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REPUBLIC OF CHAD

LAKE CHAD AGRICULTURAL DEVELOPMENT AND FARMER TRAINING PROJECT

PHASE II : Marketing & Technology Dissemination

SUBMITTED TO :

UNITED STATES AGENCY
FOR INTERNATIONAL DEVELOPMENT
(USAID / N'DJAMENA)

SUBMITTED BY :

AMERICAN ORT FEDERATION

Washington D.C., April 1991

LAKE CHAD AGRICULTURAL DEVELOPMENT AND FARMER TRAINING PROJECT

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Submitted to: United States Agency for International Development/Chad

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CONTENTS

		Page
I.	Summary Project Description	
A.	PVO Applicant	4
B.	GOC Implementing Agency	4
C.	Summary Financial Plan	4
D.	Project Goal	4
E.	Project Purpose	4
F.	Project Background	4
G.	Summary Project Description	6
H.	Brief Summary of Analyses	10
I.	Project Issues	12
J.	Design Team Members and Methodology	13
II.	Project Rationale and Detailed Description	
A.	Project Rationale	14
B.	Project Objectives	17
C.	Activity Components	24
D.	PVO Inputs to be Financed by AID	29
E.	PVO Inputs	31
F.	Other Inputs	31
III.	Cost Estimates and Financial Plan	
A.	Summary Cost Estimate	32
B.	Financial Plan	33
C.	Cost Estimates of Other Inputs	33
IV.	Implementation Plan	
A.	Implementation Responsibilities	35
B.	Collaboration with Other Donors	35
C.	Procurement Plan	36
D.	Organizational Chart	38
V.	Monitoring Plan	
A.	PVO Project Management	39
B.	AID Liaison	41
C.	GOC Project Management	41
D.	Reporting Responsibilities	42

VI. Summary Analyses

A. Summary of Marketing Analysis 43
B. Summary Technical Analysis 45
C. Summary of Environmental Analysis 48
D. Summary of Social Soundness Analysis 49
E. Summary of Economic and Financial Analysis 51

VII. Evaluation Plan

A. Monitoring 53
B. Mid-term Evaluation 53
C. End of Project Evaluation 54

ANNEXES

A. Logical Framework
B. Marketing Analysis
C. Technical Analysis of Water Resources Management Technologies
D. Technical Analysis of Agronomic Issues
E. Social Soundness Analysis
F. Economic and Financial Analysis
G. Environmental Analysis
H. Detailed Cost Estimate Budget
I. Project Implementation Schedule
J. Position Descriptions
K. Maps

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 Development du Lac (SODELAC).

C. Summary Financial Plan

AID, GOC, and ORT-generated funding:

Year 1	Year 2	Year 3	Total
$1,410,349	$996,649	$1,020,693	$3,427,691

D. Project Goal

The project goal is to achieve a sustainable increase in the incomes of wadi farmers in the Lake region of Chad.

E. Project Purpose

The project purpose is to increase the amount of wadi produce that farmers supply to the market and to increase the profits that they earn from selling that produce.

F. Project Background

In 1986, the Organization for Rehabilitation and Training (ORT) sent a five-person design team to the Lake region of Chad to assess the agricultural situation and to elaborate a program to address the region's problems. The area, like the rest of Northern Chad, had been hard hit by the drought of the early 1980s. In response to the decline in rainfall, farmers in the area were depending more heavily on irrigated agriculture, carried out in fertile depressions known as wadis. ORT decided to design a project to help these farmers increase their food production through wadi agriculture. USAID/NDjamana agreed to finance the endeavor.

The 1986 design team identified the most important constraints to increased production in the wadis as: (1) water availability, (2) water-lifting, (3) fencing, and (4) maintaining soil fertility. A three-year program was laid out to address these constraints by testing new techniques in irrigation, agriculture, and

agroforestry. The project's purpose was two-fold:

> To increase wadi food production in the Ngouri area, while maintaining or improving soil fertility; and
>
> To identify models for increased wadi food production which will be replicable in similar conditions.[1]

To achieve these purposes, ORT established an office in Ngouri, hired agronomy and water-lifting technicians, and undertook a vigorous program of experimentation, data collection, and testing of new agricultural technologies.

In June 1990, an AID team conducted the project's final evaluation. It concluded that the project had made good progress in addressing the technical constraints facing farmers and that it had developed replicable models for sustainable agriculture in the wadis.[2] The most successful project introductions included:

> the hand-drilled aquifer tap and tubewell;
> procurement, maintenance, and repair systems for the small Honda GX-110 motorpump;
> live fencing;
> crop diversification; and
> improved soil-enrichment and plot preparation techniques.

Overall, the final evaluation found that the project was a success. Appropriate new technologies had been developed that responded to farmers' needs. The project, however, did not have sufficient time to disseminate these technologies to a very large number of farmers. Nor did it have time to finish building the private supply systems necessary to assure the long-term sustainability of its achievements. Lastly, the project did not concentrate on issues of marketing, issues that grew in importance as production expanded.

A second phase to the project is necessary to capitalize on the achievements of the first, to solidify and disseminate the best of its technologies, and to make new progress in the area of agricultural marketing.

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[1] ORT, Lake Chad Agricultural Development and Farmer Training Project, Proposal submitted to USAID/N'Djamena, November 1986, p.2.

[2] Lake Chad Agricultural Development and Farmer Training Project -- Final Evaluation, USAID, June 1990.

G. Summary Project Description

The proposed project consists of four activities to be implemented over a three-year period:

1. the development of sustainable private-sector input markets to serve wadi farmers;

2. the development of profitable marketing techniques and strategies for wadi farmers' agricultural produce;

3. the dissemination of improved water-lifting and irrigation technologies successfully tested in Phase I; and

4. the dissemination and further development of sustainable agricultural technologies that were tested successfully in Phase I and/or are of strategic commercial value.

The first two activities fall squarely in the realm of agricultural marketing, while the second two activities focus on technology transfer. Sustainability and economic impact were the key concerns in the design of all four components. The project will directly target 650 households in 47 wadis over a three year period.

Agricultural Marketing

In her 1990 study of Chad's marketing system, AID consultant Chris Mock defines agricultural marketing as

> "the series of functions or services which not only transfer agricultural commodities from the farm level to the ultimate consumption point, but also deliver necessary inputs to the farmers and the providers of the marketing services."[3]

This definition highlights the essential role that both input and output markets must play in the development of sustainable and profitable agricultural systems. The Lake Chad project will work to develop private sector marketing services for both agricultural inputs and agricultural outputs.

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[3] Chris Mock, Agricultural Marketing in Chad: Preliminary Project Identification Assessment, submitted to USAID/Chad, August 1989, p. 3.

Input Agricultural Marketing

The traditional wadi farming system employs only locally-available, free, or low-cost inputs, such as thorny branches for fencing and local varieties of seed. Many of the improved farming techniques that were successfully tested and adopted during Phase I also require only low-cost local inputs, such as manure and composting. Other technical achievements, however, are more demanding in their requirements for commodity inputs. Newly-introduced crops such as carrots require new sources of seeds, improved wells require PVC pipes, and improved irrigation requires pumps, spare parts, and fuel. To its credit, Phase I of the Lake Chad project has insisted that these inputs be provided at non-subsidized prices by private sources. Project farmers obtain all of their motor-pump fuel, for example, through private merchants. The project also has successfully encouraged merchants to supply farmers with PVC piping from N'Djamena and motorpumps from Nigeria.

Phase II of the project will work to further develop these private input supply lines. This strategy is based on the conviction that private trade is the best means to assure the long-term sustainability of input availability to wadi farmers. When private merchants are able to profit by providing important farm supplies, they will be motivated to continue to provide these supplies long after the project is closed. Competition between merchants should drive profit margins down to the minimum levels necessary to insure continued supply. Unlike cooperative and State-run supply systems, private merchants rarely suffer from the fragility and complicated management problems that cause ruptures in services. Trader-supplied gasoline, for example, is reliably available in Ngouri throughout the year. Phase II will work closely with area merchants, many of whom are part-time farmers, to strengthen supply lines for agricultural inputs.

Measures to be taken include:

the development of private seed supply channels through cooperation with local merchants;

the development of private supply lines for pump parts through cooperation with local merchants;

the development of a private dealership for the sale of the bidon verseur technology on a 50% cash, 50% credit basis;

the strengthening of private pump repair services through training of mechanics and metal workers;

the development of one or more private tubewell installation enterprises;

continued strengthening of wadi farmers' capacity to obtain motorpumps through private trader sources.

Output Agricultural Marketing

Phase II of the Lake project also will work to improve the marketing of agricultural outputs -- wadi-produced fruits and vegetables. It will test and develop sustainable and profitable strategies for increasing farmers' net revenues from produce sales. Activities to be undertaken include:

identifying profitable opportunities in the N'Djamena and regional markets, and targeting production and marketing trial-runs to exploit these opportunities, (eg., producing high-value garlic to sell in Bol);

promoting early sales during high price periods by testing and promoting off-season production techniques, (eg., producing onions with transplanted bulbs);

promoting late-season sales during high price periods by testing and promoting improved storage technologies, (e.g., onion racks);

training farmers in methods to improve produce quality and salability, (eg., harvesting beets at optimal size);

testing and promoting new methods of packaging, (e.g., reinforced, aerated cases adapted to tight-loading in pick-up trucks);

continued monitoring of produce prices and movements in local markets, and coordinated tracking of vegetable prices in N'Djamena and Mao in collaboration with CARE, ACDI, and BSA.

Water-lifting and Irrigation Technologies

Phase I of the Lake Chad project made significant achievements in the testing and development of improved water-lifting and irrigation technologies. Phase II of the project will concentrate on the dissemination and further adaptation of the most successful of these innovations. Local farmers, entrepreneurs, and mechanics will be trained in the acquisition, operation, maintenance, and repair of each of these technologies:

the aquifer tap -- a simple and inexpensive device that improves well output and is popular with wadi farmers;

the <u>bidon verseur</u> -- a donkey-powered water-lifting

device that was successfully tested during the last year of Phase I. This simple technology yields almost twice the water output as the shadouf; its economic rate of return is high (29-200%), and it has aroused keen interest amongst local farmers;

the small Honda motorpump -- a popular technology that was tested during Phase I and received positive reviews from Ngouri farmers and the 1990 AID evaluation team. According to AID's final project evaluation, the motorpump leads to an average increase in production per farmer of 158-452%, and its benefits outweigh its costs by a ratio ranging from 1.24 to 1.6.[4] The pumps are procured and maintained through developing private channels;

the PVC tubewell -- a proven technology that is installed by hand drilling (the sludger method) by farmer/entrepreneur teams;

improved irrigation practices -- improvements in distribution system design and irrigation scheduling to improve water use efficiency and reduce costs; pre-irrigation to facilitate land preparation.

Agricultural Techniques

Because of the participatory common-sense approach of the project agronomist, several successful agricultural techniques were tested, modified, and adopted during Phase I of the project. A limited number of the most popular of these proven techniques will be disseminated to a larger number of wadi farmers during Phase II. The techniques are:

crop diversification (as a function of marketability);

soil building through manure and compost applications;

live fencing; and

improved plot preparation techniques, i.e., larger water-dispersing basins, and furrow and elevated row planting.

These techniques will be demonstrated to farmers through two channels: (1) the continued direct training of volunteer farmer

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[4] Lake Chad Agricultural Developmen and Farmer Training Project -- Final Evaluation, USAID/Chad, June 1990, Annex A, p. 1-2.

extension agents (delegues techniques) to share innovations with fellow wadi farmers; and (2) the continued and expanded training of SODELAC agents, who will in turn train delegues techniques.[5] (This approach will also be employed to replicate other proven project technologies such as the installation of aquifer taps).

In addition to replicating the above proven techniques, Phase II will conduct on-farm agronomic trials specifically designed to test promising market opportunities identified through the market research mentioned above. After the trials are evaluated, an AID environmental determination will be obtained before any new crops or varieties are disseminated. The project also will conduct trials in natural pest management techniques, (residue destruction, inter-cropping, etc.), to reduce the levels of pest damage currently afflicting the quantity and quality of wadi produce. No chemical pesticides or fungicides will be used or promoted by the project for any purpose.

H. Brief Summary of Analyses

The project is feasible in all aspects studied: sociological, economic/financial, technical, and environmental. Full analyses are in Annexes B through G.

Technical

The water-lifting and agricultural technologies to be promoted during Phase II were tested successfully and thoroughly during Phase I of the project. Only those that proved to be technically viable, adapted to local conditions, and of clear interest to the farmers will be disseminated and strengthened in Phase II. All of the major technologies and techniques employed at the time of the 1990 project evaluation received positive technical reviews from the team; this includes motorpumps, aquifer taps, tubewells, live fences, soil building measures, and crop diversification. Project statistics attest to the output-increasing effects of these techniques. Motorpumps, for example, have led to an average increase in production per farmer of 158-452%. Natural pest management is the only technique to be used in Phase II that has not yet been tested locally, although its effectiveness has been proven in other developing countries.

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[5] The concept of delegues techniques was jointly developed by ORT and USAID/Chad staff. A delegue technique is a farmer who volunteers to serve as an extension agent in his home wadi. The project trains him in new techniques, and he demonstrates these techniques to his neighbors. The system has functioned effectively during Phase I.

Marketing

For input marketing, the project proposes to build and reinforce private sector supply lines for agricultural inputs such as seeds and PVC tubing. Merchants have declared their eagerness to participate, and farmers have already demonstrated their willingness to pay for appropriate inputs. For output marketing, proposed technical interventions center around simple, cost-effective techniques to increase produce value. The testing of several of these techniques has already begun (storage racks, off-season onion production). Other techniques will be tested and evaluated during Phase II (improved packaging and harvesting methods).

Social Soundness

The social soundness of the project is based on two information sources: (1) four years of fruitful, collaborative relationships developed during Phase I between ORT and the administrative and traditional leaders of the target area; and (2) the findings of the project anthropologist, Dr. Ellen Brown, who has extensively interviewed local project participants during the design period and during three previous missions to the zone. ORT's proposed Phase II to the project appears to be feasible within the socio-economic context of the project zone. Phase II will continue to use the procedures and technology that succeeded in Phase I. Changes in the project, which will involve marketing, are being introduced as a direct result of the expressed need of project farmers. Marketing developments will be undertaken in conjunction with local merchants and traders, a number of whom have already expressed interest and contributed ideas. Project interventions will not cause major social upheaval and the proposed interventions respond directly to the desires of the local population.

Environmental

In November 1990, USAID conducted an Environmental Assessment (EA) of the Lake Chad project. The four-person team recommended that the project continue and that up to 300 aquifer taps and 100 tubewells be installed in the project zone. These numbers will not be exceeded in Phase II. The EA states that under this scenario, impact on the aquifer will be slight.

The Environmental Assessment also concludes that project activities have increased farmer capacity to control soil salinity and improve soil quality through organic matter management. These activities will be continued in Phase II. The EA recommends that live fencing be a component part of future ORT activities; it is included in Phase II. In addition, the EA recommends that the project continue monitoring piezometric head, water quality, crop

yields and irrigation. This will be done in Phase II, and SODELAC agents and farmers will be trained to continue the monitoring after the close of project.

Other proposed Phase II activities, such as crop diversification and post-harvest marketing techniques, were taken note of in the EA document, but were not identified as being of significant environmental consequence. An AID environmental determination will be obtained before any new crops or varieties are disseminated. No chemical pesticides or fungicides will be used or promoted by the project. The EA concludes that the project does not present health problems; on the contrary, it will improve health by increasing access to clean water and a more diversified diet.

Economic/Financial

Economic analysis of the major water-lifting devices to be promoted is positive. Calculations carried out by AID demonstrate that the extra revenues resulting from motorpump use are significantly greater than the extra costs. Benefit-cost ratios range from 1.24 to 1.60 for the motorpump and the motorpump/tubewell combination. Extra revenues resulting from the use of the bidon verseur also significantly exceed the extra costs. Internal rates of return for the bidon verseur vary between 29 and 200%.

A financial analysis of the entire project demonstrates that anticipated benefits (mainly increases in farmer incomes) justify the project's investment costs. Under "medium" to "high" scenarios the project's internal rate of return ranges from 15 to 33% over a ten year period. Under the "medium" scenario, the project's net present value is $274,779 at a 12% discount rate.

Administrative

Because Phase II of the Lake Chad project is structured similarly to the first phase, no major administrative re-organization or constraints are anticipated. Most of the local staff to be employed by the project will be drawn from the best of the current personnel. Major infrastructures -- offices, housing, and workshop -- are already in place. Project implementation will be conducted in close collaboration with SODELAC -- the government agency responsible for agricultural extension in the Lake prefecture.

I. Project Issues

During the preparation of this proposal, a large number of project issues and questions were brought up, analyzed, and

debated. The program presented in this document is a product of the frank discussions that took place on these issues with farmers, technicians, AID officials, and GOC representatives.

Discussion of these project issues is integrated in the document's technical analyses. The issues are too numerous and complex to be treated fairly in this short section of the Summary Project Description. Thus, the question of the economic viability of the motorpump is analyzed fully in Annex F and summarized in the text. The question of farmers' ability to afford water-lifting technologies is analyzed in the Social Soundness annex. The issues of transportation to markets and credit for storage are treated in the Marketing Analysis. The question of the competitiveness of Ngouri's produce is also discussed in the Marketing Analysis. Issues surrounding SODELAC's role in the project are treated in the section on GOC Project Management. Pest management issues are explored in the Agricultural Analysis.

In sum, interesting issues can be identified in most of the sub-components of the proposed project. However, there are no major issues that threaten the overall success of the project. Most of the activities proposed for Phase II are based on the proven technologies and approaches developed during Phase I.

J. Design Team Members and Methodology

The original Concept Paper for this proposal was submitted to AID in October 1990. After review, the mission invited ORT to prepare and submit a full project proposal.

The design process got fully underway in February 1991. The joint effort involved ORT staff and international consultants, in cooperation with agents of AID, SODELAC, and the Permanent Secretariat for NGOs (SPONG). Lawrence Kent of Development Alternatives, Inc. served as the team leader, and Dr. Ellen Brown served as the team anthropologist. SODELAC and SPONG were represented by M. Pismon and M. Zaboul, respectively. ORT's Bill Stringfellow, David Purkey, and Firmin Mansis made important administrative and technical contributions.

II. PROJECT RATIONALE AND DETAILED DESCRIPTION

A. Project Rationale

1. Background on Agricultural Systems and Constraints

The Lake Prefecture of Chad contains a population of 158,000, divided administratively between a sub-prefecture in Bol and another in Ngouri. ORT activities are concentrated in Ngouri, an area characterized by rolling sand-dunes, punctuated by relatively fertile depressions known as wadis and flood plains bordering the lake known as polders. The economy of the region is primarily based on agriculture, although commerce and mat weaving also play important roles.

The Ngouri area, like the rest of Northern Chad, was hard hit by the prolonged drought of the early 1980s. Production of the area's main crop, rainfed millet, dropped dramatically on the dunes, and many polders that once were irrigated by the lake dried up as that body receded. As these agricultural systems became less productive and more risky, farmers began to place more importance on irrigated farming in the wadis as a means to survive. But farming in the wadis is a difficult enterprise subject to numerous constraints. The most notable of these constraints is water-lifting. Traditionally, wadi farmers must labor long hours to irrigate their crops with the shadouf, a pivoting pole attached to a bucket that is used to draw water from shallow wells. The limited discharge of the shadouf restricts production possibilities. Additional constraints facing wadi farmers relate to fencing, maintaining soil fertility, pest control, and marketing.

2. Phase I of the ORT Lake Chad Project (1987-91)

In response to the difficulties facing wadi farmers in the Lake region, and in response to the Government of Chad's call for assistance in increasing agricultural production, ORT undertook a pilot project in 1987, with USAID funding. The project's purpose was two-fold:

> To increase wadi food production in the Ngouri area, while maintaining or improving soil fertility; and
>
> To identify models for increased wadi food production

which will be replicable in similar conditions.[6]

To achieve these purposes, ORT established an office in Ngouri, hired agronomy and water-lifting technicians, and undertook a vigorous program of experimentation, data collection, and testing of new agricultural technologies. Efforts were concentrated on developing replicable techniques that would address the constraints facing wadi farmers, especially those related to agricultural practices and water-lifting.

In June 1990, an AID team conducted the project's final evaluation. It concluded that the project had made good progress in addressing the technical constraints facing the farmers and that it had developed replicable models for sustainable agriculture in the wadis.[7] The most successful project introductions included:

The hand-drilled aquifer tap and tubewell;
Procurement, maintenance, and repair systems for the small Honda GX-110 motorpump;
Live fencing;
Crop diversification; and
Improved soil-enrichment and plot preparation techniques.

The production-increasing effects of each of these technologies is described in the project's final evaluation and the technical annexes to this proposal.

3. Remaining Opportunities and Constraints in the Wadis

At the present time, a number of opportunities remain to be seized in the Ngouri area and a number of constraints remain to be addressed. These challenges will be met through Phase II of the project.

The clearest opportunity in the project zone is to disseminate the improved technologies mentioned above to a larger number of wadi farmers. The pilot phase of the project was successful in developing appropriate innovations, but it did not focus its efforts on extending these technologies to a large number of beneficiaries. As a pilot activity, Phase I concentrated on experimentation and technology development. It was not until the final year of Phase I that ORT could claim that it had identified a basket of appropriate, proven innovations -- a basket of clear

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[6] ORT, Lake Chad Agricultural Development and Farmer Training Project, Proposal submitted to USAID/N'Djamena, November 1986, p.2.

[7] Lake Chad Agricultural Development and Farmer Training Project -- Final Evaluation, USAID, June 1990.

"winners."[8] Because Phase I did not have sufficient time to solidify and disseminate these "winners", it is up to Phase II to seize the opportunity that these technologies represent and to build sustainable structures to insure their availability to a wider number of farmers.

According to a 1990 social impact study in the zone, most wadi farmers face the same constraints today that they faced five years ago.[9] This is because most wadi farmers have not had the opportunity to adopt the technologies that ORT developed during Phase I. These farmers continue to face the constraints of: (1) water availability; (2) water-lifting; (3) fencing; and (4) soil fertility. At the present time, ORT has mastered techniques and technologies that can overcome these constraints; the challenge of Phase II is to develop sustainable mechanisms to deliver these solutions to a wider number of farmers. In addition, safe, non-chemical methods must be developed to address farmers' concern with pest attacks.

For farmers who have already adopted project innovations, the constraints are different. These farmers are interested in questions of marketing. They are concerned about purchasing the inputs that they need to farm, and they are concerned with selling their produce in the most profitable way possible. In addition, these "advanced" farmers are interested in diversifying into new, high-value fruits and vegetables. According to Dr. Ellen Brown's 1990 social impact survey, farmers who have been successful in increasing production are concerned about issues such as obtaining seeds, storing produce, and obtaining higher prices.[10] They do not have trouble selling their produce per se, but they would like to find more lucrative ways to market their output.

4. Rationale for the Design of Phase II

The design team feels that there are clear rationales for the design of each project component:

Technology Transfer. Phase I of the project was designed as

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[8] Statistics in the technical annexes attest to the production-increasing effects of these technologies. To cite two examples, composting has doubled tomato yields on several farmers' fields, and the bidon verseur has increased cultivated surface area by over 75% for other pilot farmers.

[9] Ellen Brown, Social Impact of the Lake Farmer Training Project End-of-Project Survey and Analysis, ORT, N'Djamena, September 1990.

[10] Ibid. p. 15.

a pilot effort to develop replicable models of improved wadi agriculture in accordance with GOC production objectives. The project was largely successful in developing appropriate new technologies -- technologies that address farmers' concerns about water-lifting, fencing, and soil productivity. Most wadis in the project zone, however, have not yet had the opportunity to be introduced to the new technologies. It is now the moment to share these proven innovations with a larger number of farmers. Phase II will directly target a total of 47 wadis and 650 households.

Marketing. Until recently, issues of agricultural marketing frequently were neglected by development projects in Chad. When input markets were neglected, project sustainability was unlikely. Crucial inputs such as spare parts were no longer available after the project closed.[11] And when output markets were neglected, economically unsound production decisions were taken -- crops were grown that could not be sold.[12] Phase II of the Lake Chad project will avoid these pitfalls by concentrating on building private sector marketing services for both inputs and outputs. This effort corresponds with USAID's agricultural sector goals and with the concerns of wadi farmers in the Ngouri area, as reflected in a social impact study carried out in July 1990.[13] The study revealed that farmers are concerned with procuring inputs and with selling their produce in more profitable ways.

B. Project Objectives

1. Project Goal

The project goal is to achieve a sustainable increase in the incomes of wadi farmers in the Lake region of Chad.

2. Project Purpose

The project purpose is to increase the amount of wadi produce that farmers supply to the market and to increase the profits that they earn from selling that produce.

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[11] For an example of this, see the description of the Red Cross project in Annex C, p. 7.

[12] Examples of this include irrigated rice grown by O.M.V.S.D. in Lai, and radishes promoted by P.I.S.B. in Lac.

[13] Ellen Brown, Social Impact of the Lake Farmer Training Project End-of-Project Survey and Analysis, ORT, N'Djamena, September 1990.

3. Project Outputs

There are nine outputs to the proposed project. The first five concern the development of improved private sector marketing services for agricultural inputs and outputs. The last four outputs concern the replication and strengthening of the water-lifting and agricultural technologies that proved successful during the first phase of the project (1987-91). Target figures are to be achieved by the close of project. The outputs are:

a) Sustainable private-sector input supply services are established for vegetable seeds, aquifer taps, nursery pots, spare parts, and pump repairs.

The improved and diversified agricultural practices that Phase I introduced to the Ngouri region require the use of new agricultural inputs. These include quality seeds for new crops such as carrots[14], PVC tubing for aquifer taps, nursery pots for saplings, and spare parts and repair services for small motorpumps. The design team is convinced that the best way to assure sustainable supply lines for these inputs is to work through private merchants -- merchants who will find it in their own interest to continue to sell these inputs long after the project has closed. This private-sector approach was followed by ORT during Phase I, and it will be continued and reinforced during Phase II. The project will identify local village merchants interested in selling the new inputs, and will assist them in locating wholesale suppliers in N'Djamena and Nigeria. The project will then reduce the risks associated with stocking these new items by agreeing to repurchase any unsold inventory after a given period. This process will allow merchants to experiment with new products, to familiarize themselves with supply channels, and to assess local demand -- demand that will grow as more farmers adopt project technologies and are informed of input availability. For pump repairs, the project will continue to train and support the six independent mechanics which it equipped in Phase I.

b) Sustainable private-sector supply systems are developed for bidon verseurs, tubewells, and small Honda motorpumps.

After extensive on-farm testing, Phase I of the project identified three appropriate technologies to facilitate wadi water-lifting: the bidon verseur, the hand-drilled tubewell, and the small Honda motorpump. A farmer credit cooperative was formed to facilitate the process of acquiring motorpumps, and a small group of farmers was trained in tubewell installation. Phase II of the project will

[14] All new types of seeds will be tested and submitted to an AID environmental determination before they are marketed; this is explained under output "d".

work to strengthen the supply systems for these technologies, with an increased emphasis on private entrepreneurship.

For tubewells, this will involve the transformation of the current installation team into a genuine private enterprise, trained in business skills as well as technical matters. If demand is sufficient, the project will support the creation of a second tubewell enterprise and will encourage competition with the installation team now forming in Mao. ORT's role will be to train and equip the tubewell teams, but not to subsidize their transportation or supplies -- the teams will procure these inputs through private sources.

For motorpumps, the project will continue to support the farmer credit cooperative through management training and technical assistance. The group will be encouraged to continue its practice of buying pumps through private merchants in the Ngouri zone. At the same time, the group will be encouraged to become leaner, by ceding its spare parts and tubewell activities to independent private enterprises. If motorpump demand exceeds the lending capacity of the current credit group, a second, smaller group will be established to meet farmer needs.

For bidon verseurs, the project will promote manufacture by local artisans and sales through private merchants. This will involve training metal workers in Massakory or another appropriate site to produce the bidon verseur. Ngouri-based merchants will be encouraged to purchase the device and sell it to wadi farmers, partially on credit. Initially, ORT will facilitate this process by placing orders for bidon verseurs through traders, payable upon delivery to Ngouri. Next, the project will sell the devices to local merchants for 50% down and 50% after six months, on the condition that they sell the device on similar terms to interested wadi farmers. Thus, ORT and the merchants will share the marketing risks, but the merchants will ultimately be responsible for screening farmer clients and collecting credit payments from them, thereby earning their profits. As information barriers are broken down and merchants become familiar with the trade, ORT will reduce its role, and the private sector will take control of the entire supply process.

c) Five or more value-enhancing crop storage, harvesting, and packaging technologies introduced, tested, and evaluated.

To increase the return that farmers derive from their produce, Phase I of the project began to experiment with aerated storage structures for onions and okra. In Phase II, the project will expand its testing and development of these and other value-enhancing marketing techniques. This process will begin by laying down a baseline -- carefully quantifying the problems associated with current post-harvest practices, (e.g., what percentage of

fresh okra is damaged in transport and what is the loss in value?). The next step will consist of controlled experimentation with new techniques to determine if they can outperform traditional measures. Techniques to be tested include aerated storage shelves, careful grading of onions to be stored, customized packaging crates, post-harvest cooling methods, and harvesting produce at various sizes and states of maturity. Once economically and technically attractive techniques are identified, the project will share its innovations with interested traders, farmers, and farmer groups. Information exchanges between ORT, ACDI and CARE will speed this technology development process.

d) Five or more value-enhancing techniques in off-season production and market-targeted diversification are tested and adopted.

One of the best ways for wadi farmers to increase their incomes is by diversifying into high-value vegetables. Phase I of the project facilitated this process by testing and introducing new products such as carrots, beets, papayas, and garlic. Farmers generally have been enthusiastic about these new crops because they fetch good market prices. Phase II will continue to encourage this diversification process. This will include promotion of the above-mentioned crops, and an expanded search for new vegetables that command attractive prices in the N'Djamena and regional markets, (green peppers, for example). Careful price monitoring in coordination with other donors will facilitate the search process. Once identified, new crops will be tested on a limited basis and submitted to an AID environmental determination before any steps are taken for dissemination.[15]

Off-season production is a second means for farmers to increase their incomes and to take advantage of the considerable seasonality of Chad's vegetable prices. The project will test off-season production techniques (such as shading and early onion production through bulb transplanting), and conduct off-season variety trials (such as hot-season melon production). All trials will be conducted on a limited basis and carefully evaluated and documented before steps are taken for dissemination.

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[15] AID Regional Environental Advisors visiting the project in September 1990 recognized in their Scoping Statement Document that the "encouragement of crop diversification" would be a part of the Phase II project, but they do not identify diversification to be a significant environmental issue. Appendix A: Scoping Statement Document in "Environmental Assessment - ORT/SODELAC Second Phase", December 1990.

e) Five or more trial shipments of non-traditional crops are organized, tested, and evaluated for profitability.

Analytical and empirical evidence suggests that merchants and farmers in the Ngouri zone are skilled in the marketing of traditional crops such as millet and onions -- they are aware of regional and N'Djamena prices and they are familiar with collection and sales procedures. Years of experience have honed their expertise, and there probably is little that ORT can do to increase their efficiency. However, the same cannot be said for newly-introduced crops (such as beets and carrots) with which Ngouri-based traders have little marketing experience. During Phase II, ORT will work to expand traders' and farmers' experience in marketing these products by sponsoring trial marketing runs. These trials will serve to reduce the risks involved in producing and marketing new products and to break down information barriers. The Assistant Marketing Agent will identify interested farmers and traders and "walk them through" the marketing process -- assisting them in purchasing, packaging, transporting, and selling the produce through existing private sector channels.[16] The project will absorb a percentage of the marketing costs on the initial shipments to reduce the risks associated with experimentation; however, once a market is demonstrated to be profitable, traders and farmers will no longer need project guidance -- they will find it in their own economic interest to exploit these market opportunities. Project staff will document the financial results of all trial runs.

f) Improved water-lifting technologies adopted and maintained by 400 wadi farmers.

The pilot phase of the project identified four appropriate, and economically attractive technologies to alleviate farmers' problems with water-lifting and water availability: the aquifer tap, the hand-drilled tubewell, the small motorpump, and the bidon verseur. The output-increasing effects of these four technologies are documented in the technical and economic annexes to this document. Phase II will work to extend the benefits of these proven technologies to a larger number of wadi farmers. Dissemination will be facilitated by strengthening private supply channels for these technologies (ouput "b" above), demonstrations of the technologies' capabilities (through farmer visits/field days), and training sessions for farmers and extension agents in installation, operation, and maintenance. This dissemination process will be the principal responsibility of the Water Resources Technician and his

[16] Project vehicles will not be used; the Assistant Marketing Agent will accompany the trader/farmer on commercial transportation.

or her Assistant, collaborating closely with ORT training agents and delegues techniques. The Technician will also work to improve the technologies' efficiencies through trial modifications of canal sizes and water application rates. The objective will be not only to spread the technologies to new farmers, but to ensure that those who already benefit from the devices are able to maintain and replace them as needed. Targets for the end of project are a total of 300 aquifer taps, 45 tubewells, 50 bidon verseurs, and 90 farmers using motorpumps.[17]

g) The number of farmers employing improved agronomic techniques -- proven successful during Phase I -- increases by at least 100%.

The pilot phase of the Lake project experimented with a large number of agronomic and agroforestry techniques. Four proved to be particularly successful and well accepted by wadi farmers:

diversification into new crops, (garlic, papaya, carrots, lettuce, etc);
soil enrichment through manure applications and composting;
live fencing; and
improved plot preparation methods, (row/furrow planting, larger basins, raised seed-beds).

The production-increasing effects of these techniques are documented in technical annex "D". In many cases, the techniques have increased yields by over 50%. New crops such as garlic and carrots sell quickly in local markets. 58% of the farmers in project wadis applied at least one of the improved techniques over the last farming season. 78% of farmers interviewed by the project anthropologist in June 1990 had planted live fencing -- a technique characterized as one of "the most visible and appealing attractions of the project both to participants and those who would like to join."[18] The 1990 AID project evaluation noted successes in the development of all four of the agronomic techniques. The AID Environmental Assessment recommends continued emphasis on soil

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[17] Currently in the zone there are 188 aquifer taps, 15 tubewells, 3 bidon verseurs, and 40 farmers using motorpumps. Some motorpumps are shared between two farmers. The Phase II target number of 400 farmers accounts for the fact that some technologies will be used simultaneously by the same farmer, i.e. the aquifer tap and the bidon verseur.

[18] Ellen Brown, Social Impact of the Lake Farmer Training Project - End-of-Project Survey and Analysis, September, 1990.

enrichment and live fencing.[19]

Phase II of the Lake project will not allow the agronomic accomplishments of the pilot phase to go to waste; instead, it will train an expanded number of farmers to replicate the four most successful techniques. Under the guidance of a Chadian agronomist, ORT's training agents will work through the delegues techniques to reach the farmers in project wadis that have not yet received training, as well as farmers in six new wadis per year. By the end of the project in 1994, the number of farmers employing improved techniques will have increased by at least 100% over the 1991 baseline figure.[20] This will involve approximately 600 farmers in 47 wadis.

h) Natural pest control methods introduced, tested, and evaluated.

Pest attacks have always been a constraint on the profitability of wadi agriculture. Insects, rats, and diseases not only reduce the quantity of produce harvested, but they diminish its quality and marketability. Phase II of the Lake project will take the first steps to deal with this important constraint by developing an environmentally-benign system of pest management. The project will not use or promote the use of chemical pesticides or fungicides. Instead, it will test natural control methods such as residue removal, vector destruction, crop rotation, and inter-cropping. A consulting expert in natural pest management will make two or three visits to the target zone over the project cycle. He or she will assess the problems, recommend control measures, and design experiments that the Chadian agronomist can conduct during the expert's absence. By the end of the consultant's last visit, natural control methods will have been introduced, tested, and evaluated.

i) Improved extension services -- professional and volunteer -- available in the region.

During Phase I, the project developed a new approach to agricultural extension called the delegue technique program. A

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[19] "soil organic matter and vegetation management,...live fences and wind breaks...should be component parts of ORT's continuing project," USAID, Environmental Assessement - ORT/SODELAC, December 1990, p. 17.

[20] Currently, 236 farmers employ project-introduced techniques. By the time the next baseline study is completed, this number may rise to 300. It will double by the end of Phase II.

delegue technique is a pilot farmer trained to serve as an extension agent within his own wadi in agronomy, agroforesty, or well improvement. At least one "technical delegate" was trained in each of the 29 project wadis. The 1990 AID Project Evaluation characterizes the program as well-conceived and effective.[21]

Phase II of the project will take steps to strengthen and expand the delegue technique system. At least two "DT"s will be trained in each project wadi. In previously-served wadis this will involve building on previous training; in new wadis it will involve introducing the "DT"s to the project's proven technologies. Training will be conducted on both a formal and informal level by the relevant technical staff, with the assistance of the Project Training Officer.

SODELAC's extension capabilities will also be strengthened. Agents assigned to the Ngouri zone will receive project training in water-lifting, well improvement, agronomic techniques, and extension approaches (particularly, how to use the delegue technique system). The Training Officer will determine where each training session will occur -- Ngouri, N'Djamena, Dougia, or Bol. As appropriate, interested SODELAC agents from other zones will also receive training in project techniques. A total of at least four training modules will be developed and presented.

C. Activity Components

Phase II of the Lake Chad project consists of two broad categories of activities: (1) marketing and (2) technology transfer. Each of these categories is further broken down into components; marketing is divided into inputs and outputs, and technology transfer is divided into water-lifting and agronomic techniques. Sustainability and economic profitability are key concerns weaved throughout all of these elements.

Technology Transfer -- Water-lifting

The pilot phase of the Lake project was successful in identifying several attractive technologies to facilitate irrigation in the wadi: the aquifer tap, the tubewell, the small motorpump, and the bidon verseur. The project already has begun the process of introducing these technologies throughout the 29 wadis that it currently serves. Phase II will continue the dissemination process to achieve the output targets presented in section 3b above. Responsibility for this task will fall mainly on the project's Water Resources Unit -- an expatriate water resources

[21] AID Evaluation, p. 35.

technician and a Chadian pump specialist. These two agents will work with the project's field agents to disseminate information on the technologies, demonstrate installation/operation techniques, and monitor progress. The Water Resources Unit also will organize relevant training for farmers, mechanics, extension agents, and artisans. Maintenance procedures will be emphasized in all training sessions. The self-help philosophy of Phase I will be maintained for Phase II -- farmers will pay non-subsidized prices for all technologies, even if this means that dissemination will be a gradual process over the project's three-year cycle. In addition, the Water Resources Unit will assist in building marketing channels for these technologies -- an overlapping component discussed below under input marketing.

Technology Transfer -- Agronomic Techniques

The four most successful agronomic techniques of Phase I will be retained for further replication in Phase II. These techniques consist of (1) crop diversification, (2) soil enrichment, (3) live fencing, and (4) plot preparation. Dissemination of the techniques will be the responsibility of the project's Agronomy Unit -- a Chadian agronomist, his assistant, and a forester -- working in collaboration with SODELAC agents and ORT training agents. The delegue technique approach will be the main vehicle for information transmission, and inter-wadi field trips will be organized to allow farmers to see examples of successful technique applications. The agronomy unit will focus on the process of extending the four proven techniques to as many wadi farmers as possible. To a lesser extent, the unit will also conduct small-scale diversification trials (on-farm) to test high-value crops (identified by the Marketing Unit) and off-season production techniques (see output marketing below). In addition, the agronomist will collaborate with the natural pest control consultant mentioned under output letter "h".

Sustainability will be emphasized in the dissemination of the agronomic techniques. For soil enrichment and plot preparation, no problems are anticipated. For live fences, the forester will focus on individual nurseries, direct seeding, locally-available sapling pots[22], and obtaining seeds from live fences that are already mature. For diversification, sustainability will be promoted through simple seed reproduction techniques and the development of commercial seed supplies (discussed under input markets).

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[22]These may be fired clay or reinforced plastic bags available in village boutiques. Transplanting from elevated nursery seedbeds will also be tested.

Marketing -- Inputs

Solid groundwork was conducted during Phase I for the development of reliable markets for agricultural inputs in the zone. Private merchants were allowed to gain experience in supplying the project area with motor-pumps, gasoline, oil, spare parts, and PVC tubing. Distortionary subsidies were carefully avoided.

Phase II of the project will take further steps to develop private input markets, based on the conviction that these channels offer the greatest hope for sustained input availability. The project's Marketing Unit will take the lead in this endeavor, in cooperation with the Water Resources and Agricultural Technicians. For relatively inexpensive inputs such as seeds and spare parts, the process will involve working closely with area merchants -- introducing them to urban suppliers and insuring their investments[23] until they become familiar with trade channels and local demand patterns. For more expensive inputs -- motorpumps, tubewells, and bidon verseurs[24] -- the process will be more product-specific. For motorpumps, the project will strengthen the credit group through management training, to be conducted by a specialized agency such as the N'Djamena-based training institute INADES. For tubewells, at least one private enterprise for installation will be created. For the bidon verseur, the project will train metal workers in Massakory to manufacture the device and Ngouri-based traders to market it, as explained under output "b".

Marketing -- Outputs

The project Marketing Unit will be responsible for developing improved strategies and techniques for the marketing of wadi produce. To a certain extent, these activities will be based on the pilot experiences of Phase I, which involved the testing of improved techniques for produce storage and the gathering of weekly price data at the regional market. To a larger extent, however, Phase II marketing activities will consist of new pilot activities and trials, designed to make market gardening more profitable. The first step in this process will be a complete market assessment, carried out by a consultant at the beginning of the phase. The assessment will quantify the extent of post-harvest losses in storage, handling, and transportation, to establish a baseline against which progress can be measured. Next the Marketing Unit

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[23] This can be done by assuring merchants that unsold inventory will be purchased by the project at a pre-fixed price after a given trial period.

[24] Average prices are: motorpump 200,000 FCFA, tubewell 70-120,000 FCFA, bidon verseur 65,000 FCFA.

will undertake the trials outlined above under project outputs "c", "d", and "e" -- i.e., storage, harvesting, packaging, off-season production, diversification, and new crop marketing trials. Close collaboration and information exhanges are planned with two other PVOs (ACDI, CARE) that are engaged in marketing trials and price collection. For diversification and off-season production techniques, the Marketing Unit will cooperate with the Agronomy Unit, using its market research and price data to guide all trials towards the most profitable opportunities. After trials are completed, documented, and evaluated, the project's various training agents will disseminate results to interested merchants and farmers. If the identified techniques are simple and clearly profitable, replication will be relatively simple.

Baseline Data and Ongoing Data Collection (including prices)

The collection of baseline data is fundamental to assessing the project's progress towards its objectives. Two baseline studies are planned for the beginning of Phase II. The first will focus on socio-economic and agricultural indicators -- incomes, surface areas, technique adoption rates, etc. This task will be relatively simple because of the extensive data collection conducted during the first phase of the project; essentially it will involve updating and organizing information which is already in ORT computer files. An expatriate member of the Phase I team will be retained for the first month of Phase II to carry out this task and to assist during the transition period.

Baseline information on marketing will be collected by a consultant for two months at the beginning of Phase II. He or she will provide quantified data on input markets (e.g., the number of seed vendors in the region, the volume of gasoline available, etc.) and similar data on output markets (e.g., the number of merchants trading in beets, the percentage of tomatoes lost during transport, the percentage of onions lost during storage, etc.). The consultant also will provide an overall assessment of the marketing situation, and make recommendations for specific trials to be undertaken.

Ongoing data collection will continue in Phase II along the same lines as it was in Phase I. Farm revenues, expenses, surface areas, adoption rates, and marketing patterns will be monitored by field agents and entered into the project's already-established computer data banks. Price gathering procedures will be coordinated with other PVOs and with AID's Agricultural Marketing and Technology Transfer project.

Environmental Monitoring

The AID Environmental Assessment of the Lake Chad project recommended that the second phase of the project continue to

monitor environmental indicators.[25] The Water Resources Technician will insure that these recommendations are followed. He will continue to monitor piezometric head, water quality, soil salinity, and irrigation efficiency. In addition, he will train SODELAC staff to continue this monitoring process once the project closes. Scientific monitoring equipment will be turned over to SODELAC at that time, and clear guidelines will be transmitted on the environmental significance of all measurements. Farmers also will be informed of the significance of the most important environmental indicators and be encouraged to participate in the monitoring process.

Wider Dissemination

Phase I of the Lake project set out to develop a replicable model of improved wadi agriculture. According to the USAID evaluation conducted in June 1990, the project "has achieved its primary goal...and has developed a replicable model for sustainable agriculture in the wadis."[26] Now that a successful model has been developed, Phase II will work towards its wider dissemination. This process will focus primarily on wadi farmers in the Ngouri sub-prefecture. Delegues techniques will be trained in six additional wadis in the Ngouri zone each year of the project and a total of 47 wadis will be covered by the close of the project. But the dissemination process will not be strictly limited to the Ngouri sub-prefecture. In so far as SODELAC technicians in Bol and Doum Doum are interested in project technologies, they will be invited to participate in ORT training sessions, (see output "i"), to widen the scope of the project impact. Midway through Phase II, a consultant will assess the dissemination process (the "spread effect"), survey regions in the Lake prefecture where the ORT model is applicable, confer with SODELAC officials, and recommend strategies to facilitate the replication process.

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[25] The Environmental Assessment, which reviewed ORT's project very favorably, makes its recommendations on pages 18-19. It states: "The project needs to continue its ongoing monitoring of water-table elevations...and the project should continue its present activities to measure water quality. We recommend no change in this program."

[26] Lake Chad Agricultural Development and Farmer Training Project -- Final Evaluation, USAID, June 1990.

D. PVO Inputs to be Financed by AID

1. Technical Services

a) Administration and Training Officer -- (3 years)

The Administration and Training Officer will serve as Chief of Party. He or she 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, and ORT/Washington. Major responsibilities include reporting, financial control, and personnel management. In addition, he or she will coordinate all formal project training activities, including two team-building conferences and at least four technical training sessions for SODELAC staff. He or she will help prepare training materials and insure quality control. The Administration and Training Officer will be based in N'Djamena but will travel frequently to Ngouri to address training needs. (Detailed job description in Annex J).

b) Marketing Technician -- (3 years)

The Marketing Technician will head the Marketing Unit and will be responsible for activities related to the development of agricultural input and output markets. An expatriate will fill this position, and will serve as the Primary ORT Technician based in Ngouri. (Detailed job description in Annex J).

c) Water Resources Technician -- (3 years)

The Water Resources Technician -- an expatriate -- will head the Water Resources Unit and be responsible for activities related to the transfer of technologies in water-lifting, aquifer development, and irrigation. This will include not only training and technical duties, but participation in the development of private supply channels for water-lifting technologies. The Water Resources Technician also will be responsible for environmental monitoring. (Detailed job description in Annex J).

d) Agronomy Technician -- (3 years)

The Agronomy Technician will head the Agronomy Unit and be responsible for the replication of the project's four proven agronomic techniques. He also will organize trials of new crops as a function of market demand, and trials of off-season production techniques. In addition, he will coordinate with the consultant expert in natural pest management. The Agronomy Technician will be a Chadian, either seconded from SODELAC or hired independently. (Detailed job description in Annex J).

e) Consultant Services

International consultants will provide the following studies and services:

Socio-economic baseline study and transition support;
Marketing baseline study and assessment;
Small enterprise management assistance;
Study of technology replication and strategic recommendations;
Natural pest management assessment and program recommendations;
Social impact study.

Descriptions of these consultancies are presented in Annex J.

f) Local Staffing

The technician heading each project unit -- Marketing, Water Resources, Agronomy -- will have a local assistant. A local agro-forester will work within the Agronomy Unit. Eight ORT training agents will serve as Farmer Trainers to work closely with farmers in the field. Support staff will include a bookkeeper, two administrators, one secretary, seven drivers, nine guards, and a janitor/messenger. Brief position descriptions are presented in Annex J.

2. In-country Training

Informal training of farmers in new technologies and marketing techniques will be conducted throughout the project cycle. Special attention will be focussed on training volunteer farmer extension agents in 47 wadis. In addition, formal training sessions will be organized for farmers, SODELAC agents, and project staff. The first session will be a team-building workshop to assure that staff and SODELAC agents fully understand the objectives of the project and the rationales behind its approach to marketing. Subsequent training sessions will be developed and presented on each of the project's proven technologies. Most of these sessions will last one to two days and occur in Ngouri. Management and bookkeeping training will be provided to the motorpump group, and tubewell and bidon verseur entrepreneurs.

3. Commodities

Five pick-up trucks, two station wagons, one small car, office equipment, and technical equipment are the major commodities to be procured. Because Phase II aims to cover more wadis than Phase I,

it was decided that the number of field vehicles should not be reduced below Phase I levels; seven are budgeted for. The small car was added for the use of the Chief of Party and Procurement Officer in N'Djamena. Office and technical equipment includes items such as two laptop computers and soil-testing devices. (See Annex H for detail).

4. Inflation and Contingency

A 5% annual increase in costs due to inflation has been included in the relevant (sub-)line items of the budget.

A 10% contingency to offset exchange rate fluctuations has also been included in the budget for all CFA expenditures (see line item 16 of Annex H).

E. PVO Inputs

ORT will maintain its Phase I contribution, and finance 19% of the project costs. (Combined ORT and GOC contribution will total 25%.)

F. Other Inputs

The GOC will contribute the land in Ngouri where the project compound is located. The compound will be at ORT's disposal, rent-free, for the duration of the project. SODELAC will also contribute the time of its extension personnel in the field and the time of its administrative staff in Bol and N'Djamena for project monitoring and, when necessary, project support. GOC contribution will finance 6% of the project cost. Proposal section III C provides details on the GOC contribution.

III. COST ESTIMATES AND FINANCIAL PLAN

A. Summary Cost Estimate (AID and ORT only) 1 US$ = 280 CFA

	Summary Cost Estimate (in dollars)	Year 1	Year 2	Year 3	Total
1.	Expatriate Technical Assistance	237,500	247,576	258,157	743,233
2.	International Travel and Transport	69,761	43,742	76,697	190,200
3.	Local Travel	26,625	22,783	23,922	73,330
4.	Offices, Housing, Utilities	78,118	70,639	74,039	222,794
5.	Local Hire Personnel	145,714	152,989	173,204	471,906
6.	Training	25,125	15,747	9,086	49,958
7.	Vehicles, Equipment	405,202	113,836	98,013	617,050
8.	Home Office Back-Stopping	101,479	106,554	111,881	319,914
9.	Overhead	63,605	66,786	70,125	200,516
10.	Consultants Services	93,777	35,342	3,214	132,333
11.	Other Direct Costs	28,681	15,971	17,404	62,056
12.	Contingency Reserve for CFA Expenditures	68,840	38,761	39,029	146,634
Total		1,344,427	930,726	954,771	3,229,924

B. Financial Plan

ORT/Washington 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. 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 ORT/Washington Coordinator. 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 ORT/Washington 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.

AID's Office of Contract Management, Overhead and Special Costs Branch, has approved the current ORT provisional overhead rate of 30%. The formula used to calculate the overhead rate does not include backstopping salaries. Therefore, ORT is authorized to charge both overhead and backstopping on AID projects.

ORT will use its existing Federal Reserve Letter of Commitment (FRLC) to manage this project. The system has worked well as a means for the receipt and quick disbursement of project funds. Funds from this account will be moved to the N'Djamena field office via wire transfer. Since no banking facilities exist in Ngouri, precautions will be taken to secure the overland delivery of cash to Ngouri and the security of the funds in Ngouri. High quality safes are used in both the N'Djamena and Ngouri offices, which are also secured by guards.

C. Cost Estimates of Other Inputs to the Project

The GOC will contribute the land in Ngouri where the project compound is located. The compound will be at ORT's disposal, rent-free, for the duration of the project. SODELAC will also contribute the time of its extension personnel in the field and the time of its administrative staff in Bol and N'Djamena for project monitoring and, when necessary, project support. An estimate of these contributions is provided in Chart 1.

Chart 1: GOC Estimated Contribution

a) Personnel US$1 = CFA 280

SODELAC Post	% of time	Monthly Salary (CFA)	Months	Subtotal (CFA)	Subtotal ($)
(i) Director General	0,10	350000	36	1260000	6500
(ii) Technical Dir.	0,20	250000	36	1800000	6429
(iii) Admin. & Financial Director	0,05	250000	36	450000	1607
(iv) Head of Technical Service	0,20	197000	36	1418400	5066
(v) Head of Monitoring & Evaluation Div.	0,20	165000	36	1188000	4243
(vi) Head of Monitoring & Eval. Service	0,10	140000	36	504000	1800
(vii) Head of Ngouri Agency	1,00	131000	36	4716000	16843
(viii) Chefs de Zone: 2	1,00	178300	36	6418800	22924
(ix) Chefs de Sous-Zone: 4	1,00	287600	36	10353600	36977
(x) Extension Agent	1,00	22276	36	801936	2864
(a) Subtotal	-	-	-	28910736	103253
(b) Social Security (12%)	-	-	-	3613960	12907
(c) Backstopping: SODELAC offices in NDja. & Bol	-	100000	36	3600000	12857
(d) Evaluation	-	-	-	1250000	4464
(e) Use of Ngouri Facilities (Land and buildings)	-	500000	36	18000000	64286
Total				55374696	197767

IV. IMPLEMENTATION PLAN

A. Implementation Responsibilities

1. ORT

ORT will take all responsibility for the recruitment and fielding of the expatriate project staff and international consultants. ORT will hire and supervise all local staff and assure the technical inputs of the project. ORT's Administration and Training Officer will organize the logistical and administrative support needed by the project technicians.

2. GOC

The GOC will be responsible for providing competent extension agents in the Ngouri area to assist in project implementation and to participate in training sessions. 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. USAID

USAID will have no direct implementation responsibilities, but will monitor and evaluate the project.

4. Project Implementation Schedule

A project implementation schedule is presented in Annex I.

B. Collaboration with Other Donors

1. CARE

CARE is currently implementing a "Pumps and Agricultural Marketing" project in the Kanem prefecture, which borders on the Lake region and shares many of the same characteristics. ORT and CARE have had a fruitful collaborative relationship over the past five years, a relationship that led to the joint development of the "sludger" method of tubewell installation. Continuing collaboration is envisaged in the areas of privatizing the pump

installation process and marketing. CARE has agreed to furnish ORT with copies of its weekly vegetable price surveys in N'Djamena and copies of reports on produce packaging and storage. Efforts to test new packaging and storage prototypes will be coordinated between ORT and CARE.

2. ACDI

ACDI is in the process of implementing a pilot project for fruit and vegetable marketing in the Chari-Baguirimi/N'Djamena zone. The ACDI project will test techniques in produce harvesting, handling, packing, and storage. Short-term experts in these fields will provide technical assistance. ORT will capitalize on these experts' recommendations and ACDI's experience to learn about which marketing interventions work and which do not. ACDI is also establishing a market information system in N'Djamena on fruits and vegetables that may prove useful to ORT's efforts in market research. ACDI has agreed to share price information with ORT on a regular basis.

3. "Projet Etude-Action" at Doum-Doum

The "Study-Action" project at Doum-Doum is located only one hour east of Ngouri. The project is financed by the African Development Bank and executed by SODELAC. For the past year, the project has been testing the bidon verseur with very promising results. ORT plans to share technical data with "Projet Etude-Action" and to coordinate efforts to establish mechanisms for the private manufacture and distribution of the bidon.

4. Other NGOs

As necessary ORT will turn to other NGOs for advice and support. VITA will be consulted on matters concerning credit, although formal credit will not play an important role in the ORT project. ACCRA will be consulted about produce packaging, an area in which they plan to experiment. INADES may be hired to assist in training Kida Boulim in management and basic accounting.

C. Procurement Plan

1. Authorized Source of Procurement

AID is funding the PVO/DIP under its Development Fund for Africa, whose regulations permit the procurement of commodities from any country coded "935". Although this regulation allows for the procurement of commodities of Western European and Japanese origin, for example, the ORT procurement offices will, in accordance with AID policy, seek to purchase commodities whose origin and source is, by order of preference, the U.S., Chad, or another developing country (e.g., Nigeria, Cameroon).

Pursuant to AID regulations, ORT will submit to AID/Chad at the beginning of the project a procurement plan listing the major commodities to be purchased during the course of the project, as well as the probable source and origin of these commodities. It is already apparent that due to the lack of service facilities and spare parts for U.S. manufactured vehicles in Chad the project will have to purchase Japanese (and perhaps European) manufactured vehicles.

2. Responsibility for Procurement

All in-country procurement will be the ultimate responsibility of the Chief of Party/Administration and Training Officer. (S)he and his/her staff will assure that ORT and AID procurement procedures are followed. In addition, they will be responsible for obtaining bids, filing the necessary papers for duty-free exemptions, and in-country shipping of commodities to Ngouri.

Procurement of items from the U.S. will be overseen by the ORT/Washington Coordinator, in conjunction 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 handled by the Washington office.

The Procurement Department's staff has had extensive experience in product-identification, packing and shipping, and has access to a supplier network in the U.S. and nine other countries. The ORT Procurement Department holds to a policy of obtaining the best prices coupled with reliable delivery and, most importantly, speed of dispatch. It functions as a controller of budgets and provides monthly expenditure reports to field project managers and funding agencies.

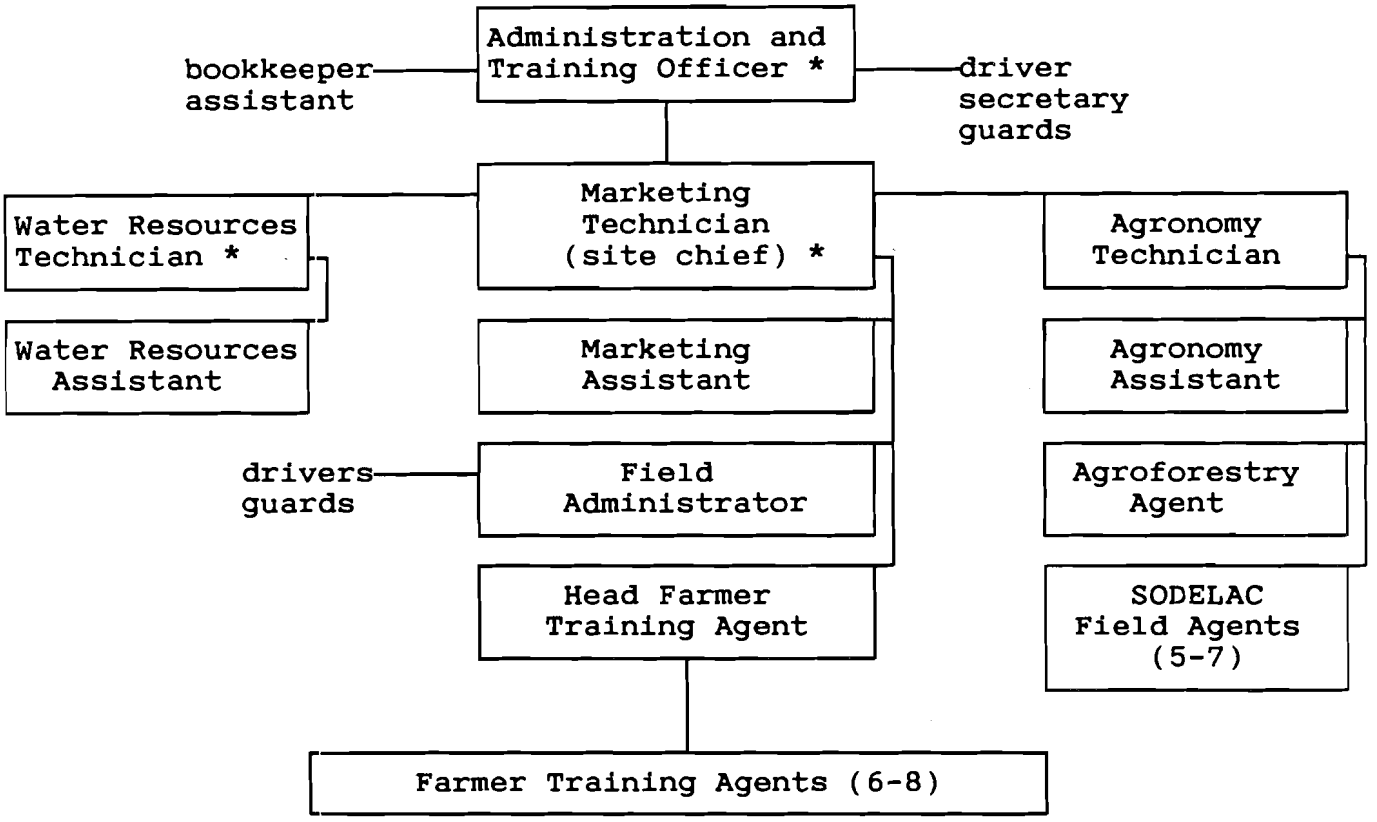
Procurement for AID-funded projects takes into account AID's Mandatory Standard Provisions for U.S., Nongovernmental Grantees and the applicable Optional Standard Provisions in the Cooperative Agreement. These provisions include, but are not limited to, the utilization of U.S. flag carriers and the enforcement of source-and-origin requirements. ORT maintains in its files all AID and Federal regulations concerning procurement.

D. Organizational Chart

An organizational chart is presented in Figure 1.

FIGURE 1 ORGANIZATIONAL CHART

Lake Chad Farmer Training Project - Phase II



* expatriate position

All assignments are to the Ngouri zone, except the Administration and Training Agent who is based in N'Djamena with office staff.

Farmer Training Agents will work in all three domains (water, marketing, agronomy), but will ultimately be responsible to the site chief.

SODELAC Agents will also participate in training in all three domains; for example, they will be trained in environmental monitoring techniques by the Water Resources Technician.

V. MONITORING PLAN

A. PVO Project Management

1. In-Country

ORT will continue to operate out of a main office in N'Djamena and a sub-office in Ngouri. The N'Djamena office will be headed by the Administration and Training Officer/Chief of Party and will be staffed by a local-hire administrative assistant, bookkeeper, and secretary. The office will be responsible for liaison with the sub-office, with AID, the GOC, other donor agencies, and ORT's home office, as well as banking, financial and narrative reporting, procurement, customs clearance, inventory, logistics, and any other necessary support functions. The Administration and Training Officer will spend approximately 20% of his/her time in Ngouri, particularly during the start-up phase of the project. S/he will organize training sessions, especially those involving the participation of trainers and/or participants from outside the project zone. Other responsibilities of the Administration and Training Officer will be to assure that progress towards meeting the overall project purpose and outputs is on schedule, to identify solutions to problems which arise during project implementation, and to carefully monitor data compilation and analysis.

The Ngouri sub-office will be headed by the Marketing Technician/Deputy Chief of Party. S/he will be expected to devote no more than 10% of his/her time to administrative matters since most of these duties will be the responsibility of the N'Djamena-based Administration and Training Officer and the Ngouri-based Field Administrator. The sub-office will also be staffed by an three assistant in the marketing, water resources, and agronomy sectors, respectively, as well as an agro-forestry agent and the head farmer training agent. The field staff will also include SODELAC extension agents and ORT farmer trainers.

A radio link-up, established during the previous project, will continue to facilitate communication between the two offices.

2. Home Office

ORT recognizes that close coordination between its field offices and home offices is essential to any project success. Therefore, extensive effort and planning go into administrative support and backstopping. 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 realms of project management, agricultural development, and training.

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

Washington Home Office

Overall project supervision will be done from ORT/Washington by a coordinator and full-time assistant. The designated coordinator, Celeste Scheib Angus, has worked with ORT for 6 years and is responsible for all AID-financed projects. Ms. Angus contributed to the design of the Lake Chad Project Phase I and has provided backstopping throughout the life of the project. These duties include: (1) coordinate and monitor all activities related to long and short-term expatriate personnel; (2) oversee evaluation planning and execution; (3) establish and to 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 inputs of all organizational resources utilized by the project; (7) maintain continuous contact with the field office in N'Djamena and to make periodic field visits; (8) assure that all program reports are submitted in a timely manner to AID/Chad and the GOC; and (9) maintain contact with AID/Washington, as required.

The bulk of procurement for AID-funded projects is implemented by the Washington procurement department. This office will also monitor all procurement expenditures and secure all U.S. procurement.

London Office

The London office houses an interdisciplinary team of trainers/technical specialists, several of whom -- an agricultural economist, as well as a training and an equipment specialist -- will be assigned on a part-time basis to provide assistance to the project in the areas of marketing (strategies and technologies) and training.

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. The controller reports to the ORT/Washington Coordinator.

B. AID Liaison

The Administration and Training Officer will keep AID/Chad informed of the status of the project, through the timely submission of narrative and financial reports, and of any proposed changes in program activities. In addition, s/he will be available to the AID Project Officer and the AID PVO Umbrella Project Coordinator responsible for supervising implementation of the PVO/DIP (677-0051).

C. GOC Project Management

The project will be implemented in close collaboration with the GOC. A basis for this collaboration was established during the design of the project when ORT sought and obtained the participation of representatives from SODELAC and SPONG (the Permanent Secretariat for NGO's, an interministerial body under the auspices of the Ministry of Plan and Cooperation), and the support of regional administrative officials and traditional leaders. It should also be noted that the Ministry of Rural Development has been extremely supportive of ORT's activities in the Lake Prefecture from the beginning. ORT is confident that this collaboration will continue throughout the new project.

SODELAC will serve as the counterpart GOC agency in project implementation. ORT envisions the following management arrangements with SODELAC:

- The Administration and Training Officer/Chief of Party will report directly to the Director General of SODELAC in N'Djamena. The Marketing Technician/Deputy Chief of Party will directly report to the Technical Director of SODELAC in Bol.

- An agronomist (ingénieur agronome) from SODELAC will be seconded to the project to serve as the Agronomy Technician. This person will serve not as a counterpart to an ORT technician, but rather as an integral member of the project staff. He will also benefit from on-the-job and formal training in a variety of sectors (the sludger technique, data collection and analysis techniques, the utilization of computers, etc.).

- The SODELAC field agents assigned in the project area will participate in project activities and will benefit from on-the-job training and formal training sessions.

- Given the similarities between this project and SODELAC's Etude-Action Project in the Doum-Doum area south of Ngouri, the two project staffs will collaborate closely on practical matters and issues of common concern (e.g.,

the bidon verseur, the agricultural extension system, training of field agents, well improvement technologies).

- The project will examine, in close collaboration with SODELAC, the potential for replicability of the Phase I accomplishments, such as well improvement techniques and the délégué technique extension system, beyond the project zone, in other parts of the Lake Prefecture.

- The project will assist SODELAC agents throughout the Lake Prefecture, especially those assigned to areas where wadi agriculture predominates, by providing training on the délégué technique extension system and a variety of other technical subjects. This program is consistent not only with SODELAC's request for the project to renew its emphasis on training, but also with ORT's institutional philosophy and expertise.

- Regular meetings between SODELAC and ORT will provide a forum for the monitoring of project progress and the discussion of potential problems and proposed solutions.

D. Reporting responsibilities

The Administration and Training Officer will be responsible for compiling quarterly progress reports based on input from the project technicians. These reports, drafted by the project technicians, will be submitted to USAID and all interested GOC agencies. They will detail accomplishments and obstacles towards meeting the project purpose and outputs and include the proposed work plan for the upcoming quarter. Further, they will be clearly relevant to the Logical Framework; that is, they will serve as the "means of verification" for the "indicators" in the Logical Framework so that the percentage of attainment of the project purpose and outputs can be determined, in accordance with AID requirements. Accomplishments will be quantified in this way in the quarterly reports whenever called for in the Logical Framework.

Quarterly reports will be submitted to AID and to the GOC in accordance with the terms of the Cooperative Agreement and the Project Agreement, respectively.

Financial reports will be submitted to AID/Washington through ORT's Washington office.

VI. SUMMARY ANALYSES

A. Summary of Marketing Analysis

Agricultural marketing concerns both the systems that deliver essential inputs to producers and the systems that deliver farm outputs -- crops -- to their ultimate consumption points. The first half of the marketing analysis presented in Annex B treats issues related to input markets for wadi agriculture in the Ngouri area. The second half discusses issues related to output markets for wadi produce and plans to improve marketing strategies.

Input Markets

The introduction of improved techniques to wadi farming has also introduced a need for improved inputs. During the pilot phase of the project, ORT took the first steps to building private delivery systems for these new inputs. During Phase II, ORT will take further steps to build and reinforce these private-sector supply lines.

The project will work with individual Ngouri-based merchants to develop commercial channels for small portable inputs such as vegetable seeds, spare parts, sapling pots, and PVC tubing for aquifer taps. The project Marketing Assistant will introduce the Ngouri-based traders to suppliers in N'Djamena, and train them to select quality materials, (e.g., non-expired seeds). Next, the project will order small quantities of the materials through these traders, who will deliver them to shop-keepers in Dibinintchi and Ngouri. For the first two shipments, ORT will share in the shopkeepers' risk by guaranteeing to repurchase at cost the inputs that are unsold by a certain date. Once merchants are fully introduced to the process, they will be expected to continue the trade on their own.

For the bidon verseur, the project plans to develop a private system of manufacture and distribution. This will involve training metal workers in Massakory to build the device, then ordering several to be delivered to shop-keepers in Ngouri and Dibinintchi. Initially, ORT will sell the bidons to the shop-keepers on credit, provided that they, in turn, sell the devices to farmers on credit. Once the shop-keepers are familiarized with the trade, ORT will withdraw from the process and merchants will become fully responsible for ordering and selling the device.

During Phase I, the project trained a five-person team of farmers to install tubewells. To date, the team has put in 17. During Phase II, ORT will take steps to privatize the tubewell business and create one or more independent tubewell enterprises. This will involve training the teams in business skills and logistics management.

ORT stimulated the creation of a local farmers' organization in 1989 to manage a revolving fund for the procurement of small motorpumps for its members. To date, the organization has purchased 25 motorpumps, five of which were purchased through its own revenues. The group orders its motorpumps through local merchants, who import them from Nigeria. Although the performance of the farmers' organization has been good, several weaknesses need to be addressed during Phase II. To strengthen the group, ORT will provide further technical assistance and training in management and bookkeeping to the group's leadership.

Output Markets

Wadi farmers in the Ngouri area produce a number of different crops. Some of these are destined mainly for family consumption needs, such as wheat, while others are produced primarily for commercial marketing purposes, such as onions. The most frequently marketed types of wadi produce are: onions, fresh tomatoes, dried tomatoes, eggplant, fresh okra, dried okra, and manioc.

The market for wadi produce in the Ngouri zone is characterized by numerous buyers and sellers. Competition is free, and prices generally are determined by supply and demand conditions. Most transactions occur at periodic markets on a weekly schedule. Vegetables are brought to these markets on donkey-back, where they are sold directly to consumers or to local traders who transport the produce on camel-back to other regional markets. A relatively small amount of vegetables are transported by truck to the urban markets of N'Djamena, Massakory, and Bol. The Ngouri area exports onions and okra to these urban markets, but it imports garlic and dried tomatoes.

Although the marketing system in Ngouri is dynamic and competitive, there are a number of constraints and opportunities that deserve closer attention. Some of these constraints -- such as high fuel and camel costs -- cannot be solved by ORT. But other constraints -- such as inadequate information about new markets and technologies -- can be addressed by the Lake Chad project.

While Ngouri's farmers and traders are very familiar with onion and dried okra markets, they are less well informed about other potentially profitable outside markets, such as the market for beets and manioc leaves in N'Djamena and Bol. Phase II will address this information constraint by sponsoring marketing trial runs for these types of products (based on market research). The project will track vegetable prices to identify other profit-making possibilities for farmers who want to diversify into high-value crops such as leeks or green peppers. And it will encourage increased production of garlic, a crop which is still imported into Ngouri from N'Djamena.

Vegetable prices are subject to seasonality in Ngouri; they tend to be low right after the harvest and relatively high in the off-season. To help farmers make the best of this situation, Phase II of the project will test and develop improved storage technologies and off-season production techniques (such as producing early onions from bulbs). In addition, the project will test and develop improved packaging technologies to reduce damage incurred during transport over hot bumpy roads.

B. Summary Technical Analysis

The pilot phase of the Lake project identified and developed several water-lifting technologies and agricultural techniques that proved to be technically successful, economically feasible, and well adapted to the needs of wadi farmers. Phase II of the project will disseminate and strengthen these technologies. Technical issues in water-management are discussed first, followed by a discussion of technical agronomic issues.

Water-lifting and Water Management

Traditionally, wadi farmers in the Ngouri region lift water from shallow wells using the shadouf, a pivoting pole with a bucket on one end and a counterweight on the other. The output of the system is limited; on a typical five-meter well the shadouf yields about 0.9 liters per second, requiring a man to work 30 hours a week to irrigate a small garden of a tenth of a hectare. Poor recharge rates of many traditional wells further limit irrigation possibilities; after an hour or two of using the shadouf, a farmer's well often goes dry. When farmers were interviewed by the original project design team in 1986, they identified water-lifting and water availability as the major constraints to more productive wadi farming.

In response, the pilot phase of the project tested a series of pumps and well-improvement measures. The four most successful were the aquifer tap, the hand-drilled tubewell, the small motorpump, and the bidon verseur. These technologies are to be disseminated during Phase II of the project to help farmers overcome what they themselves defined in 1990 as "the most pressing problem in the project zone." [27]

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[27] The finding is based on Dr. Ellen Brown's extensive interviews with area farmers in June and July of 1990, confirmed by further interviews conducted by the design team in February 1991. Dr. Brown writes, "water extraction still remains the most pressing problem for most farmers in the project zone. Now that the project has developed a viable model it should be used to help farmers in the region." Social Impact of the Lake Farmer Training Project -- End of Project Survey and Analysis, September, 1990, pp. 20-21.

The aquifer tap is a PVC tube installed in the bottom of a hand-dug well which provides a hydraulic connection through which high pressure water from the sand aquifer enters the well, thus increasing its productivity. Traditional wells that do not tap the sand aquifer can dry up, causing the farmer to lose irrigation time while he waits for the well to recharge. The aquifer tap overcomes this problem and can increase water availability by up to 36%. The project will continue to train delegues techniques to install aquifer taps using the hand "sludger" method.

The Honda GX-110 motor pump was selected during Phase I as an effective water-lifting technology for wadi farming. This selection followed an intensive 18 month period of pump testing during which manual and animal powered water-lifting devices were also tested. The motor pump, a 3.5 gasoline powered centrifugal pump, was selected due to its superior discharge relative to the shadouf (100-200% superior) and it ability to free the farmer from the task of water-lifting. Due to its increased output, the pump increases production and enhances farmer incomes. During Phase II, efforts will continue to solidify the structures established to assure the importation of the pump, the marketing of spare parts, and the existence of a local capacity to repair the pump. Maintenance monitoring and training also will be emphasized, as well as training in proper water application rates.

In many cases a hand dug well improved with an aquifer tap dries up when pumped with a motor pump. The ORT-developed tubewell is a 80 cm diameter PVC well which, being between 12 and 15 meters deep, taps the regional sand aquifer. The 6 meter long well screen allows for up to 2.82 l/sec to be extracted from the well. The water extracted is of the high water quality associated with the sand aquifer. A team of five farmers was trained during Phase I to install the tubewell using the "sludger" drilling method. During Phase II, further technical support will be provided to this team, however, efforts will concentrate on training in business and logistical management skills.

The bidon verseur is an animal traction water-lifting device using a block and tackle set-up to pull a 50 liter bucket from a hand dug well. The bucket is designed to empty itself into the primary irrigation canal. The device, which is operated by a donkey, offers an increased discharge relative to that of the shadouf and frees the farmer from the task of water-lifting. The bidon verseur that was tested over five months in Ngouri yielded 84% more water than the shadouf and facilitated a 92% increase in surface area irrigated. Seven bidon verseurs tested in the Doum-Doum area have facilitated increases in cultivated surface areas varying from 75-100%. Farmer response to the device has been enthusiastic. During Phase II, the project will continue to demonstrate the bidon to wadi farmers, and steps will be taken to build a private manufacturing and distribution capacity.

Agricultural Techniques

Aside from water-lifting, the wadi farmer faces many agricultural constraints to improved production. Most of these constraints were identified by the 1986 team that designed the pilot project. Over the past four years of project implementation, the ORT agronomist has worked closely with Ngouri farmers to come to an even clearer understanding of their agronomic problems. The principal constraints are as follows:

Declining soil fertility;
Inappropriate plot preparation;
Fencing;
Limited crop choice; and
Pest management.

During the pilot phase, the project agronomist tackled these problems with a series of on-farm trials and experiments. Some of these were fruitful while others were not. The process yielded four techniques that were clearly successful in the eyes of the farmers and outside evaluators. Replication efforts during Phase II will be limited to these four proven techniques:

Soil enrichment through compost and manure;
Improved plot preparation;
Live fencing; and
Crop diversification in response to market demand.

Soil enrichment. Intensified wadi cultivation puts increasing demands on soil nutrients. Over the years, farmers have noticed declines in per hectare production because of declines in soil fertility. During Phase I, the project introduced the idea of composting and applying manure to wadi fields. In one trial, yields of tomatoes doubled over traditional methods when composted manure was combined with new soil preparation techniques. Onion yield went from between thirteen and fifteen tons per hectare using traditional method to thirty-five tons with manure application. Farmer acceptance has been good, and efforts to continue the spread of these techniques will be pursued in Phase II through volunteer farmer extension agents.

Improved plot preparation. The initial design team identified inappropriate plot preparation as a constraint on plant growth. Very small traditional basins (1 square meter) reduced cultivatable surface area and caused seed and topsoil displacement. In response, the project agronomist proposed larger basins designed to distribute water more gradually, as well as ridge planting techniques to keep plant stems (and fruit) from prolonged contact with water. Tests revealed that these new techniques improved germination rates and increased harvests. 67% of all farmers in project-supervised wadis have adopted at least one of the improved

plot techniques. Efforts to continue the spread of these techniques will be pursued in Phase II.

Live fences. Fencing has traditionally been a constraint to wadi farming. The spiny branches that are used traditionally are becoming rarer in the Ngouri region. During Phase I, ORT proposed as a solution the planting of Parkinsonia and Procipis trees around wadi fields. Farmer acceptance has been very good, and to date 17 kilometers of trees have been planted in the 29 wadis supervised by the project. Farmers from non-supervised wadis have been sufficiently impressed to ask their neighbors for seed and to begin their own live fences. A 1990 social impact study revealed that farmers felt that trees were one of the most useful contributions that ORT made to their wadis. Phase II will continue to promote the spread of live fences. Emphasis will be placed on building sustainable sources for seeds and sapling pots.

Crop diversification. Limited crop choice restricts farmers' ability to fully exploit market opportunities. Phase I began to address this constraint by introducing several new crops to the area. Some of these crops -- carrots, garlic, papaya -- sell well in local markets and have become popular with many growers. Phase II will continue to promote crop diversification as a function of marketability. The Marketing Technician will identify potentially profitable crops, and the Agronomy Agent will test on small surface areas before moving to any wider dissemination. The Agronomy Agent will also test techniques in off-season production to better target high-price periods.

Pest management. Insect attacks have traditionally been a serious constraint to expanded production in the wadis. Phase I of the project was not designed to focus on this problem and a viable solution was not identified. During Phase II, an intensified effort will be made to develop non-chemical methods of pest management, particularly cultural methods such as removing pest vectors, inter-cropping, and destroying residues. A consulting specialist will establish experiments that will be executed by project staff.

C. Summary of Environmental Analysis

In November 1990, USAID conducted an Environmental Assessment (EA) of the Lake Chad project. The four-person team recommended that the project continue and that up to 300 aquifer taps and 100 tubewells be installed in the project zone. These numbers will not be exceeded in Phase II. The EA states that under this scenario, impact on the aquifer will be slight.

The Environmental Assessment also concludes that project activities have increased farmer capacity to control soil salinity and improve soil quality through organic matter management. These activities will be continued in Phase II. The EA recommends that live fencing be a component part of future ORT activities; it is included in Phase II. In addition, the EA recommends that the project continue monitoring piezometric head, water quality, crop yields and irrigation. This will be done in Phase II.

Other proposed Phase II activities, such as crop diversification and post-harvest marketing techniques, were taken note of in the EA document, but were not identified as being of significant environmental consequence. An AID environmental determination will be obtained before any new crops or varieties are disseminated. No chemical pesticides or fungicides will be used or promoted by the project. The EA concludes that the project does not present health problems; on the contrary, it will improve health by increasing access to clean water and a more diversified diet.

D. Summary of Social Soundness Analysis

The Social Soundness Analysis is based on four studies done in Phase I, from the beginning to the end of the project span, and on data gathered by the monitoring system set up by the project anthropologist and agronomist. For the present design the anthropologist interviewed concerned government agencies, ORT and SODELAC staff, local administrative and traditional authorities, and, of course, farmers, farm families, merchants and petty traders.

In the wider socio-economic context of the Lac and Kanem, of which the project zone is culturally and geographically an integral part, the project has helped improve agricultural production by increasing it, diversifying it and rendering it more secure. It has raised the standard of living of 1/3 of the wadi farming population in an area which had hitherto not only been neglected by GOC development agencies, but which is a zone inhabited by a culturally and economically disadvantaged group known particularly for its hard-working, competent farmers. This is a zone which suffered like the rest of the Sahel in the 1982-85 drought but where rainfall has remained so low in succeeding years that the harvest in all years except 1989, when rainfall was normal, has been only around 325 kg/ha and half of the farm families randomly sampled had harvested enough rainfed millet for only one month's consumption. In these circumstances wadi agriculture is vital to the survival of the 53% of the population who engage in wadi farming, yet before the project only one third of them were living above the margin. By the end of Phase I two thirds of wadi farm families in the project had attained what they judged an adequate living standard.

The compatibility of the project and the target population has been demonstrated by the success of Phase I of the project. At the end of the first phase, 92% of a random sample of farmers involved in the project and in wadis not participating, wanted the project to continue. People of the area are reluctant to leave the land of their fathers and forefathers yet without improvement in wadi agriculture many were faced with having to leave in order to survive. The increase in wadi production brought about by the project has allowed them to stay.

In the traditional agricultural system, rainfed farming, wadi/polders and livestock all complemented one another. A farmer who did well in one domain had to put less effort into the others. A big livestock holder would not have to work in the wadi for cash; a poor farmer with only a few goats could cover monetary needs with wadi produce. Deficits in rainfed millet could be made up by farming in polders and wadis, or by abandoning farming altogether for petty trading -- but with a high failure rate, like most small businesses. Continuing drought has thrown this system out of balance. Farmers need to increase the contribution of two of the domains to make up for the drastic drop in rainfed cereals. But livestock and polder farming suffer from drought too, leaving only wadi agriculture with any potential. But before the project, wadi agriculture was also suffering. The water table had dropped during the drought and irrigating by shadouf had grown harder and harder. The project has raised production in the wadis so that wadi farming can now compensate for the weaknesses in the other parts of the system.

The project is socially feasible, designed to retain the strengths of the first phase design, to replicate its improvements and to respond to the most pressing needs farmers now feel: marketing produce, growing adequate produce for the market, and meeting market demand. A continuing concern during Phase I was the ability of farmers to purchase pumps and repay credits. Social and agronomic data indicate that more farmers can support motorpumps than is recommended in the environmental assessment, which envisioned 100 motorpump tubewells, in other words, more farmers in the area are able to buy and repay motorpumps than the project has targeted. Though repaying a loan is always unpleasant, farmers are not adopting a technology which is beyond their means to support. The interest expressed by farmers, their ability to support the cost of water-lifting technologies, the vitality of the motorpump group, and merchant interest in the business opportunities offered by the project all make the project feasible.

The host country is committed to the project. The relevant ministries have requested that the project be continued in order to reinforce the accomplishments of Phase I. They will continue to collaborate. The beneficiaries are also committed to the project; 92% of the local farmers surveyed wanted the project to continue. Phase II responds directly to the needs they identified as most pressing.

The project can potentially benefit the 50% of families in the zone who engage in wadi agriculture. By the end of Phase I the spread effect was becoming noticeable. Non-participant wadis were planting live hedges and improving their wells. Farmers were joining the project to get training in how to use and maximize motorpumps.. However the typical social and geographical isolation of a wadi and its associated villages is a constraint on the spread effect. Farmers visit and socialize only within a limited geographical circle, If there is no project wadi and Technical Delegate in that area then the spread effect cannot work. A more even geographical repartition of project wadis must be attained in Phase II for the innovative technology to reach the take-off point.

The successful agricultural and water-lifting activities of Phase I have created a new group of people--farmers with marketing problems--who could benefit from Phase II. The spontaneous spread of these technologies will only increase this number. In other words, the numbers of farmers who can benefit from the marketing activities in Phase II will continue to increase throughout Phase II as long as the improvements of Phase I are applied by more and more farmers.

In sum, the project is socially feasible and responds directly to farmers' needs.

E. Summary of Economic and Financial Analysis

Economic analysis of the major water-lifting devices to be promoted is encouraging. According to data analysis presented in AID's final project evaluation, the motorpump leads to an average increase in production per farmer of 158-452%, and its benefits outweigh its costs by a ratio ranging from 1.24 to 1.6.[28] These are average figures, for many farmers the motorpump leads to even greater profits.

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[28] Lake Chad Agricultural Development and Farmer Training Project -- Final Evaluation, USAID/Chad, June 1990, Annex A, p. 1-2.

Extra revenues resulting from the use of the bidon verseur also significantly exceed the extra costs. Analysis conducted by the design team economist show that internal rates of return for the bidon verseur vary between 29 and 200%.

The economic rate of return of the entire project investment was calculated under several different scenarios. Benefits were divided into two dimensions: (1) scope, i.e., the number of farmers touched by the project, and (2) degree, i.e., the effect of the project on farmers' income. "Low", "medium", and "high" scenarios were calculated for each dimension. Costs are based on the project's budget and recurring costs are subtracted out when calculating net benefits. The results are presented below in Tables a and b for both seven-year and ten-year periods of evaluation.

Table a: Internal Rates of Return for Project over **Seven** Years:

SCOPE OF PROJECT IMPACT	DEGREE OF PROJECT IMPACT		
	High	Medium	Low
High	23%	8%	- 8%
Medium	14%	2%	-13%
Low	4%	-6%	-18%

Table b: Internal Rates of Return for Project over **Ten** years:

SCOPE OF PROJECT IMPACT	DEGREE OF PROJECT IMPACT		
	High	Medium	Low
High	33%	21%	6%
Medium	25%	15%	2%
Low	17%	8%	-2%

The analysis demonstrates that the project will generate more than acceptable rates of return under most of the ten-year scenarios. Over seven years, the rate of return is acceptable if one takes into account the trade and environmental benefits that are associated with the project.

Under the "medium" scope and "medium" degree scenario, the project yields a net present value of $274,779 over ten years, using a discount rate of 12%.

VII. EVALUATION PLAN

A. Monitoring

Periodic monitoring of project progress by the three partners, AID, the GOC, and ORT, will be an integral part of the on-going evaluation process. The aforementioned quarterly reports will enable ORT, as well as AID and the GOC, to monitor, and thus to evaluate, project progress. They will detail accomplishments towards meeting the project purpose and outputs, focusing on the quantifiable targets in the "verifiable indicators" section of the Logical Framework, will mention any changes in the implementation schedule, and will include the proposed work plan for the upcoming quarter. In addition, ORT headquarters will keep informed of developments through brief monthly progress reports by the project staff and the yearly site visits by its Project Coordinator.

The evaluation of the technical interventions, especially the pilot marketing and integrated pest management activities, in which project technicians will have to test and choose among various approaches and techniques, will be an important aspect of the project. Sustainability will be the main criterion in evaluating the techniques proposed and/or introduced by the project.

B. Mid-term Evaluation

AID will schedule and fund a formative evaluation at approximately the mid-term point of the project. This evaluation is expected to take three weeks and may be scheduled in conjunction with the other sub-projects of the PVO/DIP or independently. It will gauge progress towards meeting the project purpose and outputs, concentrating on the pilot marketing activities.

A detailed evaluation plan will be drawn up by AID shortly before the scheduled evaluation, by which time issues identified by AID, the GOC, and ORT will be clearly defined.

AID intends to bring in appropriate specialists (e.g., in marketing and water resources) from outside the agency to conduct the evaluation. The team may also include GOC representatives. Funds have been included in the project budget to allow for the participation of the latter on the evaluation team (e.g., per diem at the project site). AID will provide separate (i.e., non-ORT sub-project) funding for its evaluation team and for the translation of the final report into French.

Based on the conclusions drawn, the mid-term evaluation will recommend specific measures to improve implementation.

C. End-of-Project Evaluation

An end-of-project evaluation will be conducted about three or four months prior to the PACD under the same organizational and financial terms as those for the mid-term evaluation. Project purpose and output indicators will be used as benchmarks for this final evaluation. One of the main goals of this evaluation will be to determine whether the pilot marketing activities were successful enough to be expanded and extended. An analysis of the opportunities and possible problems for replication will be made in the evaluation and will be shared with the GOC and the donor community.

ANNEXES

A. Logical Framework
B. Marketing Analysis
C. Technical Analysis of Water Resources Technologies
D. Technical Analysis of Agronomic Issues
E. Social Soundness Analysis
F. Economic and Financial Analysis
G. Environmental Analysis
H. Detailed Cost Estimate Budget
I. Project Implementation Schedule
J. Position Descriptions
K. Map

ANNEX A

ANNEX A : LOGICAL FRAMEWORK

LAKE CHAD AGRICULUTURAL DEVELOPMENT AND FARMER TRAINING PROJECT
PHASE II : MARKETING AND TECHNOLOGY DISSEMINATION

NARRATIVE SUMMARY	OBJECTIVELY VERIFIABLE INDICATORS (TARGETS TO BE MET BY END OF PROJECT)	MEANS OF VERIFICATION	IMPORTANT ASSUMPTIONS
GOAL:			
To achieve a sustainable increase in the incomes of wadi farmers in the Lake region of Chad.	Measurable increase in the real incomes of a sample of participating wadi farmers by 20% or more by the close of project.	1. Ongoing project monitoring of farmer revenues and expenses; 2. Comparison between data on beneficiary and control populations during evaluations; 3. Comparison between baseline economic status of benefiaries with their status at the close of project.	1. Marketing channels are not disrupted by civil strife or effective cut-off of trade with Nigeria; 2. No extraordinary natural disasters such as floods or locusts. 3. No extraordinary price movements from recent historical averages.
PURPOSE:			
To increase the amount of wadi produce that farmers supply to the market and to increase the profits that they earn from selling that produce.	1. Farmers in 47 or more wadis adopt improved water-lifting and agricultural technologies that increase their output of marketable produce by 20% or more by close of project; 2. Farmers in 47 or more wadis adopt improved marketing techniques that result in profits that are 20% higher than what they would earn in the absence of of these techniques.	1. Ongoing monitoring of the production of participating farmers vs. the production of control farmers; 2. Ongoing monitoring of the value of the production of participants vs. the value of the production of control farmers; 3. Project reports on the net prices received by farmers adopting new marketing techniques vs. net prices received by control farmers; 4. Mid-term and final evaluations' analysis of data from monitoring mentioned above.	1. No extraordinary natural disasters such as floods or locusts. 2. No extraordinary price movements due to factors outside of project control. 3. Normal marketing and trading routes are not severely disrupted by conflicts or civil strife.

OUTPUTS:

1) Sustainable private-sector supply services for basic agricultural inputs are established.	. The following inputs are commercially supplied to the zone by one or more private merchants because of project research and training: . improved seeds . aquifer taps . nursery pots . spare parts . repair services	1. Project reports 2. Site visits 3. AID evaluations using baseline data report.	1. Trade with Nigeria remains possible.
2) Sustainable private-sector supply systems are developed for improved water-lifting equipment.	1. The motorpump group has procured pumps each year of the project cycle, and its revolving fund is sufficiently large at the close of project to ensure continued procurement of pumps; 2. 37 or more bidon verseurs are manufactured in the region and are sold through traders on a for-profit basis; 3. One or more independent tubewell installation enterprises operate in the zone by the end of project, and each has installed 20 or more wells.	1. Project reports 2. AID evaluations	1. Group cohesion can be reinforced and strengthened 2. Trade with Nigeria remains possible. 3. Welding capacity remains in the region.
3) Value-enhancing crop storage, harvesting, and packaging technologies are tested, evaluated, and adopted.	1. Two or more new crop storage techniques are adopted on a test basis and evaluated technically and economically; 2. Two or more improved harvesting techniques are adopted on a test basis and evaluated on economic criteria; 3. Two or more improved packaging technologies are adopted on a test basis and evaluated.	1. Project reports 2. AID evaluations	1. Improved technologies will prove to be attractive during testing.

4) Value-enhancing techniques in off-season production and crop diversification are adopted on a test basis and evaluated.	1. Two or more off-season production techniques are adopted on a test basis and evaluated; 2. Market intelligence is used to identify two or more profitable opportuinties for crop diversification; 3. At least five new crop/variety trials are completed and evaluated technically and economically. 4. Two or more new crops or varieties are adopted by farmers in the zone following environmental determination.	1. Project reports 2. AID evaluations 3. Trial reports	1. Agronomic team is capable.
5) Trial shipments of non-traditional crops are organized, tested, and evaluated for profitability.	. At least five trial shipments are carried out and evaluated.	1. Project reports 2. AID evaluations 3. Trial reports	1. Volunteer traders and farmers can be identified. 2. Certain profitable markets currently are not being exploited because of lack of information or experience.
6) Improved water-lifting technologies are adopted by 400 wadi farmers by end of project.	1. 300 wadi farmers are using aquifer taps by close of project, 90 farmers are using motor-pumps, 45 are using tubewells,and 50 are using bidon verseurs; 2. All farmers using improved water-lifting technologies are trained in maintenance.	1. Project reports 2. AID evaluations 3. Field visits	1. Farmers' interest in these technologies remains at least at current levels. 2. Motorpump group remains operational. 3. Unexpected technical problems do not emerge. 4. Supply systems function properly.
7) Improved agronomic and agroforesty techniques -- proven successful in Phase I -- are replicated by wadi farmers.	. The number of farmers employing improved agriculultural and agro-forestry techniques increases by at least 100% during project life;	1. Project reports 2. Comparison with baseline data during evaluations	1. Farmers reached by Phase II are as receptive as those touched in Phase I

8) Natural pest management methods are tested, evaluated and adopted on a trial basis by pilot farmers.	1. Specialist consultant analyzes situation and establishes tests, which are conducted by staff. 2. Pilot farmers in five or more wadis adopt methods on a trial basis.	1. Project reports 2. Consultant reports 3. AID evaluations	1. Competent consultant services are available.
9) Improved extension services -- professional and volunteer -- are available in the zone.	1. Two or more volunteer farmer extension agents work in each of the 47 supervised wadis by the close of project. 1. 20 SODELAC agents and 94 volunteer farmer extension agents receive training in new water-management and agricultural technologies. 2. 50% of the trained SODELAC agents adopt the "delegué technique" training system in at least one of the wadis or polders in which they work.	1. Project reports 2. Training reports 3. SODELAC reports 4. Evaluation team interviews with SODELAC field agents.	1. SODELAC remains willing to participate; 2. More volunteer farmer agents can be identified.

INPUTS:

1) Technical assistance for: . Baseline survey and analysis of input and output markets, . Input market trials and development, . Output market trials and development, . Storage, harvesting, packaging techniques, . Management training for input enterprises, . Agronomy, . Agroforesty, and . Training.	1. Appropriate long-term expatriate personnel hired and working: . Project Manager/Trainer . Marketing Technician . Water-lifting Technician 2. Appropriate SODELAC personnel assigned and working: . Agronomist . Field agents (5+) 3. Appropriate local personnel hired and working: . Pumps technician . Trader liaison agent . Agronomic trials agent . Forester . Field training agents(8) . Ngouri administrator	1. Project monitoring by ORT/Chad and AID/Chad 2. Project reports 3. Project financial reports 4. AID evaluations 5. Copies of consultants' reports.	1. Qualified expatriate personnel can be recruited; 2. SODELAC will assign competent personnel; 4. Professional consulting services are available.

	. N'Djamena administrator . Accountant . Drivers/interpreters (7) . Secretary . Guards (5) 4. Appropriate consultant services rendered: . Market baseline/analysis . Economic/Agronomic baseline and transitional assistance . Non-chemical pest management (2) . Coop management and accounting (local) . Replication survey and strategy. . Social impact study	
2) Material Inputs: . Eight Vehicles . Twelve Horses . Refurbishment of offices and housing . Refurbishing of workshop . Training materials and related inputs . Water-lifting equipment . Material for marketing trials . Inputs for agronomic trials . Environmental monitoring equipment	1. The procurement, presence and use of all specified material.	1. Project monitoring by ORT/Chad and AID/Chad 2. Project reports 3. Project financial reports 4. AID evaluations

ANNEX B

ANNEX B : MARKETING ANALYSIS

1. Introduction and Methodology

Agricultural marketing concerns both the systems that deliver essential inputs to producers and the systems that deliver farm outputs -- crops -- to their ultimate consumption points. The first half of this annex discusses issues related to the input markets for wadi agriculture in the Ngouri area. The second half discusses issues related to output markets for wadi produce and plans to improve marketing strategies.

The analysis is based on: (a) two weeks of interviews carried out in the field by the design team; (b) visits to the markets of Ngouri, Dibinintchi, Mao, Massakory, and Bol; (b) a further two weeks of interviews in N'Djamena with vegetable traders and technicians working for ORT, CARE, ACDI, BSA, and ACCRA; and (c) a review of all relevant price data and project documents.

2. Input Markets

Wadi farming, as traditionally practiced in the Ngouri region, involves very limited physical inputs. The most important input is human labor for irrigation and land preparation, followed by the shadouf apparatus, the hand-dug well, thorny fencing, seeds, and simple hand tools. All of these inputs can be obtained by the farmer himself through hard work, or traditional channels such as neighbors (for seeds) and village blacksmiths (for tools). These channels appear to function quite efficiently.

With ORT's introduction of improvements to the wadi farming system, the input mix has changed. The shadouf is being complemented by motorpumps and animal traction devices, traditional seeds are being complemented by seeds for new crops, and traditional wells are being improved through aquifer taps. New delivery systems are necessary to supply the new inputs.

During the pilot phase of the project, ORT took the first steps in building these new delivery systems and more importantly, defined its approach to input supply: (1) the private sector should participate fully at all levels to insure the sustainability of supply lines, and (2) subsidies should be avoided.

Phase II will build upon the groundwork prepared during the pilot phase and reinforce the private-sector approach. ORT will not act as an input supplier itself during Phase II; instead, it will act as a trainer of input suppliers and a breaker of barriers related to information and risk.

2.1. Vegetable Seeds

Seeds for traditional crops such as onions are available through local sources in the Ngouri zone. These seeds are reproduced in the wadis and sold in villages and markets. Seeds for non-traditional crops such as carrots, however, are not available through these same sources. Neither are high-quality seeds for preferred varieties of tomatoes and other vegetables. Phase II of the project will search for a long-term solution to this problem by encouraging private shop-keepers to tap into existing seed supply lines in other regions and sell these new seeds in the project area.[1] This should not be a very difficult process; several merchants in Mao already stock and sell high-quality vegetable seed in sealed packages, and good seeds are available (in cans and packages of various sizes) in N'Djamena and Nigeria. When the design team questioned Ngouri-based merchants why they didn't sell seeds, they replied that they simply were unfamiliar with the trade, but that they were willing to try it.

To introduce Ngouri-area merchants to the process of selling seeds, the Marketing Assistant will accompany local traders to N'Djamena to introduce them to suppliers and teach them about different seed qualities and expiration dates. ORT will then place small seed orders through the traders, who will deliver the seeds to shop-keepers in Dibinitchi and Ngouri. For the first two shipments, ORT will share in the shopkeepers' risk by guaranteeing to repurchase at cost any seeds that are unsold by a certain date. Once merchants are fully introduced to the process, however, they will be expected to continue the trade on their own, without project guarantees. Field agents will inform farmers about seed availability in these shops and inform the merchants about the varieties needed by the farmers.

All seeds will be subject to controlled testing by the project agronomist and an environomental determination by AID before any steps are taken to develop private seed supply systems.

2.2. Spare Parts

Phase I of the project encouraged the motorpump credit group to stock and sell spare parts for the Honda GX-110. The operation has worked fairly well, but some parts have been sold on credit, and repayment has been delayed. Phase II of the project will move away from dependence on the motorpump group by taking steps to introduce private traders to the spare parts trade. This will be carried out in a manner very similar to the seed supply system

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[1] In addition, and when appropriate, the Agronomy Technician will investigate methods to train farmers to multiply their own seeds once they have obtained suitable varieties.

described above. The project will order a limited number of spare parts through private traders and then confide these parts to shop-keepers who will sell them to motor-pump farmers. The project will guarantee the repurchase of any parts that are unsold after a given period, until the merchants are more familiar with the trade and local demand patterns.

2.3. Sapling pots

Phase II of the project will continue to encourage farmers to plant live fencing, but at the same time it will discourage dependence on ORT for inputs. Experiments will be conducted to find a viable alternative to the imported sapling pot/bag. Different designs of locally-produced clay pots will be tested (in collaboration with CARE), and if a suitable model is developed, artisans will be trained to produce it and sell it to interested farmers. Different types of locally-available plastic bags will also be tested, and if an appropriate model is identified, interested farmers will be encouraged to purchase these bags from local shopkeepers.

2.4. Aquifer Taps

Aquifer taps require 1.5-3 meter sections of PVC tubing. During Phase I, a merchant in Dibinitchi was encouraged to begin stocking and selling these tubes. He has been doing so successfully for the past year. During Phase II, this private sector approach will be maintained. After training deleques techniques to install aquifer taps, field staff will inform interested farmers that material is available in Dibinitchi. Prices and quantities sold will be monitored, and if it proves necessary, a second merchant will be encouraged to retail the tubes. The current price in Dibinitchi is 3,000 FCFA per aquifer tap.

2.5. Bidon verseurs

During the last year of Phase I, the project tested three bidon verseurs and monitored the testing of seven more by a neighboring project at Doum-Doum. The results have been sufficiently promising to justify plans to disseminate the technology in the Ngouri area. During Phase II, the project plans to integrate the private sector as tightly as possible in this dissemination process. The bidon verseur costs about 65,000 FCFA.

Up until now, the bidon has been manufactured in a small metal workshop in N'Djamena. Although the quality of his work has been good, the artisan has proved to be unreliable, and the distance between his shop and Ngouri makes communication difficult. To overcome this problem, the Water Resource Technician will train

metal workers in Massakory[2] to manufacture the bidon. There are two metal shops with welding capacities in Massakory that should be able to build the device. If both ORT and the Etude-Action program in Doum-Doum place their orders through these artisans, they should quickly gain experience and expertise in bidon manufacture.

During the first six months of Phase II, the ORT project will continue the process of introducing and demonstrating the bidon verseur through a geographically-diverse sample of wadi farmers. This will involve identifying 5-10 volunteer farmers and installing bidons on their wells. After one season of trying the device, the farmers will be given the option of purchasing the bidon at an amortized price, or returning it to the project. The purpose of this first six month stage will be to allow as many farmers as possible to witness the advantages of the device. Farmers that are convinced of the bidon's efficacy will become clients for the private manufacturing and distribution system to be developed during the rest of Phase II.

After the training of the artisans in Massakory, the next step will be to train traders to become private distributers of the bidon verseur. The project will accomplish this by using private traders to transport the devices from the artisan to Ngouri, where they will be purchased by the project. The project will subsequently sell the bidons to merchants in Ngouri and Dibinitchi on a six-month credit, on the condition that they, in turn, resell the devices to farmers on credit -- 50% down, and 50% at the end of the season. This system creates a positive situation where the merchant is responsible for screening clients for reliability and the merchant is responsible for collecting loan payments. His incentives are correct because his profit depends on successful credit collection. ORT's role is only temporary; once the merchant has gone through the process once or twice the project will end its intermediary position and the merchant will be put in direct contact with the Massakory manufacturers. ORT's role will be simply to facilitate contact between the players and to share in the risks during the initial two cycles. Merchants, not ORT, will be the long-term providers of short-term credit to interested farmers.

2.6. Tubewells

A five-person team of farmers was trained during Phase I to install tubewells using the "hand sludger" method. To date, it has installed 17 functioning tubewells. The team is technically skilled and its leader is able to document all drillings and calculate materials costs and set prices. However, the team is not independent; it is a sub-unit of the motorpump group Kida Boulim.

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[2] Or another apppropriate site, such as Bol, if unforseen problems arise in Massakory.

The drilling equipment belongs to the motorpump group. The cost of a tubewell varies between 70,000 and 120,000 FCFA.

During Phase II, the project will take steps to privatize the tubewell business and create one or more independent tubewell enterprises. The privatization process will involve discussions between Kida Boulim, the drilling team, and the project to define modalities. The project will then provide technical assistance and training in business skills to the tubewell team. Emphasis will be placed on business logistics, i.e., how to order materials, arrange for their delivery, calculate costs, and market the tubewell to potential customers. A Small Enterprise Development Consultant will arrive approximately nine months into the project to provide advice and support.

The tubewell team has already demonstrated its entrepreneurial spirit -- it sold a tubewell to a farmer in Massakory during the project's absence due to political events in December. This spirit will be nurtured during Phase II. If demand proves to be sufficient, the project will take steps to create a second tubewell enterprise and it will encourage competition with a private tubewell team currently forming in Mao with the assistance of CARE.

2.7. Motorpumps

After a long period of systematic and scientific testing of a variety of manual and motorized pumps during Phase I, the project decided that small motorpumps represent an appropriate technology for the Ngouri area. ORT also decided that the technology would not be subsidized and that the motorpumps would be imported from Nigeria through private traders, (the pumps are available in Maiduguri, a regular destination for Ngouri-based traders). Given the high cost of motorpumps (200,000 FCFA), it was apparent that credit would be necessary for the technology to become accessible to wadi farmers. Rather than offering this credit directly to farmers (a sure way to cause tensions between the donor and beneficiaries), ORT stimulated the creation of a local farmer organization, named Kida Boulim, to manage all motorpump loans. ORT granted revolving funds to the organization in August 1989 to be used to purchase pumps through private channels and sell them on credit to its members. Beneficiaries repay their loans to Kida Boulim, not ORT, and the group uses the payments to finance more motorpump purchases.

Kida Boulim made its first set of loans about a year ago for twenty motorpumps, (eleven in the first batch and nine in the next). The loans were scheduled to be repaid to the group in five installments over two years. The first installment was repaid in full by all of the farmers except one, whose pump was repossessed by the group. Repayment of the second installment was achieved at 100%, and although the third installment was delayed, 80% had been paid by March 25, 1991. The group has used loan repayments to

67

finance the purchase of five additional pumps, which have been sold on credit to its members. Kida Boulim decided to reschedule the repayment of the fourth installment to June, because pest attacks reduced farmers' revenues during the cold season agricultural cycle.

The Kida Boulim has several weaknesses -- it was unable to collect its members latest loan payment on schedule, and the group's leadership is unexperienced in bookkeeping and management. Overall, however, the organization has functioned surprisingly well over the past year. It has played an important role in introducing over 40 farmers to motorpump farming in the Ngouri area, and it has allowed ORT to avoid any direct role in managing credit. Despite recent delays, loan repayment rates have been very good and the group has maintained the value of its revolving fund. It should be able to continue to purchase and sell pumps in the future. The group also has cooperated productively with private traders, who supply the motorpumps and spare parts. There has been no corruption or embezzlement. Although Kida Boulim is still immature, the group is in the process of developing into a viable local institution.

Phase II of the Lake Chad project will continue to support the motorpump group in this development process. This will be achieved through technical assistance and training delivered by the Marketing Technician and the Water Resources Technician. A Small Enterprise Development Consultant also will assess the group's performance and make recommendations for management improvements. The services of a local training organization such as INADES will be engaged to train the group's leaders in basic bookkeeping and cooperative management. Project staff will provide follow-up.

The Kida Boulim currently has over sixty members, of which twenty-seven have motorpumps. The other members are waiting their turn to obtain a pump on credit. They must wait for earlier loans to be repaid so that the group can finance more pump purchases. Some members are in the process of saving up the money needed for a down payment. If, in the upcoming phase, the effective demand for pumps outstrips Kida Boulim's financial capacities (the group can finance a maximum of ten pumps annually), the project will consider creating a second, smaller motorpump group to meet that excess demand. (Economic questions related to the motorpump and its profitability are presented in Annex G).

2.8. Credit

The role of credit will be downplayed during Phase II. In almost all cases, ORT will avoid supplying credit for two important reasons: (a) collection and management problems often lead to deteriorating relations with beneficiaries; and (b) the direct provision of credit is unsustainable -- it will not survive the

end-of-project. For these reasons, ORT will not encourage the use of credit to provide seeds, fuel, or other small inputs. Credit will only be encouraged where it is absolutely necessary, that is, for large purchases (motorpumps, tubewells, bidons) that poor farmers cannot easily purchase with their own savings. In these cases, ORT will avoid a direct role in credit provision. Instead, it will encourage local institutions to provide the credit and to take responsibility for collection. Kida Boulim has already been trained to do so for tubewells and motorpumps. Private traders will be trained to do so for the bidon verseur. (explained above under "e", "f", "g").

3. Output Markets

Farmers in the Ngouri area produce a number of different wadi crops. Some of these are destined mainly for family consumption needs, such as wheat, while others are produced primarily for commercial marketing purposes, such as onions. The most frequently marketed types of wadi produce are: onions, fresh tomatoes, dried tomatoes, eggplant, fresh okra, dried okra, and manioc.

3.1. Market Structure

The market for wadi produce in the Ngouri zone is characterized by numerous buyers and sellers. Competition is free and prices generally are determined by supply and demand conditions. Most transactions occur at periodic markets on a weekly schedule. The largest local markets are at Dibinintchi (Thursdays), Ngouri (Tuesdays), Isseirom (Fridays), and Ngarango (Sundays). Over 2,000 people, 200 donkeys, 100 camels, and a dozen or so trucks typically are present at Dibinitchi on market day.

Farmers usually transport their produce to the weekly markets on donkey or camel-back. Upon arrival, they face several sales options. They can sit in the market to sell their produce in small units to local consumers; they can sell to women who will retail the produce for them; or they can sell to wholesalers, who will transport the produce in bulk to outside markets such as Massakory and N'Djamena. Alternatively, farmers can rent space on one of the commercial trucks to transport their produce themselves to outside markets for sale. The farmers' decision is mainly a function of how much product he or she has to sell, and how much time he or she is willing to invest.

About half of the produce that arrives at the weekly markets is sold by producers in small lots directly to local consumers. The other half passes through the hands of traders who transport it to other markets. Rarely specialized, these traders buy different products at different times of the year, hoping to earn a profit by

69

moving produce from areas of abundance, where prices are low, to areas of relative scarcity, where prices are higher. This process of spatial arbitrage tends to stabilize prices in the region by increasing demand in areas of production and increasing supply in areas of consumption. Produce traders in the Ngouri zone operate on several different levels. Some are on camel-back; they may buy 200 kilograms of manioc in a wadi, for example, and transport it 50 kilometers for sale at the market of Mao. Other traders rent space in small pick-up trucks to transport tomatoes, for example, to Massakory. Large traders often arrive at onion harvest time to purchase large quantities of that commodity to transport to N'Djamena.

3.2. The Relationship between Local and Outside Markets

The Ngouri sub-prefecture is not a pure exporter of agricultural produce to other zones, nor is it a pure importer. Its market position varies from product to product and from time period to time period. During "good" years, Ngouri is a major grain exporting area, and during "bad" years, such as 1990-91, Ngouri must import grain from Southern Chad. During the onion harvest, Ngouri sends truckloads of that product to N'Djamena, but at the same time, traders transport hundreds of sacks of dried tomatoes and garlic into Ngouri from outside markets. Many products, such as eggplant and carrots, are produced and consumed locally, almost never being transported into or out of the zone.

Ngouri's strongest trade links are with Massakory, N'Djamena, and Bol, all of which can easily be reached by truck on a compressed-earth road. Links also exist with Mao, Mondo, and other eastward destinations which are usually reached by donkey or camel.

3.3. Transportation, Marketing Costs, and Inter-regional Price Differentials

Trade is governed by price differentials between Ngouri and outside markets. When price differentials exceed marketing costs (transportation, handling, capital costs, etc.), trade becomes profitable, and traders rush to get involved. As long as traders are numerous and unorganized (as appears to be the case in Ngouri), competition will restrain their profits to minimum acceptable levels in the long run. In the case of onions, for example, trade with N'Djamena does not occur unless the N'Djamena price exceeds the Ngouri price by 3,000 FCFA -- enough to cover the cost of transportation, handling, and other marketing expenses.[3] If the

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[3] Transport of a sack of onions from the Ngouri area to N'Djamena is 2,000 FCFA in a pick-up; other expenses include loading, unloading, empty sack, food costs en route, capital costs, and return transport for the trader.

10

N'Djamena price exceeds the Ngouri price by much more than 3,000 FCFA, traders scramble to buy onions in Ngouri and the price is quickly bid up to the point where the price differential reverts to its "normal" level of 3,000 FCFA.

3.4. Assessment

Given the high costs that marketing agents must face in the Ngouri area (particularly transport, both truck and camel), the produce marketing system appears to function surprisingly efficiently. There appear to be no local monopolies, cartels, or monopsonies to distort prices from their efficient levels -- the levels determined by supply and demand -- , and freely floating prices allow markets to clear for almost all products. When agricultural outputs are abundant in the area, their prices fall, but the extent of this fall is limited by the linkages between Ngouri and outside markets. If, for example, onions are relatively abundant and inexpensive in Ngouri, traders increase their onion purchases to transport them to N'Djamena, Mao, and other markets. Expanded demand tends to support the local price. Similarly, when agricultural products are scarce in Ngouri, their prices increase, but the extent of the increase is limited by linkages with outside markets. When garlic is relatively expensive in Ngouri, for example, traders bring in outside supplies from Abeche, which tends to moderate price rises.

3.5. Constraints and Opportunities

Although the marketing system in Ngouri is dynamic and competitive, there are a number of constraints and opportunities that deserve closer attention. Some of these constraints -- such as high fuel and camel costs -- cannot be solved by ORT. But other constraints -- such as inadequate information about new markets and technologies -- can be addressed by the ORT project. These constraints and opportunities are described below, accompanied by an outline of the steps that will be taken during Phase II to improve the marketing of wadi produce.

3.5.1. Targeting outside markets.

Certain outside produce markets, such as the Mao and N'Djamena onion markets, are well known and well understood by Ngouri traders and farmers. Procedures for marketing onions are familiar to all involved, and prices in Ngouri are largely a reflection of prices in N'Djamena plus marketing costs. There is little that ORT can teach farmers and traders about this process that they do not already know. Onion farmers and traders keep track of prices in N'Djamena by asking local travelers who visit the capital frequently.

71

Other outside markets, however, are much less familiar to Ngouri traders and farmers. This is true of the beet, carrot, manioc leaf, and fresh okra markets in N'Djamena and Bol. There is no tradition of sending these crops to outside markets, and farmers and traders generally are unaware of who purchases these vegetables, how they should be packaged, and how they are priced. The lack of familiarity causes profitable opportunities to be ignored.

Phase II of the Lake Chad project will address this problem by helping traders and farmers to overcome information barriers and become familiar with the marketing procedures for non-traditional crops. This will be done through simple research and trial runs. The project's Marketing Unit will be responsible for the research; it will investigate the modalities of selling high-value vegetables in N'Djamena and Bol, and it will track prices for these goods. If price differentials justify trade, the Assistant Marketing Agent will organize trial runs with volunteer farmers and traders. The Assistant Marketing Agent will walk the volunteers through the marketing process -- he will advise them on how to harvest, select, and package the produce, and he will accompany them on commercial truck trips to the market destination. Upon arrival, he will introduce the volunteers to their sales options. If the Marketing Technician judges it necessary to reduce the risk associated with initial trial runs, he can decide to guarantee a minimal price to the farmers and traders who volunteer to participate. Once farmers and traders have learned about the marketing process through these trial runs, the project's task will be complete -- subsequently, it will be up to Ngouri's traders and farmers to make their own arrangements. If the trial runs demonstrate that the fresh okra trade, for example, is profitable, the traders and farmers will be motivated to continue the business on their own.

3.5.2. Targeting local markets.

Local markets in the Ngouri zone are far from saturated for many agricultural products. Garlic and dried tomatoes, for example, are still imported into the zone from Abeche and N'Djamena. Prices for these products are higher in Ngouri than in the capital. This presents a market opportunity for local wadi farmers; they can expand significantly their production of these commodities and sell them at the weekly markets. Local producers have a clear comparative advantage over outside producers because they face much lower transport costs. ORT should continue to train farmers to produce vegetables such as these, which can easily be sold on local markets.

3.5.3. Packaging.

When traders and farmers truck wadi produce to urban markets, they package the vegetables in locally available sacks and boxes. Fresh tomatoes are transported in 33-kilogram plywood tea crates,

and onions and dried okra are packaged in 100-kilogram jute sacks. The advantage of these packaging materials is that they are familiar to farmers and widely available. The disadvantage is that they may not provide sufficient protection for the produce during bumpy truck trips. CARE estimates that transport losses for tomatoes may amount to 10-25%[4] and ACDI states that "losses during transport are very high."[5] Similar estimates have not yet been defined for Ngouri, although local traders indicate that en route damage to perishables such as tomatoes is significant. The plywood tea cases do not allow suffient aeration and they can be crushed under the weight of passengers in the back of pick-up trucks. For new crops such as beets and fresh okra, most Ngouri traders are unaware of appropriate packaging procedures.

It will be up to the Market Assessment Consultant to investigate the packaging constraint. Through rapid reconnaissance methods, he or she will assess the seriousness of the packaging problem and establish baseline figures on losses/damage in transport. It will then be up to the Marketing Technician to identify and test superior packaging arrangements, including techniques to keep produce cool from farm-gate to the market. The Technician will draw on the experiences of ACDI and CARE in this domain, and the reports that are produced by the expert consultants that these PVOs are bringing to Chad.[6] The project will construct at least two prototype crates to lend to traders for trial use and evaluation. The goal will be to develop affordable packaging technologies that reduce produce losses during multiple trips in crowded trucks. If the project succeeds in developing an appropriate crate, the Marketing Unit will train artisans to build the crate and sell it to interested produce traders.

3.5.4. Storage

Vegetable prices are marked by strong seasonality in Chad as in the Sahel in general. Prices are low during the peak harvest months and they climb to relative highs during the off-season. Storage is one of the most effective ways for farmers to avoid selling produce when prices are low, and to take advantage of the higher prices available later in the season. Several vegetables cultivated in Ngouri wadis are appropriate for medium-term storage,

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[4] CARE-International in Chad, Kanem Pumps and Agricultural Marketing, April 1990, Annex II, p. 9.

[5] ACDI, Pilot Project for Fruit and Vegetable Marketing, Submitted to AID/Chad, October 1989, Annex F, p. 11.

[6] The Marketing Technician will also consult with ACCRA, a PVO based in Darda that plans to test improved crates and tomato baskets during the upcoming year.

namely onions, garlic, and dried okra.

Recognizing the important role that storage can play in increasing the prices that farmers receive for their produce, ORT embarked on a program to promote such storage during the project's first phase. The project identified two major constraints to increased produce storage: (a) farmers' need for cash immediately after the harvest, and (b) technical problems that cause produce spoilage. To address these constraints, ORT stimulated the organization of ten small marketing groups of 7-20 members each, and provided small loans to allow them to overcome their cash-flow problems and invest in produce storage, (mostly onions). The project also provided training to the groups to construct improved storage sheds.

The test program has had mixed results. During the first season, the marketing groups purchased onions at low post-harvest prices, stored them for roughly six months, then sold them at much higher prices during the off season. Two out of three groups more than doubled their money. During the second year, however, the storage operation did not work as successfully. Onion prices did not rise as dramatically and losses to spoilage ranged from 20-50%.

During Phase II, the Lake Chad project will continue to work to promote produce storage. The project, however, will focus its efforts on the technical aspects of storage, and it will downplay the role of credit. The provision of credit during Phase I served to introduce farmers to vegetable storage, but it cannot be considered as a long-term solution to the storage problem -- such credit will not be available once the project comes to an end. Appropriate storage techniques, on the other hand, can survive the close of the project... if farmers are convinced that such techniques reduce spoilage and that they can be replicated on an individual level.

The first step in the process of improving storage techniques is to research existing practices in the Ngouri area and to establish baseline figures on spoilage rates for traditional storage methods. The Market Assessment Consultant will begin this research during the baseline study, and the Marketing Unit will determine spoilage rates during subsequent testing. The next step for the project will be to carefully test improved storage techniques -- such as aerated shelves, careful grading of onions to be stored, and garlic braiding -- side-by-side with traditional techniques.[7] If the new techniques prove to be superior, further trials and demonstrations will be conducted by field agents in

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[7] Before beginning testing, ORT will consult with ACDI and CARE to learn about their experiences and the results of their consultants' studies on storage.

interested villages. These demonstrations will be either on a group or an individual basis, depending on the desires of the volunteer farmers. Storage, it should be remembered, normally is not a group activity; it is carried out most frequently in individual homes, with women playing an important role.

3.5.5. Off-season Production and Crop Diversification

Another way to take advantage of price seasonality is through off-season vegetable production. A farmer who harvests tomatoes in the hot season may earn prices four times higher than the farmer who harvests in March. A farmer who harvests onions in December may earn twice as much as he who harvests in February.

During Phase II, the Lake Chad project will introduce, test, and evaluate off-season production techniques. The Marketing Technician will furnish the necessary price data to the Agronomy Technician to guide practical research efforts towards the most profitable periods. The Agronomy Technician will supervise limited trials of heat resistant tomato varieties. He also will test methods to produce early onion harvests by transplanting bulbs in September.[8]

Similarly, the project will explore market-targeted crop diversification. The Marketing Technician will use price information and market surveys to identify promising high-value crops, such as leeks or bell peppers. The Agronomy Unit will then conduct limited on-farm trials of these new crops and evaluate their performance. If results are positive and the produce can be marketed profitably, the project will encourage a controlled and carefully-monitored disseminatation of the new crops.

3.5.6. Market Research and Price Collection

Market research and price collection will be important activities of the Lake Chad project. However, these activities will not be considered as outputs in themselves, only as tools to facilitate the achievement of other outputs. Market research, for example, will be conducted to identify high-value vegetables in the Bol market so that production can be modified to seize the opportunity. Price data, for example, will be used to identify the months when garlic is the most expensive, so that farmers can be encouraged to store until this period.

ORT has been collecting vegetable price data in Dibinitchi on a regular basis for the past three years. This process will be continued during Phase II. In addition, ORT will track vegetable

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[8] ORT and CARE have already tested this method with some success. Further on-farm trials are necessary before the technique can be replicated by area farmers.

75

prices in N'Djamena by tapping into the systems currently being established by CARE and ACDI. Both of these NGOs have agreed to furnish copies of their price sheets to ORT on a regular basis. Modalities of cooperation will be finalized by the Marketing Technician, who will be responsible for maintaining a price data base. In addition, punctual market studies will be conducted by the Marketing Unit in Bol, Massakory, and N'Djamena to learn more about marketing procedures and opportunities.

76

ANNEX C

ANNEX C : TECHNICAL ANALYSIS -- WATER RESOURCE MANAGEMENT

PART 1 : INTRODUCTION

Over the course of the first phase of the O.R.T. project in Ngouri, several useful water resource management technologies were identified for use in the wadi farming system. These technolgies cover the full spectrum of issues related to agricultural water use, from improving access to the local water resource to promoting its efficient and economic use. In light of the recent shortfalls in the rain-fed cropping system, local farmers increasingly rely on irrigated agricultural activities in the wadi for income generation and food production. As a result, these water resource management technologies are of increased importance to local farmers as they attempt to improve the productivity of the wadi farming system and to maintain its ecologic integrity over the long-term.

Below is a decription of the water resource management technologies proposed for inclusion in the second phase of the ORT project. They are listed starting with aquifer development technologies, followed by water extraction technologies, and finally on-farm water management technologies. Each listing includes a description of the technology, a rationale for its inclusion in Phase II, and an assessment of the role that the expatriate water resource specialist will play in its further integration into the local farming economy.

The initial descriptions and analysis are succinct. Further technical information on the motorpump, bidon verseur, and irrigation methods are presented in parts 3, 4, and 5 of this annex.

PART 2 : OVERVIEW OF THE TECHNOLOGIES

2.1.0 Aquifer Development Technology

2.1.1 The Aquifer Tap

Description: Below many wadis in the Ngouri area two seperate aquifers exist. The lower aquifer (the regional sand aquifer) often has a greater piezometric head than the upper aquifer (an aquifer localized in the wadi soils). Traditional hand dug wells generally tap only the upper aquifer as digging into the sand aquifer is infeasible. The wadi aquifer is often poorly yielding and of relatively poor water quality. The aquifer tap is a PVC tube installed in the bottom of a hand dug well which provides a hydraulic connection through which high pressure water from the

18

sand aquifer enters the well. The aquifer taps are installed by specially trained local farmers.

Rationale: Wells tapping only the local wadi aquifer often dry up when water is extracted using the shadouf. Observation of a man operating a shadouf on such a well revealed that even though he could extract water at a rate of 1.51 l/sec, his actual output was limited to 1.11 l/sec when time spent waiting for the well to recharge was taken into account. Water from the wadi aquifer is often of poor quality, conductivity measurements of 3000-4000 µS/cm have been recorded on occassion. Water from the sand aquifer is, on the other hand, abundant and of higher quality. Wells with functionning aquifer taps cannot be dried up by the shadouf and the well water does not exceed a conductivity of 400 µS/cm. The aquifer tap also allows for the use of the "Bidon Verseur" and on occasion the motor pump, both of which extract water at an increased rate relative to the shadouf.

Expatriate Role: The water resource specialist will assure that training of additional farmers in the installation of aquifer taps occurs, providing logistical and technical support when appropriate. He or she will also monitor aquifer taps put in during Phase I to assess the functional lifetime of the technology.

2.1.2 The Tubewell

Description: In many cases a hand dug well improved with an aquifer tap dries up when pumped with a motor pump. The tubewell is a 80 cm diameter PVC well which, being between 12 and 15 meters deep, taps the regional sand aquifer. The 6 meter long well screen allows for up to 2,82 l/sec to be extracted from the well. The water extracted is of the high water quality associated with the sand aquifer. A team of five specially trained farmers installs the tubewell using the "sludger" drilling method.

Rationale: The motor pump, described below, has been selected for introduction as a water extraction technology. To be profitable the motor pump must be installed on a well which will not dry up at normal pump operating speeds. This is not always possible with hand dug wells improved with an aquifer tap. In these cases a tubewell is a necessity. The drilling team made up of local farmers is technically capable of installing tubewells but issues related to the procurment and transport of required materials still need attention.

The creation of additional drilling teams in order to create a more competitive market would necessitate further training.

Expatriate Role: The water resource specialist will collaborate with the existing drilling team to define long-term solutions to logistical problems associated with tubewell installation. Attempts will be made to involve the private sector when ever possible. He or she will provide technical assistance to the existing drilling team when needed. In the event that additional drilling teams are created, the water resource specialist will organize the necessary training. Finally, he or she will monitor the performance of the tubewells installed during Phase I to assess the technologies' functional lifetime.

2.2.0 Water Extraction Technology

2.2.1 The Motor Pump

Description: The Honda GX-110 motor pump was selected during Phase I as the water lifting technology to be introduced in the wadis. This selection followed an intensive 18 month period of pump testing during which manual and animal powered water lifting devices were also tested. The motor pump, a 3.5 gasoline powered centrifugal pump, was selected due to its superior discharge relative to the shadouf and its ability to free the farmer from the task of water lifting.

Rationale: The motor pump allows the farmer to increase the total surface area irrigated due to its increased pumping capacity. This allows for an increase in total agricultural production and, according to data collected by the O.R.T project, increases in total agricultural revenues. The motor pump increases the profitability of the wadi farming activities. The technology is included in Phase II because activities related to integrating the infrastructure required to support the motor pump into the local economy must continue. Efforts will continue to solidify the structures exstablished to assure the importation of the pump, the marketing of spare parts, and the existance of a local capacity to repair the pump. Attempt will be made to include the private sector in these activities.

Expatriate Role: The water resource specialist will develop long-term stategies to promote collaboration between

50

private merchants and the farmer managed credit group in the importation and marketing of motor pumps and spare parts. He or she will continue Phase I interventions which promote the efficient and economic use of the motor pump. He or she will also be responsible for collaborating with local mechanics to find solutions to repair problem with may come up as the motor pumps installed in Phase I age. Finally the water resource specialist will monitor motor pumps installed in Phase 1 to assess their functional lifetime and to investigate the potential for a motor pump resale market, either in used pumps or used pump parts.

3.2.2 The "Bidon Verseur"

Description: The "Bidon Verseur" is an animal traction water lifting device using a block and tackle set-up to pull a 50 liter bucket from a hand dug well. The bucket is designed to empty itself into the primary irrigation canal. The device, which is operated by a donkey, offers an increased discharge relative to that of the shadouf and frees the farmer from the task of waterlifting.

Rationale: After having selected the motor pump as the primary water lifting technology to be introduced, the O.R.T. project recognized that its cost discourage many wadi farmers from aspiring to own one. The "Bidon Verseur" was tested in a wadi in the Ngouri area and was found to be an improvement over the shadouf, both in terms of water output and agricultural revenues. Most importantly it was received with excitement by local farmer as an attractive intermeadiate water lifting technology. The moderately-priced "Bidon Verseur" will be included in Phase II to give less advantaged farmers access to an improved water lifting technology.

Expatriate Role: As the "Bidon Verseur" was intoduced towards the end of Phase I, the water resource specialist will play a very active role in integrating it into the local farm economy. Manufacturing and distribution capacity will be developed which most certainly will involve the private sector. The water resource specialist will define creative stategies to stimulate the market so that the technology is competively priced and finanacially within reach of an average farmer. He or she will also be responsible for further refinement of the operational details for the

"Bidon Verseur", particularly as it relates to feeding and work schedules of the draft animals. Should the need arise, he or she will also develop a local repair capacity for the "Bidon Verseur" and investigate the potential for a resale market.

2.3.0 On-Farm Water Management Technology

2.3.1 Crop Water Needs-Based Irrigation

Description: Based on meteorological data collected in the Ngouri area during Phase I, the monthy potential evapotranspiration rate was calculated using Penman's Method. O.R.T. and SO.DE.LAC. agents were trained to calculate the actual crop evapotranspiration rates using the method described in F.A.O. Bulliten No. 24. In addition, they were trained to caluclate the water holding capacity of a field soil. These values, taken together, permit irrigation scheduling which responds directly to crop consumptive use without exceeding the capacity of the soil to retain water within the root zone of the plant.

Rationale: Given the operating cost associated with irrigation, efficient use of irrigation water plays an important role in the profitability of wadi agriculture. Water lost to the the plants through inefficient irrigation is, in fact, a waste of operating expenditures. Irrigation which responds directly to crop water use will logically have a positive impact on profit. In addition, water efficient irrigation can lead to production increases and thus further economic benefit for the farmer. A trail conducted during Phase I on tomatos grown during the cold season demonstrates the profitability of the needs based irrigation approach. Tomatos were grown on two identical parcels of 84.5 m^2, one parcel being irrigated traditionally the second in response to crop water needs. Using a traditional irrigation schedule, 13 liters of gasoline were consumed in producing 100,5 kg of produce. Needs based irrigation, on the other hand, consumed 8 liters of gasoline and yielded 133 kg of produce. Assuming feul costs of 250 f cfa per liter, and a tomato sale price of 125 f cfa per kilogram, traditional irrigation resulted in a profit margin of 9312 f cfa versus 14,625 f cfa for needs based irrigation, a difference of 5313 f cfa. If this difference is extrapolated onto 30 ares of tomato production the increase in profit grows to 187,500 f cfa. The production increase resulting from water efficient irrigation would be 1047.3 kg or 37

additional 28 kg cases of tomatoes.

Expatriate Role: The water resource specialist would continue to train O.R.T. and SO.DE.LAC. agents in the methods used to calculate crop water needs. He or she would collaborate with local farmers to instruct them on the financial advantages of needs based irrigation. In addition, he or she would train farmers to use the approach in their own production activities.

PART 3 : DETAIL ON THE SMALL GASOLINE-POWERED MOTORPUMP

3.1 Introduction of the Motor Pump in the Lake Region

Small gasoline powered motor pumps, hereafter refered to as the motor pump, are not uncommon to Chad and no reliable estimate can be made regarding the exact timing of their introduction. In the Lake Region, however, they were very rare prior to the drought period of 1984-1985. At that time, as a result of insufficient rainfall, irrigated wadi agriculture increased in importance relative to the increasingly risky rain-fed dune production and wealthy merchants and civil servants began to purchase motor pumps to increase the amount of water available for irrigation. These pumps generally ranged in power between 3.5 hp and 5.0 hp and where either a two-stroke model sold by Suzuki or a four-stroke model distributed by Honda or Robin. Most of these pumps were imported into Chad through private channels, primarily from Nigeria, but occassionally from Saudi Arabia.

When the O.R.T. project arrived in the Ngouri area in 1987, only a few wealthy individuals were using the motor pump. In general, motor pumps purchased through private channels were too expensive for a typical wadi farmer to afford. Having been exposed to their neighbors' motor pumps, however, many of these same farmers were convinced that the motor pump represented the best possible solution to the water lifting problems encountered in wadi farming. The project encountered a strong bias on their part, and on the part of the local administrative authorities, for the selection of the motor pump as the water lifting technolgy to be disseminated. Following an extensive period of testing, involving human, animal, and motor powered pumps, the motor pump was selected in 1989 as the primary water lifting technology to be introduced.

The O.R.T. project, however, was not the first project in the Lake Region to try and put motor pumps into the hands of wadi farmers. Following the drought period of 1984-1985, many people

displaced from the Kanem found themselves in the Lake Region. As part of "Operation Mur", designed to limit the migration of displaced people to the capital, the League of the Red Cross organized groups of people to received "Food for Work" in return for work in communal gardins in the polders around Bol. These groups used the shadouf for water lifting. Once the food crisis passed in 1987, several members of these communal groups stated a desire to continue to work in the polders if motor pumps could be obtained to facilitate water lifting.

In response to this request, the League agreed to purchase motor pumps for the groups of farmers if the farmers would cover the operating costs. Eighteen motor pumps were purchased and given to groups ranging in size from five to twelve members. The members of an individual group worked together in a common field and divided the proceeds amongst themselves. The communal nature of these groups resulted in a lack of attention being paid to the proper care and maintenance of the motor pumps and at the end of a year and a half all of the pumps were broken-down. In 1989, the League attempted to reintroduce the motor pump by subsidizing the purchase price of replacement motor pumps purchased by the nine groups who remained interested in working in the polder. Soon after this re-introduction of the motor pump, the League's project finished. Apparently several of this second batch of motor pumps still function, although they are now being used by much smaller groups of people. Lessons learned from the shortcomings of the League's approach to introducing motor pumps guided the O.R.T. project towards a more sustainable approach.

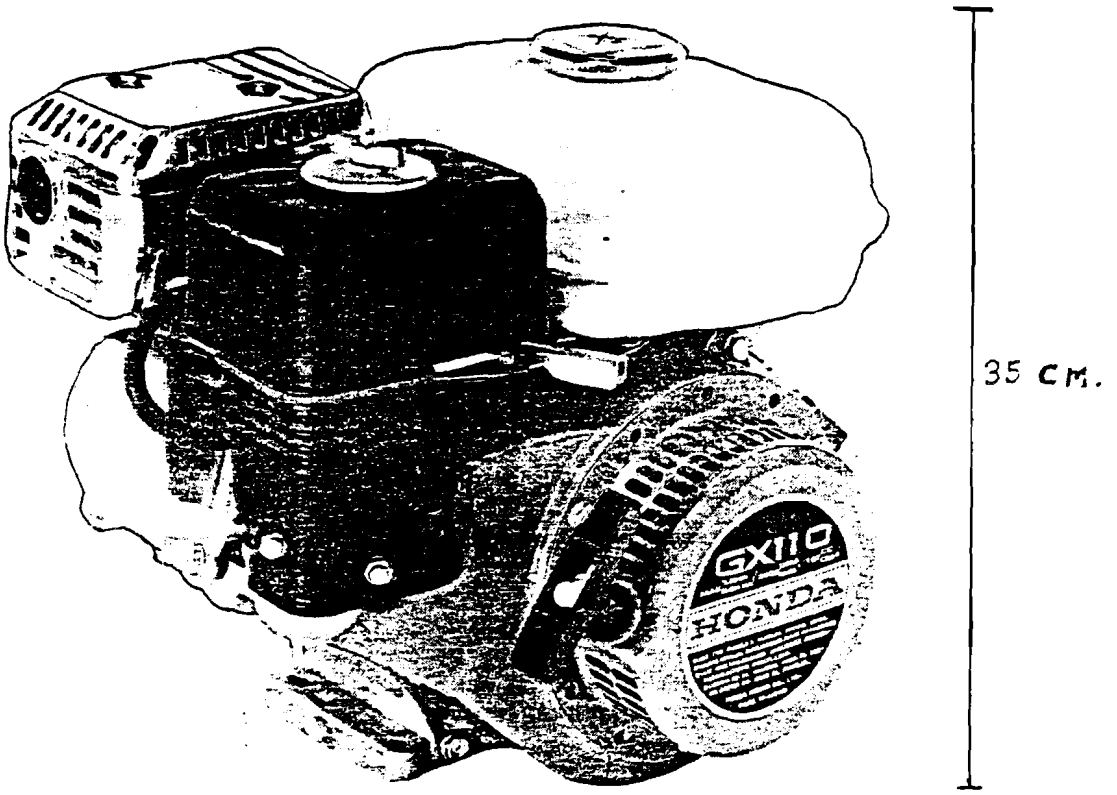
3.2 Classification of the Motor Pump

The motor pump selected by the O.R.T. project for introduction in the Ngouri area is a Nigerian Nabegu pump driven by the Honda GX-110 motor (Figure 2). The motor is a 3.5 horsepower, 4-stroke gasoline engine. A 4-stroke engine requires that gasoline and motor oil be added separately, as opposed to a 2-stroke engine where a feul-oil mixture is used. Although a 4-stroke engine necessitates that the motor oil be changed periodically, it eliminates the need for the farmer to prepare a feul-oil mixture which must follow strict proportions. It also eliminates the real danger that a farmer, finding himself without motor oil, will operate the motor pump using gasoline alone. This practice leaves the motor without lubrification and will lead to major mechanical problems.

Hydraulically the motor pump introduced in Ngouri is classified as a horizontal shaft centrifugal pump. According to Fraenkel this is "by far the most common type of engine powered pump for small to medium sized irrigation applications". A cross-section of a typical centrifugal pump is shown in Figure 3. A centrifugal pump lifts water due to the rotary motion of an impeller, driven by the motor, turning inside the pump housing.

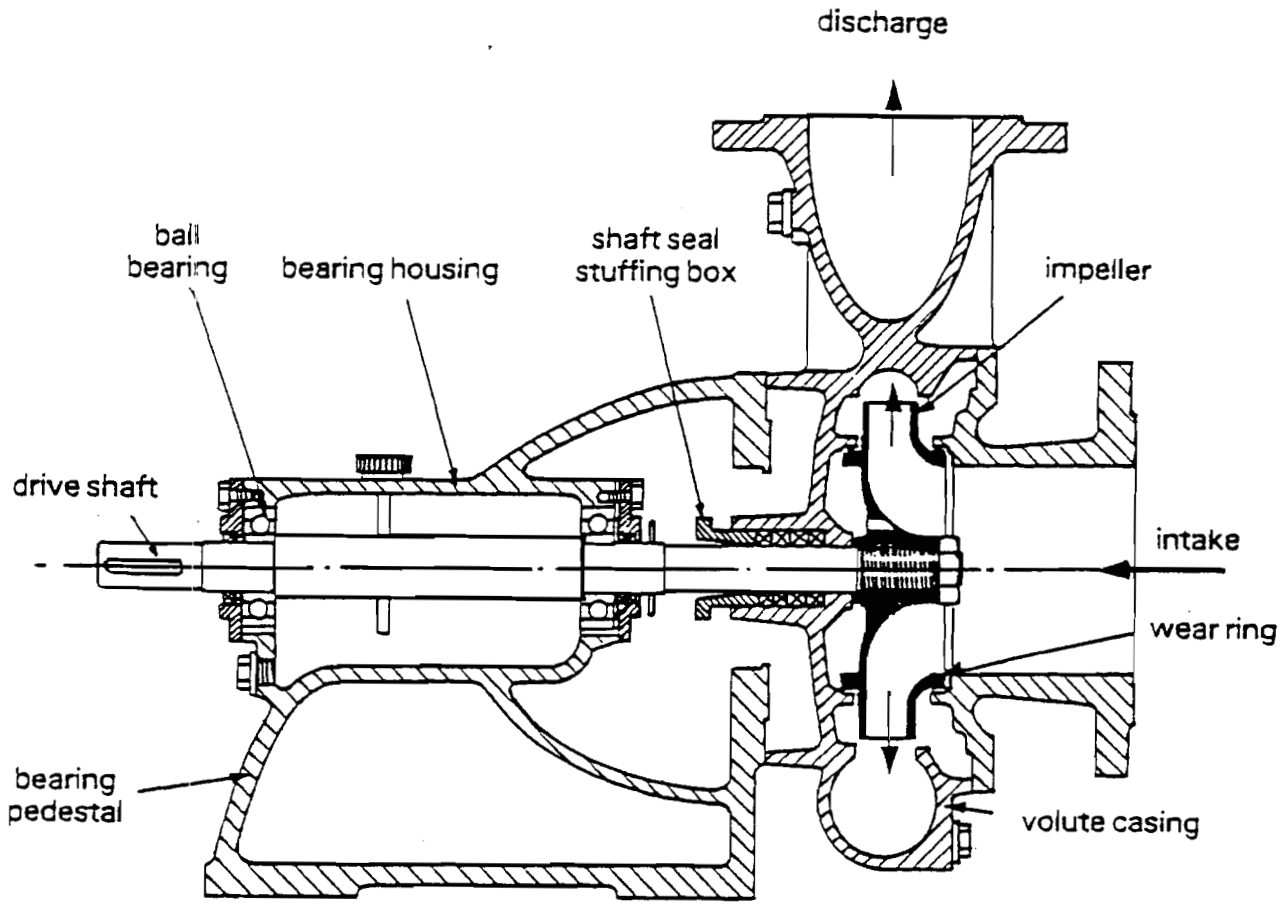
84

Figure 2 : The Honda GX110 Small Motor Pump Used in ORT Project Zone



GX110

Figure 3 : Cross Section of a Typical Centrifugal Pump Used in ORT Project Zone



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This motion creates a centifugal force that causes water at the low pressure region near the center of the impeller to move along the impeller vanes toward the high pressure region near the housing surrounding the impeller. Water in the pump is led towards the discharge pipe by the pump housing and its kinetic energy is converted into pressure energy. Based on the Principle of Hydraulic Continuity, water which moves from the center of the impeller in response to this centrifugal force, must be replaced. At the center of the impeller, which is the location of the pump intake, pressure less than atmoshperic pressure exists. This allows water to move from the water surface in the well, where the water is at atmospheric pressure, up to the pump intake, along the vanes of the impeller and out the discharge pipe.

3.3 Cavitation and Suction Limitation of the Motor Pump

In centrifugal pumps, pressure less than atmospheric pressure exists along the suction line. If at any time the pressure drops below the vapor pressure of water then cavitation occurs. According to Hwang, during cavitation "vaporized water forms small bubbles in the flow. These bubbles collapse when the reach the region of higher pressure. Violent vibrations may result from the collapse of vapor bubbles in water. Successive bubble breakup with considerable impact force may cause high local stresses on the metal surfaces of the vane blades and the housing. These stresses cause surface pitting and will rapidly damage the pump".

In order to avoid cavitation the distance over which water can be lifted by suction must be limited. The formula used the calculate this suction limit is:

$$z = \frac{P_{atm}}{G_S} - \frac{P_{vap}}{G_S} - \frac{v^2}{2g} - h_L - NPSH$$

Where:
- z = max. dist. between water and pump intake (m)
- P_{atm} = atmospheric pressure (N/m^2)
- P_{vap} = vapor pressure of water (N/m^2)
- G_S = specific gravity of water (9810 N/m^3)
- v = velocity of water (m/sec)
- g = acceleration due to gravity (9.81 m/sec^2)
- h_L = headloss in suction line (m)
- NPSH = net positive suction head (m).

The net positive suction head is, in fact, a safety factor provided by the pump manufacture based on the characteristics of the pump.

If a discharge of 3.0 l/sec (3.0×10^{-3} m^3/sec) is assumed then the velocity of the water in the 2.0" (5.08×10^{-2} m) diameter suction line, and the headloss incurred along the suction line can be determined.

$$v = \frac{Q}{A}$$

Where: Q = pump dicharge (m^3/sec)
A = cross-sectioal area of suction line (m^2)

$$v = \frac{3.0 \times 10^{-3}\ m^3/sec}{(3.14)(2.54 \times 10^{-2}\ m)^2}$$
$$= 1.48\ m/sec.$$

Assuming and 8 meter long suction line and a friction coefficient of 0.02, the headloss along the suction line can be calculated.

$$h_L = f \frac{L}{D} \frac{v^2}{2g}$$

where: f = friction coefficient
L = length of suction line (m)
D = diameter of suction line (m).

Thus,

$$h_L = 0.02 \frac{8\ m}{5.08 \times 10^{-2}\ m} \frac{(1.48\ m/sec)^2}{2(9.81\ m/sec^2)}$$
$$h_L = 0.35\ m.$$

Assuming atmoshperic pressure is one atmosphere, or 101,357 N/m^2, and that the ambient air temperature is 30°C, resulting in a vapor pressure of water of 4238 N/m^2, the maximum suction lift can be determined.

$$z = \frac{101{,}357\ N/m^2}{9810\ N/m^3} - \frac{4238\ N/m^2}{9810\ N/m^3} - \frac{(1.48\ m/sec)^2}{2(9.8\ m/sec^2)} - 0.35\ m - NPSH$$
$$= 10.3\ m - 0.43\ m - 0.11\ m - 0.35\ m - NPSH$$
$$= 9.41\ m - NPSH.$$

Unfortunately, no value for the net positive suction head was provided by the Nigerian manufacturers of the Nabegu pump. However, NPSH values given by the manufacuters of an American motor pump which operates over the same range of brake horsepower (2-3 hp) as the Honda GX-110 motor, suggest a value of 2.0 meters at a pump discharge of 3.0 l/sec. Thus,

$$z = 9.41\ m - 2.0\ m$$
$$= 7.41\ m.$$

This is greater than the deepest wells encountered in the project zone in which the depth to water is approximately 6.2 m. The motor pump is suited to the conditions existing in the Ngouri area.

3.4 Advantages of the Motor Pump

The motor pump offers several advantages relative to the shadouf, the traditional water lifting system. Primary among them is the vastly increased discharge which the motor pump yields.

This increased discharge allows for increases in the surface area cultivated and associated increases in total agricultural production. A secondary, yet very important advantage of the motor pump is that it frees the farmer from the task of water lifting, leaving him both the time and energy to concentrate on other agricultural tasks. These include improved crop maintenance, soil enrichment, and application of the project developed agronomic techniques.

3.5 Technical Constraints on the Motor Pump

Compared with the traditional water lifting system, the shadouf, the motor pump represents a significant increase in technical sophistication. The shadouf can be manufactured and repaired by local technicians using materials acquired locally. The introduction of the motor pump, on the other hand, necessitates the creation of an infrastructure which was incomplete in the Ngouri area prior 1989. The required infrastructure includes the following elements:

- a reliable system to import the motor pump,
- a local fuel and lubricant market,
- a spare parts supply network, and
- a local capacity to repair motor pumps.

The O.R.T. project has addressed each of these infrastuctural elements.

3.6 System to Import the Motor Pumps

The Honda GX-110 motor pump is sold by dealers located in Maïdougouri, in northeastern Nigeria. To date three separate batches of motor pumps have been imported from Maïdougouri to Ngouri. The first batch was purchased by a group of local farmers who travelled to Nigeria themselves. The second batch was imported by an N'Djamena merchant. The final batch was imported by a local Kanembou merchant. The third stategy was found to be the most advantageous as it is based on long-established trading relations between Kanembou merchants and traders in Maïdougouri. The final price of motor pumps imported using this system was also the most affordable. When new motor pumps are to be imported, an order is made with a local merchant who purchases the pumps during a subsequent trip to Nigeria.

3.7 Local Fuel and Lubricant Market

A weekly survey of the local gasoline and motor oil market revealed that the price of these products in the Ngouri area is quite stable. Further, the supply of these products always exceeds the demand created by the use of motor pumps for irrigation. Over the course of the survey gasoline could always be purchased for 250 f cfa per liter and motor oil was available at 500 f cfa per liter.

The average weekly supply of gasoline and motor oil in the Ngouri area were 4600 liters and 1290 liters respectively, versus and average weekly demand of 196.8 liters and 5.64 liters. As the motor pumps now in place consume only 4.8 % of the weekly gasoline supply and 0.4% of the weekly motor oil supply, the number of motor pumps can increase without overwhelming the capacity of the local market to supply these products.

3.8 Spare Parts Supply Network

Prior to the introduction of the motor pump in the Ngouri area, no spare parts were available locally. The O.R.T. project established three spare parts outlets, managed by local farmers, which stock the parts most commonly in need of replacement. These parts are sold to farmers who need them and the proceeds are used to acquire additional parts to maintain the local stock. Local merchants who trade in Maïdougouri are contracted to import the replacement parts from Nigeria. Since the outlets were established in March of 1990, they have supplied the required parts for all of the motor pump repairs which have be carried out in Ngouri area. The present inventories in the outlets have been maintained through periodic importation of spare parts from Nigeria and are sufficient to assure the expedient repair of any mechanical problems which may arise.

3.9 Local Capacity to Repair Motor Pumps

No permanent local capacity to repair small gasoline engines existed in the Ngouri area prior to the introduction of the motor pump. In response to this shortcoming, the O.R.T. project trained five mechanics in motor pump repair. The training included theoretical instruction in the workings of an internal cumbustion engine and hands-on instruction in the repair of the most common mechanical problems encountered by the motor pump. The five mechanics were outfitted, by the O.R.T. project, with the tools necessary to perform out these repairs. Since the end if their training in July of 1990, the local mechanics have repaired all of the motor pumps which encountered mechanical problems.

3.10 Operation of the Motor Pump

Each individual farmer using the motor pump is responsible for its operation and maintenance. Prior to recieving the pump, he participates in a training, conducted by the local mechanics, designed to instruct the farmer in the proper use of the motor pump. Once installed in the field, the farmer is responsible for constucting a structure to shade the motor pump from the sun. This is important as the motor pump has an air cooled engine. The farmer is responsible for noting the time of operation for the motor pump and for changing the motor oil and cleaning the air filter as perscribed by the project. The manufacturer of the motor pump, the Honda Motor Company, suggests that this routine

maintenance be conducted every 100 hours of operation. Due to the heat and dust common to the Ngouri area, the project perscribed maintenance schedule is every 50 hours of operation. Data collected since the introduction of the motor pump suggests that, on average, this maintenance is conducted every 60 hours.

The standard operation proceedure employed by the farmer includes the following steps. First, he checks the fuel and motor oil levels in the motor. If either is lacking he tops off the reservoirs; first filtering the fuel in the case of the gasoline. Next he checks the condition of the spark plug, cleaning off any carbon deposits which may exist. The motor is started by choking the engine and pulling the starter rope. Once the motor is running the farmer takes off the choke and adjusts the motor speed to the most appropriate for his particular setting (this speed was determined by the project and shown to the farmer). Under no conditions is the pump run for more than five continuous hours. After shutting off the pump, the farmer wipes of any dirt from the exterior surfaces of the motor pump and notes the time of operation in a log book.

3.11 Costs Associated with the Motor Pump

The Honda GX-110 motor pumps which were imported by a local Kanembou merchant were sold for 190,000 f cfa. This included the motor pump, six meters of suction line, a screen for the end of the suction line, four meters of discharge line, and a spark plug wrench. The average daily capital operating costs can be calculated as follows:

$$D.O.C. = T_o((C_g)(P_g) + (C_{mo})(P_{mo})/(F_{mo}))$$

Where:
- D.O.C. = daily operating costs (f cfa)
- T_o = average time of operation (hrs/day)
- C_g = average gasoline consumption (l/hr)
- P_g = price of gasoline (f cfa/l)
- C_{mo} = motor oil consumption (l/oil change)
- P_{mo} = price of motor oil (f cfa/l).
- F_{mo} = frequency of oil change (hrs/oil change)

Based on data collected by the project, the daily capital operating costs for the Honda GX-110 motor pump are:

$$\begin{aligned} D.O.C. &= 3.2 \text{ hr/day}((0.4 \text{ l/hr})(250 \text{ f cfa/l}) + \\ &\quad (0.6 \text{ l/oil change})(500 \text{ f cfa/l})/60 \text{ hr/oil change}) \\ &= 336 \text{ f cfa/day.} \end{aligned}$$

The periodic operating costs associated with the purchase of spare parts must also be considered. Unfortuately, no data is currently available to assess this cost.

3.12 Hydraulic Performance

3.12.1 Head-Discharge Relationship

The Honda GX-110 motor pump can be operated over a range of motor speeds. The relationship between the total head and the pump discharge obviously changes as a function of the motor speed. For conditions in the Ngouri area, however, 2100 r.p.m. is an appropriate motor speed. It is at this speed that the relationship between head and discharge will be analyzed. Data were collected by mesuring the flow produced by the motor pump at eight different well points. The table below presents the data collected.

Depth to Water (m)	Discharge (l/sec)
2.12	2.82
2.28	3.53
2.44	2.44
3.85	1.71
3.9	3.05
4.4	2.69
4.96	2.28
5.34	2.09

These data are plotted in Figure 4 along with measurements for the shadouf as it is operated in Ngouri. The discharge supplied by the motor pump is clearly superior to that available to a farmer using the traditional water lifting system. No manual or animal traction pump tested by the project produced such a marked increase in discharge relative to the shadouf. It is the increase associated with the motor pump which explains it popularity among local farmers as a water lifting technology.

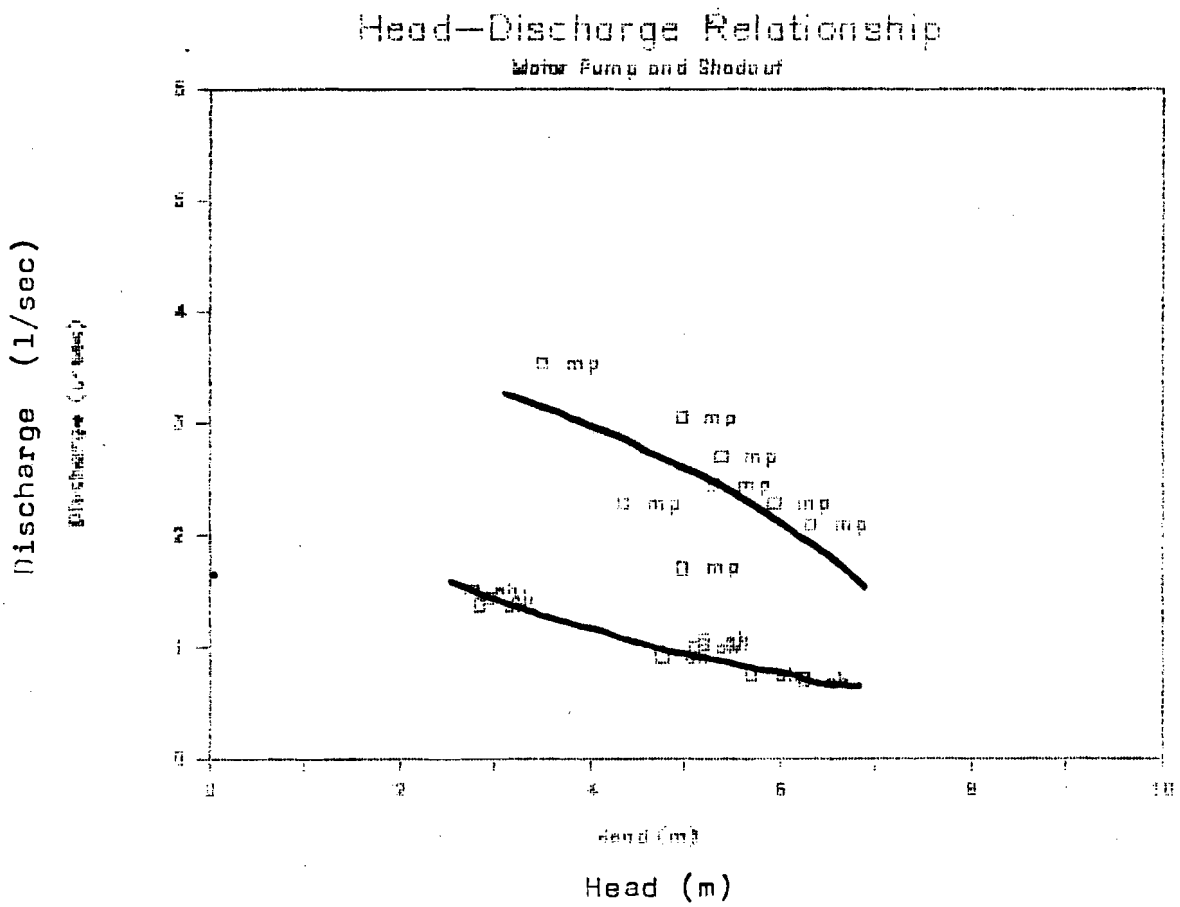
3.12.2 Mechanical Efficiency

The efficiency of a motor pump is defined by the ratio of the power derived in the form of pumped water and the power input in the form of gasoline consumed. According to Fraenkel, gasoline provides 9 kWh of energy per litre consumed. This value is used to calculate the mechanical efficiency of the motor pump based on the following equation.

$$Eff = \frac{G_S Q H}{9 \text{ kWh/l}(C)}$$

where: G_S = specific gravity of water (9,81 kN/m^3)
Q = discharge (m^3/sec)
H = total dynamic head (m).
C = gasoline consumption (l/hr)

FIGURE 4 : HEAD-DISCHARGE RELATIONSHIP
Motorpump and Shadouf



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According to Fraenkel, an "operator should probably be satisfied if a small gasoline powered system acieves 5-10% efficiency". As the Honda GX-110 motor pump operates in this range, its mechanical efficieny can be described as satisfactory.

PART 3 : DETAIL ON THE "BIDON VERSEUR"

3.1 Introduction of the "Bidon Verseur" in Chad

The "Bidon Verseur", French for pouring can, is an animal traction water lifting technology which was introduced in Chad in May, 1990. The introduction of the technology, which is well known in Niger, was facilitated by the "Etude/Action" project in Doum Doum, Lake Prefecture. This project, which is being financed by the Banque des Etats d'Afrique Centrale (B.E.A.C.) and implemented by the Société du Dévelopement du Lac (SO.DE.LAC.), hired a consultant from Niger to set-up two "Bidon Verseur" in the Doum Doum area for comparison with several other proposed water lifting technologies, including both human and motor powered pumps.

3.2 Classification of the "Bidon Verseur"

The "Bidon Verseur" belongs to a class of water lifting technologies known as bucket and rope arrangements. The simplest example of this class of water lifting devices is a bucket tied to the end of a rope, the bucket being both pulled from the well and emptied by hand. The discharge provided by this most simple technology is generally not sufficient for irrigation purposes. However, the water yield can be significantly improved by introducing wooden rollers to aid in pulling the bucket from the well and by using draft animals as prime movers. This traditional configuration is commonly used in Chad, particularly for watering animals. Despite their rudimentary approach, bucket and rope arrangements remain an important water lifting technology worldwide. According to Fraenkel, "the number (of such water lifting devices) in use today is still in the order of a million or more".

3.3 Design Advantages of the "Bidon Verseur"

The "Bidon Verseur", introduced in Doum Doum, has two primarly design advantages relative to the traditional configuration described above. First, it uses two pulleys equiped with bearings to provide a mechanical advantage while pulling the bucket from the well. Second, it has been designed so that the bucket empties itself into the primary irrigation canal once it reaches the top of the well. Consequently a single donkey, driven by a single person, can repeatedly pull a fifty liter bucket (weighing 50 kg plus the

weight of the bucket) from a well. This volume of water is impressive compared to the 15 liters contained in an average shadouf bucket. In addition, the fact that the person driving the donkey can be a child, frees the farmer from the tiring task of water lifting.

A secondary design advantage of the "Bidon Verseur" is the industrial quality of its fabrication. The component parts of the "Bidon Verseur" must be cut and welded together in a fairly sophisticated metal shop. This sophistication does not, however, exceed that already existing in Chad as the same "Etude/Action" consultant who installed the trail "Bidon Verseur" in Doum Doum sucessfully trained an N'Djamena metal shop to manufacture the "Bidon Verseur". The mechanical strength of the "Bidon Verseur" allows it to withstand the significant forces associated with water lifting and extends its operational lifetime beyond that which can be expected of locally crafted bucket and rope arrangements.

3.4 Operation of the "Bidon Verseur"

The first of two pulleys, hereafter called the fixed pulley, is attached to a superstructure built over the top of the well. The fixed pulley is placed so that it is positioned directly over the center of the well. The second pulley, hereafter called the mobile pulley, is attached to the bucket portion of the "Bidon Verseur" via a hinged frame. The normal position for this hinged frame, and hence the mobile pulley, is over the top of the upright bucket. A rope passes, in block and tackle fashion, from a fixed point on the donkey, over the fixed pulley, down and around the mobile pulley, and back up to a fixed point on the superstructure over the well (Figure 5). This configuration causes the bucket to hange one pulley diameter off-center towards one side of the well.

As the donkey walks towards the well, rope is fed over the fixed pulley down into the well. This causes the bucket and the mobile pulley to descend into the well. As the donkey walks away from the well, rope is pulled from the well over the fixed pulley. This causes the bucket and the mobile pulley to rise up in the well. The length of rope between the fixed point on the superstructure and the fixed point on the donkey is ajusted so that in walking to and from the well the the bucket and the mobile pulley move between being submerged just below the water surface in the well and being at the same height as the head of primary irrigation canal leading from the well.

The bucket is outfitted with a flap valve on its bottom. When the bucket hits the water surface in the well the valve opens and the bucket fills while remaining in the upright position (Figure 6). Once the bucket is filled, the donkey walks away from the well, and the still upright bucket rises up one pulley diameter off-center along one side of the well. The bucket is guided in its ascent by a steel cable which passes over a steel hook attached to

FIGURE 5 : BIDON VERSEUR SET-UP

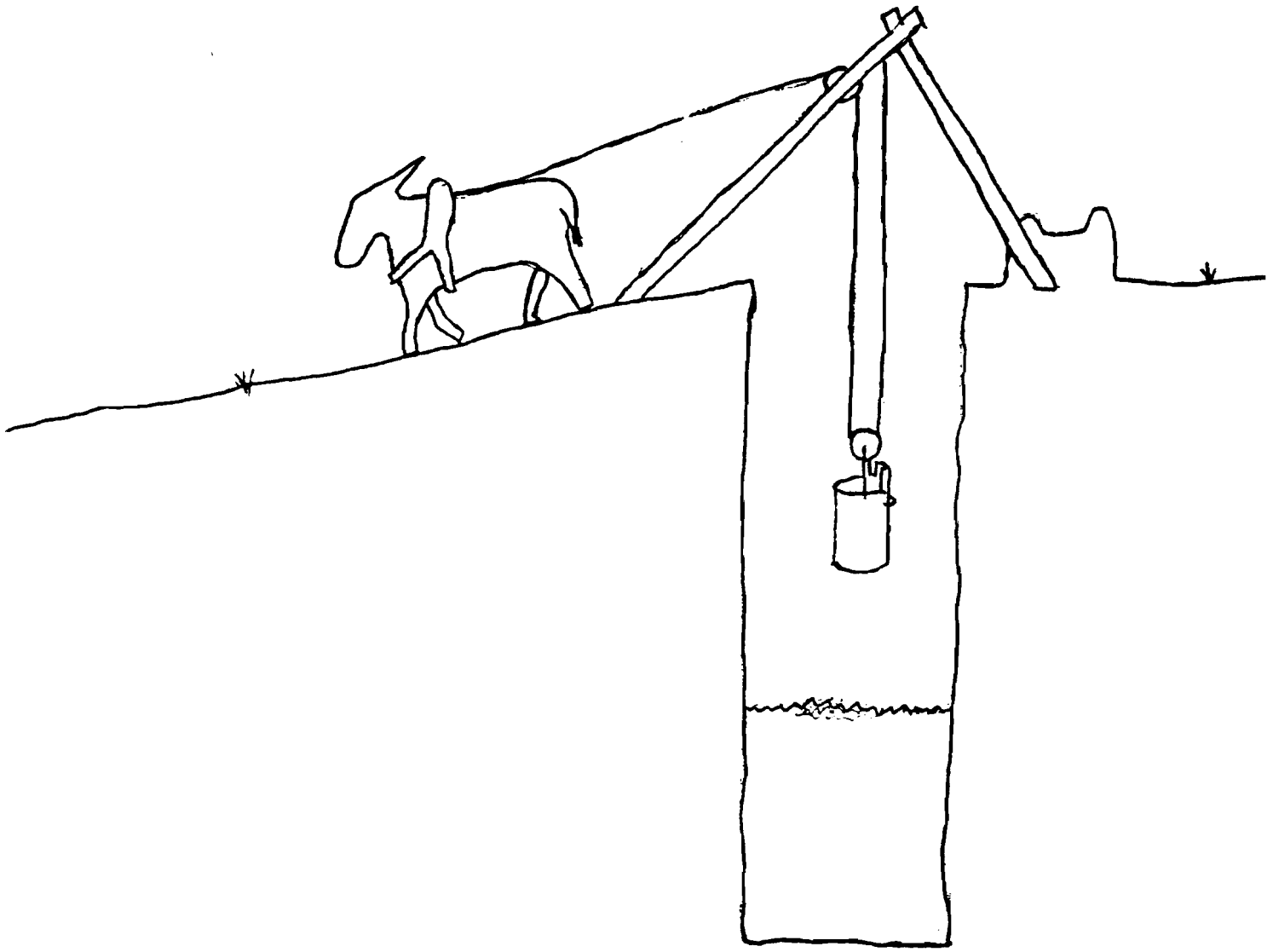
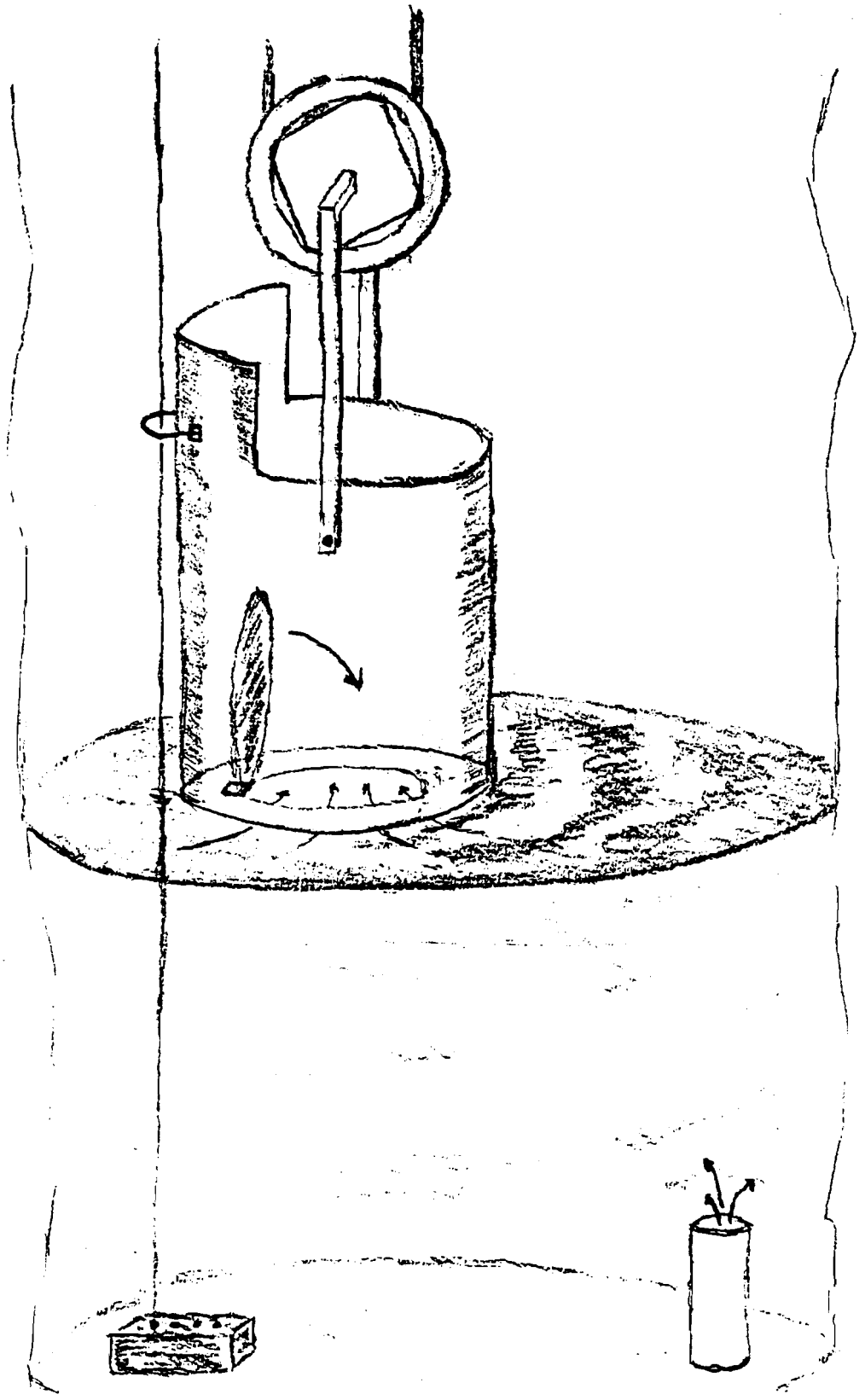


FIGURE 6 : BIDON VERSEUR FILLING AT WATER SURFACE IN WELL



the top of the wood reinforcing wall at the head of the primary irrigation canal, through a ring attached on the outside face of the bucket (the side away from the fixed pulley) and is finally attached to a counterweight lying on the bottom of the well. As the donkey reaches the end of its path away from the well, the ring on the bucket catches on the hook at the head of the primary irrigation canal and the bucket rotates on its hinges through 90° relative to the frame and the mobile pulley and empties its contents into the canal (Figure 7). The donkey then returns towards the well and the cycle continues.

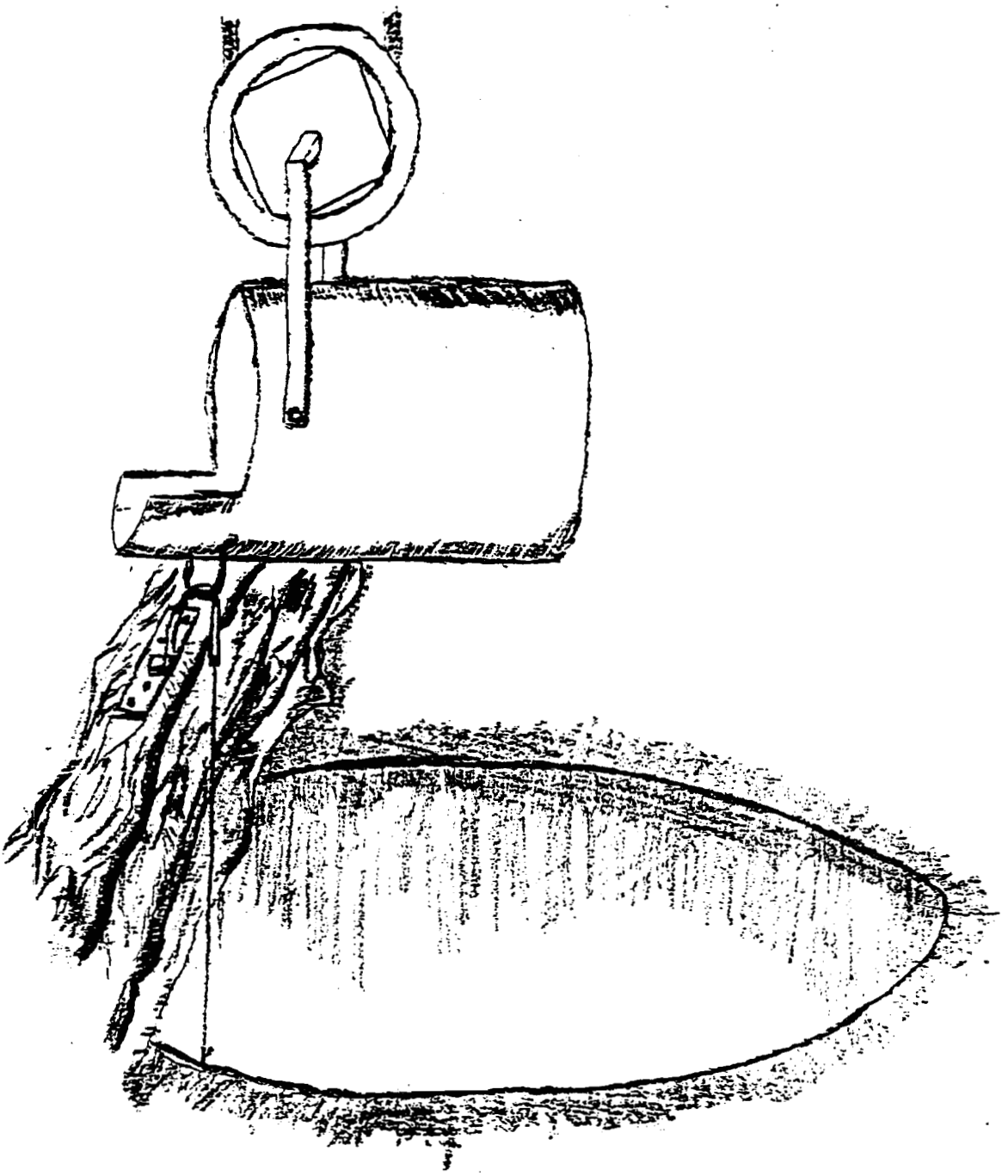
A1.5 Introduction of the "Bidon Verseur" in the Ngouri Area

Given the encouraging reports coming from the project "Etude/Action" regarding the "Bidon Verseur", a trip was organized by O.R.T. project staff to the project site in Doum-Doum on July 17, 1990. The technology had been installed on cement-lined hand-dug wells in the dry polders around Doum Doum. The conditions in these polders are very similar to those found in the wadis in the Ngouri area. The water bearing unit is fractured clay underlain by a regional sand aquifer. The water table is located at 3-6 meters below the ground surface. Farmers in the dry polders traditionally use the shadoof for water lifting and the size of irrigated parcels is of the same scale as those found in the Ngouri area. The farmers using the "Bidon Verseur" seemed genuinely impressed with the technology and the first estimates of discharge calculated by the "Etude/Action" project staff suggested an improvement over the shadoof.

Based on this visit it was decided to purchase the material needed to set up a "Bidon Verseur" in the Ngouri area. A farmer who was willing to test the "Bidon Verseur" was identified in Landé, a wadi 8 km east of Ngouri which had not previously participated in project activities. The wadi is located to the east of Ngouri, in an area where the water table is deep and activity in the wadis has been limited due to the difficulty encountered in operating a shadoof. In light of the poor millet harvest this year the farmer has taken up wadi agriculture which he had not practiced for several years.

The "Bidon Verseur" was first installed on September 19 on an old well in the farmer's parcel. The well had previously had a traditional drain installed which had since clogged up. The "Bidon Versuer" quickly dried up the well and when a project wells improvement technical delegate could not succeed in repairing the old drain the decision was made to dig a new well outfitted with an improved drain. Digging began on September 22, at project expense in order to speed up the process, and on September 27 the "Bidon Verseur" was installed on the new well. Two donkeys along with the hay and millet required to feed them were provided by the project.

FIGURE 7 :BIDON VERSEUR EMPTYING INTO THE PRIMARY IRRIGATION CANAL



3.6 Costs Associated with the "Bidon Verseur"

The total capital cost of the "Bidon Verseur" installed in Landé is decribed below:

Pulley system	20,100 f cfa
Self-emptying bucket (50 l)	23,000 f cfa
Nylon rope	5,000 f cfa
Steel cable	10,000 f cfa
Sperstructure	6,500 f cfa
Harness	5,000 f cfa
TOTAL	69,600 f cfa

Donkeys cost from 7,500 to 10,000 FCFA each; two are used at Lande. At current millet and hay cost, the recurrent cost for maintaining the two donkeys appears to be about 475 f cfa/day.

3.7 Hydraulic Performance of the "Bidon Verseur"

3.7.1 Discharge-Head Relationship

A weekly survey of the discharge of the "Bidon Verseur" being tested in the Ngouri area has yielded the following results.

	Time of Operation (hours)	Discharge (l/sec)	Total Volume (m^3)
Donkey #1:	2.25	1.29	10.4
	1.08	1.5	5.8
	3.08	1.29	14.3
	2.0	1.5	10.8
Donkey #2:	1.42	1.25	6.4
	1.35	1.47	7.1
Average:	1.86	1.38	9.2.

The well on which the "Bidon Verseur" is installed has a depth to water of 5.8 meters. Since several "Bidon Verseur" have been installed in Doum Doum, data collected by the "Etude/Action" project provide additional information about the range of discharges yielded under variant depth to water conditions. The following table presents data collected in Doum Doum.

Depth to Water (m)	Discharge (l/sec)
6.2	1.11*
6.07	1,04
3.88	1.35
3.82	1.39
3.36	1.43

* average based on performance of two donkeys.

Plotting data collected in Ngouri togehter with that collected in Doum Doum yields a Head vs. Discharge Curve for the "Bidon Verseur" (Figure 8). Plotted on the same graph is the H-Q relationship for the shadouf as operated in Ngouri. The curves reveal that for the variant depth to water conditions encountered in the Ngouri area, the "Bidon Verseur" yields a discharge superior to that yielded by the shadouf. The relative increase in discharge is most pronounced where the depth to water exceeds 4 meters. The outlier data point for the "Bidon Verseur" represents the situation in Landé where two donkeys are used for water lifting instead of one, and where the feeding of the donkeys is being financed and monitored by the O.R.T. project. This data probably reflects the optimal performance of the "Bidon Verseur" and should be the performance standard set for utilization of the technology in the wadis.

3.7.2 Mechanical Efficiency

The time averaged power output of the "Bidon Verseur" can be calculated using the expression:

$$P_o = G_s H Q$$

where: P_o = power output (W)
G_s = specific gravity of water (9810 N/m^3)
H = hyraulic lift (m)
Q = time averaged discharge (m^3/sec).

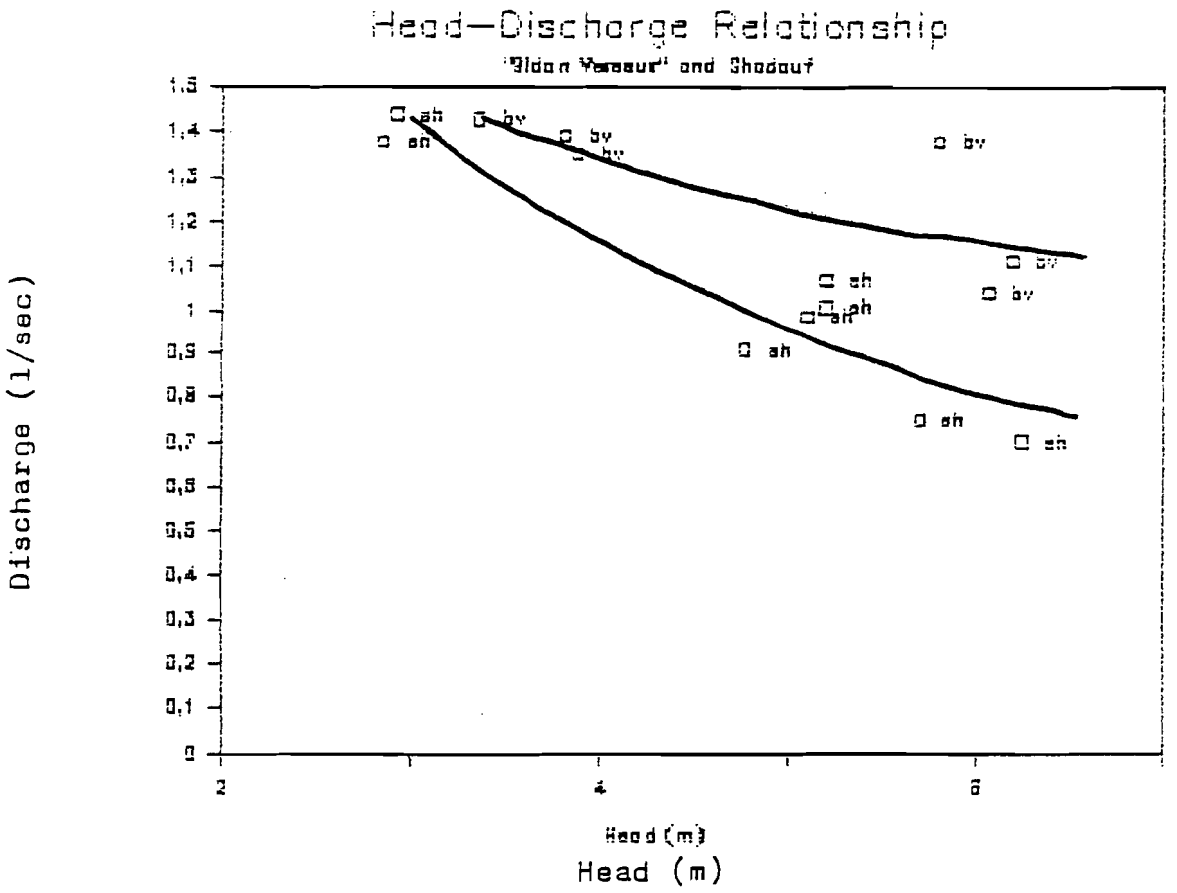
Using data collected in the Ngouri area the power output is:

$$P_o = (9810\ N/m^3)(5.8\ m)(0.00138\ m^3/sec)$$
$$78.6\ W$$

According to Fraenkel, a donkey provides between 75 and 200 W of power while pulling. Based on this range, minimum, maximum, and an average theoretical system efficiency are calculated below.

$$Eff_{min} = \frac{78.6\ W}{200\ W}$$
$$39.3\%$$

FIGURE 8 : HEAD-DISCHARGE RELATIONSHIP
Gidon Verseur and Shadouf



$$Eff_{max} = \frac{78.6\ W}{74\ W}$$

106.2 %

$$Eff_{ave} = \frac{(78.6\ W)2}{(200\ W + 75\ W)}$$

57.2 %

Based on these calculations the mechanical efficiency of the "Bidon Verseur" can be assumed to be quite good.

PART 4: CROP WATER NEEDS BASED IRRIGATION

4.1 Rationale for Crop Water Needs Based Irrigation

Simply put, the objective of irrigation is to replace the soil moisture which has been consumed by a crop in the interval since the previous irrigation event. If exactly this amount is replaced neither depletion of the soil moisture reservoir beyond exceptable limits nor drainage of excess irrigation water out of the root zone of the plant will occur. Knowledge of the consumptive water use of a crop permits the development of irrigation schedules which meet the objective stated above. It is in the best interest of farmers to irrigate in response to crop water needs to increase the water use efficiency of their irrigation systems. This is particularly true in the case of a farmer using a motor pump or a bidon verseur, who is making daily operating expenditures to assure water lifting, as irrigation water not available to the plant results in lost money. In addition, water efficient irrigation can result in actual production increases and greater agricultural revenues. The application of crop water needs (CWN) based irrigation can enable a farmer to increase the economic benefit derived from wadi agriculture.

4.2 Desciption of Crop Water Needs Based Irrigation

As it has been practiced in the Ngouri area, CWN irrigation is based on the methodology presented in the F.A.O. Irrigation and Drainage Bulliten No. 24, intitled Crop Water Needs. The method uses recorded weather data, collected in the vicinity of the irrigated zone in question, to calculate average values of the potential evapotranspiration rate (ETP) in millimeters od water per day. These values can be daily, weekly or monthly averages depending on the length of the historical record on which they are based. A short record of weather data is well suited to calculating average mnothly values of ETP but not well suited to

calculating daily averages. By multiplying ETP by a crop coefficient for the crop in question, the actual evapotranspiration rate (ETA) in millimeters of water per day can be determined. Soil analysis performed in the irrigated zone in question permits calculation of the water holding capacilty (WHC) of the soil. The WHC represents the amount of water which can be retained within the root zone of the plant. Knowing how much soil moisture is consumed per day, ETA, it is possible to determine when the soil moisture reservoir is sufficiently depleted to merit irrigation. Further the amount of water needed to completely refill the soil moisture reservoir without irrigation water loss due to deep percolation can be quantified. Irrigations are scheduled and application depths calculated to maintain the soil moisture status at an acceptable level while eliminating losses associated with excess irrigation.

4.3 Methodology of Crop Water Needs Based Irrigation

The first step, determining ETP for the Ngouri area, uses the Penman Method. Penman's Equation states:

$$ETP = (W)(R_N) + (1-W)(f(u))(e_a - e_d)$$

Where: W = coefficient related to humidity and wind speed
R_N = net ratiation (mm/jour)
f(u) = function related to wind speed (.27(1+u/100))
u = average wind speed 2 meters above ground (km/day)
e_a = saturation vapor pressure (mmbars)
e_d = actual vapor pressure (mmbars).

The variables can be quantified basded on measurements of temperature, relative humidity, wind speed, and the hours of sunlight per day. The first three variables were measured daily in Ngouri by the O.R.T. project during Phase I. The hours of sunlight per day was interpolated from data collected by the Chadian Weather Service in Bol and Mao. Collection of the weather data began in July, 1988. Since that date, the average monthly values of ETP were as follows:

Month	ETP (mm/day)
Jan	5.3
Feb	5.7
Mar	6.1
Apr	6.2
May	6.1
Jun	6.0
Jul	5.6
Aug	5.7
Sep	5.3
Oct	5.3
Nov	5.1
Dec	4.9

These values of ETP are used to determine ETA for a crop grown in the Ngouri area.

This second step, determining daily crop water consumption, involves the use of crop coefficients (k_c). These coefficients account for the developmental status of the crop in question. Field research results from around the world have been studied and compiled by the F.A.O. and values of the crop coeeficient during each of four developmental stages, along with the length of these stages, have been printed for most of the important crops grown worldwide. Thus if the planting date of a particular crop is known, its water consumption on a given day can be determined by using the appropriate values of k_c and ETP in the following equation:

$$ETA = (k_c)(ETP).$$

The crop coefficient can be adjusted to account for local conditions such as the size of irrigated fields, the presence or absence of wind protection, and the potential variability of local atmospheric conditions.

The final step in CWN irrigation, the development of irrigation schedules and application depths, takes into account the daily water consumption of a crpo along with the WHC of the soil in which it is planted. Using the gravimetric analytical method, the soil moisture content of the soil at field capacity and at the permanent wilting point are determined prior to the start of the growing season. The difference in moisture content between these two values, considered over the root zone of the crop,is the total available water (TAW). It is standard irrigation management practice to allow up to half of TAW to be consumed prior to irrigation (total consumption of TAW means the soil attains the permanent wilting point and the plant dies). If one assures that the soil is at field capacity after the first irrigation, the daily water consumption, ETA, can be subtracted from TAW to determine the updated soil water status. This updating continues until TAW is half depleted, at which point an irrigation is scheduled to add back just the amount rerquired to replenish TAW(ie: to return the soil to field capacity) without exceeding the WHC of the soil. Following irrigation, daily updating of the soil water status based on ETA continues until TAW is once again half depleted at which point irrigation occurs, and so on. In effect, irrigation management becomes a simple accounting proceedure in which only the soil water consumed by the crop is replaced.

4.4 Introduction of Crop Water Needs Based Irrigation in Ngouri

The practice of CWN irrigation was introduced during the final year of Phase I of the O.R.T. project. CWN irrigation was tested in collaboration with certain farmers using motor pumps. It was thought that those paying the daily operating costs associated with

the motor pump would be particularly receptive to improving irrigation water use efficiency if they could be convinced of an economic benefit. Four farmers were identified to participate in the test, two growing onions and two growing tomatoes. In each case two plots of identical surface area and field layout were installed, one to be irrigated traditionally as the farmer deemed necessary, the second to undergo CWN irrigation. The O.R.T. and SO.DE.LAC. field agents were trained to determine irrigation schedules and apllication depths using the method described above and they collaborated with the farmers so that the experimental plots were irrigated in response to crop water needs. The O.R.T. porject provided and closely monitored the gasoline consumed in irrigating both plots and the production from each plot was carefully recorded. At the end of the growing season a comparison was made between the costs and revenues associated with both traditional and CWN irrigation management.

4.5 Potential Benefit of Crop water Needs Based Irrigation

The initial testing of CWN irrigation showed mixed results but suggested real potential. One of the two farmers who grew onions had to abandon the experiment when his motor pump broke down during the test. The second farmer growing onions saw no significant difference in profit between traditional and CWN irrigation, although it must be stated that the irrigation of the two plots followed very similar schedules. The two farmers who grew tomatoes on the other hand did notice an increase in profit derived from the CWN irrigation plot., in one case a significant increase. This farmer used a traditional irrigation strategy which varied greatly from CWN irrigation and he was impressed by the economic advantage gained in applying the technology.

The farmer, who farms in the Molo wadi near Hgouri, planted two identical 84.8 m^2 plots of tomatoes. The table bello shows the difference between the two irrigation stategies applied.

	Traditional	CWN
Total Number of Irrigations	42	28
Ave. Irrigation Interval (day)	3.5	5.1

The farmer irrigated more frequently using the traditional irrigation strategy. Due to the greater frequency the traditonal irrigation method consumed more gasoline than CWN irrigation. This lead to over irrigation and wasted operating expenditures as shown in the table below.

	Traditional	CWN
Gasoline Consumed (l)	13	8
Tomato Production (kg)	100.5	133

The increased production under CWN irrigation is likely the result of improved soil water management which allowed for increased soil aeration between irrigations. Using the data shown above, it is possible to calculate the total operating expenditures and the total agricultrual revenues associated with the two irrigation methods. A gasoline price of 250 f cfa per liter and a tomato sale price of 125 f cfa per kilogram are used in these calculations.

	Traditional	CWN
Operating Expenditures (f cfa)	3250	2000
Agricultural Revenues (f cfa)	12662.5	16625
Total Profit (f cfa)	9412.5	14625

The difference in profit between the traditional irrigation plot and the CWN irrigation plot is 5212.5 f cfa. If this increase is extrapolated onto 30 ares of tomato production then the increase in profit due to CWN irrigation would be 184,404.5 f cfa. This is a significant sum of money whcih represents an important economic advantage for the farmer.

4.6 Phase II Crop Water Needs Based Irrigation Activities

During Phase II work will be done to determine which crops are traditionally irrigated in a manner which could be improved using CWN irrigation. Further field tests will be conducted to convince a greater number of farmers of the economic advantage of this approach. Training of field agents will be continued to assure that they can preform the soil analysis necessary to determine the WHC of the a soil in a farmers field. General CWN irrigation guidelines will be developed and tested so that in the future farmers will be able to use CWN irrigation without the assistance of a field agent.

ANNEX D

18

ANNEX D : TECHNICAL ANALYSIS OF AGRONOMIC ISSUES

1. Overview

When the original design team visited the Ngouri area in 1986 they found a population crushed by the effects of the Sahelian drought. Fortunately for the people of this zone, they had a tradition of shadouf cultivation in wadis, low-lying depressions where the groundwater is close to the surface. As a result the local farmers had been able to some extent to make up the deficit in rainfed cereal by growing grain in the wadi or by growing vegetables to sell in order to buy grain. Farmers were acutely aware of the value of wadi agriculture but they were also aware that this valuable resource was a fragile one, for the same drought that had devastated the rainfed crops was causing the water table in the wadis to drop. Shadouf irrigation was becoming more and more difficult, which put a premium on producing as much as possible in the smallest possible area, in order to reduce the need for irrigation. At the same time the farmer had a vital interest in maximizing production to that he could obtain enough cereal to feed his family. Although the drought has ended in other parts of the Sahel, in the Ngouri area it still continues. From 1980 to 1990 there has only been one year with normal rainfall, 1988. The problem of maximizing wadi production to support a family remains as pressing today for most farmers in the Ngouri area as it was when the original project team visited five years ago.

ORT realized there were two ways to increase a farmer's wadi production: increase the surface area through improved water-lifting and increase the yield per are through improved agronomic practices. The project began a series of field tests to discover agronomic techniques which would help the farmer increase production. But the techniques not only had to be technically capable of raising yields, they had to be acceptable to the farmer or else it would have been only an academic exercise. Furthermore the farmer had to master the techniques or the increase in production would not be sustainable. Therefore, once the field tests had revealed which agronomic techniques succeeded in increasing yield, then they were monitored to see how acceptable they were to the farmers.

ORT's agronomist also searched for techniques which could stand alone. Each technique should in and of itself increase yield, so that even if a farmer adopted only one new technique his production would go up. The downfall of many agricultural projects is that a "technical package" is introduced; if all the new techniques are not used then the others will fail--improved varieties of seed will not give a higher yield, for example, if fertilizer is not used. Instead the agronomist developed a "basket" of techniques through which a wadi farmer could rummage to find the techniques which suited him but which would increase his

production. The fact that 78% of farmers involved in the project have adopted at least one new technique means that 78% of the farmers have been able to increase their yield. However the number of techniques farmers tend to adopt increases the more exposure they have to them, i.e. the longer they have been in the project. So, for example, by the time of the project final evaluation in June 1990, 51% of farmers who had been in the project only two years had adopted a number of techniques, each of which gave an incremental increase in yield, and 31% of farmers who were just beginning with the project had adopted at least one new technique.

By the end of the project the agronomist had found four techniques which raised production and which were widely accepted by the farmers in the project. The four winning techniques were:

- soil enrichment through compost and manure
- improved irrigation basin design and plot layout
- live fencing
- crop diversification in response to market demand.

The first phase of the project was devoted to identifying appropriate techniques and making sure they were acceptable. The purpose was to identify a model for increasing wadi production which could be widely adopted. By the end of phase I the project staff had created a model which identified useful and acceptable techniques and the way in which to teach farmers how to use them. In this process the project worked with 3-5% of the population. The model was developed for reaching the rest of the population.

Local farmers have found these four winners so effective in raising production that they have been spreading spontaneously. This augurs well for the sustainability of the technology. However this does not mean that the model the project developed for technology transfer, the Technical Delegate system, is unnecessary. There is a very basic constraint on the spread effect in this zone. It became clearer and clearer as the project continued that the farmers in the area lead an exceedingly cloistered life. Very few of them have ever been more than 20km from home. Travel is very difficult--by foot for most men. Social contacts are limited to visits with relatives and in-laws in nearby wadis (most marriages are within the village or close by) and the local markets. For example, before the regional motorpump group was formed most of the members had never visited the wadis of the 60 other members. Thus while the spread effect can be very effective, its range is limited to the area near the project wadi. In order for the project's winning techniques to spread throughout the area a certain density of project wadis, with their visible improvements--the waving trees of the living hedges, the larger surface areas, the healthy plants, the moister soil--and of Technical Delegates, the farmers who can explain to other farmers how to achieve these results, must be developed. Otherwise the increased yield which will improve the standard of living of the farmers, help them achieve food self-sufficiency, and furnish the markets with the varieties and qualities of produce that people demand, will not occur except on

a limited scale.

2. The four most important agricultural improvements

The principle constraints to improved production identified by the project agronomist and local farmers are:

- declining soil fertility
- inappropriate irrigation basin preparation
- fencing
- limited crop choice
- pest management

During the pilot phase the project agronomist tackled most of these problems, but pest management was not in his scope of work. It is however a major problem and one which must be addressed in order for farmers to grow the quantity and quality of vegetables and fruits necessary for marketing.

The solutions to these constraints, techniques which were clearly successful in the eyes of the farmers and of the outside evaluators, are as follows:

- soil enrichment through compost and manure
- improved irrigation basin preparation
- live fencing; and
- crop diversification in response to market demand

3. Reasons for limited production in wadi agriculture

Why these solutions work can only be understood within the context of traditional wadi agriculture. The physical setting of the wadis, the climate and the distressing changes which have occurred in rainfall and temperature, and the traditional agronomic practices of the local farmers all conjoin to limit the production of a potentially fertile area. The four most successful techniques succeed in breaking the bonds which fetter production.

3.1 Physical Setting and Conditions

A. Geographic location

The project wadis are located on the north-east shores of Lake Chad, between the large towns of Massakory and Bol. Access since 1989 has been improved by the construction of a packed earth road to replace the sandy, unpaved tracks which had severely limited access to the area up till then. As a result of the road vehicle traffic has grown and access to Bol, Massakory and the nation's administrative and economic center, NDjamena, has improved. Because

of the road the market at Ngouri, hitherto in the shadow of Dibininchi market even though it occurred in the Sub-prefecture's capital, has increased. The project zone contains a number of important local markets and some of regional importance such as Dibininchi, Mao, Bol, Baga Sola, Mondo, Doum Doum and Massakory, where Ngouri area farmers sell their produce.

B. Relief

The project area is part of a sandy dune plateau where dunes alternate with depressions, known locally as wadis, which are fossil remnants of polders left as Lake Chad retreated. The altitude above sea level at Ngouri is 290 meters. The dunes lie in a north-west to south-east direction. In the east of the project zone the wadis are long and thin, often several kilometers in length; indeed the unpaved roads used to take advantage of their compact surfaces by passing through their length. In the center of the zone, in Dibininchi canton, they are oviform, about 800-1000 meters in length and 200-400 m. wide. In the west, near Ndjiguidada their are either thin and long (sometimes as much as 3 km) or, to the north, they have the more circular form which is characteristic of the Kanem. The difference between the wadi surface and the level of the dunes increases from east to west, going from about 2m in Canton Yalita to 12-20 or more meters in Ndjiguidada Canton. In all wadis the dune is steeper on the windward side and in many cases the dune is encroaching on the wadi surface from that side.

C. Climate

i. Rainfall patterns

The wadis in the Ngouri area are situated in the 350mm Sahel-Saharan isohyet, the southern border of which extends from NDjamena to the south of Abeche and covers 11% of the nation.

Average rainfall recorded over a 32 year period in Bol, just to the west of the project zone, totaled 297.0 mm. The total annual rainfall at Ngouri has been slightly higher than this average for Bol, for example 382.7 at Dibininchi in 1988, 379.8 at Ndjiguidada, but only 128.9 at Ngouri. Another indication of the very uneven geographical distribution of rainfall comes from two neighboring polders near Bol where rainfall was measured and varied widely between 219 and 365mm.

The monthly repartition of the 32 year average at Bol was:

jan	feb	mar	apr	may	jne	july	august	sept	oct	nov	dec
0.0	0.0	0.0	0.4	6.0	9.7	61.0	167.4	45.6	6.9	0.0	0.0

In a 1966 study Cheverry noted that the average rainfall in the Lac fluctuated markedly from year to year, noting extremes of

46mm and 300mm. The rains are intense when they occur; for example in one rain in August 1988 at Ngouri, rainfall was about 1.28mm/minute, creating a high runoff component despite the great permeability of the dune sands.. In the early part of the rainy season the downfall is most intense, perhaps 210mm/hr, but later amounts to only 5-10mm/hr.

At the height of the drought in 1984 and 1985 the rainfall at Ngouri was only 80mm and 156.7mm respectively. Detailed records have been kept by the project during its lifetime; it is clear that the rainfall, while better than those years is still lower than the 300mm average of the earlier 32 year period and is so badly distributed over the growing season that dune agriculture is exceedingly chancy. These results are supported by the findings of the social impact study which show that most farmers cannot support themselves on dune millet alone. The 1988 rainfall in the project zone which was mentioned above was the best during the project's lifetime. In other years the rainfall rarely got up to 200mm/year.

ii. Temperature

The project has also kept track of temperature in the project zone. In the cold season temperatures may sink as low as 6 degrees Celsius on the dune and 4 degrees in the wadi. In March the temperature and evaporation increase drastically in a shift from the cold season to the hot season, during which temperatures can easily reach 40 degrees.

iii. Evaporation and Evapo-transpiration

The total amount of evaporation in a year in this area may reach 4 meters. The average relative humidity during the year is 45%. Evapotranspiration reaches or surpasses 300mm during the months from October to April.

a. Rainy Season (June-September)
Evapotranspiration is the lowest at this season.

b. Cool, Dry Season (November-February)
The air is dry, with a relative humidity of about 20-30%.

c. Hot, Dry Season (March-May)
In this season the absence of moisture, the force and frequency of drying winds and the high temperatures leave to very high evapotranspiration.

iv. Wind patterns

The Harmattan blows from the northeast from October to April. In January and February it is filled with sand and very hot in April. From May through September the wind blows from a southwesterly direction.

D. Soils

i. Types of soils

a. Dune soils

Because of the drought and continuing poor rainfall the earth on the dunes is progressively degrading for lack of vegetative matter and manure. The brown soils are very porous.

b. Wadi soils

The earth varies from 20-30% clay to 20-30% limestone. Generally the lithology is:

0-1 meter loam
1-3 meters fractured clay
3-6 meters compacted clay
6-80 meters sand

Most wadis are characterized by a layer of hardpan at a depth of about 60 cms. The soil is deficient in organic matter, less than 2%, which makes it difficult for water to penetrate to a plant's roots. Organic matter is concentrated in the top 30cms of the soil. The pH is alkaline except at Boui which is slightly acid. While calcium is present in large quantity other elements are negligible. The high level of calcium reduces the risk of sodic salinity.

ii. Hydric pattern of wadi soils

a. Hydric capacity

The project has been carrying on studies of the hydric capacity of wadi soils in order to suggest the most effective rates of water application. These results are not yet final.

b. Permeability

Permeability is relatively good, about 40. There is no problem with standing rainwater or with waterlogging.

iii. Ground water

The water table on the dunes is about 26m or more. Though the villages are built on the dunes for health and, formerly, safety reasons they get their water from a nearby wadi (hence every village is associated with at least one wadi). The water table within the wadis varies:

6m. in Baderi Canton in the east
5m. in Ngouri, Yalita and east Dibininchi
3-4m. in Dibininchi and north Ndjiguidada
2m. near Ndjiguidada town

In areas with shallow ground water the slow recharge rate

is a problem. In areas with a deep water table the effort required to work a shadouf is much greater. Well depth also often goes beyond the capacity of the shadouf. In general the ground water table varies with the annual rainfall.

The ground water table is sometimes located in the fractured clay, sometimes the compacted clay or the sand. Where it is located determines the kind of well improvement possible. In the east, in Cantons Baderi and Yalita, ground water often occurs in such a soil configuration that the techniques developed by the project will not work.

iv. Salinity problems

Outside of some salty pockets the salinity of wadis currently under exploitation is supported by the crops grown. Salinity is a problem particularly in wadis with a shallower water table since there water rises more easily by capillary action to the surface where it quickly evaporates because of the dryness (see 3 and 4 above). Hence there is a high proportion of natron--calcium carbonate--in these wadis especially. Since the same soil is remixed season after season, each time the irrigation basins are rebuilt, saline soil is not removed.

v. Fertility of wadi soils

A wadi is an almost closed system. Unlike lake polders it no longer gets alluvial deposits from rising lake waters. Moreover, with the decrease in rainfall in recent years less organic matter is washed down off the dunes into the wadis to enrich the soil. Moreover the natural vegetation is dying out because of the dryness so there is less organic matter available for rainwater to carry down. Wadi soil contains only about 2% organic matter. Wadi soil's chemistry shows it to be low in nitrogen as well. Farmers work the same plots year after year until the soil is so impoverished that production drops way down. Then they move on to another part of the parcel, dig another well, or several, and start again. This not only diminishes soil quality but favors the development of parasites and depletes the soil.

E. Vegetative cover

Natural vegetation in the wadis has suffered from continuing drought and has been greatly depleted. Cultivation and wood cutting have also reduced the trees to those which people protect because of their productive value. Farmers have also planted some fruit trees in their parcels. Live fencing, which has become very popular--over 17km of fence were planted during Phase I--has introduced new perennial to the wadi. Throughout the wadis sedge

grass (Cyperacaea) frequently grows in parcels between cropping seasons and requires considerable effort from the farmer, who must dig around 30 cms down, to extirpate it.

3.2. Traditional farming system

The traditional farming system has three basic components: dune farming; wadi or polder farming; and livestock. Whether or not it was added at some point or has always been a feature of the system, commerce is today an important adjunct, though not an integral part of the system. No one part of the system can provide an adequate livelihood all the time. Dune farming must be supplemented by additional production and by the fertilizer and milk livestock provide. Neither livestock nor shadouf farming in the wadi could provide enough grain for an average family. Today commerce also serves as a source of income for cereal purchases for the family.

A. Rainfed dune farming

The average family, which is 5 people, usually has 2ha. of dune sown in millet. The whole family works in the fields. The work in the fields goes on from May till October. Millet farming consumes most of the family's effort so that other activities during this period are limited. The yield of dune millet is very dependent on the quantity and the timing of the rain. The average yield in Ngouri in 1988 was 350kg/ha, 50kg/ha in 1989, and practically nothing in 1990. These variations highlight the importance of a system flexible enough to provide a family with grain from more than one source. It also highlights why a family may be reluctant to liquidate its savings, which it holds in the form of animals, for all but the most compelling reasons, since they may be needed in the future for grain purchases.

B. Wadi farming

A survey of wadis in the Ngouri area done in 1959 gives a historical perspective to wadi farming in the project zone. At the time of the survey about 100 wadis in Ngouri, Ndjiguidada and Dibininichi each, were under cultivation with wheat, corn and vegetables. They faced problems of salinity and flooding, which was often so bad that large parts of the wadi were inundated for long periods of time. Back around 1920 many of these same wadis had been abandoned because of a drop in the water table. Now again the water table is dropping. Wadis no longer suffer from flooding and corn, which demands lots of water, is no longer grown in the wadis. Instead the common crops are:

- rainy season: sorghum and "ligi", a quick-maturing variety of millet
- cool season: wheat and vegetables
- hot season: "ligi" and gumbo.

Surface area: The average wadi parcel size of a family is 36.43 ares. Only 33% of wadi farmers have less than 20 ares. The total surface area cultivated in a year varies according to the depth of the water table and the crops preferred in the zone (and now, with the presence of a motorpump). In the Ngouri zone surveyed farmers planted between 10-40 ares in one year. In Dibininchi farmers planted more than 20 ares, in Ndjiguidada 25-40 ares. Motorpump farmers are able to irrigate a larger surface area; the average at Ngouri was 64 ares. Clearly the motorpump can increase production.

The climate, temperature and evapotranspiration affect the surface area farmers cultivate in different seasons. In the cool season farmers do 44% of their wadi farming, in the hot season 25% and in the rainy season 31%.

Water lifting: With the shadouf, the traditional water-lifting device, a farmer in Ngouri can pull up 2.5 cubic meters/hour. In a 5 hour working day a farmer can irrigate with 12.5 cubic meters. If he waters each part of the parcel once every 3-5 days he can only irrigate 7.5-12.5 ares at the maximum. In Dibininchi and Ndjiguidada, where the wells are not as deep, a farmer can irrigate about 25 ares. With a motorpump the average surface area under cultivation/year is 64 areas but one farmer got up to 72 ares.

Crops grown: The usual crops traditionally grown vary according to the season. In the cool season farmers plant: eggplant, onions and wheat. In the hot season they grow: onions, gumbo, ligi millet and cucumbers. The rainy season is usually devoted to gumbo, hot peppers, sorghum and ligi millet. After the irrigated polder project at Bol in the 1960s some farmers began planting a few vegetables such as cabbage and salad in the cold season. Manioc is grown in large quantities in some wadis but it takes a long time to mature--18 months. Farmers also care for fruit trees in the wadis. Dates are traditional. There are also some lime trees. The project has introduced papaya, guavas and bananas.

Soil preparation: Soil preparation is the task of the wadi farmer, usually the household head. The farmer uses a special short handled hoe for preparing the wadi soil. First he clears the field of and grass and bushes; traditionally he burned them but now some farmers use the debris to make compost.

Seedbed preparation: The wadi farmer also prepared the seedbed. He built a system of squares about 1 meter square, intended to store water, once it was flooded, for a long time so as to infiltrate as slowly as possible. The traditional square had a surface which was watered of 1 square meter but the whole square was about 1,43 square meters, i.e. 40% of the surface area was taken up by the retaining walls of the irrigation basins. The project has introduced a number of different basin conformations adapted to different crops and to different water-lifting devices; more than 70% of the farmers have adopted these new styles.

Irrigation: The male wadi farmer usually works the shadouf. He

is helped by a young child who opens and closes the dirt irrigation channels with a hoe in order to direct the flow of water. The child will also do some weeding at the same time. This is about all the weeding, and thinning the plants will receive.

The wadi farmer seems generally to favor a large surface area over an adequate water application. Thus the plants may go too long without water, a problem for the plants compounded by the high evapotranspiration. Ironically they also suffer from asphyxiation because of the force and depth of the water when it enters the basin.

Crop protection: Wadi crops are attacked by a whole series of predators: domestic animals, rats, squirrels, porcupines, etc., and by termites, thrips (Thrips tabaci), aphids, white flies, cochineal bugs (Henoseptitachna laterii), curculionides, cantarides, and cryptogamic attacks on cereal crops are some of the problems. Some wadis in the zone have at times encountered such problems with pests that they give up cultivating a given crop entirely. Boui wadi stopped cultivating onions about 1980 because of thrips; many at Loura gave up wadi farming because of rats which destroyed all their manioc, the only crop they could cultivate given their water table. Farmers have no traditional ways of protecting crops except for getting the marabouts, holy men together to lead prayers for the crop's salvation. Those farmers who can get pesticides have applied them whenever they can. The favored method at the moment is to sprinkle it on the crops with a broom. Farmers who use pesticides do so without any knowledge of the type of chemical, its use or its purpose. The dosage is often incorrect and its application done incorrectly or at the wrong time in the pest's life cycle. While they may observe certain pests they know little of its habits and in many cases they are unable to diagnose the cause of the problems they observe with their crops.

4. The positive impact on production of the four most successful techniques

It is clear that a number of different causes produce one symptom. Declining soil fertility is due, for example, to the farmer's propensity to work the same area until it is almost sterile in order to avoid having to dig another well. It is due to the way in which he builds his traditional basin, which removes the rich soil and leaves the plants to grow in the poorer soil, and which leads to the formation of hardpan. It is due to the way in which the farmer clears his field by burning all the organic matter. It is due to the drop in rainfall which means fewer nutrients are washed down off the dunes into the wadi. It is due to the type of soil which typifies the region. And so forth. Therefore a number of actions can be taken to improve soil fertility. The trick was to find an action which would dramatically raise soil fertility and which most farmers would use. According to the final evaluation report the four improvements which farmers have

preferred have succeeded in advancing crop production in the wadis, with project results clearly superior to traditional methods for most of the economically important crops.

A. Soil enrichment: Farmers have learned to add manure, compost and sand to change the texture of soil. This not only increases porosity, which allows better water retention and better root development, but also decreases salinity. When a plant is able to develop a good root structure it is more vigorous and grows larger, gives more fruit, and lasts longer. With plants such as onions, carrots or beets, which are root crops, highly porous soil allows the bulbs or roots to grow much larger. The addition of manure, compost, etc. visibly increases crop yields because it adds nutrients to the soil and increases the soil's capacity to hold water, which makes irrigation more efficient. Unfortunately in the traditional system of shadouf irrigation, a farmer works the soil only to a depth of about 10-15cm. All this does is scrape off the top layer of soil where all of the decomposed humus and nutrients lie. This rich soil is used only to build the walls of the basin which retain the water, while the plants are grown on the denuded soil below. This habit also contributes to the formation of hardpan, which the environmental assessment noted directly below the tillage depth in most of the wadi. The hardpan layer is effectively impermeable to applied water, keeps valuable nutrients from reaching the plant roots, and encourages the rapid evaporation of irrigation water and the concentration of salts.

The final evaluation team observed composting in all the wadis they visited. Soil testing in September 1987 showed that there was a considerable deficiency in organic matter and nitrates. Test results of composted manure showed that yields of tomatoes doubled over traditional soil preparation. Onion yields went from 13-15t/ha. with traditional methods to 35t/ha with manure application. Onions are the region's most important cash crop and its major export. The results of using compost and manure were so striking to farmers that by May 1989, half-way through the project 64 farmers were using manure or compost.

B. Increased basin size and altered conformation: a number of different basin configurations and sizes were developed in response to different plant's water needs and farmers' ability to keep them properly irrigated. The wadi farmer seems in general to favor a large surface area over an adequate water application. Thus the plants may go too long without water, which distresses plants already are suffering from high evaportranspiration. The traditional square had a watered surface of 1 meter square, but the basin itself took up about 1.43 square meters because of the retaining walls and canals. In other words 40% of the surface area a farmer irrigated was taken up by the retaining walls and irrigation canals. The project has introduced a number of different basin conformations adapted to the needs of different crops and to the capacity of different water-lifting devices. The

farmers have found them so much more efficient that more than 70% of project farmers have adopted these new styles. 78% of project farmers have altered their basins to large basins with interior furrows. Basins with more closely spaced furrows, appropriate for crops, such as gumbo, which require more frequent irrigation have been almost as widely adopted. Changes in basin conformation also alter the place where the plants grow in the basin. In the new basins they are planted on the sides instead of the bottom. This has an immediate effect on yield because plants are not asphyxiated and so they develop more vigorously and more quickly. Moreover their leaves do not fall off for lack of air and so the plants remain in production for 2 or 3 months longer. With the new configuration seeds take less time to germinate; the time between seeding and transplanting onions, the most important cash crop in the area, is reduced from 45-50 days to 35 days in the new plots. They can, therefore, be transplanted sooner and come into production sooner, before most onions have reached the market. These plants are also noticeably more vigorous, not stunted and yellow, because they receive more oxygen. With tomatoes, when a basin is built with furrows the leaves and fruit of the plant are kept up, out of the water, so that the leaves do not fall off and less of the fruit rots. Because the plants are able to keep their leaves the length of the harvest is prolonged by 1-2 months.

Changes in basin size and shape were a necessity; for motorpump farmers. When pumps were first introduced farmers built the traditional small basins but the force of the water pumped out swept away the basin walls and canals. The speed with which water entered the basin had, in fact, been a cause of decreased productivity even in traditional shadouf irrigation. When the water entered the basin it destroyed the plants near the mouth of the basin. In nurseries the water swept away many of the seeds so that parts of the plot remained naked, without seedlings. The simplest change in basin shape which the project introduced, and the one to which practically all farmers respond positively, has been to dig a deep furrow all around the edge of the basin and to use that dirt to build the basin walls. This leaves a ditch just inside the perimeter of the basin into which the water flows in all its force. The propulsion is diminished when the water beats up against the middle of the basin which is at a higher level; then the water in the basin rises slowly and gently fills the basin without disturbing the plants inside. Another attractive feature of this conformation is that, instead of scraping up the surface dirt which is rich in nutrients, the way traditional farmers do, the interior of the basin is left undisturbed and the walls are built with dirt which is taken only from the adjacent ditch. This traditional method of soil preparation also contributes to the formation of hardpan, because the soil is not worked to any depth. Hardpan also inhibits root development. Thus even the simplest modification of irrigation basin preparation which the project has introduced has vastly increased crop yields, crop precocity and tardiness (and therefore the produce fetches higher prices), and reduced the negative environmental impact by combating hardpan formation.

C. Live fencing: Farmers were initially interested in live fencing because they had difficulty finding thorny branches to build the fences which were vital to keeping out domestic animals which ate the crops. The predations of goats and cows have grown worse as the continuing poor rainfall reduces the amount of forage available outside the wadis. Farmers were also hassled by the hefty fines the Foresters required them to pay every time they cut a branch to build or repair a wadi fence--3-4,000 CFA a branch, often as much or more as he earned selling his wadi produce each week. Live fencing has been a popular innovation in the project zone. Over 17 km. of live fencing has been planted in project wadis, an impressive figure if it is remembered that these trees must be watered by shadouf just like the farmer's productive crops. The value of live fencing to the farmers is so great that as many farmers followed in random surveys had planted live fences as had planted the economically valuable fruit trees. By mid-1990, 78% of surveyed farmers had planted live fences.

An interesting evolution in these farmers' view of live fencing has occurred as the trees have matured and grown. While initially the farmers were delighted by the fencing which kept the animals out of their wadi fields and the Forestry agents out of their pockets, now more and more farmers mention that they have observed that the fences act as windbreaks. They can see that the plants near the fence are more likely to bear fruit and are less stunted. A few farmers have started to plant fence-tree seeds in rows in the interior of their plots as windbreaks.

Live fencing is the most visible attention-getter of the projects activities and the most often mentioned by farmers who are not in project wadis. These strangers can look down from a distance on the waving green trees as they pass by along the dunes on business or for a visit. The spread effect of live fencing is great and the demand for seeds and for Technical Delegates to demonstrate planting methods is high.

D. Crop Diversification

Crop diversification has consisted of: 1) finding the best varieties of crops which farmers already grow and introducing them to other farmers; 2) introducing farmers to crops which others in the region grow but they do not--manioc for example was not grown in the eastern wadis; and 3) introducing crops new to the farmers but which would sell in the market, such as carrots.

Finding the best variety involved testing local varieties to determine their qualities, and comparing these varieties with commercial seeds. With gumbo, the agronomist learned that certain wadis grow gumbo which the consumer considers better quality and prefers to buy if she finds it in the market. The gumbo which some wadis grow tends to crush easily and turn to useless powder when it is dried. So the agronomist had to take the preferred varieties and get the farmers to see how they grow in the wadis to which they

were introduced. The farmers also tested new varieties from Senegal for example which had long green spineless pods and which might therefore appeal to the consumer. The aim was to find the highest yielding variety which would grow well and store well and be the most preferred by customers. The same sorts of trials were done for tomatoes, etc.

Some wadis specialize in certain crops, onions, or manioc for example. This quasi-monocropping has the detrimental effect of depleting the soil of certain nutrients and of creating an environment favorable to the development of pests which attack those crops. Yet within the project zone other wadis do not grow these crops at all. The agronomist and farmers ran tests to find which crops would grow in which wadis. Was manioc not grown in the eastern region, for example, because it was unsuitable or because farmers were not accustomed to growing it? The tests showed that at Ygra in the east it would not grow because of soil and water conditions while at Made in the east it grew well. Now the farmers at Made grow manioc, which gives them another product to sell on the market and gives them a bigger variety of produce to take to market -- which increases their chances of making a sale. Growing manioc gives them a crop which they can plant along the dikes, a space otherwise unused, and which can be stored in the ground until the time when there is little other produce coming out of the wadi and so they are having trouble finding something to sell. Introducing gumbo into a wadi where the monocropping of onions was common has the same effect, and also begins some form of crop rotation to help the soil and combat pests.

Farmers tried new crops such as carrots and potatoes to see how they grew and how they sold. These two crops have been an instant hit. They are consumed by the farmer's family and sell well in the local market. If any is left it can be exported. The same is true of garlic. Some farmers' wives have become wholesalers in garlic; they go early to the market and sell lesser quantities to other women who then sell it retail. Thus the introduction of garlic has given a new source of revenue not only to the farm family that grows it but to others in the zone. These new varieties also have a beneficial side effect of diversifying the local diet; carrots' Vitamin A is especially useful as a replacement for the Vitamin A lost from the dairy products which people now rarely consume because of livestock losses in the drought.

Some new crops are so alien to the local consumer that they have only a limited market. Some farmers grow beets and turnips, for example. They know if they take them to market and the local teacher or administrator comes that there is a sure sale; on the other hand, if someone who knows how to prepare these groceries does not appear, then there is no market for such an item. Increased variety has opened up new possibilities for the farmer but also presented him with the problem of marketing. The same goes for the spread of varieties which have higher yields; the farmer must find a larger market for his increased production. Thus the farmer's needs have evolved directly into a problem of finding

markets. At the same time the farmers know that a market already exists for certain items if only they can produce them and so they are interested in finding early- and late-producing varieties of popular items such as onions or tomatoes.

Limited crop choice limits farmers' ability to fully exploit market opportunities and therefore limits his ability to increase his income. It also has detrimental effects on crop yields. By diversifying the crops farmers grow the project has had a positive impact both on farmer income and on wadi yields.

5. Farmers Problems with Pest Management

Pest attacks have always been a serious constraint to expanded production. Phase I of the project was not designed to concentrate on pest management, though the agronomist tried to find pest-resistant varieties and to introduce the farmers to techniques which would be less favorable to the development of pests. The problem of pests is, however, a serious one. The ravages of rats and other predators in the early years of the project discouraged many farmers from wadi farming. In the cold season of 1991 pests' development was enhanced by unusual climatic conditions. Curly top, caterpillars (larvae of Heliothis armigera) althernariosis fungus, thrips and aphids, the list goes on, attacked the plants. The farmers' continual battle against pests serves as reminders that pest management is a problem which must be addressed if wadi production is to increase. Integrated Pest Management is the only non-chemical way for farmers to combat pests. It would have other benefits: less soil depletion through crop rotation, soil enrichment through the cultivation of leguminous crops, the introduction of fodder crops, etc. During Phase II an intensified effort will be made to develop non-chemical methods of pest management, particularly cultural methods such as removing pest vectors, inter-cropping and destroying residues. Integrated Pest Management is far less dangerous to the farmer and consumer than are the farmers' present attempts to combat insects, predators and disease (see section 3.2 B above). A consulting specialist will establish experiments in IPM that will be executed by project staff. At the same time as field trials of IPM methods are being done, the Farmer Trainers and Technical Delegates should have a simple pest education in order to work with the farmers with whom they are conducting trials. The Technical Delegates will subsequently be able to help other farmers link symptoms with causes and identify pests so they will see some purpose to using IPM and so they will know what to do when faced with an invasion.

. Increase in Wadi Production with New Agronomic Techniques

The four changes in agronomic technique most commonly made by local farmers has had a remarkable impact. By themselves or in conjunction with improved water-lifting these techniques have succeeded in increasing wadi production. A comparison of

traditional yields and averages attained by farmers using the new methods is convincing. Likewise the quantities of new vegetables produced are large.

	traditional	improved
Gumbo:	30 t/ha	40 t/ha
Onions:	20-24 t/ha	30 t/ha shadouf 40 t/ha motorpump
Wheat:	0.9- 2.5 t/ha	3.5-4 t/ha motorpump and shadouf
Sorghum:	1 t/ha	3.5 t/ha motorpump and shadouf

Vegetables such as eggplants are now producing much better: 40 t/ha with motorpump and 25 t/ha with shadouf. Tomatoes are at 35 t/ha with motorpump and 25 t/ha with shadouf; the harvest also lasts at least 2 months longer. Thus not only are yields increased with the new methods, which means larger revenues, but tomatoes produced beyond the time other farmers are growing will bring higher prices.

When farmers apply any of the four winning agronomic techniques their yields and income increase. They have realized that crop diversification has given them new markets to tap. But they have also realized that increased yield and diversity means that they must also find new markets. The use of these techniques leads inevitably to the need for marketing technology. Without these techniques the traditional markets will suit. The link between agricultural production using these new techniques and agricultural marketing is indissoluble and must be supported. Phase II has been designed to retain this support.

ANNEX E

ANNEX E: SOCIAL SOUNDNESS ANALYSIS

1. Methodology

The design team consisted of an economist/marketing expert and a social anthropologist. The anthropologist began her 16 days in Chad discussing the project with ORT technical and administrative staff, USAID, SODELAC (the development agency involved) and the Ministry of Plan. Accompanied by officials of SODELAC, the Ministry of Plan, USAID and ORT the team consulted local and traditional officials in the project area and, of course, farmers and merchants. The social anthropologist was already well acquainted with the project, having participated in the original design and completed two baseline data studies and a social impact study in mid-1990. On this trip she visited the project area again and compared the situation in the project and control wadis which had been monitored since 1987, before the project began. She surveyed the continuing evolution in farmers' needs and expectations. Past performance, present successes and problems, and possible modifications in the project were covered in conversations and meetings with ORT trainers, technical staff, credit groups and farmers. The marketing of inputs and outputs was discussed with farm families and merchants. Harvest and post-harvest activities which affect marketability were discussed with farmers and especially with farmers' wives who are in charge of these activities. Project reports and files were also reviewed.

2. Socio-Cultural Context

2.1 Wider economic and political environment

The Lac Prefecture, which runs along the north and east of Lake Chad, is part of the greater geographical and cultural area of Kanem. In 1962 the Lac Prefecture was subtracted from Kanem Prefecture, which now borders it on the north. The government hoped this partition would enable it to develop the potential riches of Lake Chad and its polders--fertile, naturally humid areas along the edges of the lake. Control of agricultural production and marketing in the Lac Prefecture was given to a parastatal organization, SODELAC, which was created to oversee the agricultural development of the Lac area. Over the years the Lac has been one of the major beneficiaries of development aid given to the GOC but, until after the 1980-85 drought, the area beyond the lake shore felt practically no development impact.

126

Like the rest of Sahelian Chad, the Lac Prefecture suffered extensive livestock losses, poor harvests and much social displacement during the 1980's drought. The drought hit production in the Prefecture, and especially Ngouri sub-prefecture, in three ways: poor rainfed millet harvests; corn, wheat and cotton polders which went out of production as the lake water level fell; and increasingly difficult shadouf farming in wadis as the water table dropped. As a result, the government became determined to help those farmers who were not so fortunate as to live along the lake shore. Since the end of the drought three major development efforts have been undertaken which have helped them. In 1988-9 the Italian government aid agency, FAI, built a compacted earth road east to west over the sand dunes, clay pans and salt flats from Massaguet to Ngouri-Bol-Baga Sola, greatly reducing the isolation of an area where transportation rates had been the highest in the country except for the Sahara desert.[1] ORT developed a basket of irrigated agriculture techniques which helped the wadi farmer bring land back into cultivation, increase surface area and improve production. The African Development Bank Doum-Doum project developed a bidon verseur for low cost irrigation in polders and wadis.

The importance of these development projects for the hitherto neglected parts of the Lac has been increased by continuing poor harvests in this region. For the last 10 years the area's staple crop, pennicillum millet, has suffered from inadequate rainfall. Except for 1989, the rainfed millet harvest has been little better than at the height of the drought. Although recently the lake level has risen slightly, most polders to which Ngouri farmers have access are still high and dry and unexploitable. Much of the livestock that died off during the drought is beginning to be replaced by new animals, but because of the lack of rain and poor forage many animals must be entrusted to pastoralists who graze them outside the zone. Hence the Ngouri farmers who own them do not profit from their milk products or the manure which improves fertility of rainfed fields, even though they are increasing their savings in on-the-hoof accounts. Fish, milk and butter, which had been important nutritional components of people's diet before the drought, are still hard to find and expensive. Most striking is the continued importance of wadi agriculture. During the drought it was

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[1] During Phase I of the ORT project the road was maintained by FAI; the road was recently handed over to the GOC. The same level of road maintenance and ease of transport will be an important assumption for the marketing aspect of Phase II. While developing marketing in local and regional markets will be important in Phase II because such markets are not yet saturated and because many more farmers own transport to get to these markets, markets in the zone should also be targeted because access to more distant markets may become much more difficult if the road degrades.

the only sustainable type of farming possible in the region. Since rainfed and polder production have not improved much during the project's existence, wadi farming has remained a major productive activity in the region. Wadi farming by shadouf has grown more and more difficult as the water table dropped. It is nevertheless the most viable form of agricultural production as is witnessed by the fact that once water extraction is not too difficult people will work in the wadis. At least 6/44 motorpump farmers and the bidon verseur field test farmer had given up wadi farming until the project, and some had even left the zone. The same is true for some simple shadouf farmers in the project whose wells were improved.

In the last few years the local administration has been exercising duties which during the disruptions of the early and mid-80s had fallen aside. Administrators have a better comprehension of the area under their control because census taking/tax collection has been reestablished throughout the area. As a result they understand more clearly the needs of the populace and can cooperate more fully with the project.The judicial system above the traditional level has become effective and so quarrels over land and chieftainships, disputes which had the most impact on project activities, are more readily quashed. Insecurity can always remain a problem but the only project farmers who seem to have been faced with difficulties were those who had valuable motorpumps or who held the savings of the Motorpump Group, Kida Boulim. They coped by hiding their valuables in the wadis.

2.2 Compatibility of Project and Society

The compatibility of the ongoing and proposed project and the people of the project zone is high. The main ethnic group in Ngouri Sub-prefecture is Kanembou. They are closely linked culturally to the people of Kanem to the north and of Bornou in Nigeria, who have a long history of powerful conquering states and sultans who rose and fell from the throne. The Kanembou of the project zone, though their long connections with these ancient empires, also maintain a hierarchical government structure and a strong feeling of the importance of the past and of the power of tradition.

A major effect of this reverence for tradition is that people of the Lac region are committed to the land of their fathers and forefathers, to their villages and to the farming traditions of their ancestors. They do not want to leave the area, dislike leaving the area, and do so only because of economic necessity. Although unmarried teenage boys often travel seasonally to the city to earn money to help out, they almost inevitably settle in the village once they marry. Here the lure of urban areas rarely competes with the joys of home. One of the most frequent requests Kanembou made to the team during the initial project design in 1986 was to find a way to allow them to continue wadi farming, which they had been taught by their parents from early childhood, so that

they would not have to leave their homes and the area they loved and move to the city where they could find cash employment. This commitment to the wadis remains. While intensity of wadi farming varies slightly according to the quality of the rainfed millet harvest, most farmers will continue wadi cultivation. The impact of a good rainfed crop on the amount of wadi land under cultivation will have a negative economic impact only on those farmers who have motorpumps and must earn enough from wadi farming in the rainy season to pay their credit[2]. If the Motorpump Group modifies its payment schedule to vary the size of payments due with the productiveness of the season, as has been proposed in the General Assembly of the Motorpump Group, the negative impact will be greatly reduced.

Commitment to the wadis and the wadi farming traditions of their ancestors does not, however, mean that the farmers of the project zone are conservative and unwilling to change. The 61% of project farmers using at least one new agronomic technique and the 11% of project farmers using motorpumps (with a waiting list more than twice as long as the number of pumps available, which shows the constraint is lack of money, not lack of interest) both testify to the openness of local farmers to adopting new methods which they deem useful. One characteristic of the project's intervention has been of great importance in getting farmers to adopt new techniques: the fact that ORT has developed a "basket" of techniques, not a "package". The farmer can pick and choose techniques which he finds suitable and helpful. The techniques are not all so closely linked that adopting one without the other, improved seed without fertilizer, for example, will lead to the failure of all. Each farmer can therefore progress at his own speed, according to his own needs [3]. A number of project farmers gave their critiques of various innovations, during the end-of-project sociological impact survey, saying not only that a certain

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[2]. Negative impact on farmers with bidon verseurs is much less likely since the bidon will probably be paid off in one cropping season and it is unlikely that anyone would take out a credit to farm in the poorest wadi cultivation season, the rainy season.

[3]. In the final evaluation of Phase I it is noted that the farming techniques were hardly accepted and that farmers remained attached to their traditional techniques (Annex B, p2) and that the new methods are being tested on small plots but not extended to the whole farm (Annex C, p.5). It is not surprising to the anthropologist that a subsistence farmer should be cautious about committing his entire field to a new method which may not work in as yet untested circumstances, even for several years in a row, since weather is never the same. Nevertheless two techniques, large basins and basins with furrows are not only accepted by large numbers of farmers but considerable areas are under cultivation with these methods.

technique was good for such and such a reason but that they had seen, or had heard, that their grandfather employed the technique but it had fallen into disuse. The anthropologist does not have information to judge whether this is or is not true but it is clear that retroactive social acceptance of "new" techniques is being conferred.

The importance of status and hierarchy in Kanembou culture has a number of more and less subtle consequences. The project has dealt directly with the more evident ones. The project, recognizing their capacity for obstructionism, has worked from the beginning with and through the traditional leaders of the area. In Phase II the project should use the high visibility and the role of information clearinghouse of traditional leaders to help with the spread effect. Traditional leaders should be kept fully informed and up to date on project activities, modes of access to project knowledge, etc. so that they can inform those of their subjects who are interested, and perhaps even do some propagandizing. To date traditional leaders have been very enthusiastic and helpful and are eager that the project continue as before.

A less direct effect of this preoccupation with status is the importance of having a title or a position. Having a title or visibility without power is more important than exercising power without any recognition. This means that people's positions must always be accorded honor and deference in order to avoid disgruntlement, but it also means that if one gives recognition one may be able to retain power and exercise it through other back channels which are more effective. The relevance of this for getting around obstructionists is evident. Another consequence is that a person may work very hard and be very committed to something which will give him high visibility and importance, so that a title or status symbol may be a very good motivator. Obversely, someone with a title but who does no work may fight very hard to hang on to that position. The project can use titles and status symbols as powerful motivators and, where that does not work, realize that people who hold a position may not necessarily resent someone else quietly exercising the power that goes with it.

The importance of hierarchy and status also creates an environment in which factionalism is rampant, both among political groups and within families. Manoeuvering among factions, which continually appear and disappear on the political scene, is endemic. It has been and will be inevitable that the project will become involved in local factional disputes over access to wadi land, access to credit, etc. but the project has not created these divisions within the society; it is simply being used as a pawn by factions which would have expressed themselves in some other way. Because factions are trying to gain control they want to manipulate but not to destroy what they eventually hope to gain for themselves. It is unlikely that factions would try to undermine the project, rather they will support it and try to manipulate it so

that their wadi gets access to the project. The project should continue to work through regularly constituted authorities and let them resolve any unpleasantness that a faction may create. So far the project has been able to implement its activities by remaining unperturbed and neutral; this should continue.

Factionalism within the family bears a number of consequences which the project has recognized. It has found small-scale technologies which allow the traditional configuration of wadi parcels and allow traditional irrigation by an individual, spouse and children. Any groups which are formed are made up of people who voluntarily associate themselves with people they feel they can rely on and trust and want to work with. All this reduces the chances that people who are working in the project will refuse to cooperate because of family feuds.

2.3 Ethnic Overview

The history of what is now the Lac Prefecture is intimately bound with what happened to the north, in central Kanem. The Ngouri area has felt the comings and goings of different groups over many centuries as warfare over control of the Kanem-Bornou (Chad-Nigeria) empire shifted from one ethnic or political group to another. The Ngouri area has the ethnic composition of present day Kanem but with a special twist: as a border area it was often politically independent or less directly controlled by the central authority in Mao. Hence people often chose to settle in this zone to avoid close supervision and many of the present-day inhabitants are members of a minority group which is widely discriminated against.

The Kanembou are divided into a number of clans claiming kinship with one another. Some areas are for the most part inhabited by one clan but in the target area around Ngouri no one clan is dominant[4]. The homogeneous character of each village is particularly striking and most people in a village are related. 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, a mythical explanation for the fact that these two clans are "Haddad", a subordinate caste of ironworkers, potters, tanners, weavers, etc. A disadvantaged, pariah group, the Haddad are looked down upon and cannot intermarry with other Kanembou. 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, qualities which were typical of wadi farmers. Indeed many wadi

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[4] M. Bouquet, 1974, Les iles et rives du Lac Tchad, p.42.

farmers are Haddad, especially in the Ngouri area. However, with the drought many wealthier Kanembou lost their fortunes and Haddad wadi farmers, who were used to exploiting what became one of the few remaining viable resources, found their relative economic position somewhat improved.

The Kanembou were part of the Empire of Bornou, historically dependent on Bornou (now in Nigeria) and its representative in the Kanem, 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 the government administration who confers upon them the position of chef de canton.

Traditionally the Mai, also known as the chef de canton, is "owner" of the land and organizes and controls the population. The people under his control are administered by Mara Kerei or village chiefs who are the liaison between the villagers and the Mai. Mai at sometime in the past made land grants of dunes used for rainfed agriculture to Mara Kerei in exchange for their fealty and gifts donated by the people. They made similar grants of wadi land to Mara Blai, who control only the land in the wadi, not any people. The Mara Kerei and Mara Blai are often from the same family if not the same person. Any dune or wadi land not so granted remains under the control of the Mai; not only can he grant it, he can also reclaim land grants of his ancestors and give them to someone else. Customary annual payments recognizing farmers' indebtedness to the traditional chiefs who granted the land and retain final control are now voluntary, not required. It is generally accepted that a farmer has no moral obligation to pay if his harvest was poor.

The Mara Kerei administers the population living on the land granted to him or his antecedents as both the traditional Mara linking the populace to the Mai and as the official representative of the national government, the Chef de village who reports and gives tax payments to his superior, the chef de canton, who then reports to the sub-prefect. The Mara Blai has no official government function or recognition. He still actively fulfills his traditional role.

Officially the state is the owner of the land and can grant it to individuals who take the necessary legal steps to acquire part of the national domain. In fact the traditional and legal systems overlap, as the administrative organization of the area shows, and almost, if not all, landholders have only traditional rights to their fields, rights which are upheld by the local and administrative courts. The project has therefore dealt with the status quo of landholding. It is always possible,if wadi land becomes valuable enough, that some people may try to lay legal claim to land traditionally exploited by others. This is unlikely to occur within the 3-year lifetime of Phase II.

2.4 Traditional Economy of the Project Area

Most people in Ngouri sub-prefecture are sedentary agropastoralists. They grow their main food, rainfed pennicillum millet, on the dunes and keep small herds of animals which they pasture near home so that they can be milked and their manure can fertilize the dune fields. Many also farm in the polders or wadis which are found in this zone. Because polder farming and some wadi farming is done after the results of the rainfed harvest are known, wadi and polder farming, rainfed agriculture, and commerce are all linked together. A farmer tries to compensate for poor results in any one domain by increasing production in another. As a result the intensity of wadi or polder cultivation depends greatly on the size of the millet harvest. In the 6 original project wadis, for example, the wadi area cultivated dropped from 38 ha. in 1987 (the first year of the project) to 33 ha. in 1989, following the good rainfall of 1988, but bounced back in 1990 to 40 ha.after the poor harvest of 1989.

Farmers in the southwest part of the project zone, which is nearest the polders, frequently cultivate in the polders from November to June, which nicely complements the rainfed season of June-October. Yields in the polders can go as high as 3.5 tons per hectare for corn and 4 tons per hectare for wheat, which considering that the investment in time and money is not great (usually only one weeding is done), is very profitable. The yield may also be much lower, depending on the soil's humidity and the weather but, again, the investment is not great. In some years the polders are unexploitable because the lake level does not rise enough. The area nearest the polders is already 50 km distant; farmers from other cantons in the project zone are less willing to travel longer distances. Farming in the wadis is a more certain proposition than in the polders but it requires much more labor -- in the southwest, where wells are relatively shallow, a farmer still can cultivate only 15-25 ares with a shadouf, and in the rest of the zone where wells are deeper only 7.5-12.5 ares are cultivated at a time. The amount of time a farmer puts into wadi farming is secondary to the demands of dune agriculture; 31% of wadi farming is done in the rainy season, even though the rain reduces the amount of irrigation required, compared to 44% in the cold season when more irrigation is required.

The small surface areas -- averaging from 12 ares/year in Ngouri to 24 in Dibininchi -- indicate the difficulty of irrigating by shadouf in a climate with strong winds, low humidity and high evapotranspiration. While the project has introduced technologies which reduce the difficulties, only 3-5% of the project zone's population has been reached so far. The concerns of the majority of wadi farmers in the project area remain food and water. Since rainfall has remained erratic and millet harvests insufficient for the most part farmers have turned particularly to wadis to make up the deficit. However the problems identified before the original

project -- wells and water-lifting, sufficient production and fencing -- remain a problem for most wadi farmers.

Ngouri farmers have two strategies for increasing their access to cereals through wadi production: (1) cultivate additional wadi cereals or (2) cultivate cash crops, usually vegetables, to buy supplemental grain in the market. Cereals are more often grown in wadis with a shallow water table (Ndjiguidada and Dibininchi) because the large surface areas demand more irrigation. 58%of Dibinininchi project wadis'surface area was in cereals in 1989-90 and 28% of Ndjiguidada. In the deeper water areas of Cantons Ngouri, Yalita and Baderi farmers more often elect to grow cash crops; 23% of Ngouri was in cereals and less in the other two. 21/27 pilot wadis emphasize wadi cereal/manioc production during the rainy season and the cold season when wheat can be grown. This could be a concern as far as motorpump farming goes, since mechanized farming requires cash to fuel and repay the pump. Since most wadi cereal is grown for home consumption and since it is low value produce it becomes harder to pay for a motorpump. However up to now more often those who chose to use motorpumps are farmers who live where shadouf farming is difficult, i.e. deep water zones, precisely the areas where more high value cash crops are grown. Hence, although only 20% of cultivated wadi surface area was irrigated by motorpump in 89-90, 61% of deep water Ngouri was under motorpump, 20% in Dibininchi and 5% in Ndjiguidada. Motorpump farmers are, on the whole, concentrating on cash crops and shadouf farmers on cereals. Also some motorpump farmers who grew cereals in the first season they owned a pump subsequently switched to vegetables. The bidon verseur may fill an intermediate role, being a cheaper way to augment surface area and a more efficient, less backbreaking way to ensure adequate water for cash crops.

The third strategy for augmenting rainfed cereal production is to engage in commerce. In areas where wadi and polder farming is less widespread trading is more common; people use the profits to buy grain.

Table 1

% OF HEADS OF FAMILIES ENGAGED IN ACTIVITIES:

Canton	wadis	polders	commerce
Ndjiguidada	97	39	7
Dibininchi	74	10	14
Ngouri	38	1	27
Yalita	31	13	43
Baderi	17	0	39

Rainfed and polder agriculture might interfere with wadi farming since a good rainfed year takes pressure off the household to produce supplementary grain. Farmers may more actively engage in wadi irrigation and apply project techniques and technology in bad years but be less assiduous (and less able to repay credits or save for amortization) in good rainfed years. Some project farmers have, however, indicated that they now perceive that high value crops are a better subsistence guarantee than cereal crops; other farmers are not yet convinced. Secondly, merchants may put their business before wadi farming. Selection of project participants by amount of income derived from agriculture, however, would reduce the risks involved in involving people who will abandon wadi farming for commerce, since farmers who earn below a certain farm income are more likely to engage in commerce than those who earn more.

Seeing commerce in the context of an individual's development makes its role clearer. A pre-teen or young teenager in a family strapped for cash will often hawk wares on market days to supplement the family's income and help his father do wadi farming the rest of the week. More mature teenagers and young men who are only recently married and have no family responsibilities (the wife has not yet come to live with him) often go in the dry season to towns to work as street hawkers or brick makers. If they are lucky they may earn enough to buy a few petty trade items to sell at home and earn more. Likewise the dream of poor young wadi farmers is often to sell enough produce to have a capital to go into petty trade. In other words hawking and wadi farming are ways out of poverty. With the capital from these sources a few will succeed and make enough from trade and rainfed farming to live and some may even become fairly well-off merchants. Many petty traders fail; they go back to wadi and polder farming to supplement their income, some disabused of the possibilities of trade and committed to wadi farming, a few still dreaming. A few remain farmer/traders, dependent on both rainfed farming and minor trading for a living.

It appears, from preliminary data, that the motorpump and bidon verseur may be offering new opportunities in this scenario. The bidon verseur may offer capital poor farmers a chance to increase their income without the fatigue of shadouf farming and the risks of commerce. The motorpump is another place for a farmer who has made quite a bit out of commerce to invest his capital productively, and so stay in wadi farming instead of leaving it entirely for commerce.

A rural village might contain several farmer/traders; sometimes one of them will have succeeded in amassing enough capital that business is his main occupation, supplemented by rainfed farming. Thus a village here and there will have an onion or a natron trader, a "commis de charge" who negotiates providing full loads for truckers, etc. These are all people firmly linked to the farmers of their locality, who live among them and yet have

business ties with the outside. The most successful may set up boutiques in town, or even move there but there is available to the project a wide range of merchants with different talents who are well aware of farmer needs and demands and who have an interest in helping them, if it is a reasonable business proposition.

For the poor other non-agricultural sources of income may be one of the traditional trades: blacksmithing, tanning, etc. or pottery and hairdressing for the women, if they are "Haddad". Many make bricks in the dry season. The 1990 Social Impact Study found, however, that these marginal wadi farmers were less likely to adopt new project techniques. Some of these talents may be used for sustainable production of clay tubes for wells, tools and bidon verseur.

The final element in the traditional economy is livestock. Cattle are a highly desired sign of status and wealth, as well as a useful productive asset (milk and manure) and a form of savings-on-the-hoof. The Kanembou are sedentary cattle owners; the majority of the family stays at home with a small domestic herd of milk cows when the pasture is depleted while one or two family men take the remainder of the herd elsewhere, or else confide them to some nomads. Wadi farming and cattle-keeping (and large-scale livestock holdings of any sort) are antithetical. People with lots of animals tend to move away from wadis to reduce the chances their animals will destroy wadi produce. People who engage in wadi farming tend to be poorer because all it demands is "sweat equity", not capital, as livestock does. Nevertheless every farmer's dream is to own cattle; the problem this poses for the project and for sustainable agricultural development is whether farmers will invest in technology and amortization costs and sell their "savings bulls" if they need cash to pay debts or buy new equipment.

Transport animals are also kept with the family herd. Donkeys are the most commonly owned transport, at least one per family. Before the drought Kanembou did not commonly own camels, which could not tolerate the climate year-round. Now camels are a preferred form of transport because they can carry so much, but they have two drawbacks: they are expensive (7-8 times the price of a donkey, 2 times the price of a middling piece of horseflesh) and, unless born of another Kanembou camel, liable to be "reclaimed" by some pastoralist who says it was stolen from him. Only 1 out of 6 families owns a camel. To transport large quantities a person will either borrow more donkeys from a friend or relative, rent a camel (which for one week's rent costs half the purchase price of a donkey), or pay for automobile transport if it can be found. These transport difficulties limit donkey owners to the local markets, camel owners to regional markets, and risk-taking farmers to automobile transport since they need to cover their transportation costs. Traders fill the niche of moving produce to more distant markets.

An aspect of the traditional economy which needs to be studied by the marketing specialist is the onion-marketing group which exists at Molori in Canton Ndjiguidada; perhaps similar groups exist elsewhere or for other produce. It might also serve as a model for marketing. Farmers (men) confide their produce to the Mara Kerei/Blai for sale. Much of the marketing of produce is, however, in the hands of women; they do the selling but the revenue belongs to the male head-of-household if there is one. Likewise most of the harvest and post-harvest activities and transformation are in the hands of women, including storage and culling. The storage facilities are, however, built by men. These activities also need to be more clearly understood. In addition, it should be noted that there are a few women traders who own boutiques, move entire truckloads of goods, and regularly engage in cross-border trade. They too might have a role to play.

The financial status and food reserves of farmers in the project area can be projected from project statistics. The income figures of wadi farmers gathered as baseline data in 1987 for the Ngouri area, figures which should be fairly representative of the condition of farmers not yet affected by the project in 1991, are as follows:

Average income: 149,000 CFA

Median income: 122,000 CFA

The modes of incomes for 29 wadi farmers on whom the project kept very accurate records shows:

Table 2

% wadi farmers with CFA incomes below:

60,000	150,000	200,000	300,000	400,000
24	31	10	28	7

The harvest figures gathered in June 1990, i.e. from the particularly bad 1989 harvest, and not therefore what farmers are eating in 1991, shows that the sampled families had harvested enough cereals for the following number of months:

Table 3 : % of farmers having this many months worth of cereals

months	0	1	2	3	4	5	6	7	8	9	10	11	12
only dune farmers	53	16	16	2	6	4	0	0	0	0	0	0	1
dune/polder farmers	38	21	21	2	2	10	2	2	0	0	0	0	2

137

These figures indicate how dependent many farmers in the Ngouri zone are on wadi farming or other sources of income in order to have enough grain to feed their families. For those lucky enough to have a usable polder, farming there can make a difference -- 10% of polder farmers ate up to three months longer than simple dune farmers who had good harvests -- but even polder cereals were not enough to fill the void for 5 months of the year.

3. Feasibility

The proposed project appears to be socially feasible. It has been designed to be similar to Phase 1 and to use both the technical and organizational strengths of Phase 1. The Social Impact Survey done at the end of Phase 1 found that 90% of the randomly selected farmers in both project and control wadis were in favor of the project continuing. Each year of the project's existence a number of wadis have voluntarily asked to be included in the project, another indication that it is well-accepted. During the final sociological survey all the randomly selected farmers were asked how they wanted the project to be modified. Farmers already participating did not want any changes but those who had been longest in the project hoped that problems of inputs, marketing and land preparation would be addressed. Control wadi farmers hoped that they would get access to project techniques. During the design of Phase II local merchants and petty traders were also consulted and many expressed an interest in the business opportunities which input and output marketing offered to them.

It is perhaps useful to reiterate a point made in the original design document (Annex K , p.8) because it bears heeding in the second phase as much as it was followed in the first. Although the traditional government structure is strongly hierarchical, decision-making and implementation at the local and village level is very democratic. The village chief may state that his villagers will participate in the project but in fact it is the villagers, not the Mara, who determine whether they will participate. They will discuss it among themselves, its pros and cons, and decide whether they will participate or not. The Mara cannot get the villagers to do anything they do not accept. This decision making process, where a series of discussions leads to a general consensus, occurs over any project intervention. While one cannot count on the Mara to "deliver" on any promises he makes unless his followers also agree, this process does guarantee general support for any activities which the villagers undertake.

Some wadis were uninterested or refused to participate in the project during Phase I. Since the refusal of some was based on the misapprehension that their lands would be appropriated by the project or SODELAC this does not mean the project is not feasible, only that an attempt at informing and educating people in the zone should be made. Other non-participating wadis were afraid to get

involved with higher authorities or open themselves to political manoeuvering by different factions. However, of 26 wadis considered for inclusion in years 2 and 3 of the project only 3 did not wish to participate, which does not indicate much of a problem with feasibility.

The most important problem concerning the feasibility of the second Phase is the problem of farmers' ability to purchase motorpumps, tubewells or bidon verseur, to repay credits and to keep up operations and maintenance of their water-lifting devices. The viability of the Kida Boulim, the motorpump credit group, is part and parcel of this problem.

The 1990 Social Impact Study demonstrated that farmers earning more than 250,000 CFA in annual agricultural income could probably purchase or replace their pumps without credit or with credit and a large downpayment. According to Table 3, 7% of the farmers in the study had income over 300,000 CFA. Farmers earning 150,000-299,000, or 38% of the farmers, could probably repay credit, although those below 200,000 would have more difficulty. Between 60,000-149,000 (31%), some farmers could probably manage credit payments but others might default. Below that level farmers' commitment to wadi farming is too tenuous. Income earners ranging between 60,000 and 150,000 are probably good targets for the bidon verseur. Those earning 150,000-299,000 will need some form of credit to purchase a motorpump or could buy a bidon verseur without difficulty. The longer term problem of sustainability, i.e. the ability to replace a defunct pump, is more disconcerting. It is extremely difficult for farmers, no matter how wealthy, to save large sums of money because they face continual problems of cash flow and social demands. The project must continue to discuss the problems of amortization with farmers. The Kida Boulim might also consider taking in additional payments from a farmer after he had paid off the motorpump credit; these payments would go into the revolving fund for purchasing motorpumps for other members but would also be counted as prepayments for another replacement pump. The merchants who import the motorpumps may also be willing to work out some arrangement.

According to these figures and the economic analysis presented in Annex F, motorpumps and bidon verseur are both viable technologies. Why then should the Kida Boulim have trouble with credit repayments? Initially the motorpump group had no problems with repayment and it was only after the rainy season wadi harvest that some farmers had trouble making payments. This is because much less wadi farming is done in this season--some farmers don't plant in the wadi at all--and much of what is grown is cereal rather than the cash crops necessary for credit payments. The subsequent due date passed with very few payments being made for two reasons: the cold season harvest had been ravaged by pests and, much more importantly, the rumor had been circulating widely that because the project was coming to an end ORT was going to reclaim the motorpump

fund. Once this rumor was quashed the repayment rate went rapidly up to 80% by the end of March 1990, the last date for which information for this report was available. Several lessons can be drawn about the viability of the motorpump group from the actions members took when faced with these two problems. Preeminently, the Kida Boulim has become a vital and active group, able to take decisions on its own, without the advice of ORT, and able to fight to defend its own interests. Faced with the (imagined) possibility they might loose their funding the Executive Committee met and agreed that no one would speak or take any actions vis a vis ORT or the design team until the entire body gathered for the General Assembly. They also agreed on an agenda which would protect their members, i.e. the non-payment of arrears until the situation was clarified. At the general meeting they took steps which showed that they were willing to act independently of ORT and would make their own decisions. The meeting was marked by factional plays and outburst of long-standing rancor, but the underlying verity was that the Kida Boulim was standing on its own feet, without ORT's support. The group itself had learned several lessons from its repayment problems; they proposed in the meeting that the dates of payment be modified to fall in conjunction with the sales of wadi produce. Another conclusion to be drawn, beside the fact that the pest problem must be dealt with, is that even with a bad harvest most motorpump farmers will try to keep their pumps. Another is that the motorpump group itself should be in charge of repossessing motorpumps for non-payment; the date of repossession should be clearly stated as X days after the due date, and that date should fall before the sowing for the next season has begun, since the farmer may plant too large a surface area for a shadouf if he thinks he will have a motorpump. The final lesson about the viability of the Kida Boulim is that it is extremely jealous of its status as provider of motorpump credit in the zone and wishes to maintain its monopoly. If alternative providers are set up it must be handled very delicately and, if possible, be done in areas outside the geographical domain of the Kida Boulim.

The interest expressed by farmers, their ability to support the cost of water-lifting technologies, the vitality of the motorpump group, and merchants' interest in the business opportunities offered by the project all make the project appear feasible.

4. Host Country Commitment

The Ministries concerned with the proposed project were consulted during the design process. The Ministry of Plan and SODELAC, the collaborating agency, sent representatives with the design team for site visits. They conferred intimately and worked closely with the team in elaborating the project. Both the Ministry of Plan and the Ministry of Agriculture have expressed the hope that the project would be continued in Phase II in order to consolidate the important gains made in Phase I.

SODELAC's cooperation can be one measure of the host country's commitment. Before the ORT project, activities of the SODELAC agents assigned to the Ngouri area had been hampered by lack of resources, especially transportation, and, for many agents, a language barrier. As a result their impact in the zone was limited. The training system ORT developed using local trainers and farmers to train other farmers has resolved the problems of communication and contact with distant wadis. In the field a number of agents from SODELAC and the GOC forestry agency have worked closely with ORT and shared the same resources. Many agents have found working in concert with the project and using the ORT system of technology transfer allows them to accomplish their jobs in a more satisfying way than before. They are convinced of the value of the "Delegue Technique" system and would like to see it extended to other areas where SODELAC agents are still hampered as they once were. They also see the potential for ORT's water-extraction technology in other SODELAC areas. If SODELAC wished to select qualified and cooperative agents they could be trained to use the successful ORT methods in Ngouri and elsewhere in the Prefecture. At the same time they would serve as a link between the farmer and the regional development agency and the national government.

SODELAC has signaled its willingness to continue its collaboration with the project in a second phase.

Regional Administration authorities have always been helpful to the project in the past. Traditional authorities in the area are also convinced of the project's usefulness for their people.

5. Collaboration

GOC collaboration is an integral part of the project. SODELAC agents will continue to perform an important part of the project's activities. SODELAC agents will also receive training in project techniques and implementation methods.

6. Beneficiary Participation in Problem Identification

In interviews, village notables and farmers were invited to identify their major problems and possible solutions. In the control wadis and wadis not participating in the project the major problems mentioned were those which the design team had encountered in 1986-7:

- the shadouf is an exhausting and limiting water-lifting technology
- traditional wells do not provide enough water
- it is difficult to produce enough in the wadi to make up

141

for the deficit in rainfed cereals

- fencing

In the wadis where the project had intervened for the last 1 to 3 years there was a clear evolution in farmers' concerns.

Table 4

Number of mentions by 46 randomly surveyed farmers:

number yrs in prjct	1	2	3	Ctl
transport	26	4	0	0
credit	19	2	0	0
seeds/fences	16	3	3	2
marketing	15	3	0	0
land preparation	14	2	0	0
water-lifting	5	2	2	2
storage	4	1	0	0
gas	2	0	0	0
pesticides	1	0	1	2

NB. The number of farmers sampled in years 2 and 3 were only 12/50, hence the numbers for these years are much smaller.

Farmers who had spent the longest time in the project were the most concerned with marketing since their farming techniques had evolved the most (the length of time a farmer spends in the project is correlated with an increasing number of techniques adapted). Others were proportionately more concerned with food, water and fencing.

7. Social Consequences, Benefit Incidence, Equity

7.1 Beneficiaries

The present population of Ngouri sub-prefecture, the project zone, is 82,216 people, according to government figures. From the ORT project studies showing that the average family size is 5

142

people it would appear there are about 16,216 families in the zone. Since ORT studies also show that approximately half the families in this area engage in wadi farming,this means about 8,714 families could benefit from the project.

A 1987 project survey distinguished 627 wadis in the Ngouri sub-prefecture, of which 173 were being farmed and 278 were not exploited even though they had suitable soil and non-saline water. Some of these 278 wadis have been abandoned over time. Old people recall that wadi farming was more widespread in pre-drought times, before 1980, when a shallow water table which used to characterize many wadis required less effort from a shadouf farmer. Thus one and a half times as many wadis could be used in wadi agriculture as at the present time.

The farmers' capacity to pay for improved water-lifting technologies and tubewells will not restrict the number of farmers who can benefit during the project's lifetime. Using the income figures from Table 2 and the extrapolated figure of 8714 wadi farming heads of household gives the following:

> 600 heads of wadi farming households able to buy advanced water-lifting technology without difficulty
>
> 3300 heads able to buy motorpumps with credit or <u>bidon verseur</u>
>
> 2700 heads able to buy <u>bidon verseur</u>

Thus the potential client base for the dissemination of these improved technologies is substantial.

In the first phase of the project only about 3-5% of the population of the Ngouri project zone has been reached. The positive reaction and desire to be included in the project expressed by many farmers who were not touched by project interventions but who were monitored throughout the first phase [5] shows that many of the remaining farmers in the project zone still face the same problems (see Table 4) in food production and would like to participate in the project [6]. In other words the model developed in phase I has a receptive audience of up to 8,713 wadi farming families, and perhaps more if others return to or take up wadi farming, waiting for its replication in Phase II [7]. The limit

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[5]. Pp. 11-2, 44, Social Impact, 1990.

[6]. Ellen Brown, <u>Social Impact of the Lake Farmer Training Project End-of-Project Survey and Analysis</u>, ORT, N'Djamena, September 1990, p. 15-16.

[7]. <u>Ibid</u>, p.iii.

on the number of beneficiaries reached in Phase II is not the number of people interested but the project's capacity to reach them.

8. Spread Effect

The spontaneous spread effect of the project increased markedly towards the end of Phase I. At the time of the Social Impact Study, which was done three years after the project had begun its activities in the field, the technique which had begun spontaneously to spread to other wadis was live fencing. As the most visible of project interventions it was easy for non-project farmers to see its impact. They could also apply the technique without much difficulty. All a farmer had to do was get the seeds from someone; the methods of planting and watering were the same as those used on traditional wadi crops. Farmers who were monitored in the control wadis were vaguely aware of a number of the changes in agronomic techniques -- changes in irrigation basins, for example -- and aware that some project farmers were using motorpumps. Some even knew how to construct the new basins because they had observed them in the parcels of friends in other wadis. But they were still unwilling to use them because they felt they did not fully understand the consequences that basin changes would have on the amount of irrigation they would have to do. For this reason they were interested in having project personnel and delegues techniques come work in their wadi. At the time of the Social Impact Study the spread effect was therefore limited to the idea that the way to acquire new technology was to ask for project intervention. This particular sort of spread effect had already become noticeable. A number of wadis had asked the project to be included in the project so that they could benefit from the opportunities they had seen in other wadis. Some individuals had asked to join the motorpump group and receive training in operations, maintenance and agronomy. Other farmers in these motorpump farmers' wadis asked for help from project personnel when they came to visit the motorpump farmer. However, six months later, when the design team for Phase II visited the area, the social scientist found that the monitored non-project farmers, and other non-project wadis also, had begun to ask their peers, the delegues techniques in other wadis, to intervene. One wadi chief (Mara Blai) had asked a delegue technique to come improve his traditional well. If it worked the other farmers in the wadi were prepared to ask him the very same day to apply the same techniques to their own wells, because their water table had dropped sharply in the last wadi farming season. In another wadi the farmers had chosen one of the young farmers to go apprentice himself to the delegue technique of the neighbouring wadi so that he could learn the new techniques and teach them at home. The farmers in the non-project wadi even referred to this young man as their "Delegue Technique." The project's techniques were beginning to have a strong spread effect.

There is, however, a powerful constraint on the spread effect

144

in the zone. The wadis in the area are physically isolated and travel is difficult. Most people in the zone lead very constrained lives. Many of the sampled farmers had never been more than 20 km. from home. People travel mainly to other villages where they have relatives and in-laws (and marriages tend to be in villages nearby) and to local markets. Their knowledge of what is happening in their prefecture, beyond a very limited circle around their own village, is practically non-existent. Most of the 60 farmers who have joined the motorpump group had never visited the wadis of other group members until the unit was formed. This geographical and social isolation means that the spread effect of project techniques is limited to a confined zone around a project wadi. The spread effect within that zone may be considerable, as it now appears is the case, but beyond that zone it is almost impossible for the project to have any spread impact, simply because the farmers never come into contact with any of the effects of the project. In order for the spread effect to work throughout the zone the project in Phase II needs to attain a fairly even geographical distribution of project wadis so that the wadis surrounding them will be able to learn from observation and from the delegues techniques. It will not be necessary for the project to intervene in every wadi to reach the remaining 95% of the population. A small investment in the training of more ORT Farmer Trainers and delegues techniques is all that is needed. Since Farmer Trainers travel by foot or by horse and visit their wadis at least once a week to support the delegues techniques, the zone one Trainer must cover cannot be too large. But once the Farmer Trainers and Technical Delegates are lightly scattered throughout the zone the spread effect in areas as yet untouched should be the same as is happening around where the project has already intervened.

9. Conclusion

In summary the proposed Phase II project fulfills all of the criteria for a socially sound project: it is culturally compatible, will cause little social disruption, and will help socially and economically disadvantaged farm families who have a strong agronomic ability. The project is feasible because it follows the same overall approach and organization that proved successful in Phase I. It responds to the strongly felt needs of farmers in the area, both those who have already participated and those who have not yet benefitted.

145

ANNEX F

ANNEX F: ECONOMIC AND FINANCIAL ANALYSIS

Introduction

This annex is divided into three parts. Part 1 presents a financial analysis of the entire project investment. Part 2 presents an economic analysis of the motorpump and other individual project interventions, (Part 2 is extracted directly from the AID final evaluation of the project). Part 3 is an economic analysis of the bidon verseur technology.

PART 1 : FINANCIAL ANALYSIS OF PROJECT INVESTMENT

Benefits

Benefits associated with implementation of Phase II of the Lake Chad project are based on three sets of assumptions about the degree of impact that adoption of project techniques can have on a participating farmer's annual wadi income.[1] Estimates are derived from the base economic data presented in Annex F, Parts II and III.

The most significant tangible benefits are expected to accrue in the following areas:

a) **Increased crop production due to improved wells and water-lifting techniques.** Improved wells increase the availability of water for irrigation, and improved water-lifting devices allow for expanded and intensified land use. The resulting increases in production result in increased farmer income.

b) **Increased crop production due to improved agricultural practices.** The experience of Phase I demonstrates that the application of soil-building techniques, new plot preparation designs, and crop diversification measures can have significant impacts on production and the ultimate value of that production.

c) **Increased sales revenues for farmers employing improved marketing techniques and strategies.** Farmers will benefit from increased average farm-gate prices due to improved storage and packaging techniques, and the opening of new marketing avenues for crops such as beets and fresh okra.

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[1] The analysis is based on the model presented in Kanem Pumps and Agricultural Marketing, a proposal presented to USAID/Chad by CARE in April 1990.

141

Two dimensions to project benefits are distinguished. The **scope of impact** refers to the extent to which project interventions are replicated and adopted by farmers of the target population within four years of the end of the project activities, i.e., the number of farmers who replicate improved water-lifting, agricultural, and marketing techniques. The **degree of impact** refers to the significance of the benefits accruing to each adopting participant, i.e., the amount of the increase in the net income of farmers adopting project techniques.

Costs

Project costs are represented by the three-year total budget, including both USAID and ORT-generated funding. Investment and operating costs of water-lifting equipment have been subtracted from the revenues generated by these technologies, thus calculating the net benefit only. Straight-line depreciation methods were used for the motor-pump and bidon verseur.

Increased seed and labor costs associated with expanded production also have been netted out, based on the average prices presented in Annex F, Part 2. Incremental increases in recurring costs associated with project marketing interventions will be minor, and are taken into account in our net benefit estimates.

Time frame

Costs and benefits are compared over a seven year period. Benefits are assumed to increase in an arithmatic fashion as the number of beneficiary farmers expands from its low in year one to its peak in year seven. For years 7 through 10, benefits are assumed to remain stable.

Scope of impact

1. It is expected that the project will result directly in the installation and maintenance of a variety of improved water-lifting and water-management techniques during the three-year project cycle. These interventions will benefit at least 400 farmers by the close of the project. There are 173 wadis under cultivation in the Ngouri sub-prefecture and an even greater number of fertile polders within the Lake prefecture. Given the project's focus on replicability and the building of sustainable input supply lines, it is likely that several hundred more farmers will adopt the new water-lifting technologies in the years following the close of project. Scenarios of 800 to 1,000 beneficiaries by year 7 are reasonable.

2. Under Phase I of the project, 58% of all farmers in ORT-supervised wadis adopted improved agricultural techniques. The

techniques were also spontaneously replicated in non-supervised wadis. If this rate of adoption is maintained in Phase II, an additional 500 farmers will benefit from the techniques by the close of project. Given the large number of wadis and polders in the Lake region where these simple techniques can be adopted, and given their easily replicable nature, it is expected that several hundred more farmers will employ the improved agricultural techniques in the years following the close of project. Scenarios of 1,000 to 2,000 beneficiaries by year 7 are reasonable.

3. The project will test and introduce improved marketing techniques in storage, packaging, and exploring markets for new crops. Assuming that some of the trials will be successful, the project will train farmers and traders to put them into practice. Scenarios of 800 to 1,200 farmers benefiting by year 7 reflect the replicability of the practices to be introduced.

Degree of Impact

1. Techniques which increase water availability and facilitate water-lifting have a positive effect on production and income. All calculations are based on the economic data in Annex F Part 2, converted to dollars at a rate of 280 FCFA = $1 US.

- The aquifier tap can increase water availability by 25%, thus allowing a 25% increase in irrigation and a corresponding increase in production. For a farmer cultivating an average garden, this involves an increase of net income of $207 per year.

- The motorpump increases the average annual wadi revenue of a Ngouri farmer from $841 to $2,197 at an increased annual expense of $770, plus $179 in depreciation costs. The net increase in annual income is $407.

- The bidon verseur can increase the annual wadi revenue of an Ngouri farmer from $841 to $2,197 at an increased annual expense of $409, plus $56 in depreciation. The net increase in annual income is $667.

Assuming adoption rates for these three techniques that are in proportion to the targets selected in the project logframe[2], one can calculate the weighted average net increase in annual income due to adoption at $300 per beneficiary. A low scenario (-20%) would yield a figure of $240, and a high scenario (+20%) results in a figure of $360.

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[2] A ratio of 300/90/50.

2. Improved agricultural practices can have a significant impact on production and farmer income. The application of soil enrichment and other simple techniques increased vegetable yield figures from 20 to 100% during the project's first phase. If we assume that beneficiaries who adopt these techniques will apply them to 35% of their garden space, the increase in production will range from 7% to 35% per beneficiary. For an Ngouri farmer using a shadouf, this translates into a net increase in annual income of $59 under the low, $177 under the medium, and $294 under the high scenario.

3. The successful development of improved marketing techniques can be expected to increase the revenues received by farmers when they sell their produce. Storage can increase the value of vegetables by 100% or more within a few months. The harvesting of onions one month early can double the price at which they are sold. The opening up of new markets for fresh okra is expected to bid up the farmgate price, and the reduction of transport losses for tomatoes should increase their value and thereby drive up the farmgate price. At this point it is not possible to predict with any certainty which of these techniques will prove successful and to what degree. If improved marketing practices increase the average price that a participating Ngouri farmer receives for his produce by 25% to 50%, annual benefits will range from $210 to $421.

This analysis has not attempted to consider other benefits which, although difficult to quantify, may be significant. These include (1) **environmental benefits** derived from the planting of live fencing and the reduction of soil salinity through improved leaching, and (2) **increased incomes of traders and artisans** who will be involved in the project's input and output marketing activities.

Choice of scenarios

Variables in each of these dimensions are considered under three scenarios -- "low", "medium" and "high" as follows:

Categoy of benefits	Scenarios: "Low"	"Medium"	"High"
Scope of impacts			
Number of farmers benefitting from improved irrigation technologies by year 7:	800	900	1000
Number of farmers benefitting from improved agricultural techniques by year 7:	1000	1500	2000
Number of farmers benefitting from improved marketing techniques by year 7:	800	1000	1200
Degree of impact			
Average increase in beneficiary's annual income from irrigation improvements:	$240	$300	$360
Average increase in beneficiary's annual income from agricultural improvements:	$ 59	$177	$294
Average increase in beneficiary's annual income from marketing improvements:	$210	$316	$421

Tables of analysis

The tables appended to this annex give details on the analysis and calculations. They present the summaries of costs and benefits over ten years for the nine scenarios identified above -- three levels of scope of benefits and three levels of degree of benefits. They also show Internal Rates of Return and Net Present Values for both seven-year and ten-year time frames. Net Present Values have been calculated based on a discount rate of 12%.

Conclusion

The results of the analyses indicate that the project will generate positive rates of return under five of the nine possible scenarios

over seven years, and eight of the nine possible scenarios over ten years. Under the "medium scope" and "medium degree" scenario, the Internal Rate of Return is 2% over seven years and 15% over ten years. Under the "medium" scenario, the Net Present Value is -$650,347 over seven years and +$274,779 over ten years.

Rates of return over **seven** years:

S C O P E	D E G R E E		
	High	Medium	Low
High	23%	8%	- 8%
Medium	14%	2%	-13%
Low	4%	-6%	-18%

Rates of return over **ten** years:

S C O P E	D E G R E E		
	High	Medium	Low
High	33%	21%	6%
Medium	25%	15%	2%
Low	17%	8%	-2%

It is clear that the project investment yields a more than acceptable rate of return over a ten year period. Over seven years, the rate of return is acceptable if one takes into account associated trade and environmental benefits.

SUMMARY ECONOMIC ANALYSIS HIGH SCOPE, HIGH DEGREE
US$

	Project costs	BENEFITS FROM: Water Tech.	Ag. Tech.	Marketing	Net Benefit
Year 1	1344428	51429	84000	72171	-1136828
Year 2	930725	102857	168000	144343	-515525
Year 3	954771	154286	252000	216514	-331971
Year 4		205714	336000	288686	830400
Year 5		257143	420000	360857	1038000
Year 6		308571	504000	433029	1245600
Year 7		360000	588000	505200	1453200
Year 8		360000	588000	505200	1453200
Year 9		360000	588000	505200	1453200
Year 10		360000	588000	505200	1453200

Internal Rate of Return (7 yrs) 23%
Internal Rate of Return (10 yr) 33%

Net Present Value (7 yrs): 742848
Net Present Value (10 yrs): 2321701
(NPVs are calculated at 12%)

SUMMARY ECONOMIC ANALYSIS HIGH SCOPE, MEDIUM DEGREE
US$

	Project costs	BENEFITS FROM: Water Tech.	Ag. Tech.	Marketing	Net Benefit
Year 1	1344428	42857	50571	54171	-1196828
Year 2	930725	85714	101143	108343	-635525
Year 3	954771	128571	151714	162514	-511971
Year 4		171429	202286	216686	590400
Year 5		214286	252857	270857	738000
Year 6		257143	303429	325029	885600
Year 7		300000	354000	379200	1033200
Year 8		300000	354000	379200	1033200
Year 9		300000	354000	379200	1033200
Year 10		300000	354000	379200	1033200

Internal Rate of Return (7 yrs) 8%
Internal Rate of Return (10 yr) 21%

Net Present Value (7 yrs): -229633
Net Present Value (10 yrs): 892904
(NPVs are calculated at 12%)

SUMMARY ECONOMIC ANALYSIS HIGH SCOPE, LOW DEGREE
US$

	Project costs	BENEFITS FROM: Water Tech.	Ag. Tech.	Marketing	Net Benefit
Year 1	1344428	34286	16857	36000	-1257285
Year 2	930725	68571	33714	72000	-756439
Year 3	954771	102857	50571	108000	-693342
Year 4		137143	67429	144000	348571
Year 5		171429	84286	180000	435714
Year 6		205714	101143	216000	522857
Year 7		240000	118000	252000	610000
Year 8		240000	118000	252000	610000
Year 9		240000	118000	252000	610000
Year 10		240000	118000	252000	610000

Internal Rate of Return (7 yrs) -8%
Internal Rate of Return (10 yr) 6%

Net Present Value (7 yrs): -1209524
Net Present Value (10 yrs): -546780
(NPVs are calculated at 12%)

SUMMARY ECONOMIC ANALYSIS MEDIUM SCOPE, HIGH DEGREE
US$

	Project costs	BENEFITS FROM: Water Tech.	Ag. Tech.	Marketing	Net Benefit
Year 1	1344428	46286	63000	60143	-1174999
Year 2	930725	92571	126000	120286	-591868
Year 3	954771	138857	189000	180429	-446485
Year 4		185143	252000	240571	677714
Year 5		231429	315000	300714	847143
Year 6		277714	378000	360857	1016571
Year 7		324000	441000	421000	1186000
Year 8		324000	441000	421000	1186000
Year 9		324000	441000	421000	1186000
Year 10		324000	441000	421000	1186000

Internal Rate of Return (7 yrs) 14%
Internal Rate of Return (10 yr) 25%

Net Present Value (7 yrs): 124165
Net Present Value (10 yrs): 1412714
(NPVs are calculated at 12%)

SUMMARY ECONOMIC ANALYSIS MEDIUM SCOPE, MEDIUM DEGREE
US$

	Project costs	BENEFITS FROM: Water Tech.	Ag. Tech.	Marketing	Net Benefit
Year 1	1344428	38571	37929	45143	-1222785
Year 2	930725	77143	75857	90286	-687439
Year 3	954771	115714	113786	135429	-589842
Year 4		154286	151714	180571	486571
Year 5		192857	189643	225714	608214
Year 6		231429	227571	270857	729857
Year 7		270000	265500	316000	851500
Year 8		270000	265500	316000	851500
Year 9		270000	265500	316000	851500
Year 10		270000	265500	316000	851500

Internal Rate of Return (7 yrs) 2%
Internal Rate of Return (10 yr) 15%

Net Present Value (7 yrs): -650347
Net Present Value (10 yrs): 274779
(NPVs are calculated at 12%)

SUMMARY ECONOMIC ANALYSIS MEDIUM SCOPE, LOW DEGREE
US$

	Project costs	BENEFITS FROM: Water Tech.	Ag. Tech.	Marketing	Net Benefit
Year 1	1344428	30857	12643	30000	-1270928
Year 2	930725	61714	25286	60000	-783725
Year 3	954771	92571	37929	90000	-734271
Year 4		123429	50571	120000	294000
Year 5		154286	63214	150000	367500
Year 6		185143	75857	180000	441000
Year 7		216000	88500	210000	514500
Year 8		216000	88500	210000	514500
Year 9		216000	88500	210000	514500
Year 10		216000	88500	210000	514500

Internal Rate of Return (7 yrs) -13%
Internal Rate of Return (10 yr) 2%

Net Present Value (7 yrs): -1430648
Net Present Value (10 yrs): -871661
(NPVs are calculated at 12%)

SUMMARY ECONOMIC ANALYSIS LOW SCOPE, HIGH DEGREE
US$

	Project costs	BENEFITS FROM: Water Tech.	Ag. Tech.	Marketing	Net Benefit
Year 1	1344428	41143	42000	48114	-1213171
Year 2	930725	82286	84000	96229	-668211
Year 3	954771	123429	126000	144343	-561000
Year 4		164571	168000	192457	525029
Year 5		205714	210000	240571	656286
Year 6		246857	252000	288686	787543
Year 7		288000	294000	336800	918800
Year 8		288000	294000	336800	918800
Year 9		288000	294000	336800	918800
Year 10		288000	294000	336800	918800

Internal Rate of Return (7 yrs) 4%
Internal Rate of Return (10 yr) 17%

Net Present Value (7 yrs): -494519
Net Present Value (10 yrs): 503727
(NPVs are calculated at 12%)

SUMMARY ECONOMIC ANALYSIS LOW SCOPE, MEDIUM DEGREE
US$

	Project costs	BENEFITS FROM: Water Tech.	Ag. Tech.	Marketing	Net Benefit
Year 1	1344428	34286	25286	36114	-1248742
Year 2	930725	68571	50571	72229	-739354
Year 3	954771	102857	75857	108343	-667714
Year 4		137143	101143	144457	382743
Year 5		171429	126429	180571	478429
Year 6		205714	151714	216686	574114
Year 7		240000	177000	252800	669800
Year 8		240000	177000	252800	669800
Year 9		240000	177000	252800	669800
Year 10		240000	177000	252800	669800

Internal Rate of Return (7 yrs) -6%
Internal Rate of Return (10 yr) 8%

Net Present Value (7 yrs): -1071061
Net Present Value (10 yrs): -343346
(NPVs are calculated at 12%)

SUMMARY ECONOMIC ANALYSIS LOW SCOPE, LOW DEGREE
US$

	Project costs	BENEFITS FROM: Water Tech.	Ag. Tech.	Marketing	Net Benefit
Year 1	1344428	27429	8429	24000	-1284571
Year 2	930725	54857	16857	48000	-811011
Year 3	954771	82286	25286	72000	-775200
Year 4		109714	33714	96000	239429
Year 5		137143	42143	120000	299286
Year 6		164571	50571	144000	359143
Year 7		192000	59000	168000	419000
Year 8		192000	59000	168000	419000
Year 9		192000	59000	168000	419000
Year 10		192000	59000	168000	419000

Internal Rate of Return (7 yrs) -18%
Internal Rate of Return (10 yr) -2%

Net Present Value (7 yrs): -1651772
Net Present Value (10 yrs): -1196542
(NPVs are calculated at 12%)

ANNEX F, PART 2 : ECONOMIC ANALYSIS OF MOTORPUMP AND OTHER INDIVIDUAL PROJECT INTERVENTIONS

The following is extracted from Lake Chad Agricultural Development and Farmer Training Project Final Evaluation, USAID, June, 1990.

This economic analysis is based on average areas irrigated with shadoufs or with motorpumps in each of ORT/SODELAC intervention zones. Obviously, actual benefits will vary from farmer to farmer. The model estimates actual benefits received from the shadouf and traditional well utilization and compares them with benefits received from motorpump and tubewell operations. Benefits gained from the project will help explain the farmer's financial incentives to participate in the project. Market average prices of agricultural products are used in this analysis.

1. Water Management

1) Cost-effectiveness of Motorpumps

To better determine the cost-effectiveness of the small motorpump, we have studied two cases in each area of intervention: Ngouri area, Djiguidada area and Dibinintchi area. The first case included areas of non-intervention by ORT or areas where shadoufs and traditional wells are still being used; the second case addressed areas of intervention or areas where motorpumps and tubewells are being used. From the water lifting technology stand point, these two cases represent the two ends of the spectrum.

Ngouri Area: The economic analysis of agricultural activities in this area with the shadouf and traditional wells has demonstrated that a farmer exploiting a cultivated area of 12 ares would make on an average a net benefit of 9,820 F CFA in the first year of activity and 46,520 F CFA in each of the subsequent 10 years, assuming that the cultivated areas, the crops grown and their market prices would remain more or less the same (see Annex A).

The economic analysis also shows that a farmer who has adopted the motorpump can exploit an average area of 40 ares and would make on an average a net benefit of 65,940 F CFA in the first year of investment and 418,440 F CFA in each of the subsequent 10 years with the same assumptions as the traditional method above. The net present value (NPV) of these future values, using an interest rate of 12%, shows that the motorpumps would allow the farmer to increase the NPV of benefits by 450% compared to 330% increase in the NPV of costs. The benefit-cost ratio (B/C) is 1.47.

19

Moreover, the utilization of motorpumps and tubewells would allow the farmer to reduce his labor costs by 71% and increase his cultivated land area by 230%. In short, with the introduction of the motorpumps, the farmer can now cultivate more land with relatively less labor requirement.

Djiguidada Area: Here also, the adaptation of motorpumps compared to the traditional system (shadoufs and traditional wells) has demonstrated the cost-effectiveness of the motorpumps. A farmer who has adopted the motorpump and the tubewell, has increased his cultivated area to 60 ares. The economic analysis shows that his net benefits would be 52,980 F CFA in the first year but would increase to 347,000 F CFA in each of the subsequent 10 years. This translates to a NPV of benefits of 3,597,700 F CFA and NPV of costs of 2,226,000 F CFA, assuming a constant interest rate of 12%. With the motorpumps, the costs would increase by 310% but the benefits would also increase by 159%. The B/C ratio is 1.6 for the motorpumps and tubewells, and 1.26 for the traditional system.

Dibinintchi Area: A comparison between the traditional farming and the motorpump farming indicated that: the average area per farmer increased from 26 to 60 acres, or an improvement rate of 130%; the NPV of benefits would increase from 1,330,000 to 3,475,000 F CFA, that is a growth rate of 160%; the NPV costs would go up from 644,000 to 2,800,000 F CFA, an increase by 335%. The labor costs would decrease by 57%. The benefit-cost ratio is 1.24.

In the above three areas (Ngouri, Djiguidada and Dibinintchi), it can be seen that the motorpump is very profitable. The labor costs are reduced by 71, 46 and 57 percent respectively, increases in cultivated land areas range from 130 percent to 200% and the benefit cost ratios are all significantly more than 1. Field observations also indicated that better yields have been obtained from crops irrigated with motorpumps than from those irrigated with the shadoufs (see Annex B). This is not entirely due to motorpumps but also to the introduction of improved farming techniques.

Farmers themselves demonstrated their interest: the motorpump group could provide its members with 20 motorpumps only and 18 others are impatiently waiting to receive theirs. The motorpump group president stated that his objective was to provide each member with his own motorpump. In the meantime, members have to form small groups among themselves to apply for credit.

The women's group which had never worked previously in the wadis asked for a motorpump when they learned of the motorpump effectiveness and the ease of irrigation with the pump. Local officials also noted that the Ngouri area has a new physionomy due to the introduction of motorpumps.

2) Improvement in Water Structures

a) Improvement in Traditional Wells

Farmers who had asked for the improvement of their traditional wells were not followed up. We are aware that of all the tested methods of well improvement, only three methods were successful including the wood tube, the baked clay tube and the PVC. Improvements using wood tube and baked clay tube allow farmers to have a more sustainable water source but this does not enable the farmer to increase significantly the cultivated land area as the water lifting technology is still the shadouf which uses human strength. The labor requirement will certainly remain the same as that of traditional well. Only the crop yield can be slightly increased as there is enough water to meet the needs of crops All things considered, the improved wells using wood tube or clay represent a minor change in the traditional system but a significant one for those who cannot afford a motorpump. Even though the traditional system is profitable at the cost from 10,000 to 15,000 F CFA, this first stage improvement which costs only between 1,000 and 3,000 F CFA is very effective. The PVC improvement is certainly the best one. Its cost is very minimal and the benefits considerable. The well can be fitted with a motorpump and used as tubewell; the advantage is that a shadouf can be used should the motorpump be out of order. Data on the use of improved PVC wells are not available but it is assumed that for this analysis results will be better than those for tubewells for, although the operation and maintenance costs are a little bit higher than those of tubewells because of land crumbling, the investment costs are minimal and the returns equal. The farmers in the Ngouri area understood such benefits and this was demonstrated by their request for 58 PVC, 23 baked clay and 88 wood tube improvements.

b) Installation of Tubewells from Farmer Standpoint

Tubewells installation is integral part of motorpump; this is to be used with motorpumps. The previously undertaken analysis demonstrated the motorpump efficiency. Farmers who have a problem with their crumbling traditional wells can now carry out their activity thanks to tubewells. Unfortunately, not all farmers can take advantage of such technology because they will need motorpump. Therefore a credit program has been put in place by ORT to make up for the problem. To date, 13 tubewells have been installed in the 27 project wadis. For those farmers who are yet suspicious about the tubewell program, technical delegates were trained to deal with the operation and private merchants were given the opportunity to sell PVC on market.

Despite the technical success of the tubewells, only 13 were installed by farmers against 20 motorpumps. Such purchases within three years seem to be insufficient as 20 motorpumps imply more than 20 farmers involved. This shows the farmers' economic character. Most of them prefer to improve their traditional wells. Such wells are already built and now why to bore another one? and if the motorpump happens to lack fuel, spare parts or mechanic, it can be immediately replaced by the shadouf perhaps even on a temporary basis. With tubewells, one is obliged to wait and see the crops wither and possibly a reduced yield.

2. Agricultural Technology and Extension

Comparison between the Traditional and Motorpump Farming System

The new farming techniques diffused by ORT, such as composting, soil preparation, line seeding, soil aeration techniques and use of large plots (beds) for irrigation, were accepted by more than 190 wadis farmers reached by ORT. These techniques, coupled with the use of motorpumps helped increase yields in all areas: onions 25 to 50%, tomatoes 20 to 60%, hot pepper 67%, eggplants 33%, okra 23 to 33%, wheat 50 to 88%, sorghum 50 to 100% and finger millet 15 to 50%. In order to measure the effects on the yield of the farming technologies alone, the ORT technicians tested onion crops in the same wadi, using the same amount of water and submitted to the same climate conditions. The only factor which changed was the farming techniques. Thus, it was noticed that the 16 metric tons yield per hectare for onions in the traditional basin increased to 28 metric tons per hectares when the traditional basin is manured to 48 tons per hectare when the basins are replaced by beds and manured. It should be noted that cassava and cucumber which were not among the crops targeted by improved techniques did not have their yields increased; however, their yields remained the same.

In addition to the advantage mentioned in the above cost-effectiveness section, the tubewell effects are less detrimental to the environment. Well collapse and drying-up are no longer current.

4. Credit Program

a. Agricultural credit program for motorpumps and tubewells

We saw that net income for farmers using traditional farming technique in the Ngouri area would be 9,200 F CFA in the first

year and 46,520 F CFA in each of the subsequent ten years, on a land area of 12 acres. In Djiguidada, their net income would shift from 114,930 F CFA in the first year to 156,770 F CFA in each of the subsequent ten years, on a land area of 25 acres. For those in Dibinintchi working under the same conditions, such figures are 82,240 F CFA and 128,840 F CFA respectively on a land area of 26 acres.

Under these circumstances, the only way to acquire motorpumps would be the credit program or saving money over several years up to their price of 250,000 F CFA . The motorpump credit program which was entirely managed by the Kida Boulim group is running smoothly and has proved itself effective. The program provides a particular flexibility to encourage the area farmers to take part by enabling those who cannot afford it to form 2 or three-member groups and apply for motorpump credit. When ORT initiated the credit program, a total of 31 farmers were immediately interested to participate. Eleven of them received motorpumps initially and with the repayment, the group could purchase its first motorpump three months later.

The credit conditions set forth in the "motorpump credit agreement" require that one has down payment equal to 10% of the motorpump cost, 25 liters of diesel and 2 liters of motor oil before receiving the motorpump. Such conditions are good for farmers who are not group members; as described in the credit agreement, nothing would preclude application for motorpump credit from a farmer who is not group member. What he needs to do is to comply with the above conditions. These credit conditions have to be softened for those members who pay contributions. Further, the credit for tubewells is repayable within three years and four months, while that for motorpump is repayable within one year and eight months. These payback periods must be the same.

Average Prices of Agricultural Products

Crop	Unit*	1987/88	1988/89	Ave.Price	Price/Kg
Tomato	Koro	423.0	375.0	399.0	362.7
Okra	Koro	570.0	279.0	424.5	606.4
Pepper	Koro	326.0	197.0	261.5	747.1
Onion	Sac	6033.0	6581.0	6307.0	63.1
Cassava	Kowo	2423.0	3014.0	2718.5	34.0
Millet	Koro	255.0	107.0	181.0	72.4
Maize	Koro	216.0	88.0	152.0	60.8
Garlic	Koro	989.0	655.0	822.0	644.7
Eggplant					71.0
Cucumber					90.0
Wheat					100.0
Sorghum					35.0
Maize					

* 1 Koro=3.25 kg onion, 1.1 kg tomato, 0.7 kg okra, 0.575 kg pepper, 1.275 kg garlic and 2.5 kg cereals.
1 sac = 100 kg onion, 37 kg tomato, 21 kg okra and 100 kg cereals
1 Kowo = 80kg cassava;1 diarom=19kg onion, 16kg eggplant, 19kg tomato

Seed Rates and Prices

	Gr/are	Kg/ha	Price/gr	Price/are	Price/ha
Tomato	4.0	0.4	0.3	1.2	116.0
Okra	50.0	5.0	0.9	47.0	4700.0
Pepper	10.0	1.0	1.1	11.4	1140.0
Onion	50.0	5.0	5.6	278.0	27800.0
Cassava*	100.0	10.0	10.0	1000.0	100000.0
Millet	320.0	32.0	0.1	38.4	3840.0
Eggplant	4.0	0.4	7.1	28.6	2856.0
Cucumber	25.0	2.5	1.7	43.5	4350.0
Sorghum	100.0	10.0	0.1	8.0	800.0
Wheat	700.0	70.0	0.2	112.0	11200.0
Maize					
Garlic					

* Cassava is given in cuttings;
a 2 meter stem yields 5 cuttings

TABLE 1. BENEFITS AND COSTS OF PRODUCTION
Chadouf & Traditional Well
Ngouri Area

Crops	Area Are	Yield Kg/are	Prod'n Kg	Fr/kg	Value (1000 CFA)
Onion Bulbs	6	200	1,200	63	76
Onion leaves	6	190	80	123	10
Fresh Tomato	1	63	63	63	4
Dry Tomato	1	188	15	363	5
Eggplant	1.0	300	300	71	21
Okra	1	150	14	606	8
Wheat	1	16.0	16	100.0	2
Sorghum	1	15.0	15	35.0	1
Millet	1	10.0	10	72.4	1
Gross Prod'n	12.00				127.18

Prod'n Cost:	Seed	Fuel	Oil	Tools	Labor	Others	(1000 CFA)
Onion	1668.0	0.0	0.0	2700.0	33810.0	0.0	38.2
Tomato	1.2	0.0	0.0	2100.0	10060.0	0.0	12.2
Eggplant	28.6	0.0	0.0	0.0	8375.0	0.0	8.4
Okra	47.0	0.0	0.0	0.0	11005.0	0.0	11.1
Wheat	112.0	0.0	0.0	0	4745.0	0.0	4.9
Sorghum	8.0	0.0	0.0	0	2995.0	0.0	3.0
Millet	38.4	0.0	0.0	0.0	2970.0	0.0	3.0
Total	1903.1	0.0	0.0	4800.0	73960.0	0.0	80.7

CASH FLOW ANALYSIS. (10 Years Data)

a) Inflow (Benefits)	Year 1	2	3	4	5	6	7	8	9	10
Gross Production	127.2	127.2	127.2	127.2	127.2	127.2	127.2	127.2	127.2	127.2
Other Benefits	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
TOTAL a)	127.2	127.2	127.2	127.2	127.2	127.2	127.2	127.2	127.2	127.2
b) Outflow (Costs)										
Production Costs	80.7	80.7	80.7	80.7	80.7	80.7	80.7	80.7	80.7	80.7
Well + Chadouf	12.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Fence + Materials	23.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
TOTAL b)	117.4	80.7	80.7	80.7	80.7	80.7	80.7	80.7	80.7	80.7
c) Net Benefit (a-b)	9.8	46.5	46.5	46.5	46.5	46.5	46.5	46.5	46.5	46.5
d) Net Benefit w/o Proj	9.8	46.5	46.5	46.5	46.5	46.5	46.5	46.5	46.5	46.5

NPV Benefi.= 718.6
NPV Costs = 488.5
B/C Ratio = 1.5
* i = 12%

TABLE 1A. MOTORPUMPS AND FORAGE: BENEFITS AND COSTS OF P
Ngouri Area

Crops	Area Are	Yield Kg/are	Prod'n Kg	Fr/kg	Value (1000 CFA
Onion Bulbs	18	300	5,400	63	341
Onion leaves	18	285	359	123	44
Fresh Tomato	4	100	400	63	25
Dry Tomato	4	300	96	363	35
Eggplant	5.0	400	2,000	71	142
Okra	2	200	36	606	22
Cucumber	3	300.0	900	90.0	81
Wheat	2	30.0	60	100.0	6
Sorghum	4	30.0	120	35.0	4
Millet	2	15.0	30	72.4	2
Gross Prod'n	40.00				701.77

Prod'n Cost:	Seed	Fuel	Oil	Tools	Labor	Others (1000 CFA) (fees)	
Onion	5004.0	52500.0	4725.0	1345.0	32040.0	1080.0	96.7
Tomato	4.6	24750.0	2227.5	400.0	7480.0	240.0	35.1
Eggplant	142.8	26500.0	2385.0	462.5	6950.0	300.0	36.7
Okra	94.0	9750.0	877.5	180.0	9240.0	120.0	20.3
Cucumber	130.5	5000.0	450.0	197.5	2670.0	180.0	8.6
Wheat	224.0	5000	450.0	145	2590.0	120	8.5
Sorghum	32.0	5250.0	472.5	250	5240.0	240	11.5
Millet	76.8	2750.0	247.5	125.0	2570.0	120.0	5.9
Total	5708.7	131500.0	11835.0	3105.0	68780.0	2400.0	223.3

CASH FLOW ANALYSIS. (10 Years Data)

a) Inflow (Benefits)	Year 1	2	3	4	5	6	7	8	9	10
Gross Production	701.8	701.8	701.8	701.8	701.8	701.8	701.8	701.8	701.8	701.8
Other Benefits										
Forage	0.0									
Moto pump	0.0									
TOTAL a)	701.8	701.8	701.8	701.8	701.8	701.8	701.8	701.8	701.8	701.8
b) Outflow (Costs)								701.8	701.8	701.8
Production Costs	223.3	223.3	223.3	223.3	223.3	223.3	223.3	223.3	223.3	223.3
Forage payment	150.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Pump payment	250.0				250.0				250.0	
O&M *	12.5	60.0	60.0	60.0	12.5	60.0	60.0	60.0	12.5	60.0
TOTAL b)	635.8	283.3	283.3	283.3	485.8	283.3	283.3	283.3	485.8	283.3
c) Net Benefit (a-b)	65.9	418.4	418.4	418.4	215.9	418.4	418.4	418.4	215.9	418.4
d) Net Benefit w/o Pr	9.8	46.5	46.5	46.5	46.5	46.5	46.5	46.5	46.5	46.5
e) Incremental net Be	56.1	371.9	371.9	371.9	169.4	371.9	371.9	371.9	169.4	371.9

NPV Benefi.= 3965.2
NPV Costs = 2103.5
B/C Ratio = 1.9
* i=12%

* O&M are assumed to be 5% of the motor-pump cost the first year of operation and 15% of total investment over the next 3 years.

TABLE 2. BENEFITS AND COSTS OF PRODUCTION
Chadouf & Traditional Well
Djiguidada Area

Crops	Area Are	Yield Kg/are	Prod'n Kg	Fr/kg	Value (1000 CFA)
Onion Bulbs	3	200	600	63	38
Onion leaves	3	190	40	123	5
Okra	6	300	162	606	98
cassava	8.0	350.0	2,800	34.0	95
Wheat	3	20.0	60	100.0	6
Sorghum	3	20.0	60	35.0	2
Millet	2	13.0	26	72.4	2
Gross Prod'n	25.00				246.12

Prod'n Cost:	Seed	Tools	Labor	Other	Value (1000 CFA)
Onion	834.0	3780.0	8280.0	0.0	12.9
Okra	282.0	2100.0	38250.0	0.0	40.6
Cassava	8000.0		12480.0	0.0	20.5
Wheat	336.0		6855.0	0.0	7.2
Sorghum	24.0		4860.0	0.0	4.9
Millet	76.8		3190.0	0.0	-3.3
Total	9552.8	5880.0	73915.0	0.0	89.3

CASH FLOW ANALYSIS. (10 Years Data)

a) Inflow (Benefits)	Year 1	2	3	4	5	6	7	8	9	10
Gross Production	246.1	246.1	246.1	246.1	246.1	246.1	246.1	246.1	246.1	246.1
TOTAL a)	246.1	246.1	246.1	246.1	246.1	246.1	246.1	246.1	246.1	246.1
b) Outflow (Costs)										
Production Costs	89.3	89.3	89.3	89.3	89.3	89.3	89.3	89.3	89.3	89.3
Well	18.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Hoes	5.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Fences	18.8									
TOTAL b)	131.2	89.3	89.3	89.3	89.3	89.3	89.3	89.3	89.3	89.3
c) Net Benefit (a-b)	114.9	156.8	156.8	156.8	156.8	156.8	156.8	156.8	156.8	156.8
d) Net Benefit w/o Proj	114.9	156.8	156.8	156.8	156.8	156.8	156.8	156.8	156.8	156.8

NPV Benef.= 1390.6
NPV Costs= 542.2
B/C ratio= 2.6
i=12%

TABLE 2A. MOTORPUMPS AND FORAGE: BENEFITS AND COSTS OF PRODUCTION
Djiguidada Area

Crops	Area Are	Yield Kg/are	Prod'n Kg	Fr/kg	Value (1000 CFA)
Onion Bulbs	8	250	1,950	63	123
Onion leaves	8	237	129	123	16
Okra	14	300	389	606	236
cassava	19.2	350.0	6,720	34.0	228
Wheat	7	30.0	216	100.0	22
Sorghum	8	30.0	234	35.0	8
Millet	4	15.0	54	72.4	4
Gross Prod'n	59.80				636.74

Prod'n Cost:	Seed	Fuel	Oil	Tools	Labor	Others	(1000 CFA)
Onion	2168.4	23400.0	2632.5	434.0	12246.0	566.0	41.4
Okra	676.8	67900.0	2182.5	1240.0	63504.0	284.0	135.8
Cassava	19200.0	0.0	0.0	434.0	29952.0	170.0	49.8
Wheat	806.4	17267	3330.0	372.0	9252.0	850	31.9
Sorghum	62.4	10250.0	922.5	310.0	8580.0	454	20.6
Millet	138.2	5250.0	472.5	310.0	3870.0	226.0	10.3
Total	23052.2	124066.7	9540.0	3100.0	127404.0	2550.0	289.7

CASH FLOW ANALYSIS. (10 Years Data)

a) Inflow (Benefits)	Year 1	2	3	4	5	6	7	8	9	10
Gross Production	636.7	636.7	636.7	636.7	636.7	636.7	636.7	636.7	636.7	636.7
TOTAL a)	636.7	636.7	636.7	636.7	636.7	636.7	636.7	636.7	636.7	636.7
b) Outflow (Costs)										
Production Costs	289.7	289.7	289.7	289.7	289.7	289.7	289.7	289.7	289.7	289.7
Forage Payment	150.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Pump payment	250.0	0.0	0.0	0.0	250.0	0.0	0.0	0.0	250.0	0.0
O&M	12.5	60.0	60.0	60.0	12.5	60.0	60.0	60.0	12.5	60.0
TOTAL b)	689.7	289.7	289.7	289.7	539.7	289.7	289.7	289.7	539.7	289.7
c) Net Benefit (a-b)	-53.0	347.0	347.0	347.0	97.0	347.0	347.0	347.0	97.0	347.0
d) Net Benefit w/o Pro	114.9	156.8	156.8	156.8	156.8	156.8	156.8	156.8	156.8	156.8
e) Incremental net Ben	-167.9	190.2	190.2	190.2	-59.8	190.2	190.2	190.2	-59.8	190.2
f) Present Values										
at 98 %	-167.9	96.1	48.5	24.5	-3.9	6.3	3.2	1.6	-0.3	0.4
at 104 %	-167.9	93.3	45.7	22.4	-3.4	5.4	2.6	1.3	-0.2	0.3

IRR = 1.04
NPV Benef.= 3597.7
NPV Costs= 2226.1
B/C ratio= 1.6
i=12%

* O&M costs are assumed to be 5% of the motor-pump cost the first year of operation and 15% of total investment over the next 3 years.

TABLE 3. BENEFITS AND COSTS OF PRODUCTION
Chadouf & Traditional Well
Dibinentchi Area

Crops	Area Are	Yield Kg/are	Prod'n Kg	Fr/kg	Value (1000 CFA)
Onion Bulbs	4	200	800	63	50
Onion leaves	4	190	53	123	7
Fresh Tomato	3	250	750	63	47
Dry Tomato	3	250	60	363	22
Eggplant	2.0	300	600	71	43
Okra	2	200	36	606	22
Pepper	2	150.0	27	747.1	20
cassava	1.0	250.0	250	34.0	8
Wheat	6	20.0	120	100.0	12
Sorghum	4	20.0	80	35.0	3
Millet	2	13.0	26	72.4	2
Gross Prod'n	26.00				235.42

CROPS	Seed	Fuel	Oil	Tools	Labor	Others	(1000 CFA)
Onion	1112.0	0.0	0.0	4779.0	13700.0	0.0	19.6
Tomato	3.5	0.0	0.0	2100.0	16800.0	0.0	18.9
Eggplant	57.1	0.0	0.0	0.0	9080.0	0.0	9.1
Okra	94.0	0.0	0.0	0.0	14970.0	0.0	15.1
Piment	22.8	0.0	0.0	0.0	10130.0	0.0	10.2
Cassava	1000.0	0.0	0.0	0.0	1560.0	0.0	2.6
Wheat	672.0	0.0	0.0	0	17100.0	0.0	17.8
Sorghum	32.0	0.0	0.0	0	7640.0	0.0	7.7
Millet	76.8	0.0	0.0	0.0	5650.0	0.0	5.7
Total	3070.2	0.0	0.0	6879.0	96630.0	0.0	106.58

CASH FLOW ANALYSIS. (10 Years Data)

a) Inflow (Benefits)	Year 1	2	3	4	5	6	7	8	9	10
Gross Production	235.4	235.4	235.4	235.4	235.4	235.4	235.4	235.4	235.4	235.4
TOTAL a)	235.4	235.4	235.4	235.4	235.4	235.4	235.4	235.4	235.4	235.4
b) Outflow (Costs)										
Production Costs	106.6	106.6	106.6	106.6	106.6	106.6	106.6	106.6	106.6	106.6
Well	22.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Fence	23.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
TOTAL b)	153.2	106.6	106.6	106.6	106.6	106.6	106.6	106.6	106.6	106.6
c) Net Benefit (a-b)	82.2	128.8	128.8	128.8	128.8	128.8	128.8	128.8	128.8	128.8
d) Net Benefit w/o Proj	82.2	128.8	128.8	128.8	128.8	128.8	128.8	128.8	128.8	128.8

NPV Benefit= 1330.2
NPV Cost = 643.8
B/C ratio = 2.1
i = 12%

TABLE 3A. MOTORPUMPS AND FORAGE: BENEFITS AND COSTS OF PRODUCTION
Dibinentchi Area

Crops	Area Are	Yield Kg/are	Prod'n Kg	Fr/kg	Value (1000 CFA)
Onion Bulbs	10	250	2,500	63	158
Onion leaves	10	237	166	123	20
Fresh Tomato	7	100	700	63	44
Dry Tomato	7	300	168	363	61
Eggplant	4.0	400	1,600	71	114
Okra	5	250	113	606	68
Piment	4	250.0	90	747.1	67
cassava	3.0	250.0	750	34.0	25
Wheat	15	30.0	450	100.0	45
Sorghum	8	30.0	240	35.0	8
Millet	4	15.0	60	72.4	4
Gross Prod'n	60.00				615.06

Prod'n Cost:	Seed	Fuel	Oil	Tools	Labor	Others	Value (1000 CFA)
Onion	2780.0	29250.0	2632.5	518.0	15700.0	400.0	51.3
Tomato	8.1	43250.0	3892.5	362.0	11620.0	280.0	59.4
Eggplant	114.2	21250.0	1912.5	207.0	4720.0	160.0	28.4
Okra	235.0	24250.0	2182.5	258.0	22050.0	200.0	49.2
Piment	45.6	24750.0	2227.5	207.0	4500.0	160.0	31.9
Cassava	3000.0	0.0	0.0	155.0	4680.0	120.0	8.0
Wheat	1680.0	37000	3330.0	775	19275.0	600	62.7
Sorghum	64.0	10250.0	922.5	413	8800.0	320	20.8
Millet	153.6	5250.0	472.5	207.0	4300.0	160.0	10.5
Total	8080.6	195250.0	17572.5	3102.0	95645.0	2400.0	322.1

CASH FLOW ANALYSIS. (10 Years Data)

a) Inflow (Benefits)	Year 1	2	3	4	5	6	7	8	9	10
Gross Production	615.1	615.1	615.1	615.1	615.1	615.1	615.1	615.1	615.1	615.1
Other Benefits										
	0.0									
	0.0									
TOTAL a)	615.1	615.1	615.1	615.1	615.1	615.1	615.1	615.1	615.1	615.1
b) Outflow (Costs)										
Production Costs	322.1	322.1	322.1	322.1	322.1	322.1	322.1	322.1	322.1	322.1
Forage Payment(prin	150.0	0.0	0.0	0.0	150.0	0.0	0.0	0.0	150.0	0.0
Pump payment(prinpa	250.0	0.0	0.0	0.0	250.0	0.0	0.0	0.0	250.0	0.0
Fees,O+M *	12.5	60.0	60.0	60.0	12.5	60.0	60.0	60.0	12.5	60.0
TOTAL b)	734.6	382.1	382.1	382.1	734.6	382.1	382.1	382.1	734.6	382.1
c) Net Benefit (a-b)	-119.5	233.0	233.0	233.0	-119.5	233.0	233.0	233.0	-119.5	233.0
d) Net Benefit w/o Pr	82.2	128.8	128.8	128.8	128.8	128.8	128.8	128.8	128.8	128.8
e) Incremental net Be	-201.7	104.2	104.2	104.2	-248.3	104.2	104.2	104.2	-248.3	104.2
f) Present Values										
at 7.9 %	-201.7	96.5	89.5	82.9	-183.2	71.2	66.0	61.2	-135.2	52.5
at 71 %	-201.7	60.9	35.6	20.8	-29.0	7.1	4.2	2.4	-3.4	0.8

IRR = 0.078

* O&M are assumed to be 5% of the motor-pump cost the first year of operation and 15% of total investment over the next 3 years.

NPV Benefit= 3475.3
NPV Cost = 2800.5
B/C ratio = 1.2
i=12%

Increase in Main Crops Yields due to the Introduction of motor-pumps and Drilled wells. (Kg/ha)

	Ngouri		Djiguidada		Dibinintchi	
	Ch	M.P	Ch	M.P	Ch	M.P
Onions	200	300	200	250	200	250
Tomatoes	188	300			250	300
Eggplants	300	400			300	400
Okra	150	200	300	300	200	250
Cucumbers	300	300				
Wheat	16	30	20	30	20	30
Sorghum	15	30	20	30	20	30
Millet	10	15	13	15	13	15
Cassava			350	350	250	250
Pepper					150	250

Comparison of Costs and Benefits in the Intervention Zones:

	Ngouri		Djiguidada		Dibinintchi	
Water Table (m)	5-6		2-3		3-4	
No. Chadouf/ Farmer	1,0		1,4		1,77	
	C	MP	C	MP	C	MP
Aveg. Cultivated Area/farmer (are)	12	40	25	60	26	60
NPV Benefits (1000 F CFA)	719	3.965	1.390	3.598	1.330	3.475
NPV Costs (1000F CF)	489	2.104	542	2.226	644	2.80
B/C Ratio	1,47	1,89	2,6	1,6	2,07	1,24
Labor Cost (Man-days)	120	35	57	31	72	31

ANNEX F, PART 3 : ECONOMIC ANALYSIS OF THE BIDON VERSEUR

3.1 Performance

A bidon verseur was carefully tested by the ORT project during the 1990-91 gardening season in a wadi near Ngouri. The Bidon Verseur was operated by a volunteer farmer on his own garden. The economic results are positive.

The irrigation discharge of the bidon verseur averaged 1.38 liters per second, compared to an average shadouf discharge of 0.75 liters per second on wells of a similar depth (5.8 meters). The bidon verseur was operated for 17.5 hours per week to irrigate a surface area of 12.5 ares. A shadouf operating 17.5 hours a week under similar conditionts irrigates only 6.5 ares. Results are summarized below:

	Shadouf	Bidon Verseur	Percent Increase in performance
Discharge (l/s)	0.75	1.38	+84%
Surface irrigated per season (ares)	6.50	12.50	+92%

These results are similar to those coming out of the Etude-Action project in Doum-Doum, which has been testing seven bidon verserus over the past year. On the gardens of seven volunteer farmers, the bidon verseur has facilitated increases in cultivated surface areas from 75-100%.

3.2 Benefits

The additional revenue generated by the bidon verseur can be determined by caculating the value of the increased production that it makes possible. In the case of the Ngouri bidon, 6 additonal ares of onions were harvested. Using actual onion yields and average annual prices, the additional revenue comes to 170,100 FCFA per season.

(6 addition ares)*(450 kg/are)*(63 FCFA/kg) = 170,100 FCFA

If we make the conservative estimate that the farmer uses his bidon verseur only two of the three annual agricultural

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seasons, the annual increase in revenues is calculated at 340,200 FCFA.

(170,100 FCFA/season)*(2 seasons/year) = 340,200 FCFA

If one repeats these calculation using the unusually low onion prices that prevail at the time of this writing, (35 FCFA/kg), the value of the benefits is estimated at 189,000 FCFA//ear.

3.2 Costs

The bidon verseur engenders additional operating costs compared to the shadouf. During testing in Ngouri, the donkeys used to operate the shadouf were fed a total of seven koros of millet and seven bales of hay per week for five months. Using average annual millet and hay prices, this involves a total cost of 45,500 FCFA/season:

(7 koros/wk)*(175 FCFA/kr)*(20 wks) = 24,500 FCFA
(7 bales/wk)*(150 FCFA/bl)*(20 wks) = 21,000 FCFA
45,500 FCFA

Assuming two seasons per year, the additional cost is 91,000 FCFA.

If one repeats the calculations using the unusually high feed costs that prevailed during the 1990-91 test period (250 FCFA/koro, 225 FCFA/bale), the annual cost is 133,000. If one employs the feeding rate used by farmers in Doum-Doum, (5 koros millet/week), the annual cost falls to between 35,000 and 50,000 FCFA/year.

Because more surface area is irrigated by the bidon verseur, additonal seed costs are incurred. For six additional ares of onions, this involves 1,800 FCFA/season, or 3,600 FCFA/year. Repair and maintenance costs are estimated at 20,000 FCFA/year, and the useful life of a bidon verseur is estimated at six years.

The cultivation of more land also involves additional labor for land preparation; however, the use of the bidon verseur requires less labor than the shadouf for irrigation. The farmer can work in his field at the same time that he supervises his donkey. For this reason, we assume that the labor trade-off is a wash -- the time saved using the bidon verseur is roughly equal to the time used to prepare the land for six additional ares per season.

Adding all of these costs, we arrive at additional annual costs of 114,600 FCFA when average feed prices are used, and 156,600 FCFA when unusually high feed prices are used.

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3.4 Summary of operating costs and benefits:

	Scenario using average prices	Scenario using unfavorble prices
Additional Annual Benefits	340,200 FCFA	189,000 FCFA
Additional Annual Costs per season (ares)	114,600 FCFA	156,600 FCFA
NET ANNUAL BENEFIT	225,600 FCFA	32,400 FCFA

3.5 Initial Investment Cost

The bidon verseur and its associated hardware costs approximately 65,000 FCFA, delivered to Ngouri. A donkey costs 10,000 FCFA and a harness is 5,000 FCFA. The uselife of the bidon is estimated at six years, and that of the donkey/harness is estimated at three years.

Under the scenario using average millet and onion prices, the investment will pay for itself in one agricultural season. Under the scenario using unusually high millet prices and low onion prices, the investment will pay for itself after two and a half years.

3.6 Net Present Values and Rates of Return

A cash flow analysis is presented on the next page. It reveals that investment in a bidon verseur is profitible. Under a scenario where average onion and feed prices are used, the net present value of the investment is 836,857 FCFA and the internal rate of return is 281%. Under a acenario where onion prices are unusually low and feed prices are unusually high, the net present value of the investment is 42,533 FCFA and the internal rate of return is 29%.

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a. Cash Flow Analysis for the Bidon Verseur -- based on average annual onion and feed prices

(Figures are in FCFA, assumes flows occur at end of period, bidon has six-year life)

	Year 0	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6
Additional revenues with the bidon	0	340200	340200	340200	340200	340200	340200
Additional operating costs with bidon	0	114600	114600	114600	114600	114600	114600
Investment cost - bidon	65000	0	0	0	0	0	0
Investment cost - donkey	15000	0	0	15000	0	0	0
Net cash flow	-80000	225600	225600	210600	225600	225600	225600

Net Present Value at a 12% discount rate: 836857

Internal Rate of Return (IRR): 281%

b. Cash Flow Analysis for the Bidon Verseur -- based on unfavorable onion and feed prices

(Figures are in FCFA, assumes flows occur at end of period, bidon has six-year life)

	Year 0	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6
Additional revenues with the bidon	0	189000	189000	189000	189000	189000	189000
Additional operating costs with bidon	0	156600	156600	156600	156600	156600	156600
Investment cost - bidon	65000	0	0	0	0	0	0
Investment cost - donkey	15000	0	0	15000	0	0	0
Net cash flow	-80000	32400	32400	17400	32400	32400	32400

Net Present Value at a 12% discount rate 42533

Internal Rate of Return (IRR): 29%

5.11. Energy requirements and conservation potential of various alternatives and mitigation measures

- Fuel. This EA did not analyze moto-pump petroleum fuel requirements. We know, however, that fuel needs will increase. At the present time, agricultural incomes are sufficient to cover fuel costs.

- Fuelwood as a conservation potential. Although the project does not require fuelwood, live fences, agroforestry, forestry and fruit tree plantings all produce fuelwood. This will reduce domestic demand on natural vegetation.

- Trees. The traditional shadouf is seriously depleting natural stocks of the ronier palm. As shadoufs are replaced by motopumps or improved dalous, pressure on the palm and other trees should decrease.

- Labor. The objective of this project is to increase food production. The technology it develops reduces labor requirements because it replaces the shadouf with motors or with improved, animal-driven dalous.

- Transportation. Increased food production will require goods transport to market. Much of this transport will be by motor truck; some will be by donkey and camel. This will increase regional energy requirements.

5.12. Required monitoring

- Piezometric head. The project needs to continue its ongoing monitoring of water-table elevations. The project monitors and records water level in existing wells for different seasons of the year. This can easily be done by farmers.

- Water quality. The project should continue its present activities to measure water quality. We recommend no change in this program. However for the sustainability of this activity after the project, farmers should be provided with simple skills to identify indicators for water quality modification. Since the indicator method is site specific, particularly in the wadi ecosystems, the project will develop this in collaboration with farmers.

- Soil quality. Periodic monitoring should be made of soil salinity, soil hardness, and organic matter content. With salinity, ORT should use true extracts (Appendix H) to develop a correlation between soil extracts and 1:1 soil and water mixes. Thereafter, soil salinity should be measured from the 1:1 mix and correlated to its extract level.

- Crop yields. Crop yields should be measured and correlated to project inputs, land ownership, and other variables.

5.8. Relationship between local short term and long term effects

The regional aquifer is declining due to non-project related drought. The project will slightly increase this rate from 25 years to lose 1 meter of piezometric potential to 23 years. Eventually, piezometric head will drop to below the level of the overlying confining siltstone that lies below the wadi. When this happens, wadi groundwater will penetrate into the Kanem, possibly polluting it. In addition, wadi ground-water tables will seriously decline. To prevent this, developed traditional (shadouf) wells should eventually be lined. Tubewells are already lined with pvc pipe and don't share this risk.

5.9. Irreversible and irretrievable commitments of natural and cultural resources

In the long run, farmers may lose their need for the traditional shadouf as improved systems replace it.

5.10. Means to mitigate adverse environmental impacts

- Water quality. Unlined improved wells should be lined as piezometric potential drops below confining siltstone underlying wadi aquifers.

- Soils. Irrigation should be to a high standard to prevent nutrient migration away from crops. Pre-irrigation, deep tillage, and soil organic matter improvement are important to reduce hardpans. Soil organic matter and vegetation management is important to improve soil fertility and tilth.

- Cropping technology. Farmer skills need to improve in order to better manage increased water and agricultural surface area.

- Natural vegetation. The loss of natural vegetation can be compensated, in part, by agroforestry, forestry, live fences and wind breaks. These activities should be component parts of ORT's continuing project.

- Dune encroachment. Continuing dune encroachment requires their stabilization. Livestock should not concentrate on the windward side of the wadi fringe. ORT should integrate livestock management into its project activities so that cattle don't contribute to degradation of dune vegetation near the project wadis. Livestock watering points should be downwind rather than upwind of wadis.

5.3. Direct and indirect effects and their consequences

See Section 5.2 above.

5.4. Possible conflicts of proposed action to plans for land and resources use

In effect, there are no other plans for land and resource use other than for agriculture.

5.5. Reasonably foreseeable impact of proposed action on the human environment and assessment of positive and negative effects

Agricultural surface area will expand and crop yields will increase. Because ORT has a marketing objective, much of this production is destined to enter the market economy. It will help improve farmer wealth as well as that of the region.

Because ORT is improving access to high quality water, human health will improve. Because crop diversity is increasing, human diet will also improve. Previous analyses have shown that the project will have no adverse impact on water-borne diseases: malaria, diarrhea, oncho, shisto.

Because ORT is reversing wadi ecosystem recession, crucial wadi environments will not disappear. This means that biodiversity will stabilize rather than decline.

5.6. Adverse impacts on endangered species and habitats

Increased activities in Wadi will limit wildlife access to project Wadi only, in addition, the number of wadi involved in the project is not significant compared to the total cultivable and non cultivable other wadi of the area available for wildlife access. The project will not have any significant impact on endangered species and their habitats.

5.7. Reasonably foreseeable adverse environmental impacts which cannot be avoided

ORT is furthering a trend in which natural ecosystems are being replaced by agriculture in project wadis. As pointed out above those wadis are limited in number and the project area is limited. Therefore the foreseeable impacts that cannot be avoided are limited to the number of project wadi and also limited within the Kanem region.

wells; alternative 3 was 200 tubewells and 400 improved traditional wells. Alternative 2 will leave about 200 traditional wells tapping into the overlying wadi aquifer. The advantage of this alternative over others is that it achieves a balance between withdrawals from the two aquifer systems, and also in agricultural inputs and capacity. Its environmental consequences are minimal over the current situation of 12 tubewells and 188 improved traditional wells. The following paragraphs describe this alternative and its impacts in detail.

5.2. Impacts of alternatives

The impacts of the different alternatives analyzed in this EA are described in Section 3. The impacts of the preferred alternative (Alternative 2) are as follow:

- Withdrawal of 907 000 m3/a of water from the Kanem aquifer for surface irrigation.

- Increase regional aquifer drawdown from 0.038 m/a to 0.043 m/a. The aquifer will lose 1 meter of piezometric potential in 23 years instead of the current 25.

- Recharge about 15 percent of this water into overlying wadi aquifers, possibly playing a crucial role in wadi survival.

- Dilute with high quality Kanem water the slightly lower quality water in the overlying wadi aquifer.

- Reduce the salt leachate requirement because high quality irrigation water is replacing water of lessor quality.

- Possibly allow slightly saline water from the wadi aquifer to penetrate the Kanem aquifer once piezometric potential drops below the elevation of the overlying siltstone that separates the two aquifers.

- Improve project capacity to control soil salinization because the regional aquifer supplies higher quality water than the wadi aquifer.

- Expand biomass production and improve the capacity of the project to manage soil organic matter.

- Increase the capacity of the project to manage hardpan formation by allowing pre-irrigation to soften hard soils, and by increasing biomass production for mulch and compost to improve soil tilth and fertility.

- Expand human presence in the wadis, thereby increasing hunting pressure and habitat destruction on endangered species.

- Improve general land and water management — the general ecosystem will improve.

In the overall project area including the dunes, there are no protected areas (faunal reserves, national parks). The most important species requiring protection are endangered Addax (unknown numbers) and Scimitar-horned oryx (about 300).

The current situation of fauna in the wadi can be described as follows: (1) Few large mammals are reported to be present in the wadi. (2) Gazelles (Damas, Dorcas and slender-horned gazelles according to some authors) and Addax are reported to be remnant in the wadi at night for water and to feed on natural vegetation and crops. Some wadi with dense vegetation provide shelter. (3) Wart hogs are no longer present near NGouri but occur further south in the lake area. (4) Hyenas, jackals and african foxes are found mainly in the dunes. They use densely vegetated wadi for shelter, and may be small cattle predators. (5) The area counts a high number of two or three sub-species of falcons. (6) Rodents such as rats, squirrels and hares are present in the wadi and are crop pests. (7) Large sized poisonous snakes are reported to be numerous in the wadi. Pythons also are reported. (8) Wadi provide refuge to a large number of insects, many of them being crop pests.

Very little natural vegetation is left in the wadi. All the land that can be cropped has already been cleared. A few trees, relics of the original vegetation, are considered useful by the local population and are left in the cultivated areas. These include Acacia albida, Jujuphus sp, Ficus sp, and doum palm.

Agricultural ecosystems have widely replaced natural ecosystems in the project wadi. Traditional dead fences provide habitats to different kinds of species, especially rats. Newly introduced agricultural practices have already started to modify the agriculture ecosystems: where live fencing is introduced rat and snake habitats diminish.

It is unfortunate that the political situation during the assessment did not allow the EA team to meet with local institutions such as forest or agricultural services.

5. ENVIRONMENTAL CONSEQUENCES

5.1. Introduction and summary

Based on the analyses presented in this EA, the EA team recommends the project adopt Alternative 2 as its course of action for future activities. This alternative recommends ORT install up to 300 improved wells and 100 moto-pump tubewells that tap into the Kanem aquifer. Alternative 1, the no project alternative, would provide no change from the present situation of 12 tubewells and 188 improved traditional

management. In general, soil salinization risk appears low and is being well managed by ORT.

3.2.4. Significant issue number four: SOIL QUALITY

The comments listed under alternative 1 are valid for this alternative. Productive soils are generally healthy soils. Because the project is using high quality irrigation water, plant productivity will increase over a broader surface than if farmers were relying only on wadi water. This should increase the biomass available for such activities as composting and mulching.

3.2.5. Significant issue number five: HARDPAN FORMATION

Field observations show that hardpans are forming in wadi peripheral areas where soils are prone to intermittent drying. The increased role of irrigation water under this alternative, both for plant production and for pre-irrigation to soften hardened soils, will play a crucial role in soil management.

3.2.6. Significant issue number six: SPECIES AT RISK

As pointed out in alternative 1, increased activities in wadi will limit wildlife access to project Wadi only. However with this alternative, 300 improved wells and 100 motor-pumps, the number of wadi involved will not increase and more human presence in project wadi will not increase pressure on wildlife habitat.

3.2.7. Significant issue number seven: ECOSYSTEM MODIFICATION

With improved agriculture practices, wadis can support intensification of agriculture without significant harm to soils or water quality and quantity. With increased wadi investment and training from project activities, it is expected that land and water management will improve.

4. AFFECTED ENVIRONMENT

The project area is located in the Sahello-Saharan climatic zone: between 200 and 400 mm isohyets, rainy season of three months (July to September). Representative locations are Bol and Mao. The wadi have specific vegetation that is different from the dunes area — dunes are classified as Sahelian deciduous bushland and woodland dominated by scattered individual trees.

ANNEX G

The environmental analysis of the proposed project was conducted by a USAID team in Novemeber and December 1990. The report is presented below. The team examined three possible scenarios for project intervention. The one recommended by the team (300 aquifer taps and 100 tubewells) is the one accepted for Phase II. The other two scenarios have been edited out.

ENVIRONMENTAL ASSESSMENT
LAKE CHAD AGRICULTURAL DEVELOPMENT
AND FARMER TRAINING
(677-0051-F)
ORT - SODELAC

1. SUMMARY

This Environmental Assessment (EA) examines the second phase of ORT/USAID subproject 617-0051: PVO Development Initiatives. The project is executed by the Organization for Rehabilitation through Training (ORT) near Ngouri east of Lake Chad. Its goal is to increase local food production by improving water availability to food crops, improving farmer agronomic and water management skills, and implementing agroforestry and forestry.

In September, 1990, the REDSO/WCA Environmental Officer and Advisor in collaboration with AID/Chad ADO and the PVO Project Manager carried out an Environmental Review. The findings resulted in the identification of activities that presented environmental issues the significance of which were in question. The review recommended an Environmental Assessment to evaluate the impact of those issues thought to be significant.

The EA team recommends the project continue. The findings of the team indicate that a project design aimed at a point midway between the no project alternative and a development level resulting in resource depletion will fulfill project objectives while not creating adverse environmental impacts. ORT has currently assisted farmers with the installation of 12 moto-pump tubewells and 188 improved traditional wells which is the existing pre-project (second phase) condition. The team recommends that ORT be authorized to install up to a total of 300 improved traditional wells and 100 moto-pump tubewells tapping the regional aquifer.

The project relies on irrigation water withdrawn from a regional aquifer. Although the groundwater is largely fossil in origin, recharge plays an important role in project area water balance changes. Climatic conditions effect the groundwater reservoir inflow and outflow. Persistent Sahelian drought is causing the water table to drop. Although the project will increase aquifer withdrawals, its impact will be slight. Water table drawdown will increase from 0.038 meters/annum (m/a), the current non-project related rate, to 0.043 m/a thereby taking only 23 years instead of 25 to lower the piezometric head 1 meter. Regional aquifer water is of high quality and meets or exceeds irrigation water requirement parameters, so its use will increase farmer capacity to control soil salinity.

In addition, the project will increase biomass production by increasing crop yields and planted surface. This will increase the capacity to improve soil quality, principally by increasing soil organic matter. It will reduce hardpan formation by permitting pre-irrigations to soften soil for tillage and by improving its structure through organic matter management.

There will probably be increased human presence in the twenty-nine targeted project area wadis. Wildlife may suffer in these wadis from reduced natural habitat and increased hunting pressure, but should thrive in the other two hundred wadis which are not irrigated or have been abandoned by farmers as agriculturally uneconomic.

The project, by increasing food production, will improve the region's economic potential. Human health will also improve through access to this high quality water.

The project design must establish systems to monitor piezometric head, water quality, soil quality, crop yields and irrigation.

2. PURPOSE

2.1. DESCRIPTION OF PROPOSED ACTION

USAID has two Program Sub-Goals in the agricultural sector in Chad: (1) to improve food security for at-risk populations and (2) to increase rural producers' household incomes for target areas. Its strategic objective is to improve the efficiency of the agricultural marketing system.

The proposed project is part of this program. It has two purposes: (1) "to stimulate agricultural production (in the Ngouri area) by removing market constraints and transferring appropriate technologies", particularly in water management; and (2) to raise the incomes of the wadi farmers through increased production and profit maximization. The following activities have been proposed by ORT to achieve these goals:

<u>Agricultural marketing:</u>

- to promote crop diversification in the wadis based on the results of ongoing tests;

- to strengthen the existing marketing credit program;

- to promote the farmers' efforts to organize the marketing of their produce beyond the project area;

- to continue pilot post-harvest activities — or initiate others — to improve the storage, packaging and processing of wadi produce;

Transfer of appropriate technologies:

- to strengthen the existing credit program managed by a regional farmer's group to purchase motor pumps and install tube wells;

- to strengthen the capacity of the local tube well drilling service and, if necessary, promote the establishment of others;

- to continue work to reinforce the nascent motor pump infrastructure;

- to diffuse any other appropriate water lifting technology that could serve as an intermediate alternative to the shadouf and the motor pump (e.g. animal powered devices);

2.2. REASON FOR PROJECT

Over the last 20 years Chad has experienced combined recurrent war and severe drought. At present, drought is a continuing and persistent contributor to human distress in Chad. Since the 1982 Geneva Conference, considerable donor assistance has been planned and some has been delivered for basic reconstruction and rehabilitation. Studies, especially those by CILLS / Club du Sahel / CONACILLS, have identified development priorities. AID/Chad policy is to devote the largest part of its development assistance over the next decade to food production. To achieve this, AID/Chad focuses on essential targets and means where current experience and analyses indicate feasibility and potential for future development. AID support is provided through its PVO Development Initiatives Project.

3.2. ALTERNATIVE 2 : the number of improved wells increases to 300 and the number of motor pumps to 100.

3.2.1. Significant issue number one:
AQUIFER DEPLETION

Under this alternative improved unlined wells increase to 300 and moto-pump tubewells to 100. This will withdraw 907 000 m3/a of Kanem groundwater for surface irrigation, and increase aquifer drawdown from its current level of 3.8 cm/a to 4.3 cm/a. At this rate of extraction, the aquifer will lose 1 meter of piezometric potential in 23 years instead of the current 25. About 15 percent of this water will recharge wadi aquifers, possibly playing a crucial role in wadi flora and fauna survival.

3.2.2. Significant issue number two:
WATER QUALITY DEGRADATION

This alternative brings to the surface about twice the quantity of Kanem groundwater than alternative 1. Because this water has only between 25 to 30 percent of the dissolved solids content of wadi water, it has considerable dilution potential. The high quality of this water for irrigation means less water is required for effective salt leaching than is the case if only wadi water was available.

The rate of water-table decline under this alternative seems only a marginal increase over the rate computed for alternative 1. Water table decline should be monitored, however, as it could lead to penetration of wadi water into the Kanem aquifer from unlined wells once piezometric head drops below the locally confining sandstone.

3.2.3. Significant issue number three:
SALINIZATION

The comments in section 3.1.3 are also true for this alternative. The increased use of Kanem groundwater in this alternative will improve project capacity to control soil salinization. As with alternative 1, ORT should continue its ongoing efforts to teach farmers water

management. In general, soil salinization risk appears low and is being well managed by ORT.

3.2.4. Significant issue number four: SOIL QUALITY

The comments listed under alternative 1 are valid for this alternative. Productive soils are generally healthy soils. Because the project is using high quality irrigation water, plant productivity will increase over a broader surface than if farmers were relying only on wadi water. This should increase the biomass available for such activities as composting and mulching.

3.2.5. Significant issue number five: HARDPAN FORMATION

Field observations show that hardpans are forming in wadi peripheral areas where soils are prone to intermittent drying. The increased role of irrigation water under this alternative, both for plant production and for pre-irrigation to soften hardened soils, will play a crucial role in soil management.

3.2.6. Significant issue number six: SPECIES AT RISK

As pointed out in alternative 1, increased activities in wadi will limit wildlife access to project Wadi only. However with this alternative, 300 improved wells and 100 motor-pumps, the number of wadi involved will not increase and more human presence in project wadi will not increase pressure on wildlife habitat.

3.2.7. Significant issue number seven: ECOSYSTEM MODIFICATION

With improved agriculture practices, wadis can support intensification of agriculture without significant harm to soils or water quality and quantity. With increased wadi investment and training from project activities, it is expected that land and water management will improve.

4. AFFECTED ENVIRONMENT

The project area is located in the Sahello-Saharan climatic zone: between 200 and 400 mm isohyets, rainy season of three months (July to September). Representative locations are Bol and Mao. The wadi have specific vegetation that is different from the dunes area — dunes are classified as Sahelian deciduous bushland and woodland dominated by scattered individual trees.

In the overall project area including the dunes, there are no protected areas (faunal reserves, national parks). The most important species requiring protection are endangered Addax (unknown numbers) and Scimitar-horned oryx (about 300).

The current situation of fauna in the wadi can be described as follows: (1) Few large mammals are reported to be present in the wadi. (2) Gazelles (Damas, Dorcas and slender-horned gazelles according to some authors) and Addax are reported to be remnant in the wadi at night for water and to feed on natural vegetation and crops. Some wadi with dense vegetation provide shelter. (3) Wart hogs are no longer present near NGouri but occur further south in the lake area. (4) Hyenas, jackals and african foxes are found mainly in the dunes. They use densely vegetated wadi for shelter, and may be small cattle predators. (5) The area counts a high number of two or three sub-species of falcons. (6) Rodents such as rats, squirrels and hares are present in the wadi and are crop pests. (7) Large sized poisonous snakes are reported to be numerous in the wadi. Pythons also are reported. (8) Wadi provide refuge to a large number of insects, many of them being crop pests.

Very little natural vegetation is left in the wadi. All the land that can be cropped has already been cleared. A few trees, relics of the original vegetation, are considered useful by the local population and are left in the cultivated areas. These include Acacia albida, Jujuphus sp, Ficus sp, and doum palm.

Agricultural ecosystems have widely replaced natural ecosystems in the project wadi. Traditional dead fences provide habitats to different kinds of species, especially rats. Newly introduced agricultural practices have already started to modify the agriculture ecosystems: where live fencing is introduced rat and snake habitats diminish.

It is unfortunate that the political situation during the assessment did not allow the EA team to meet with local institutions such as forest or agricultural services.

5. ENVIRONMENTAL CONSEQUENCES

5.1. Introduction and summary

Based on the analyses presented in this EA, the EA team recommends the project adopt Alternative 2 as its course of action for future activities. This alternative recommends ORT install up to 300 improved wells and 100 moto-pump tubewells that tap into the Kanem aquifer. Alternative 1, the no project alternative, would provide no change from the present situation of 12 tubewells and 188 improved traditional

wells; alternative 3 was 200 tubewells and 400 improved traditional wells. Alternative 2 will leave about 200 traditional wells tapping into the overlying wadi aquifer. The advantage of this alternative over others is that it achieves a balance between withdrawals from the two aquifer systems, and also in agricultural inputs and capacity. Its environmental consequences are minimal over the current situation of 12 tubewells and 188 improved traditional wells. The following paragraphs describe this alternative and its impacts in detail.

5.2. Impacts of alternatives

The impacts of the different alternatives analyzed in this EA are described in Section 3. The impacts of the preferred alternative (Alternative 2) are as follow:

- Withdrawal of 907 000 m3/a of water from the Kanem aquifer for surface irrigation.

- Increase regional aquifer drawdown from 0.038 m/a to 0.043 m/a. The aquifer will lose 1 meter of piezometric potential in 23 years instead of the current 25.

- Recharge about 15 percent of this water into overlying wadi aquifers, possibly playing a crucial role in wadi survival.

- Dilute with high quality Kanem water the slightly lower quality water in the overlying wadi aquifer.

- Reduce the salt leachate requirement because high quality irrigation water is replacing water of lessor quality.

- Possibly allow slightly saline water from the wadi aquifer to penetrate the Kanem aquifer once piezometric potential drops below the elevation of the overlying siltstone that separates the two aquifers.

- Improve project capacity to control soil salinization because the regional aquifer supplies higher quality water than the wadi aquifer.

- Expand biomass production and improve the capacity of the project to manage soil organic matter.

- Increase the capacity of the project to manage hardpan formation by allowing pre-irrigation to soften hard soils, and by increasing biomass production for mulch and compost to improve soil tilth and fertility.

- Expand human presence in the wadis, thereby increasing hunting pressure and habitat destruction on endangered species.

- Improve general land and water management -- the general ecosystem will improve.

5.3. Direct and indirect effects and their consequences

See Section 5.2 above.

5.4. Possible conflicts of proposed action to plans for land and resources use

In effect, there are no other plans for land and resource use other than for agriculture.

5.5. Reasonably foreseeable impact of proposed action on the human environment and assessment of positive and negative effects

Agricultural surface area will expand and crop yields will increase. Because ORT has a marketing objective, much of this production is destined to enter the market economy. It will help improve farmer wealth as well as that of the region.

Because ORT is improving access to high quality water, human health will improve. Because crop diversity is increasing, human diet will also improve. Previous analyses have shown that the project will have no adverse impact on water-borne diseases: malaria, diarrhea, oncho, shisto.

Because ORT is reversing wadi ecosystem recession, crucial wadi environments will not disappear. This means that biodiversity will stabilize rather than decline.

5.6. Adverse impacts on endangered species and habitats

Increased activities in Wadi will limit wildlife access to project Wadi only, in addition, the number of wadi involved in the project is not significant compared to the total cultivable and non cultivable other wadi of the area available for wildlife access. The project will not have any significant impact on endangered species and their habitats.

5.7. Reasonably foreseeable adverse environmental impacts which cannot be avoided

ORT is furthering a trend in which natural ecosystems are being replaced by agriculture in project wadis. As pointed out above those wadis are limited in number and the project area is limited. Therefore the foreseeable impacts that cannot be avoided are limited to the number of project wadi and also limited within the Kanem region.

5.8. Relationship between local short term and long term effects

The regional aquifer is declining due to non-project related drought. The project will slightly increase this rate from 25 years to lose 1 meter of piezometric potential to 23 years. Eventually, piezometric head will drop to below the level of the overlying confining siltstone that lies below the wadi. When this happens, wadi groundwater will penetrate into the Kanem, possibly polluting it. In addition, wadi ground-water tables will seriously decline. To prevent this, developed traditional (shadouf) wells should eventually be lined. Tubewells are already lined with pvc pipe and don't share this risk.

5.9. Irreversible and irretrievable commitments of natural and cultural resources

In the long run, farmers may lose their need for the traditional shadouf as improved systems replace it.

5.10. Means to mitigate adverse environmental impacts

- Water quality. Unlined improved wells should be lined as piezometric potential drops below confining siltstone underlying wadi aquifers.

- Soils. Irrigation should be to a high standard to prevent nutrient migration away from crops. Pre-irrigation, deep tillage, and soil organic matter improvement are important to reduce hardpans. Soil organic matter and vegetation management is important to improve soil fertility and tilth.

- Cropping technology. Farmer skills need to improve in order to better manage increased water and agricultural surface area.

- Natural vegetation. The loss of natural vegetation can be compensated, in part, by agroforestry, forestry, live fences and wind breaks. These activities should be component parts of ORT's continuing project.

- Dune encroachment. Continuing dune encroachment requires their stabilization. Livestock should not concentrate on the windward side of the wadi fringe. ORT should integrate livestock management into its project activities so that cattle don't contribute to degradation of dune vegetation near the project wadis. Livestock watering points should be downwind rather than upwind of wadis.

5.11. Energy requirements and conservation potential of various alternatives and mitigation measures

- Fuel. This EA did not analyze moto-pump petroleum fuel requirements. We know, however, that fuel needs will increase. At the present time, agricultural incomes are sufficient to cover fuel costs.

- Fuelwood as a conservation potential. Although the project does not require fuelwood, live fences, agroforestry, forestry and fruit tree plantings all produce fuelwood. This will reduce domestic demand on natural vegetation.

- Trees. The traditional shadouf is seriously depleting natural stocks of the ronier palm. As shadoufs are replaced by motopumps or improved dalous, pressure on the palm and other trees should decrease.

- Labor. The objective of this project is to increase food production. The technology it develops reduces labor requirements because it replaces the shadouf with motors or with improved, animal-driven dalous.

- Transportation. Increased food production will require goods transport to market. Much of this transport will be by motor truck; some will be by donkey and camel. This will increase regional energy requirements.

5.12. Required monitoring

- Piezometric head. The project needs to continue its ongoing monitoring of water-table elevations. The project monitors and records water level in existing wells for different seasons of the year. This can easily be done by farmers.

- Water quality. The project should continue its present activities to measure water quality. We recommend no change in this program. However for the sustainability of this activity after the project, farmers should be provided with simple skills to identify indicators for water quality modification. Since the indicator method is site specific, particularly in the wadi ecosystems, the project will develop this in collaboration with farmers.

- Soil quality. Periodic monitoring should be made of soil salinity, soil hardness, and organic matter content. With salinity, ORT should use true extracts (Appendix H) to develop a correlation between soil extracts and 1:1 soil and water mixes. Thereafter, soil salinity should be measured from the 1:1 mix and correlated to its extract level.

- Crop yields. Crop yields should be measured and correlated to project inputs, land ownership, and other variables.

- Irrigation efficiency. Irrigation efficiencies should be monitored as in ORT's ongoing program. We should have a clear idea of the relationship between inputs and outputs. Farmers should learn simple methods to gage and evaluate depths to water table, crop yields, irrigation water requirements and other elements of day-to-day farming activities.

6. LIST OF PREPARERS AND CONTRIBUTORS

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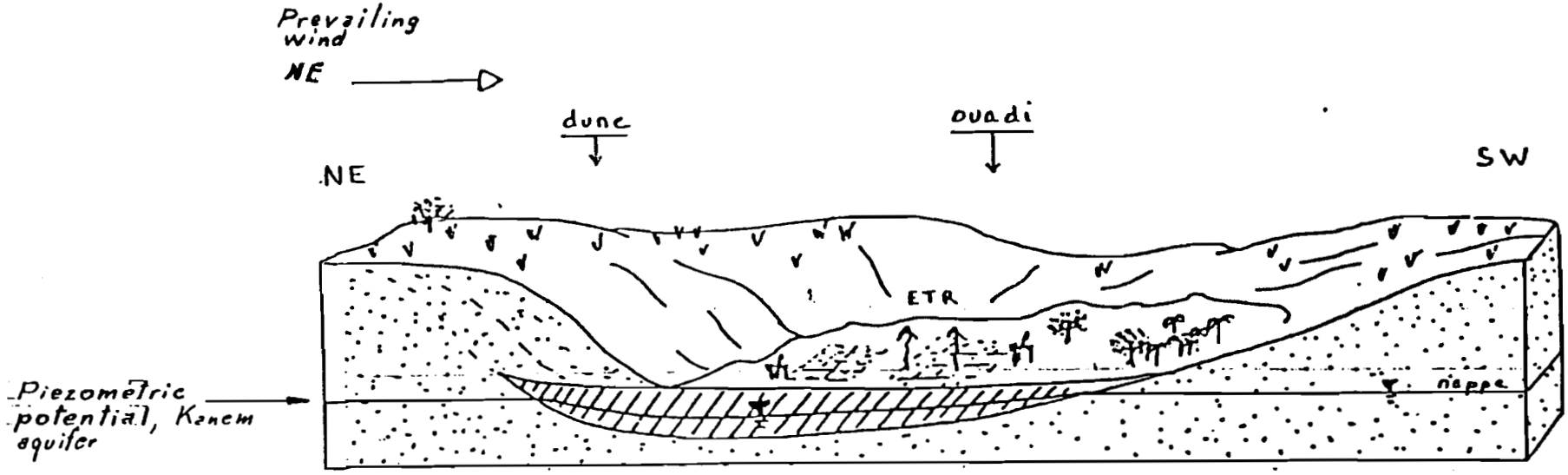

Lacustrine deposits: silty clays and silt loams overlying varved siltstone.

Very fine to fine, well sorted aeolian sand.

Source: Eberschweiler, 1990

TYPICAL WADI CROSS SECTION

ANNEX H

ANNEX H : DETAILED COST ESTIMATE

1. Expatriate Technical Assistance

Position	Year 1 $	Year 1 CFAx1000	Year 2 $	Year 2 CFAx1000	Year 3 $	Year 3 CFAx1000	Total CFAx1000	Total $
a) Chief of Party/Administrative and Training Officer (36 months-N'Djamena)								
Base salary of $45,000/year	45,000		47,250		49,613			141,863
Post differential (25% of base salary)	11,250		11,813		12,404			35,467
Fringe benefits (30% of base salary)	13,500		14,175		14,884			42,559
Education allowance	12,000		12,000		12,000			36,000
b) Marketing Specialist (36 months-Ngouri)								
Base salary of $45,000/year	45,000		47,250		49,613			141,863
Post differential (25% of base salary)	11,250		11,813		12,404			35,467
Fringe benefits (30% of base salary)	13,500		14,175		14,884			42,559
Education allowance	12,000		12,000		12,000			36,000
c) Water Resources Specialist (36 mo.-Ngouri)								
Base salary of $40,000/year	40,000		42,000		44,100			126,100
Post differential (25% of base salary)	10,000		10,500		11,025			31,525
Fringe benefits (30% of base salary)	12,000		12,600		13,230			37,830
Education allowance	12,000		12,000		12,000			36,000
	237,500		247,576		258,157		0	743,233

2. International Travel and Transport

Expense	Year 1 $	Year 1 CFAx1000	Year 2 $	Year 2 CFAx1000	Year 3 $	Year 3 CFAx1000	Total CFAx1000	Total US$
a) To/from post								
(i) Airfare to & from post: $2300/one-way ticket (in Year 1) x 3 experts x 4 persons/expert's family x 2 trips	27,600		0		30,429			58,029
(ii) Unaccompanied baggage: 300 kgs. per family at $10.30/kg., or $3090/family	9,270		0		10,220			19,490
(iii) Excess baggage: 10 kgs/family	561		0		619			1,180
b) R & R: $2300/rtn x 3 experts x 4 persons/ expert's family	27,600		0		30,429			58,029
c) Home leave: $3240/rtn x 3 experts x 4 persons/expert's family	0		38,880		0			38,880
d) Inspection trips: Wash.-N'Dja.-Wash.								
(i) Airfare: $2630/rtn	2,630		2,762		2,900			8,292
(ii) Per diem: 10 days x $210/day	2,100		2,100		2,100			6,300
	69,761		43,742		76,697		0	190,200

3. Local Travel

Expense	Year 1 $	Year 1 CFAx1000	Year 2 $	Year 2 CFAx1000	Year 3 $	Year 3 CFAx1000	Total CFAx1000	Total $
a) Per diem for expat. staff		780		819		860	2,459	8,782
b) Per diem for local hire staff		795		835		877	2,507	8,954
c) 12 horses: 115,000 CFA/horse, including accessories (harness, shelter, etc.)		1,380					1,380	4,929
d) horses (15): operations and maintenance (25,000 CFA/horse/mo. x 12 mo x 15 horses)		4,500		4,725		4,961	14,186	50,665
		7,455		6,379		6,698	20,532	73,330

4. Offices, Housing, Utilities

Expense	Year 1 $	Year 1 CFAx1000	Year 2 $	Year 2 CFAx1000	Year 3 $	Year 3 CFAx1000	Total CFAx1000	Total $
a) Rent for N'Djamena office (400,000 CFA/m)		4,800		5,040		5,292	15,132	54,043
b) Utilities: N'Dja. office (125,000 CFA/mo.)		1,500		1,575		1,654	4,729	16,889
c) Rent for N'Djamena houses: for Chief of Party and transit house (600,000 CFA/mo.)		7,200		7,560		7,938	22,698	81,064
d) Utilities:								
(i) 2 N'Djamena houses: 301,667 CFA/month		3,620		3,801		3,991	11,412	40,757
(ii) Ngouri compound: 83,550 CFA (excl. water & electricity in 6.a below)		1,003		1,053		1,106	3,162	11,291
e) Repairs for Ngouri compound		3,750		750		750	5,250	18,750
		21,873		19,779		20,731	62,383	222,794

5. Local Hire Personnel

Position	Year 1 $ CFAx1000	Year 2 $ CFAx1000	Year 3 $ CFAx1000	Total CFAx1000	Total $
a) Agricultural Engineer (Ngouri)	3,250	3,412	3,732	10,394	37,121
b) Marketing Agent (Ngouri)	1,300	1,365	1,542	4,207	15,025
c) Pumps Agent (Ngouri)	2,350	2,467	2,768	7,585	27,089
d) Agronomy Assistant (Ngouri)	2,325	2,441	2,638	7,404	26,443
e) Administrator (Ngouri)	2,825	2,966	3,431	9,222	32,936
f) Monitoring/Evaluation Assistant (Ngouri)	1,150	1,207	1,385	3,742	13,364
g) Agro-Forester (Ngouri)	1,625	1,706	1,910	5,241	18,718
h) Field Trainers (Ngouri): 8	5,750	6,037	6,802	18,589	66,389
i) Guards: 9 (Ngouri - 3; N'Djamena - 6)	5,150	5,407	6,187	16,744	59,800
j) Drivers: 7 (Ngouri - 6; N'Djamena - 1)	7,350	7,717	8,730	23,797	84,989
k) Bookkeeper (N'Djamena)	2,175	2,284	2,690	7,149	25,532
l) Administrator (N'Djamena)	2,900	3,045	3,596	9,541	34,075
m) Secretary (N'Djamena)	2,075	2,179	2,356	6,610	23,607
n) Janitor/Messenger (N'Djamena)	575	604	730	1,909	6,818
	40,800	42,837	48,497	132,134	471,906

6. Training

Expense	Year 1 $ CFAx1000	Year 2 $ CFAx1000	Year 3 $ CFAx1000	Total CFAx1000	Total $
a) Team retreat at Dougia: room and board for 3 days: 25,000 CFA/person/day x 20	1,500			1,500	5,357
b) Training equipment	1,500			1,500	5,357
c) Development of training materials	300	315	331	946	3,379
d) Production of training materials	450	473	497	1,420	5,071
e) Sessions on water lifting at Ngouri	150	158	166	474	1,693
f) Sessions on agronomy at Ngouri	150	158	166	474	1,693
g) Sessions on agro-forestry at Ngouri	150	158	166	474	1,693
h) Conference in N'Djamena		1,500		1,500	5,357
i) Manufacture of "bidon verseur"	150	0	0	150	536
j) Food for inter-wadi sessions	315	331	348	994	3,550
k) Training for project staff	400			400	1,429
l) Cooperative Management & Accounting(local)	870	870	870	2,610	9,321
m) African travel:					
(i) Input market research in northern Nigeria: 2 trips x 3 persons x 6 days	425	446	0	871	3,111
(ii) "Bidon verseur" market research in Niamey: 3 persons x 8 days	675	0	0	675	2,411
	7,035	4,409	2,544	13,988	49,958

7. Vehicules, equipment,furnishings & supplies

Expense	Year 1 $	Year 1 CFAx1000	Year 2 $	Year 2 CFAx1000	Year 3 $	Year 3 CFAx1000	Total CFAx1000	Total $
a) 8 vehicles								
(i) 5 pick-up trucks: 8,600,000 CFA/unit		43,000		0		0	43,000	153,571
(ii) 2 station wagons: 10,100,000 CFA/unit		20,200		0		0	20,200	72,143
(iii) 1 light vehicle: 4,600,000 CFA/unit		4,600		0		0	4,600	16,429
b) Vehicle operations and maintenance: 2,000,000 CFA/vehicle/year		16,000		16,800		17,640	50,440	180,143
c) 2-wheeled vehicles								
(i) 1 motorcycle		0		475		0	475	1,696
(ii) 1 bicycle		80		0		0	80	286
(iii) operations and maintenance for 1 motorcycle and 2 bicycles		275		289		303	867	3,096
d) Test packaging materials		75		79		83	237	846
e) Test storage materials		100		105		110	315	1,125
f) Marketing trials expenses		100		105		110	315	1,125
g) Workshop tools		450		0		0	450	1,607
h) Tubewell equipment		0		725		0	725	2,589
i) "Bidon verseur" equipment		650		0		0	650	2,321
j) Motor pump revolving fund		0		2,500		0	2,500	8,929
k) Maintenance team tools		250		0		0	250	893
l) Aquifer tap tools		150		50		50	250	893
m) Soil testing equipment and supplies	850			0		0	0	850
n) Environmental monitoring tools	850			0		0	0	850
o) Seeds for testing		50		50		0	100	357

p) Seed testing materials and supplies		75		75		0	150	536
q) Agro-forestry materials and supplies		1,500		1,575		1,654	4,729	16,889
r) Electric generator for Ngouri compound								
(i) purchase (incl. 10% for spare parts)		6,160		0		0	6,160	22,000
(ii) operations: fuel and oil		3,006		3,156		3,314	9,476	33,842
(iii) maintenance		750		788		827	2,365	8,446
s) Photocopy machines: 2 (for N'Dja. & Ngri.)								
(i) purchase (including spare parts)		931		1,875		0	2,806	10,020
(ii) operation & maintenance (560,000 CFA per unit)		373		373		373	1,120	4,000
t) Fax machine	1,000							1,000
u) Laptop computers: 2 ($2350/unit + freight)	5,200		0		0			5,200
v) Computer maintenance		400		420		441	1,261	4,504
w) Office supplies: 165,000 CFA/month		1,980		2,079		2,183	6,242	22,293
x) Office & household equipment & furnishings		9,000		0		0	9,000	32,143
y) Radio:								
(i) installation (at new office) & maint.		300		125		125	550	1,964
(ii) operator fees: 230,000 CFA/year		230		230		230	690	2,464
z) Procurement services	2000							2000
	9,900	110,685	0	31,874	0	27,444	170,002	617,050

8. Home Office Backstopping

Position	Salary Year 1	% of time	Base Backstop.	Fringe Backstop.	Year 1	Year 2	Year 3	Total $
a) Ag. Economist*	$48,060	45%	21,627	5,623	27,250	28,613	30,044	85,907
b) Wash. Coordinator#	$49,000	45%	22,050	4,851	26,901	28,246	29,658	84,805
c) Asst. Wash. Coordinator#	$20,000	20%	4,000	880	4,880	5,124	5,380	15,384
d) Secretary#	$24,223	30%	7,267	1,599	8,866	9,309	9,774	27,949
e) Controller#	$56,250	15%	8,438	1,856	10,294	10,808	11,348	32,450
f) Bookkeeper#	$32,069	15%	4,810	1,058	5,869	6,162	6,470	18,501
g) Training Specialist*	$77,500	15%	11,625	3,023	14,648	15,380	16,149	46,177
h) Equipment Specialist*	$44,015	5%	2,201	572	2,773	2,912	3,058	8,743
			82,018	19,462	101,479	106,554	111,881	319,914

U.S. fringe benefits = 22%
* Head office fringe benefits = 26%

9. Overhead

	Year 1	Year 2	Year 3	Total CFA	Total $
a) Year 1:					
(i) 30% x $130,000					
(ii) 30% x $ 82,018	63,605	0	0	0	63,605
b) Year 2:					
(i) 30% x $136,500 = $40,950					
(ii) 30% x $ 82,018 x 1.05	0	66,786	0	0	66,786
c) Year 3:					
(i) 30% x $143,325 = $42,998					
(ii) 30% x $ 82,018 x1.05x1.05	0	0	70,125	0	70,125
	$63,605	$66,786	$70,125	0	$200,516

10. Consultant Services

Position	Year 1 $	Year 1 CFAx1000	Year 2 $	Year 2 CFAx1000	Year 3 $	Year 3 CFAx1000	Total CFAx1000	Total $
a) Marketing baseline data collection and analysis: 6 weeks (i) Fee: $307/day x 36 days (ii) Per diem: - $210/day (N'Dja.) x 28 days - $45/day (Ngouri) x 14 days (iii) Airfare: $2750 RT		20,312		0		0	0	20,312
b) Socio-economic baseline study & transition support: 6 weeks (i) Fee: $307/day x 36 days (ii) Per diem: - $210/day (N'Dja.) x 28 days - $45/day (Ngouri) x 14 days (iii) Airfare: $2750 RT		20,312		0		0	0	20,312
c) Integrated Pest Management: 2 trips x 4 wk (i) Fee: $307/day x 48 days (ii) Per diem: - $210/day (N'Dja.) x 28 days - $45/day (Ngouri) x 28 days (iii) Airfare: $2750 x 2 trips = $5500 (iv) Misc: lab fees (pest identification), excess baggage, etc: approx. $5000		32,376		0		0	0	32,376
d) Replicability Study: 4 weeks (i) Fee: $307/day x 24 days (ii) Per diem: - $210/day (N'Dja.) x 18 days - $45/day (Ngouri) x 10 days = $ 450 (iii) Airfare: $2750 RT		14,348		0		0	0	14,348

e) Small enterprise management assistance: 4 weeks (i) Consulting firm's fee: $450/day x 24 days = $10800 (ii) Per diem: - $210/day (N'Dja.) x 18 days - $45/day (Ngouri) x 10 days = $ 450 (iii) Airfare: $2750 RT	0		17,780		0		0	17,780
f) Socio-Economic Impact Study: 4 weeks (i) Fee: $307/day x 24 days (ii) Per diem: - $210/day (N'Dja.) x 18 days - $45/day (Ngouri) x 10 days = $ 450 (iii) Airfare: $2750 RT	0		14,348		0		0	14,348
g) Translations (reports) and follow-up data collection activities (local)		1,800		900		900	3,600	12,857
	87,348	1,800	32,128	900	0	900	3,600	132,333

11. Other Direct Costs

Expense	Year 1 $	Year 1 CFAx1000	Year 2 $	Year 2 CFAx1000	Year 3 $	Year 3 CFAx1000	Total CFAx1000	Total $
a) Storage of household effects: $2400/year x 3 persons	7,200		7,560		7,938		0	22,698
b) Communications: postal fees, fax, telex, telephone, etc.: 175,000 CFA/month		2,100		2,205		2,315	6,620	23,644
c) Temporary housing allowance: $109/day x 30 days x 3 persons = $9810	9,810		0		0		0	9,810
d) Pre/post medical exams: $200 x 3 persons	600		0		662		0	1,262
e) Mid-term & final evaluations: local costs	0			150		150	300	1,071
f) Office installation fees		1,000	0		0		1,000	3,571
	17,610	3,100	7,560	2,355	8,600	2,465	7,920	62,056

12. Subtotal	Year 1	Year 2	Year 3	Total CFA	Total $
a) CFA expenses (in CFA x 1000)	192,748	108,533	109,279	410,560	1,466,286
b) $ expenses	587,203	504,346	525,460	-	1,617,009
					3,083,295

13. Contingency Reserve for CFA expenditures

Expense	Year 1	Year 2	Year 3	Total CFA	Total $
10% contingency for exchange rate fluctuation (10% of line item 12.a) in CFA x 1000	19,275	10,853	10,928	41,056	146,629

14. Total	Year 1	Year 2	Year 3	Total CFA	Total $
CFA expenses (line items 12.a + 13)	212,023	119,386	120,207	451,616	-
Dollar equivalent of CFA expenses	757,225	426,379	429,311	-	1,612,915
Dollar expenses (line item 12.b)	587,203	504,346	525,460	-	1,617,009
TOTAL in $ at 280 CFA/US$	1,344,428	930,725	954,771		3,229,924

ANNEX I

ANNEX I : PROJECT IMPLEMENTATION SCHEDULE

(Based on August or September 1991 start-up)

ACTIVITY	QUARTERS-YR 1				QUARTERS-YR 2				QUARTERS-YR 3			
	1	2	3	4	5	6	7	8	9	10	11	12
SIGNING OF ORT/GOC PROJECT AGREEMENT	xx											
PROCUREMENT OF NEW OFFICE EQUIPMENT AND VEHICLES	xxxxxxx											
PROCUREMENT OF TECHNICAL EQUIPMENT	xxx				xxx							
HOUSING ARRANGEMENTS	xx											
LOCAL STAFFING ARRANGEMENTS	x											
SOCIO-ECONOMIC BASELINE STUDY AND TRANSITION HELP	xx											
MARKETING BASELINE DATA COLLECTION AND ANALYSIS		xx										
TEAM BUILDING SESSION AT DOUGIA		x										
TECHNOLOGY CONFERENCE IN NDJAMENA								x				
AQUIFER TAP TRAINING FOR DELEGUES TECHNIQUES			x	x		x		x		x		
BIDON VERSEUR DEMONSTRATIONS		xxxxxxxxx										
BIDON VERSEUR ARTISAN TRAINING			xxxxxx		xxx							
BIDON VERSEUR MARKETING TRIALS					xxxxxxxxxxxx				xxx			
TECHNICAL ASSISTANCE TO MOTORPUMP GROUP(S)	xxxxxxxxxxxx				xxxxxxxxxxxx				xxxxxxxxxxxx			
MANAGEMENT TRAINING FOR MOTORPUMP GROUP(S)		x				x				x		

ACTIVITY	QUARTERS-YR 1				QUARTERS-YR 2				QUARTERS-YR 3			
	1	2	3	4	5	6	7	8	9	10	11	12
TECHNICAL ASSISTANCE TO TUBEWELL ENTERPRISE(S)			xxxxxx		xxxxxxxxxxxx				xxxxxxx			
MANAGEMENT TRAINING FOR TUBEWELL ENTERPRISE(S)			x			x					x	
MAINTENANCE MONITORING FOR ALL TECHNOLOGIES	xxxxxxxxxxx				xxxxxxxxxxxx				xxxxxxxxxxxx			
TRAINING OF PRIVATE REPAIR SERVICES			x				x				x	
TRAINING SESSION FOR FIELD AGENTS IN TECHNOLOGIES	x				x				x		x	
TRAINING SCDELAC AGENTS IN ENVIRONMENETAL MONITORING									xxxxxxxxxxxx			
ENVIRONMENETAL MONITORING	XXXXXXXX				XXXXXXXXX				XXXXXXXXX			
SMALL ENTERPRISE DEVELOPMENT CONSULTANCY					x							
TRAINING AND MONITORING OF DELEGUES TECHNIQUES	xxxxxxxxxxxx				xxxxxxxxxxxx				xxxxxxxxxxxx			
DISSEMINATION OF PROVEN AGRICULTURAL TECHNIQUES	xxxxxxxxxxxx				xxxxxxxxxxxx				xxxxxxxxxxxx			
NON-CHEMICAL PEST CONTROL CONSULTANCIES		x	x									
AGRONOMIC TRIALS IN DIVERSIFICATION AND PEST CONTROL		xxxxxxxx				xxxxxxxxx				xxxxx		
TRAINING SESSION FOR FIELD AGENTS IN AG TECHNIQUES	x				x				x			
CONSULTANT STUDY ON REPLICATION STRATEGIES								x				
COLLECTION OF ECONOMIC AND TECH DATA ON TECHNOLOGIES	xxxxxxxxxxxx				xxxxxxxxxxxx				xxxxxxxxxxxx			
MARKETING TRIALS FOR SMALL INPUTS - SEEDS, PARTS, ETC.	xx		xx		xx		xx		xx			

ACTIVITY	QUARTERS-YR 1				QUARTERS-YR 2				QUARTERS-YR 3			
	1	2	3	4	5	6	7	8	9	10	11	12
MARKETING TRIALS FOR NEW WADI PRODUCE - BEETS, ETC.		xxxx		x		xxxx		x		xxxx		
NEW PACKAGING/HARVESTING DEVELOPMENT AND TRIALS		xxx		x		xxx		x				
STORGE TECHNOLOGIES DEVELOPMENT AND TRIALS				xxx	xx			xxx	xx			
DISSEMINATION OF SUCCESSFUL TESTED MARKETING TECHNIQUES								xxx	xxxxxxxxxxxx			
MARKET RESEARCH AND PRICE MONITORING	xxxxxxxxxxxx				xxxxxxxxxxxx				xxxxxxxxxxxx			
SOCIO-ECONOMIC IMPACT STUDY								xx				
MID-TERM, FORMATIVE EVALUATION							x					
SUMMATIVE EVALUATION												x

ANNEX J

ANNEX J : POSITION DESCRIPTIONS

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1. CHIEF OF PARTY/ADMINSTRATION AND TRAINING OFFICER

LOCATION: N'DJAMENA

LENGTH OF CONTRACT: 3 YEARS

General Responsabilities

The Administration and Training Officer will serve as Chief of Party and will be responsible for overseeing all administrative and logistical aspects of the project. He or she will serve as liaison between the Ngouri-based team, GOC officials, AID, and ORT headquarters. The Administration and Training Officer will be the spokesperson for ORT in Chad, representing ORT to the GOC, AID and other international donors and NGOs. He or she will assure the smooth functioning of the ORT N'Djamena office and assist the Deputy Chief of Party in the administration of the regional office in Ngouri. In addition, the Administration and Training Officer will organize and coordinate all formal training sessions in Ngouri and elsewhere. He or she will be based in N'Djamena but will spend 20% of his or her time in Ngouri.

Specific Responsibilities

1. Draft quarterly reports on the progress of project implementation. Ensure that project activities are carried out in accordance with established work plans and contribute to project objectives.

2. Prepare annual budgets; account for and monitor project expenditures.

3. Organize the hiring of local personnel; support and supervise all national and expatriate project staff.

4. Oversee procurement of project equipment and supplies; arrange for all housing and office space.

5. Establish and implement a vehicle and office operations and maintenance system.

6. Prepare scopes-of-work for, and manage, short-term consultants.

7. Ensure observation of ORT policies and procedures relating to accounting, inventory, vehicles, procurement, personnel and other support functions.

8. Oversee all aspects of project implementation, taking into account technical expertise of field staff, and taking the

lead in all formal training activities.

9. Organize the team-building retreat at Dougia early in year one and the N'Djamena conference on project accomplishments late in year two.

10. Develop materials for and organize regular formal training sessions for field staff and SODELAC agents on various project-related topics, e.g., live fencing, use of the deleque technique system, pump maintenance, etc. Most sessions are to be held in Ngouri; technical staff will implement actual sessions in most cases.

11. Develop materials and organize similar training sessions for farmers in the Ngouri area.

12. Carry out other tasks requested by ORT headquarters.

Qualifications

The Administration and Training Officer should have a minimum of three years previous work experience in Africa and should have excellent French and English. Experience in logistics and administration of development projects is required. The Officer should have good organizational, inter-personal, and writing skills. In addition, he or she must have previous experience in developing training materials, planning, and implementing training sessions in a developing country.

2. AGRICULTURAL MARKETING TECHNICIAN/SITE SUPERVISOR

LOCATION: NGOURI

LENGTH OF CONTRACT: 3 YEARS

General Responsabilities

The Marketing Technician will serve as site supervisor in Ngouri, representing ORT in the project area and supervising all project staff assigned there. He or she will defer to the Water Resources and Agronomy technicians in technical matters but will be ultimately responsible for ensuring that project objectives are met in the Ngouri zone. The Marketing Technician will be responsible for developing sustainable private-sector supply lines for relevant agricultural inputs, and profitable marketing strategies and techniques for wadi produce. Based in Ngouri, he or she will travel to urban markets as necessary for research.

Specific Responsibilities

1. Manage the Ngouri project office and vehicle fleet.

2. Supervise and support all project staff in the zone.

3. Draft and submit activities reports to the Administration and Training Officer.

4. Represent ORT to GOC and donor officials in the Ngouri area and maintain constructive relationships with them.

5. Undertake activities to develop sustainable private-sector supply services for basic agricultural inputs for wadi farmers.

6. Strengthen the motorpump farmers' group through management training and technical assistance.

7. Undertake activities to develop private-sector capacity to manufacture and distribute the bidon verseur technology.

8. Facilitate the organization of an independent tubewell enterprise and provide necessary management training and support.

9. Introduce, test, and evaluate value-enhancing crop storage, harvesting, and packaging technologies.

10. Identify profitable opportunities in off-season production and diversification; coordinate relevant trials with the Agronomy technician and ensure follow-up.

11. Organize and evaluate trial shipments of non-traditional crops to urban markets.

12. Organize market research and data collection on produce prices; ensure its relevancy to project decision-making.

Qualifications

The Marketing Technician must have a Masters degree in agricultural economics, business administration, or another relevant field. He or she should have at least three years experience in development in Africa and should speak good French. Experience in staff supervision and small enterprise development is highly desirable. Some knowledge of Arabic would be helpful. The Marketing Technician should enjoy working closely with small traders in the field and he or she should demonstrate a clear understanding of the private-sector approach to marketing.

3. WATER RESOURCES TECHNICIAN

LOCATION: NGOURI

LENGTH OF CONTRACT: 3 YEARS

General Responsabilities

The Water Resources Technician will be responsible for achieving project goals related to the strengthening and dissemination of water resources technologies: the aquifer tap, the tubewell, the small motorpump, needs-based irrigation techniques, and the bidon verseur. He or she will train farmers and staff in the use, maintenance, and repair of the technologies, and will conduct environmental monitoring.

Specific Responsibilities

1. Draft and submit activities reports to the Administration and Training Officer.

2. Organize and implement training sessions for farmers and staff in the use, maintenance, and repair of the technologies.

3. Adapt and improve the technologies as necessary.

4. Work with the Marketing Technician to develop sustainable supply lines for the technologies and spare parts.

5. Train artisans in the production of the bidon verseur and ensure the development of a viable private manufacturing system; coordinate this effort with the Doum-Doum project.

6. Develop and execute a plan to demonstrate the bidon verseur to as many farmers as possible in the zone; coordinate efforts to develop a private distribution system with the Marketing Technician.

7. Provide technical assistance and logistical training to the motorpump group(s).

8. Provide technical assistance and logisitical training to the tubewell enterprise(s).

9. Train and re-train pump repairmen in the zone.

10. Monitor the maintenance of all water lifting devices; establish and execute viable maintenance program.

11. Monitor environmental indicators and train SODELAC agents to continue this monitoring after close of project.

12. Manage workshop and technical equipment inventory.

Qualifications

The Water Resources Technician must have a Masters degree in a relevant technical field, or at least three years of practical experience working with technologies similar to the ones listed above. He or she should have at least three years experience in development in Africa and should speak good French. Experience in technology transfer is highly desirable. In addition, he or she must be capable of conducting environmental monitoring tasks, (e.g., measuring soil salinity and water quality). The Water Resources Technician should not only be technically qualified, but should be interested in marketing and dissemination aspects of the technologies.

4. AGRONOMY TECHNICIAN

LOCATION: NGOURI

General Responsabilities

The position of Agronomy Technician will be filled by a qualified Chadian, either seconded from SODELAC, or independent. He will be responsible for overseeing project activities related to agronomy and the dissemination of the agricultural techniques which proved successful during Phase I.

Specific Responabilities

1. Draft and submit activities reports to the Administration and Training Officer.

2. Train field staff and deleques techniques in the agricultural techniques which proved successful during the project's first phase.

3. Supervise and support agricultural field staff.

4. Conduct on-farm trials in crop diversification and off-season production in coordination with the Marketing Technician.

5. Organize all logistics associated with these trials, explore different sources for seeds, and draft reports on results.

6. Ensure that appropriate data is collected on adoption rates, surface areas, etc.; ensure that only relevant data is collected and that it is analyzed on a regular basis.

7. Coordinate storage, harvesting, and packaging trials with the Marketing Technician, and oversee their implementation.

8. Implement trials in non-chemical pest management, as

recommended by consulting specialist; evaluate and write-up results.

9. Take steps to strengthen extension services in the zone; organize training, and stress the deleque technique system.

Qualifications

The Agronomy Technician will head a major component of the project and therefore must have a degree as an ingénieur agronome (agent de conception). He also should have experience in conducting agronomic trials and be willing to work closely with farmers in the wadis. French is necessary; Arabic and Kanembou language skills would be helpful. The Agronomy Technician must be able to work within a team, and should have good inter-personal and personnel management skills.

5. SHORT-TERM CONSULTANT FOR MARKETING BASELINE AND ANALYSIS

The consultant will have six weeks to gather baseline information on agricultural input and ouput markets for wadi farmers in the Ngouri zone. This will involve describing current marketing practices and gathering baseline numbers against which project progress can be monitored, e.g., how many shopkeepers currently sell seeds? which varieties? what are farmers' traditional onion storage practices? what percentage of tomatoes are damaged during transport? etc., (other questions should be based on indicators in the logical framework). The consultant will also analyze the marketing situation and make recommendations within the framework of the program outlined in the project proposal. He or she should have a relevant Masters degree and have previous experience using rapid rural appraisal techniques to analyze agricultural markets in the Sahel.

6. SHORT-TERM CONSULTANT FOR SOCIO-ECONOMIC BASELINE STUDY AND TRANSITIONAL SUPPORT

The consultant should be a current member of the ORT team in Chad who can facilitate the transition between the outgoing and in-coming project management teams. For six weeks, he will serve to advise the in-coming team on logistical procedures, previous data collection, and technical project issues. In addition, he will establish the agricultural and economic baseline that will serve as a point of departure for Phase II. This will involve bringing all ongoing data collection activities up to date, and synthesizing the information in such a way that it can be used to guage future progress, e.g., average wadi income, average surface area cultivated per season, number of farmers who have adopted composting techniques, number of farmers using aquifer taps, percentage of surface area devoted to garlic, etc.

7. SHORT-TERM CONSULTANT FOR SMALL ENTERPRISE MANAGEMENT ASSISTANCE

For four weeks, the consultant will analyse the systems in place for motorpump procurement, tubewell installation, and bidon verseur manufacture and distribution. He or she will make recommendations on how to strengthen the enterprises undertaking these activities, how to attract clients, how to keep accounts, and how to manage the businesses profitably. He or she will design a training program to achieve these goals.

8. SHORT-TERM CONSULTANT FOR REPLICABILITY STUDY AND STRATEGY FORMATION

The success of the ORT project depends on replicability -- the ability of one farmer to copy the improvement his neighbor has undertaken, without depending on the project to do so. The consultant will study this phenomonon and consider whether project innovations are "spreading" to other farmers and wadis. He or she will analyze the "spread effect" and make recommendations on how to speed the process. In addition, she or he will survey the Lake prefecture to identify areas where specific ORT technologies are appropriate and where they are likely to catch on if introduced. The consultant will consider SODELAC's role in technology dissemination, and will make practical recommendations on how ORT and SODELAC can best cooperate to facilitate the dissemination process. This will probably involve definining a training program for SODELAC agents who are outside of the immediate project zone.

9. SHORT-TERM CONSULTANT FOR SOCIO-ECONOMIC IMPACT STUDY

The socio-economic impact study will examine the impact the project has had on farmers and farm families involved in the project and on controls who do not participate. It will also determine the impact of the marketing activities on merchants and petty traders in the zone. For four weeks the consultant will conduct end-of-project surveys and analyse the data collected through the continued monitoring of the survey sample used in Phase I. Additonal farmers and merchants and controls should be selected and followed as the project expands throughout the project zone and becomes involved in new activities.. The data on these additional farmers will give a valid picture of the socio-economic impact of the project.

10. LOCAL STAFF POSITION -- WATER RESOURCES ASSISTANT

The Water Resources Assistant will work under the Water Resources Technician in Ngouri. He will assist the head technician in all aspects of the water resources program, but will specialize in motorpump maintenance and repair training. It is anticipated that this position will be filled by ORT's current Pumps Technician.

11. LOCAL STAFF POSITION -- MARKETING ASSISTANT

The Marketing Assistant will work under the Marketing Technician in Ngouri. He will assist the head technician in all aspects of the marketing development program. He will serve as a liaison between local traders and the project. He will assist in researching marketing matters and will help identify those merchants who are best suited to participate in project activities. The Marketing Assistant will accompany traders and farmers on project-sponsored trial runs designed to test new marketing techniques and strategies. It is anticipated that this positon will be filled by one of the drivers currently working with ORT who has extensive trading experience and Kanembou language skills.

12. LOCAL STAFF POSITION -- AGRONOMY ASSISTANT

The Agronomy Assistant will work under the Agronomy Technician in Ngouri. He or she will assist the head technician in all aspects of the agronomy program. He or she will assist in executing and evaluating trials in crop diversification and natural pest management techniques. He or she will participate in the careful documentation of all trials and will assist in the process of obtaining Environmental Determinations from AID. The Agronomy Assistant will be expected to cooperate fully with SODELAC and Farmer Training Agents. He or she must have graduated from an agronomic studies program deemed sufficiently advanced by the Chief of Party.

13. LOCAL STAFF POSITION -- AGROFORESTRY AGENT

The Agroforestry agent will work under the Agronomy Technician. He will focus on the dissemination of live fencing techniques in the wadis. He will experiment with ways to produce saplings without the use of plastic pots and he will search for sustainable seed sources. The Agroforestry agent will maintain a small nursury to backup the individual wadi nursuries that he is promoting and monitoring. It is anticipated that this position will be filled with ORT's current agroforester.

14. LOCAL STAFF POSITON -- FIELD ADMINISTRATOR

The Field Administrator will be responsible for logistical, administrative, and financial matters at the Ngouri sub-office. He will be directly supervised by the Marketing Technician/Site Chief. The Field Administrator will manage Ngouri's vehicle fleet, housing, and office affairs. He will operate the radio and assure regular communication with N'Djamena. He will assist in local personnel matters and write regular reports monitoring financial and logistical affairs in Ngouri. It is anticipated that this position will be filled with ORT's current Field Administrator.

15. LOCAL STAFF POSITION -- HEAD FARMER TRAINING AGENT

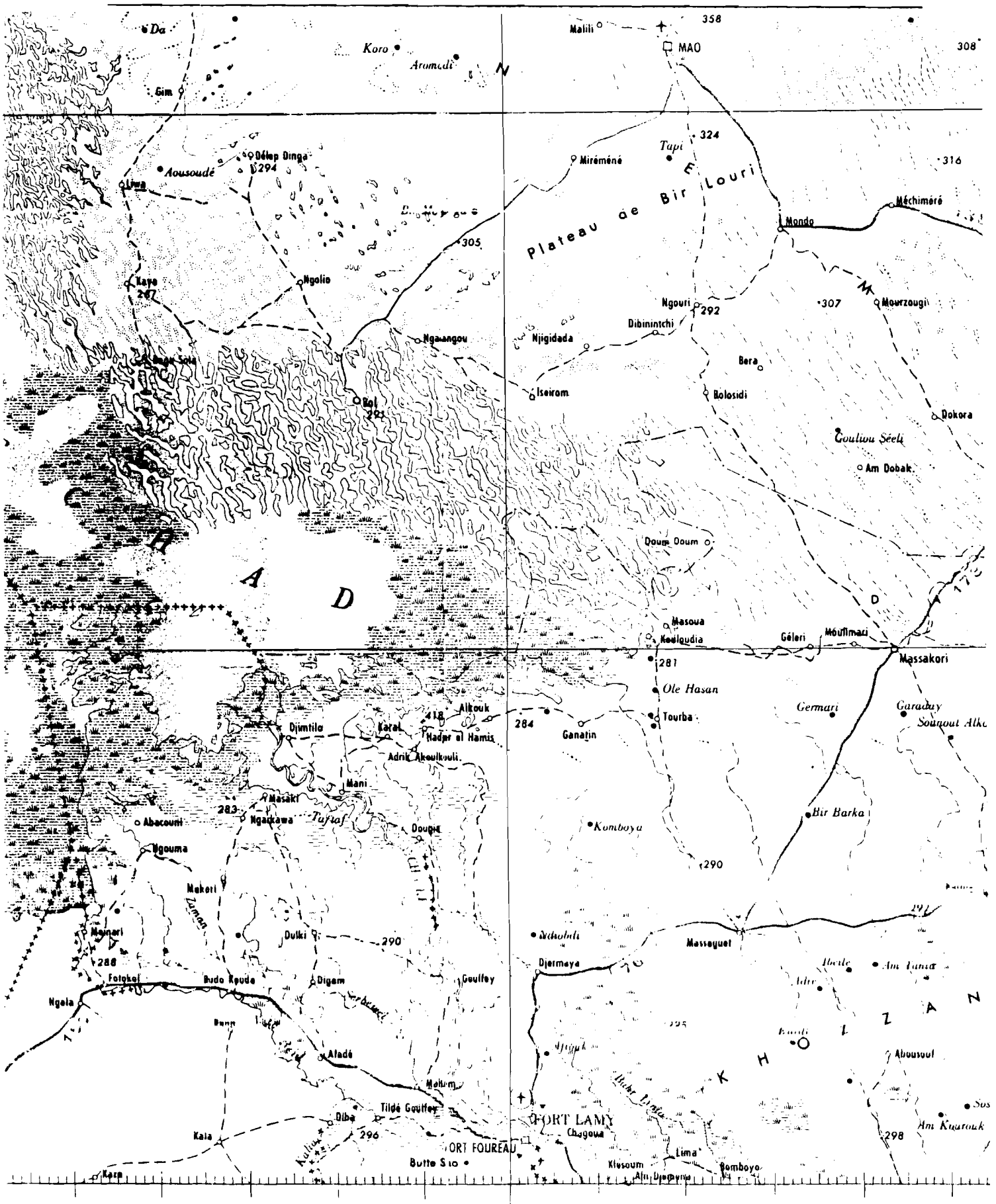
During Phase I, ORT hired six Farmer Trainers to work closely with wadi farmers and to train the delegue techniques. As the project expands its dissemination effort in Phase II, the number of Farmer Trainers will expand to eight. The Head Farmer Agent will serve to coordinate and oversee their activities. When necessary, he will serve as a liaison between the Farmer Trainers and the Technicians and Field Administrator, visiting the Farmer Trainers in the field to collect reports and pass along communications. He will be based in Ngouri and will assist the Field Administrator in monitoring and reporting responsabilities. It is anticipated that this position will be filled by the best of the Phase I Farmer Trainers.

16. LOCAL STAFF POSITION -- FARMER TRAINING AGENTS

During Phase I, ORT hired six Farmer Trainers to work closely with wadi farmers and to train the delegue techniques. AID's final project evaluation characterized this personnel set-up as "effective." As the project expands its dissemination effort in Phase II to 47 wadis, the number of Farmer Trainers will expand to eight. Each Farmer Trainer will cover five to six wadis, travelling on horseback. He will monitor wadi activities, provide technical assistance, and train the delegues techniques in project technologies. The Farmer Trainers will be village-based and will be supervised by the Head Farmer Training Agent, the Field Administrator, and ultimately the Site Chief. The Farmer Trainers will cooperate regularly with all Technicians in implementation.

ANNEX K

ANNEX K : MAP


Da
Koro
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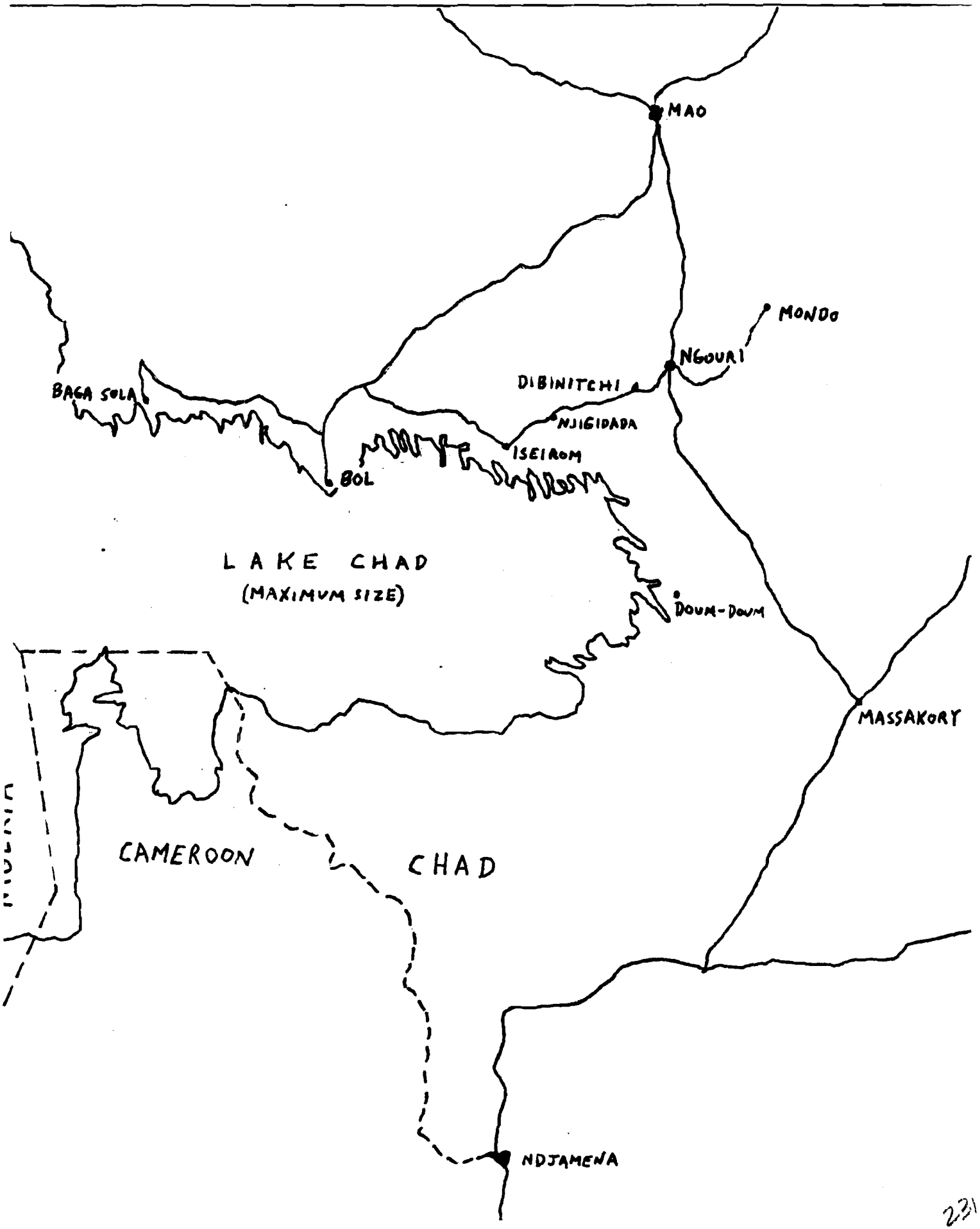
Gim
Malili
MAO
358
308
Tapi
324
316
Miréméné
Plateau de Bir Louri
Méchiméré
Mondo
Aousoudé
Délap Dinga
294
Liwa
305
Kaya
267
Ngolio
Ngouri
292
307
Mourzougui
Dibinintchi
Njigidada
Ngasangou
Bera
Iseirom
Bolosidi
Dokora
Bol
293
Coulivu Séeli
Am Dobak
Doum Doum
Masoua
Koulqudia
Géleri
Moufimazi
Massakori
281
Ole Hasan
Germari
Garabay
Tourba
284
Ganatin
Alkouk
418
Djimtilo
Karal
Hadjer el Hamis
Adrik Akoulkouli
Mani
Masaki
283
Ngaskawa
Tafiaf
Abacouni
Dougui
Komboya
Bir Barka
Ngouma
290
Makeri
Lamin
Mainari
288
Dulki
290
Massaguet
Djermaya
Fotokol
Budo Kouda
Digam
Goulfey
Ngala
Aladé
Abousoul
Mokum
Tilde Goulfey
Diba
296
PORT LAMY
Chagoua
Kala
PORT FOUREAU
Butte Sio
Klesoum
Lima
Bomboyo
Am Djemena
Am Kuarouk
298
15°

ANNEX K : MAP


MAO
MONDO
NGOURI
DIBINITCHI
BAGA SOLA
NJIGIDADA
ISEIROM
BOL
LAKE CHAD
(MAXIMUM SIZE)
DOUM-DOUM
MASSAKORY
CAMEROON
CHAD
NDJAMENA