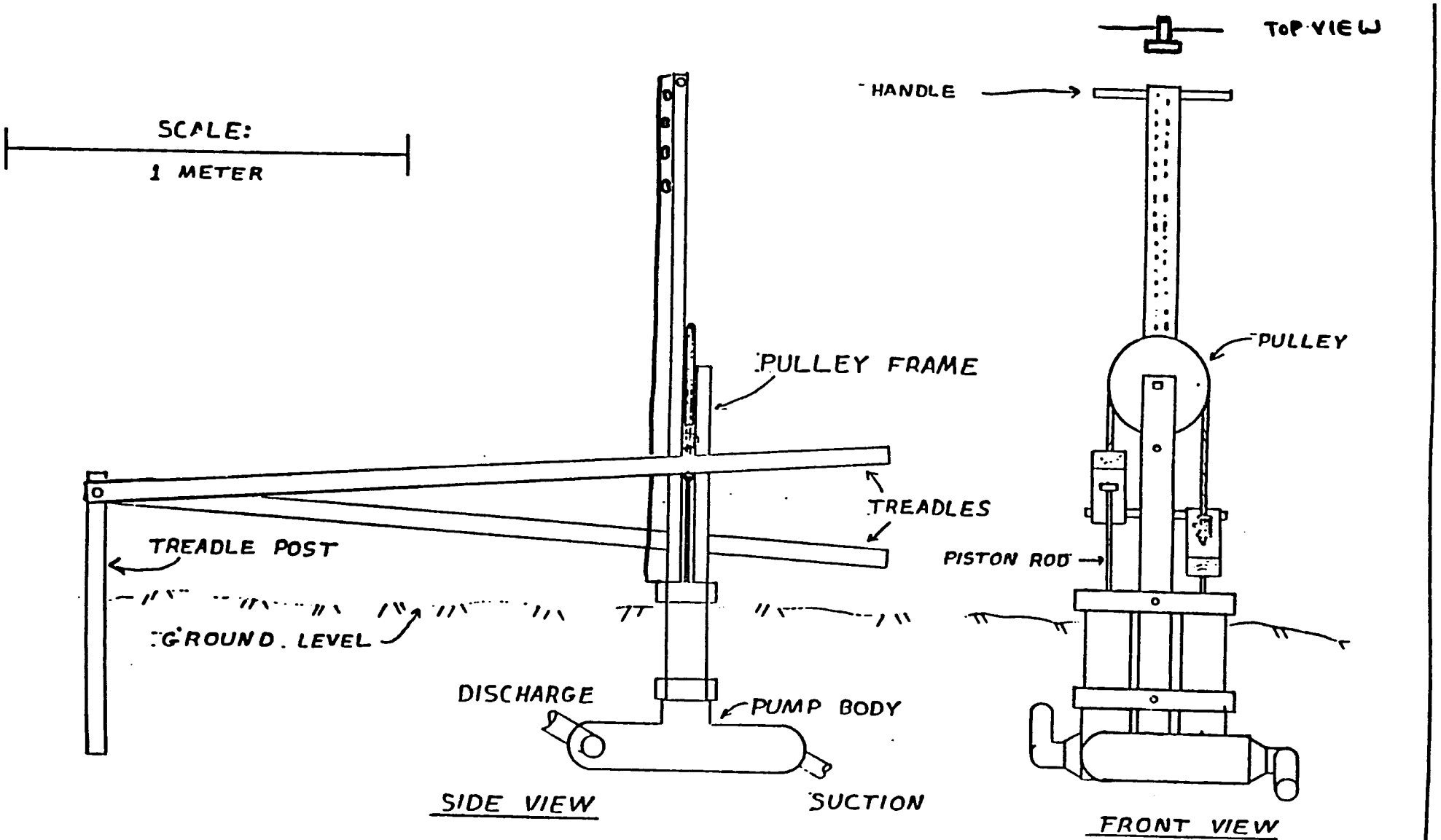
The Rower is a simple hand operated pump designed for small plot irrigation. It was developed in 1977-78, by an MCC volunteer in Bangladesh, George Klassen. The name comes from the operating action, which is similar to that required to row a boat. Rowers can be used wherever the depth to the water table is less than 7m.

OPERATION

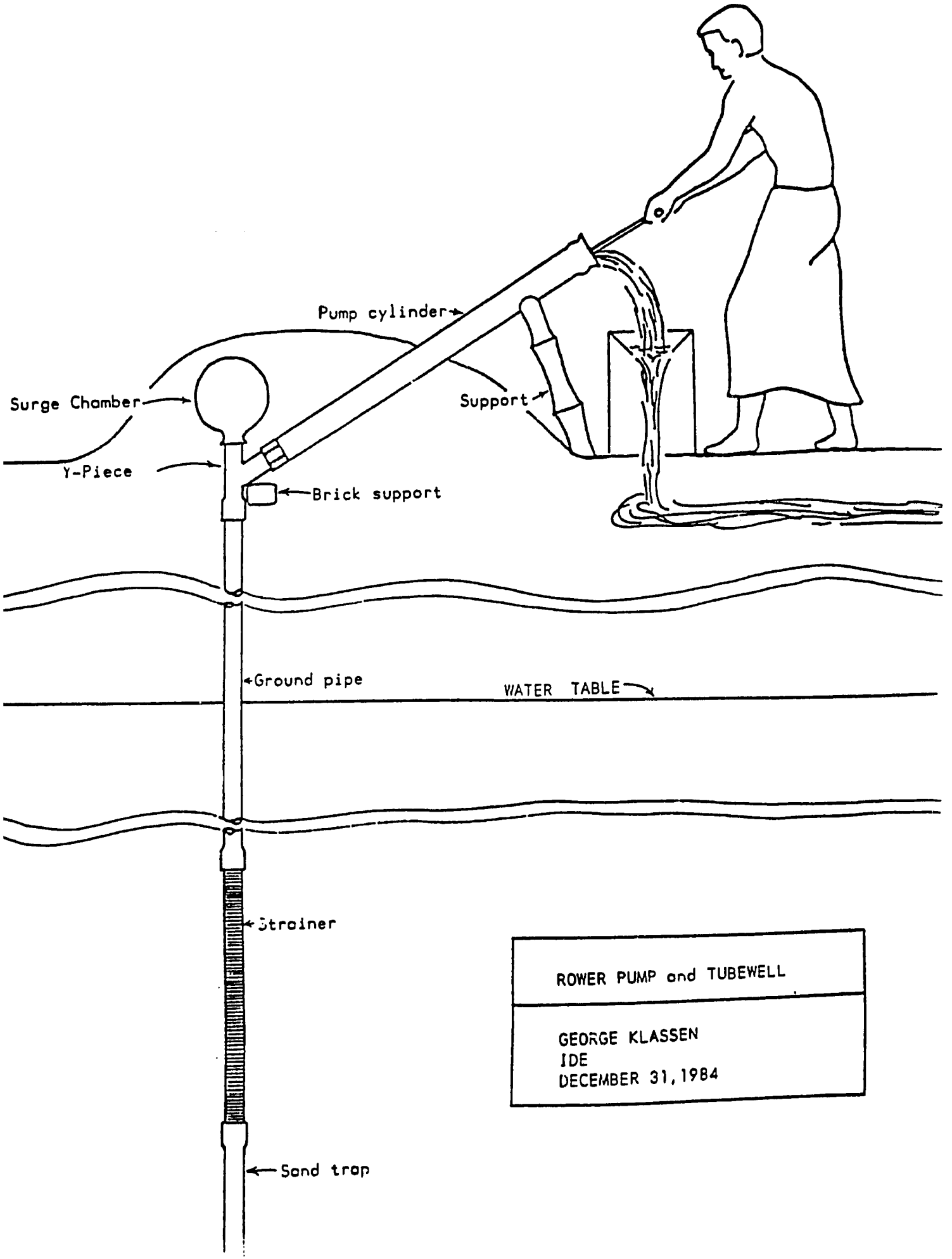
The water flows from the mouth of the cylinder as the piston rod is pulled. The surge chamber on top of the well casing evens the flow, to permit a smooth and easy pumping effort.

USE

About 10,000 Rower Pumps are now in use in Bangladesh. Approximately 15% of these are used for irrigation only, and about the same number for drinking water only. The majority are used for both purposes.



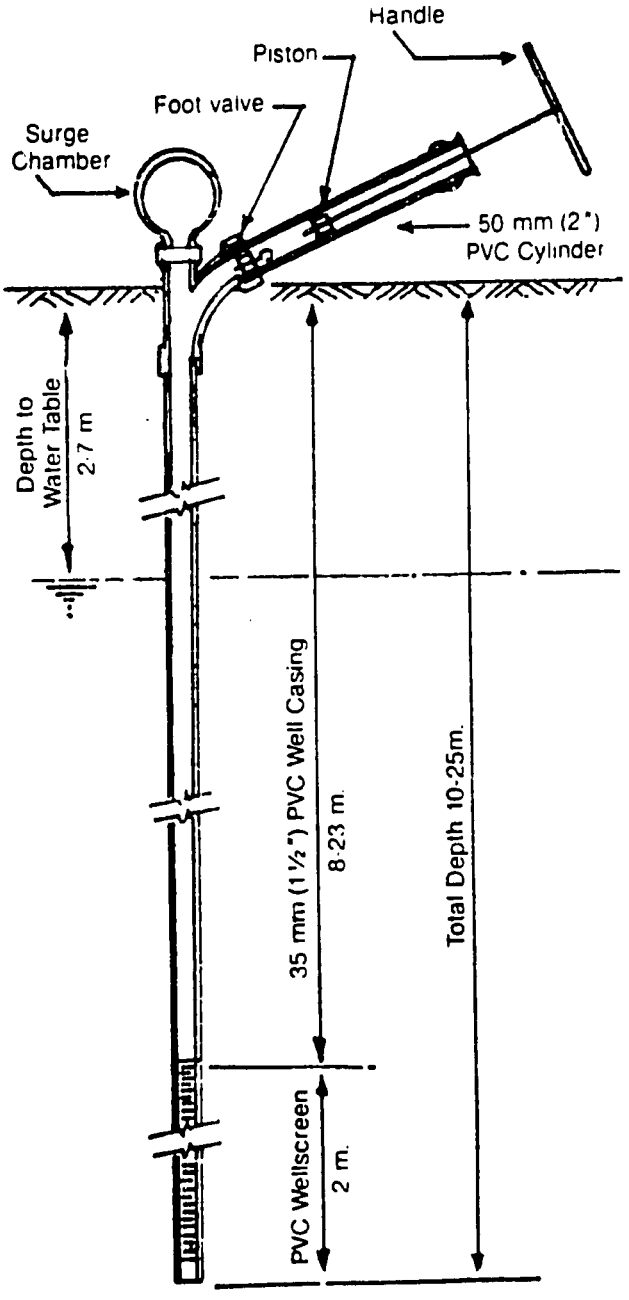
USAID UNIVERSAL TREADLE PUMP
FOR HUMAN POWERED IRRIGATION
SHEET 1 OF 11 (DEC 1985)



ROWER PUMP and TUBEWELL

GEORGE KLASSEN
IDE
DECEMBER 31, 1984

TYPICAL ROWER PUMP INSTALLATION



INSTALLATION

Although Rowers have been put on open wells, and operate fine from streams and ponds, the standard installation is on a 35mm casing. (plastic pipe is most commonly used) in a 60mm well drilled to between 10 and 25m, depending on the depth of local clay and sand layers Water enters through a 2m. length of screen. In soft alluvium, installation to a depth of 15-20m. can be done by three men in less than 6 hours with only simple tools

MAINTENANCE

Under normal operation the Rower requires very little maintenance The parts are few and simple, and can be replaced by hand, without dismantling the pump. The rubber flaps of the piston and footvalve are made from old inner tubes, always to be found in the village.

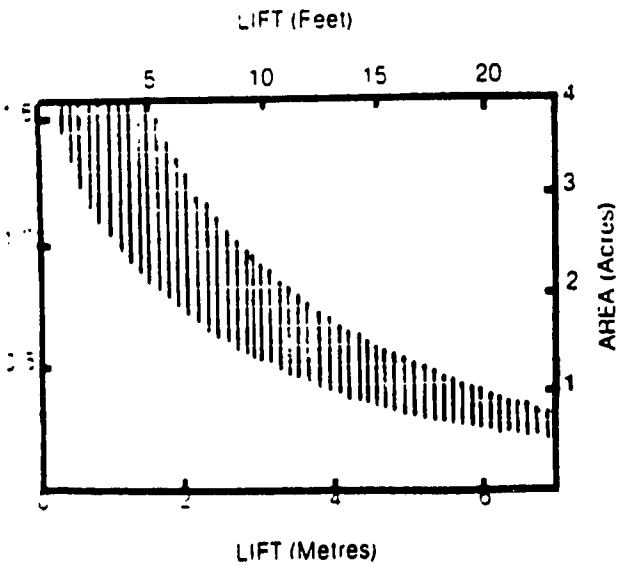
PERFORMANCE

Water Output

This, of course, varies with the depth to the water table. Two healthy men, taking turns, can produce about one lit/sec (16gpm) at a 4m (13ft) lift for long periods. Thus a daily output of 20-25 cu.m is easily achievable. If the lift is less, the output can be increased, and, if it is more, the output is proportionately decreased.

Irrigation Areas

Many factors determine the area irrigable with any hand pump. The following diagram shows typical areas, which depend mainly on water table depth, for vegetables on average soils, under average weather conditions.



COSTS

The pump itself costs less than $15. A typical well costs $25-$45, depending on the depth and the material used for the casing and screen, PVC is normally used, specially for deeper wells. Where total depth is less than 12m bamboo can be used for both casing and screen. Total installed costs thus vary between $40 and $60.

For more information contact:

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Phone: 41 25 06

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Winnipeg, Manitoba
Phone: (204) 944-1995

→ 1901 Kipling (Suite 24)
Lakewood, Colorado 80215
Phone: (303) 232-4336

2. The Treadle Pump

a) Information from "Human And Animal-Powered Water-Lifting Devices", W.K. Kennedy and T.A. Rogers, Intermediate Technology Publications, 1985.

Since 1971 the Rangpur-Dinajpur Rehabilitation Services (RDRS) has been involved in assisting small-scale farmers (since 1981 the target group was farmers with 2 acres or less - before 1981 the 'ceiling' was 3 acres). The government's agricultural extension programme was supported through research and training, appropriate innovations (pumps with bamboo tubewells for irrigation, and other farm implements) and the introduction of new crops, e.g. wheat.

RDRS has worked on simple, manual and affordable agricultural implements, one of the most obvious successes being the bamboo treadle pump. Many models were tested under field conditions and a production model - a twin-cylinder pump - was available in November 1980. During the next two years, nearly 7000 of these irrigation pumps were installed in the field. The simplest twin cylinder model delivers 5.5m^3/h from 5.5m. Note that this data gives a 'water watts' output of approximately 80, which suggests that the human power input is considerable - perhaps about 140 watts. This level of human effort could not be sustained for extended periods even with the weight-shift treadle-action operation of this pump.

The metal and plastic parts of the treadle pump cost only US$7. The farmer provides the bamboo and hires a tubewell sinker who charges an average of US$0.30 per meter for the installation. The total cost (pump plus typical installation) is about US$13-17. In comparison with this is a typical commercially manufactured hand pump costs about US$100 and provides a flow rate of about 2.7m^3/h only, at a pumping head of 5.5m.

To ensure optimum results, farmers as well as local sinking groups are trained to install the pump properly and to treat the bamboo with chemical preservatives. Small farmers purchase their own pumps and pay for the installation (they benefit from a small subsidy of US$3).

At present, only 4.35% and 3% of the arable land in Rangpur and Dinajpur districts, respectively, is under irrigation farming. Hence there is considerable scope for increasing food production by enabling the farmers to grow two or more crops per year. During 1982, the programme

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sold 4733 irrigation pumps (plus 869 drinking water pumps). To meet the growing demand for pumps, in addition to the main RDRS workshop in Rangpur, three other private workshops have been established with RDRS assistance. The four workshops have a production capacity of 3000 pump heads per month. There are seven models of the irrigation pump, and one domestic model available.

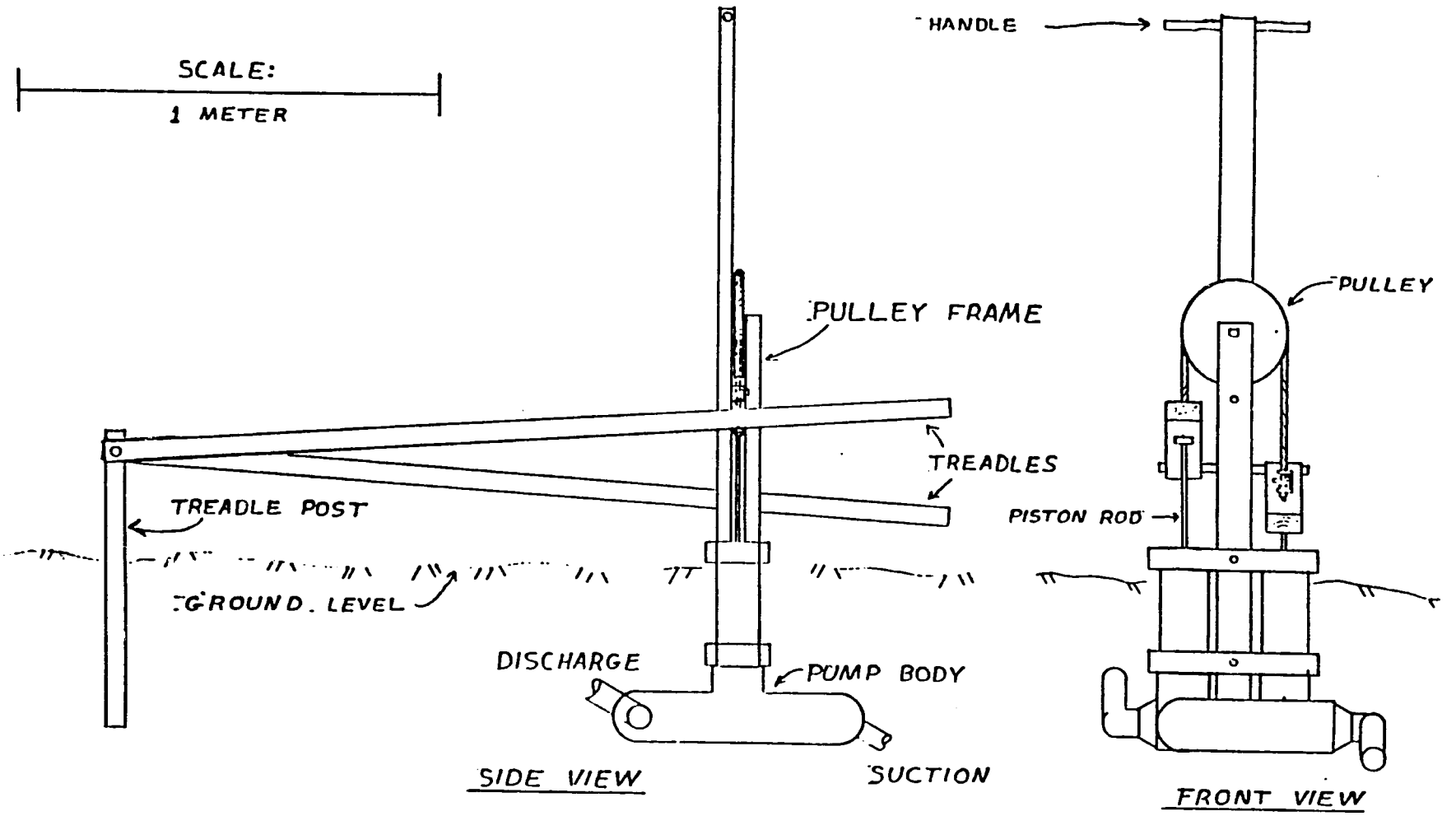
Some comparison between RDRS pumps and diesel pumping is relevant here. The subsidized cost of a diesel-operated pump (0.75 cu.sec) is US$1040 - 1250, while 10 treadle pumps with bamboo tubewells cost only about US$125. The field life of a diesel pump is about 3 to 5 years, while the bamboo tubewell (with the bamboo treated with preservatives) is expected to last over 10 years (untreated bamboo lasts only about 4 to 5 years). These reasons plus the rising fuel costs make RDRS pumps more appropriate and viable for the majority of small farmers.

b. Information from "USAID Universal Treadle Pump for Human Powered Irrigation", Dan Jenkins, USAID/Abidjan, Dec. 1985.

Installation: For proper operation and long life the pump and treadles should be installed reasonably leveled and well aligned. The rope must be tied to a length to assure proper positioning of pistons in the cylinders. Nylon rope has a tendency to slip and stretch so it may be necessary to tie several centimeters short initially. A rope clamp may be more practical than tieing.

For the Universal Model it is advantageous to keep the pump near the source and do most of the conveying or lift on the pressure side. All pipe (suction and pressure) should be 58 mm (2.2 inch) inside diameter or larger. Elbows are well suited to connect suction and discharge pipe to the Universal Model because they can be turned to give any desired angle. Large radius elbows are preferred if available to minimize friction loss. A minimum pressure head of about one meter must be maintained for the bleeder valve to function properly.

The shallow Tubewell Model is designed for use with low-cost manually installed tubewells in shallow alluvial aquifers. Wells can be easily installed by the "slugger" method used in Bangladesh and South East Asia. Casing can be 60 mm PVC pipe or other suitable material. Screens can be made from perforated PVC pipe wrapped with synthetic fabric of the desired mesh.



USAID UNIVERSAL TREADLE PUMP
FOR HUMAN POWERED IRRIGATION
SHEET 1 OF 11 (DEC 1985)

Source: "USAID Universal Treadle Pump for Human Powered Irrigation", Dan Jenkins, USAID/Abidjan, December 1985

ANNEX P: SOCIO-ECONOMIC BASELINE DATA

If the road to success were paved with donors' good intentions, the Lac Prefecture would now be the breadbasket and breadwinner of Chad. In the 1970's large amounts of money were spent on Lake Chad polder production of commercial crops such as wheat and vegetables for national and export consumption. Eventually these projects failed. The hostilities from 1979-1983 certainly played an important role in bringing about these failures but so did the technical and social problems.

Polder development has been going on since 1950 at least. A great many studies have been done, and a great deal of information has been gathered since that time about the ecology, technical matters and problems with project design. This information has been published in reports, journals, and studies, and is available to those who wish to profit from the wisdom of others and avoid the mistakes of the past. Prior to the full scale implementation of this project, ORT will gather some of this information for the use of its technical staff.

Some of the important information which should be gathered either from existing documents or on the site during the first phase of the project are listed below:

A. More detailed study of wadi farming system in each of the three seasons (rainy, cold and hot)
   1. Rainy season
      a. importance relative to dunes
      b. crops produced, relative importance
      c. extent to which irrigation is employed
      d. per centage of available land put into production
      e. major production problems, and productivity
      f. allocation of labor time

   2. Marketing and Consumption
      a. identify marketed versus consumed portion of each crop
      b. estimate earnings received per crop
      c. identify marketing method per crop

   3. Other income earning/household activities
      a. outline schedule of activites outside of agriculture over the course of the year
      b. identify significant blocks of time devoted to activities which might conflict with the project production calendar

c. estimate farm family income
d. estimate family cash requirements and financial aspirations

B. Market Surveys
1. Survey of regional markets (to include Mao, Massakoury, Massaguet as well as Lac Prefecture major markets)
a. mapping, identify market days, estimate size, principal products if unusual, area served.
b. transport system service available at each market and current rates
c. storage facilities available and rates
d. major commerants active in each market

2. Agricultural product prices
a. prices of food grains, local produce, animal products
b. quantities or value traded of major items
c. points of origen of major products traded
d. farmer sales vs. commerant resales
e. purchases for export to other regional markets
f. area served by market (people coming from where?)

3. Identify products with potential for export to N'Djamena or neighboring African countries.
a. products traded actively in N'Djamena
b. products currently being exported to or in demand in Nigeria, Niger, Cameroon, CAR

C. Survey of wadis in project area
1. Resources
a. water
b. soils, salinity
c. fruit trees, etc.

2. Current Use
a. number of exploitations
b. crops produced
c. productivity
d. persons, families, village origens

3. History of wadis
a. increasing or declining use?
b. land tenure problems or disputes?

4. Identify control wadis to observe over life of project
a. farmed
b. unfarmed

D. Rough census of project region
   1. Village populations
      a. per centage active in farming, age distribution estimate
      b. migratory patterns

   2. Productive activities
      a. annual cycle of agricultural activities
      b. non-farming activities

E. Polder Agricultural Survey
   1. Productivity
      a. crops
      b. yields
      c. method and level of effort required for production
      d. particular production problems

   2. Typical family exploitation
      a. area farmed
      b. total harvest
      c. other productive activities undertaken (livestock, fishing)

   3. Health conditions
      a. history of health conditions
      b. observation of current problems
      c. recommendations for cost effective response

F. Reasons for migration to N'Djamena
   1. Discussions with individuals who migrate
      a. reasons for leaving
      b. earnings achieved (gross and net savings)
      c. attitude toward possibility of staying in area and farming

G. Sample survey to quantify metric equivalent of local units of measure
      a. korro
      b. sack
      c. corde
      d. requires some measuring instruments for weight and distance

H. Export market potential
   1. Neighboring country studies
      a. grains
      b. vegetables
      c. fruits
      d. livestock products

2. European market potential
   a. conditions of export - storage, transport
   b. local agents ??
   c. history of similar efforts

3. Potential domestic and export uses for local agricultural products
   a. Industry
   b. Food processing
   c. cosmetics
   d. condiments, spices

J. Study of family structure
   1. kinship terminology
   2. corporate groups
   3. ownership and control of land, material and spiritual property
   4. modes of inheritance
   5. rights and obligations
   6. marriages
   7. domestic cycle
   8. relationships of interdependence
   9. production and consumption groups

K. Study of political structure
   1. hierarchy of office holders and incumbents
   2. office holders' legal powers
   3. people/places over which officeholders have control
   4. rights and obligations of super- and subordinates
   5. communication between superior and subordinate
   6. decision-making at each level of hierarchy
   7. actual vs. legal exercise of powers
   8. character, interests and abilities of actual officeholders

L. Land Tenure
   1. survey of all wadis and their village ownership
   2. survey of villages and their wadis and polders
   3. map of each wadi in project and control group listing parcels, current owners, area currently in production or fallow/abandoned fields and reasons for abandonment.
   4. chefs de terre/village and other village officials
   5. customary payments
   6. actual vs. theoretical transfer of land ownership

ANNEX Q: REMARKS ON LAKE FITRI

The Lake Fitri region appeared to offer very interesting possibilities for agricultural development. Favorable factors included:

1) Active commercial sector,
2) Good roads (relatively speaking) for part of the year,
3) Large number of transporters,
4) Substantial capital available in Ati and Am-Djamena-Bilala (Yao had a certain appearance of wealth also),
5) Some major products exported - fish in particular,
6) Water available year round, and
7) Potentially rich soils.

Unfavorable factors were:

1) Water resource difficult and costly to manage,
2) Soils very difficult to manage, underlain by sand layer,
3) Roads impassable for several months a year,
4) Poor climate - difficult living conditions.

The major attraction of the Lake Fitri area from an economic perspective was the potential the area offered for commercial development of agriculture. There is already a very active vegetable market (in fact, vegetables are in surplus), and berbere is traded out of the area. The transportation system, while still far from ideal, is vastly superior to the Lac Prefecture system, although Yao itself is closed to road traffic for three to four months a year when the lake rises. There is an active commercial sector already (apoproximately fifteen tons of fish were observed being loaded for N'Djamena after market day). Many merchants are active in trading both large and small quantities of agricultural products.

These factors provide a setting which would permit the introduction of a level of technology (i.e., investment and operating expense) not possible in the Lac Prefecture at present. However, the problem of finding the right crops to commercialize, and developing a marketing system for them, would still be very challenging.

Despite the apparent agricultural richness of the area, the people still are at the mercy of an unmanageable water resource. We heard many complaints of hunger and insufficient food production. The reports of yields of the berbere crop from farmers indicated production was in the range of 300 - 500

kg per ha., while the official figures are claiming 800 - 900. Both water and soils are very difficult to manage in the lake bed. The vertisols, unless a certain level of soil moisture is maintained, crack very deeply. This reduces the effectiveness of any rainfall, and speeds soil moisture loss from evaporation. The major problem, however, seemed to be the late fall in the lake level, resulting in many late plantings of the berbere crop, and drastically reduced yields as the crop matured at the time of the harmattan.

In brief, the agricultural conditions here suggest potential, but pose some difficult technical problems. The farming population is in need of food production assistance. The commercial sector offers good conditions for commercial agricultural development (transport, capital, competition), although defining a specific cash crop opportunity may be difficult.

ANNEX R: SOCIOLOGICAL AND ECONOMIC EVALUATION CRITERIA

1. Implementation Progress Evaluation/Sociological.

a. Village:

(i) changes in agricultural calendar, techniques, technologies, yields. emigration, polder, dune and wadi cultivation.

(ii) monitor village decision-making groups. Discuss their experiences and attitudes, the decisions they have made. Discuss each innovation:
a) does it take more/less time, effort, money?
b) does it increase yield?
c) does it require changes or behavior which are acceptable or unacceptable?
d) does it affect the production group?
e) does it affect the family?
f) does it affect other social relationships?

(iii) monitor attitudes and interests of:
a) traditional officials.
b) administration officials.
c) SODELAC officials and agents.

(iv) monitor:
a) increase/decrease in number people in villages using wadi irrigation.
b) characteristics of people who begin or cease irrigation.

(v) monitor interest expressed by individuals or villages as a whole:
a) which techniques/technologies interest them.
b) their reasons for interest.
c) degree to which they comprehend techniques/technologies.
d) degree of willingness to join project.

b. Individual:

(i) monitor among random individual farmers in project and control group. Ask reasons to explain each change:
a) increase/decrease in dunes fields.
b) increase/decrease in wadi fields.
c) increase/decrease in polder fields.
d) increase/decrease in use of irrigation
e) increase/decrease of available land.

f) increase/decrease in yields.
g) changes in crops cultivated.
h) changes in marketing behavior.
i) changes in earnings.
j) changes in allocation of labor and time outside of farming.
k) changes in farm family income.
l) impact of changes on each member of family.
m) impact on marriage relationship.
n) impact on inheritance.
o) impact on social status.

(ii) monitor project entrepreneur and randomly-selected artisans; reasons given to explain each change.
a) increase/decrease in income.
b) increase/decrease in cash flow.
c) economic problems encountered.
d) social problems encountered.

2. Self-Evaluation:
Sociological Criteria for Success of Project:

a. End of first year:
(i) 50% of original people in project using new techniques or technologies.
(ii) 80% of original people in project willing to continue.
(iii) at least 1 additional farmer/wadi wants to join project (number really depends on size of wadi).
(iv) at least three wadis have done reforestation.

b. End of second year:
(i) 80% of all people in project using new techniques/technologies.
(ii) at least 2 new farmers/wadi want to join.
(iii) at least 1 new wadi wants to join.
(iv) at least 7 new wadis have done reforestation

c. End of third year:
(i) 80% of all people in project using new techniques/technologies.
(ii) at least 7 of new wadis have done reforestation.
(iii) other wadis, farmers express interest.
(iv) at least one model of new agricultural techniques, water removal, and salinity control has been found.

3. Implementation Progress Evaluation/Economic

a. Productivity of Innovations - "Objective Evaluation"
   (i) Measurement of farmer, land and water productivity increases.
      a) increase area farmed?
      b) increased yield per unit of land?
      c)increased yield per unit of water?

   (ii) Labor time devoted to:
      a) water lifting
      b) cultivation
      c) harvest
      d) supplementary activities - distinguish project and non-project induced (tree planting/maint., drainage system maint., composting, etc.).

   (iii) Increased interest in wadi farming.
      a) additional acreage brought into production.
      b) additional persons working in wadis - doing what before?

   (iv) Changes in supplementary income sources - project/non-project e.g., forage crops, fruit, animal products, by-products.

b. Productivity of Innovations - "Subjective Evaluation"
   (i) Farmer perceptions of and satisfaction with productivity of innovations.

   (ii) Same regarding level of time and efforts required.

   (iii) Farmer intentions with respect to future practices.

c. Family Benefit Effects of Project
   (i) Quantities of food produced

   (ii) Quantities retained for consumption

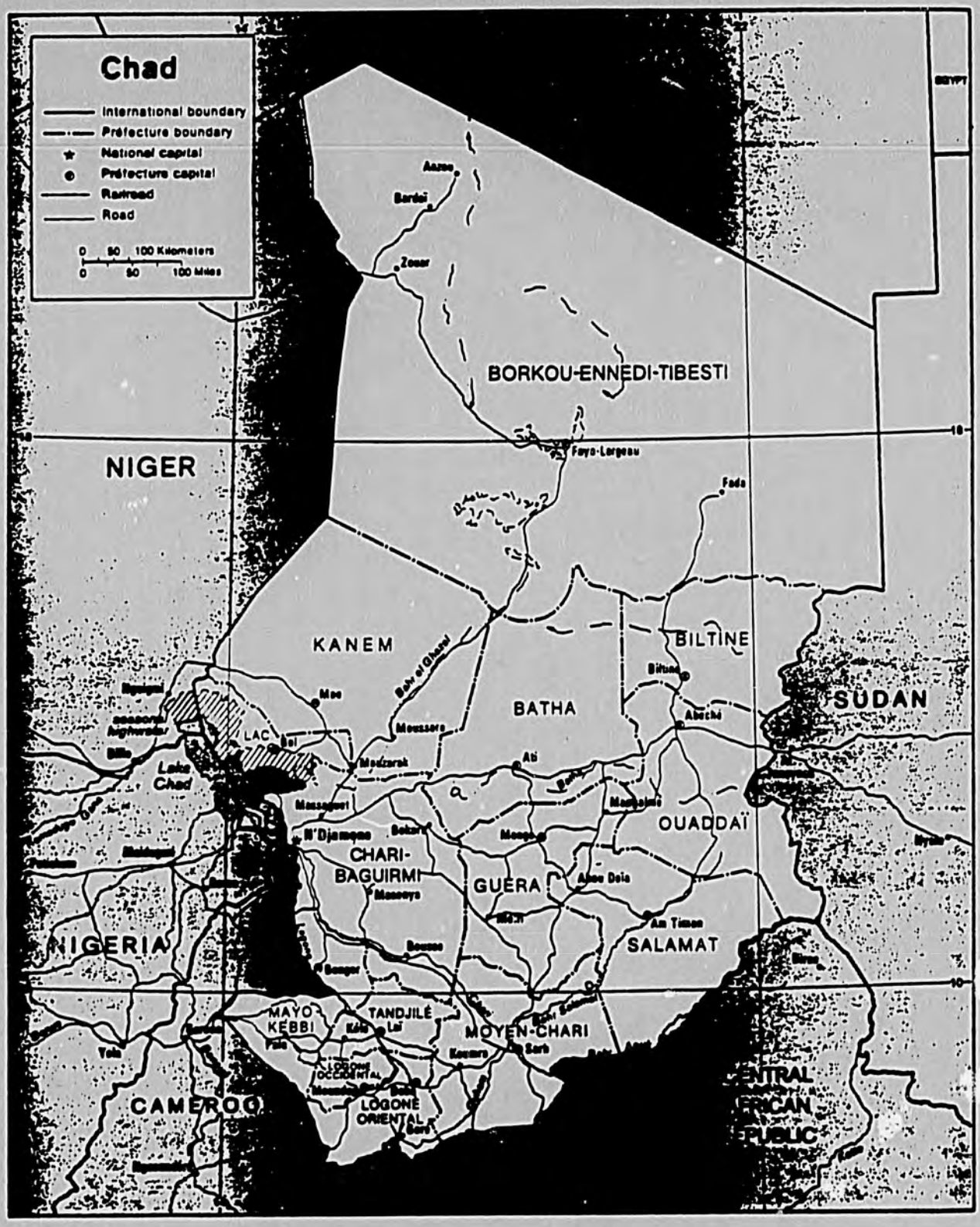
   (iii) Quantities marketed
      a) Prices received
      b) Ease of marketing
      c) Satisfaction with revenue, ease of/access to marketing

   (iv) Other perceived benefits - e.g., diet, health, avoided migration , etc.

d. Project Economics and Farm Family Finance
   (i) Purchased goods for farming.
      a) identify what, when, where, how much, price, etc.
      b) Input market problems - availability of desired/needed inputs.

   (ii) Benefit attributed to purchased goods.
      a) Productivity increase directly attributable.
      b) Secondary effects on wadi, family economy.
      c) Farmer stated perceptions of value of resource.

   (iii) Family financial requirements.
      a) basic necessities - identify cash expenses.
      b) non-basic necessities, especially tea & sugar.
      c) family maintenance - clothing, housing.
      d) investment - trees, livestock, other capital goods.
   (iv) Financing of purchases for family and farming.
      a) cash or credit?
      b) financial difficulties, loan repayment problems?
         1. factors under farmer control.
         2. factors not under farmer control.


Chad
International boundary
Préfecture boundary
National capital
Préfecture capital
Railroad
Road
0 50 100 Kilometers
0 50 100 Miles
EGYPT
Aozou
Bardaï
Zouar
BORKOU-ENNEDI-TIBESTI
Faya-Largeau
Fada
NIGER
KANEM
BILTINE
Biltine
Abéché
SUDAN
BATHA
Mao
Bahr el Ghazal
Moussoro
LAC
Bol
Mondarak
Ati
Lake Chad
Massakori
Mangalme
OUADDAÏ
N'Djamena
Bokoro
Moundou
CHARI-BAGUIRMI
Massenya
GUERA
Abtéu Deia
Am Timan
SALAMAT
NIGERIA
Bousso
N'Djaména
MAYO KEBBI
Kélo
TANDJILÉ
Laï
MOYEN-CHARI
Sarh
Kyabé
LOGONE OCCIDENTAL
LOGONE ORIENTAL
Bongor
CENTRAL AFRICAN REPUBLIC
CAMEROON

217

REGION DU LAC

0 10 20 30 km

Rig-Rig
MAO
Liwa
Fouli
Méchim
Mondo
NGOURI
Dibinentchi
Ngéléa
Ngarangou
Mijigidada
Baga-Sola
Isseirom
BOL
LAC TCHAD
Boum Doum
Kouloudia
MASSAKORY

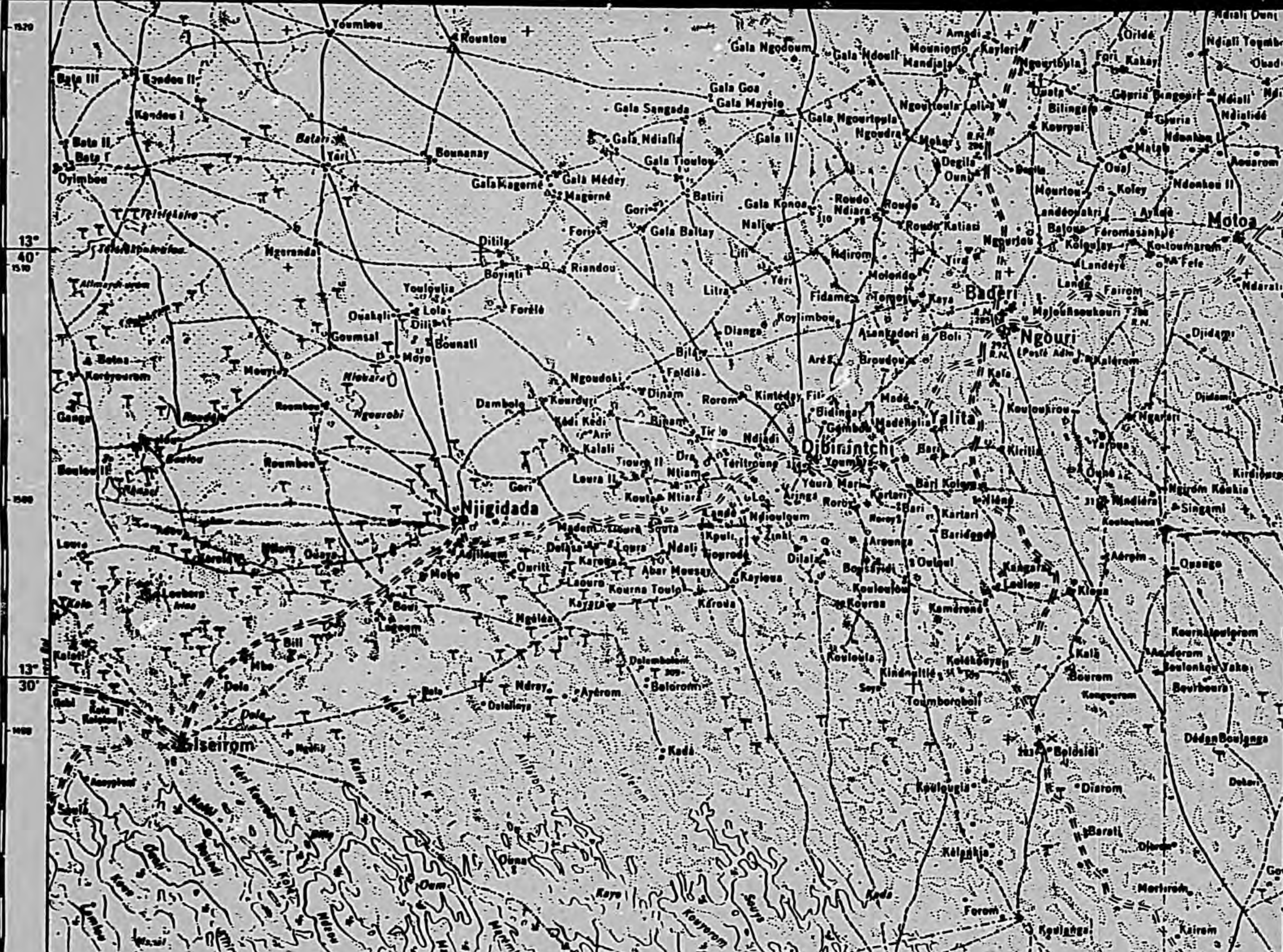
Terrains de parcours
Culture du mil sur dunes associée à l'élevage
Culture du mil
Mil et sorgho
Mil, sorgho et arachide
Mil, sorgho, arachide et coton
Terre d'ouadi : légumes, cultures irriguées
Polder : blé, maïs, légumes
Digue de polder
Gommeraie

Zone inondable
Extraction du natron
Limite d'état
Limite de préfecture
Limite de sous-préfecture
Chef-lieu de préfecture
Chef-lieu de sous-préfecture
Autre localité
Route
Piste importante
Autre piste

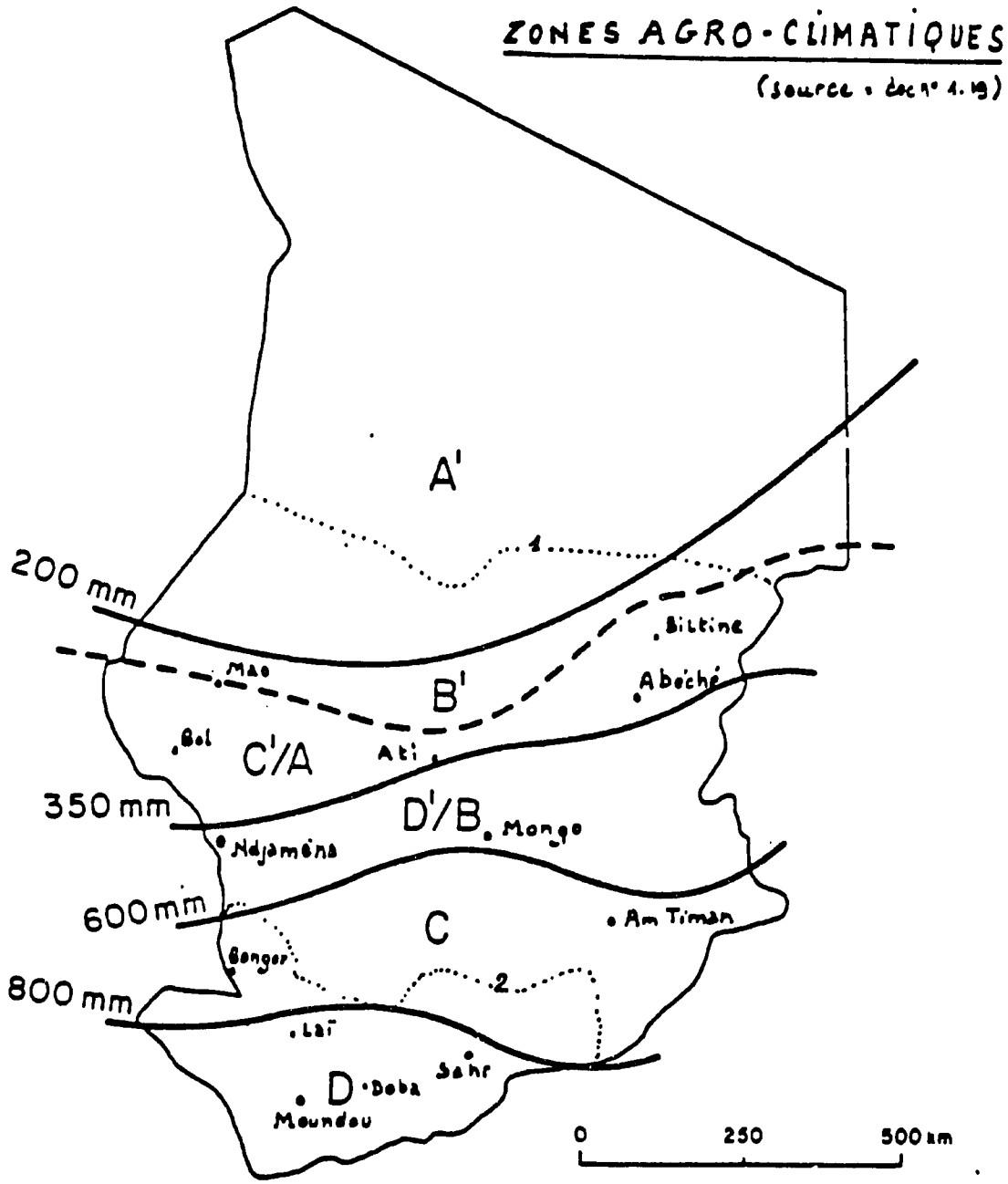
Hôpital
Centre médical
Infirmerie
Dispensaire
Ecole normale
Lycée
Centre d'apprentissage
C. E. G.
Ecole primaire
Ruines

maquette : marie-cle

278



13°
40'
13°
30'
Youmbou
Rountou
Bala III
Kandou II
Kandou I
Bala II
Bala I
Oyimbou
Balari
Yéri
Bounanay
Gala Kagerné
Gala Médey
Magerné
Gala Ngodoum
Gala Ndouli
Gala Goa
Gala Mayelo
Gala Sangada
Gala Ndiafia
Gala Tioulou
Gala II
Gala Ngourtoula
Gala Konoa
Gala Baltay
Batiri
Gori
Foris
Nalier
Roudo
Ndiara
Lifi
Yéri
Litra
Dilila
Ngeranda
Riandou
Bovinti
Youloulia
Lola
Forélé
Ouakali
Dili
Goumsal
Bounati
Moyo
Mouyi
Niakara
Ngourobi
Roumbou
Dambola
Ngoudoki
Kourdugi
Kédi Kédi
Dinam
Binam
Foldia
Bija
Dianga
Koyimbou
Fidamé
Rorom
Kintéday
Bidingay
Gambou
Madé
Madéhalia
Yalita
Ndjadi
Kalali
Dibirintchi
Youmbi
Tiouro II
Ntiam
Ntiara
Loura II
Gori
Njigidada
Adjilloum
Madem
Souta
Delaka
Karoua
Loura
Ndali
Nguralé
Ndjoulgoum
Kayioua
Abor Mousay
Kourna Toulo
Kaysta
Karoda
Dilala
Arounga
Ouloul
Boussidi
Kouloulou
Kouras
Kaméroné
Kouloula
Kindouillé
Soyo
Toumboroboli
Kadé
Dolembolom
Belorom
Ayérom
Ndray
Delalaya
Bala
Ngéléa
Nobo
Boui
Lagoum
Bili
Mbo
Dola
Kaloff
Gaba
Kolo
Loubora
Ganga
Boulou
Roumbou
Boulou II
Louva
Koroia
Mbora
Ouaga
Kolo II
Kolodou
Moilou
Kelseirom
Kaoussa
Keri Kourou
Keri Kolé
Oum
Ouna
Kaye
Kouyerom
Sayo
Kada
Koulougia
Kolékia
Ferom
Koulanga
Amadi
Kayleri
Mouniomo
Mandjala
Ngourtoula
Ngoudra
Mokor
Degila
Ouni
Roude
Roude Katiasi
Ndirom
Molondo
Ngourjou
Yira
Bidéri
Tomoni
Kaya
Asankadori
Boli
Broudou
Arés
Ngouri
(Poste Adm.)
Kafa
Kouloukrou
Bari
Kirilla
Bari Koiom
Kartari
Kariari
Baridjede
Kangalari
Loulou
Kiaua
Kalé
Kolékdoyan
Boorom
Kangourom
Beldsidi
Diarom
Baralé
Djaron
Mortirom
Kairoim
Oridé
Ndjali Dunj
Ndjali Toumbr
Fori
Kakay
Ouadi
Oyalo
Bilinga
Kourpoi
Gauria
Ndiali
Ndialidé
Matab
Ndonkou II
Ouaj
Kouarom
Mourtou
Koley
Ndonkou II
Andéouakri
Ayjaé
Motoa
Batoua
Féromasanbé
Koloulay
Koutoumarom
Landéyé
Fele
Ndarala
Landa
Fairom
Majoubsoukouri
Djidami
Kalérom
Ngarfi
Yarpua
Ouné
Kirdiouna
Ngirom
Koukia
Madiéré
Singami
Koulouheur
Aérgin
Ouaga
Kournaloulgrom
Aouderom
Boulonkou Yako
Bourbouro
DédanBoulanga
Dobov



Zones

culture - A B C D

pâturage - A' B' C' D'

limite approx. des cultures — — —

....1... Limite Sud des préfectures du B.E.T.

....2... Limite Nord des préfectures dites soudaniennes (SUD-TCHAD).

ANNEX T Detailed Research versus Production
Worksheet Estimates

Line Item	Ngouri Production	Percent	Research	Percent	Total
1. Expatriate Technical Assistance					
a. Agronomist	97953	67	48245	33	146198
b. Rural Works Engineer	100610	67	49554	33	150164
c. Administrative Officer	106495	67	52453	33	158948
d. Pump Specialist	43694	50	43694	50	87388
	347327	64	195371	36	542698
2. International Travel and Transport	64604	64	36340	36	100944
3. Local Travel					
a. Air charters (Massakory/Bol)	12000	100	0	0	12000
b. Air charter (Ati)	0	0	2400	100	2400
c. Horses	22950	90	2550	10	25500
	34950	88	4950	12	39900
4. Housing					
a. Rent-Administative Officer	24120	67	11880	33	36000
b. Rent-Pump Specialist	9000	50	9000	50	18000
c. Utilities-N'Djamena	26784	62	16416	38	43200
	59904	62	37296	38	97200
5. Local Hire Personnel	115005	64	64690	36	179695
6. Construction	160000	100	0	0	160000
7. Training	127600	100	0	0	127600

Line Item	Ngouri Production	Percent	Research	Percent	Total
8. Vehicles, Equipment, Furnishings and Supplies; Procurement Services	374348	64	210570	36	584918
9. Home Office Backstopping	233719	64	131467	36	365186
10. Overhead	104134	64	61095	36	162709
11. Short Term Consultants					
a. Paris Data Collection	2880	80	720	20	3600
b. Communications Expert	10400	100	0	0	10400
c. Health Specialist	16640	80	4160	20	20800
d. Forester	22640	80	5660	20	28300
e. Social Scientist	18640	80	4660	20	23300
f. Maintenance Trainer	3620	80	905	20	4525
g. Environmental Soils or Marketing Expert	8420	80	2105	20	10525
h. Local Hire or BIEP	20000	50	20000	50	40000
	73554	52	67896	48	141450
12. Evaluation	19600	50	19600	50	39200
13. Other Direct Costs	116685	64	65635	36	182320

Line	Item	Ngouri Production	Percent	Research	Percent	Total
14.	Peace Corps (Project Financed)	85317	70	36565	30	121882
15.	Health Component	54000	90	6000	10	60000
16.	Subtotal	2004934	69	900768	31	2905702
17.	Contingency/Inflation	200493	69	90077	31	290570
18.	Total	2205428	69	990844	31	3196272
19.	Peace Corps (Peace Corps Financed)	87500	70	37500	30	125000
20.	GOC	84000	60	56000	40	140000
21.	GRAND TOTAL	2388278	69	1072994	31	3461272
22.	PERCENTAGE	69		31		100

ANNEX T Detailed Cost Sharing Worksheet

Line Item	ORT	AID	Total
1. Expatriate Technical Assistance	0	542698	542698
2. International Travel & Transport	0	100944	100944
3. Local Travel	0	39900	39900
4. Housing	0	97200	97200
5. Local hire personnel	0	179695	179695
6. Construction	0	160000	160000
7. Training	58696	68904	127600
8. Vehicles, Equipment, Furnishings and Supplies	18918	566000	584918
9. Home Office Backstopping	280186	85000	365186
10. Overhead	97709	65000	162709
11. Short-Term Consultants			
a. Paris Data Collection	3600	0	3600
b. Communications Expert	0	10400	10400
c. Health Specialist	0	20800	20800
d. Forester	0	28300	28300
e. Social Scientist	0	23300	23300
f. Maintenance Trainer	4525	0	4525
g. Environmental Soils or Marketing Expert	0	10525	10525
h. Local Hire or BIEP	0	40000	40000
	8125	133325	141450
12. Evaluation	0	39200	39200
13. Other Direct Costs	0	182320	182320
14. Peace Corps (Project financed)	25000	96882	121882
15. Health Component	60000	0	60000
16. Subtotal	548634	2357068	2905702
17. Contingency/Inflation	54863	235707	290570
18. Total	603497	2592775	3196272*

19. GRAND TOTAL	Amount	Percent
AID	2592775	81
ORT	603497	19

*minus Peace Corps and GOC contributions.