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IRRIGATION WATER-LIFTING IN THE SHEBELLI WATER MANAGEMENT PROJECT

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ACRONYMS AND ABBREVIATIONS

ADC	Agricultural Development Corporation
AEFM	Agricultural Extension and Farm Management project
AFMET	Agricultural Farm Management and Extension
AID	U.S. Agency for International Development
ARD	Associates in Rural Development, Inc.
CARS	Central Agricultural Research Station
CSBS	Commercial and Savings Bank of Somalia
DLWR	Department of Land and Water Resources, MOA
ERDGS	Ecumenical Relief and Development Group in Somalia
FAO	Food and Agriculture Organization of the United Nations
GBMIP	Genaale-Buulo Mareerta Irrigation Project, MOA
GSDR	Government of the Somali Democratic Republic
GTZ	German Agency for Technical Cooperation
IQC	indefinite quantity contract
LibSoma	Libya-Somalia (irrigation project near Afgoi)
MMP	Sir M. MacDonald and Partners, Ltd.
MOA	Ministry of Agriculture, GSDR
MOP	Ministry of Planning, GSDR
ONAT	National Farm Machinery and Agricultural Supply Service
PID	project identification document
PP	project paper
PPA	proposed project area
PTO	power take-off
PV	photovoltaic(s)
RET	renewable energy technology
SAR	sodium absorption ratio
SCF	Save the Children Federation
SDB	Somali Development Bank
SOW	scope of work
S&T/EY	Bureau for Science and Technology, Office of Energy, AID
SURERD	Somali Unit for Research on Emergencies and Rural Development
SWMP	Shebelli Water Management Project
TAMS	Tippetts, Abbett, McCarthy and Stratton
UDHIS	general union of cooperatives
UNHCR	United Nations High Commission for Refugees
UQIB	association of agricultural cooperatives
USAID	U.S. Agency for International Development
WMSII	Water Management Synthesis II

PREFACE

The work described in this report was performed by Associates in Rural Development, Inc. (ARD) under an energy indefinite quantity contract (IQC) work order (number PDC-1406-I-13-2167-00) with the U.S. Agency for International Development (AID) for USAID/Somalia's Comprehensive Groundwater Development Project. The IQC activity involved the comparative evaluation of a range of options for irrigation water pumping systems. The ARD team consisted of the firm's senior engineer, Mr. Richard McGowan; an agricultural economist, Mr. Larry Johnston; an ARD senior associate who specializes in sociology, Dr. Alfred S. Waldstein; and two water-quality specialists, Mr. John Speed and Dr. Gus Tillman (ARD's senior environmental scientist).

This report describes the findings of month-long visits to Somalia by ARD team members. The first two, Mr. McGowan and Mr. Johnston, arrived in early August 1986. Initial field trips to the two project areas under consideration (Shalambood and Faraxanne), established the site-specific constraints under which the various pumping systems would operate. Farming systems issues related to the proper choice and management of pumps were examined as well. Data gathered during these field visits were also made available to the Water Management Synthesis II (WMSII) team preparing the scope of work (SOW) for the SWMP project paper (PP), whose visit to Somalia partially overlapped with that of the ARD team. Two other ARD team members (Dr. Waldstein and Mr. Speed) arrived in early September to begin their field data collection efforts.

Numerous individuals provided valuable support and assistance in the gathering of the information given here. We would particularly like to thank Engr. Abdiqani Fara, renewable enery coordinator for the Ministry of Agriculture, who was instrumental in the data-collection phase of this effort. We appreciate the guidance offered by the project officer, Bill Darkins, and the mission's Office of Agriculture, particularly Roger Garner. The WMSII team--Jack Keller, Tom Weaver and John Mayo--provided useful insights into our initial findings. JESS project team members, particularly Jim and Nancy Merryman, provided useful input based on their professional experience in Somalia. Especially helpful were the many farmers, pump operators and MOA personnel who were so forthcoming with information in spite of our unceasing questioning. Karen Wiese provided a very careful review of several sections of this report. We also thank Laurie Gee and Lisa Powlison for their assistance in the report's timely completion.

I. EXECUTIVE SUMMARY

In August 1986, Associates in Rural Development, Inc. (ARD) undertook a study of irrigation water-pumping/water-lifting issues for USAID/Somalia and the Ministry of Agriculture (MOA) of the Government of the Somali Democratic Republic (GSDR). The study focused on two proposed project areas (PPAs) of the planned Shebelli Water Management Project (SWMP) in the Lower Shebelli Region. During four weeks in the Lower Shebelli Region, the ARD team (an engineer, an agricultural economist, a sociologist and a water-quality specialist) made several field trips and discussed various aspects of the project and local agricultural irrigation needs with USAID/Somalia and GSDR officials in Mogadishu. The team conducted extensive interviews with MOA representatives, groups of farmers, agricultural cooperatives, and pumping system owners, operators and suppliers in the Lower Shebelli Region and in Mogadishu.

The three major components of the SWMP are:

- irrigation-focused adaptive research;
- rehabilitation of physical water management structures; and
- a river basin approach to management of the irrigation network.

It is the authors' initial impression, based on their field interviews and observations, that although these three major project components are certainly important aspects of increasing agricultural output in the region, they do not necessarily represent the major constraints to agricultural production in the PPA, as initially presumed.

Production constraints, such as availability of good seed, fertilizer, and adequate agricultural mechanization (primarily tractors for field preparation), as well as an acute shortage of field labor, were emphasized by both MOA officials and farmers as being of equally immediate concern. The adaptive research component of the SWMP should include determination of the marginal benefits of irrigation water pumping in the Lower Shebelli Region, thereby allowing the prioritization of additional irrigation water supplies within the hierarchy of agricultural production constraints. Decision-quality analysis of pumping issues in the PPAs will require a much more extensive knowledge of existing conditions than would be attained during a short-term reconnaissance. Therefore, this effort focused on the identification of those factors which will be most critical in the project design phase.

The consultants have developed an extensive qualitative data base of information related to water-lifting in the PPAs. The most common water-pumping applications in the areas of interest were catalogued, and a survey of pumps installed in those areas was performed. At present, there are relatively few pumps being used in either of the PPAs. Since the Shebelli River in those areas is one to two meters above the surrounding fields, by far the majority of small farm irrigation is gravity-fed. Pumps are used only by government or private cooperatives, wealthy individual farmers or large companies, almost invariably to support perennial fruit production (primarily bananas, but also grapefruit, papayas, mangoes, etc.). Small farmers grow only annual crops--primarily maize, sesame, and small vegetable crops, principally for personal consumption.

This analysis of the existing situation suggests that pump applications in the SWMP are not likely to be extensive. However, design of the project physical rehabilitation has not occurred yet. The WMSII group working on preliminary project design suggested additional pump applications that might be included in the SWMP design. The ARD team concludes that the most probable pumping applications in the PPAs (assuming that annual, not perennial crops are to be supported, as suggested in the project identification document) are:

- pumping out of gravity-filled, off-stream storage reservoirs back into secondary canals during low-water periods in the Shebelli River; and

- pumped drainage for removing excess water and for salinity control.

Based on these probable applications, a preliminary screening of a wide variety of pumping-system options was performed. Considering the limited demand profile data currently available, estimated pumping requirements and the known technical characteristics of each of the options considered, stand-alone standard diesel pumps appear to be the best option for off-stream storage pumping. Depending on the as yet unknown capacity requirements and demand profile for pumped drainage, mechanical wind pumps may be able to partially meet these requirements. Any demand not met by wind pumps could be met with stand-alone diesels. If wind pumps are used, high-quality machines are available from and can be supported by a manufacturer in Kenya. No significant indigenous wind-pump manufacturing capability currently exists in Somalia.

While only limited cost data are available at this point, a representative small farm budget suggests that water pumping appears marginally cost-effective at best, given existing cropping patterns and limited agricultural production inputs. Small farmers do not appear to generate sufficient cash to pay even the recurrent costs of mechanical water-lifting. Indeed, water-lifting costs may further exacerbate existing small farm cash-flow problems. As farmers are provided access to additional inputs, additional irrigation will become a more critical production constraint, and the costs of additional pumped irrigation will be more justifiable. Concerted efforts to improve irrigation efficiency by training farmers in proper water application techniques would be a useful initial step.

Water-lifting applications in the PPAs will be limited primarily to cooperative schemes where groups of farmers jointly manage medium-scale (30- to 100-HP) stand-alone pumpsets, mainly for pumping off-stream storage in a secondary canal for common access. This cooperative arrangement could simply be an extension of existing water-management associations, whose primary task is organizing farmers for the performance of semi-annual secondary and tertiary canal maintenance activities. The MOA is nominally responsible for operation and maintenance of civil works for the major irrigation network, including barrage dams, large headgates and primary canals.

If more detailed economic analysis suggests that water pumping is determined to be cost-effective in the project, consideration should be given to taking advantage of the locally existing support infrastructure for diesel-pump operation and maintenance. This implies the use of Italian equipment, for which spare parts and experienced technicians are locally available. Importing equipment from other sources will tend to further compound existing support infrastructure deficiencies. Where possible, standardization with existing equipment should be one of the major selection criteria for new equipment.

Currently, private-sector equipment suppliers (with the exception of the largest supplier, SomalFruit) do not have any significant inventory of pumping equipment and must special-order equipment (normally from Italian distributors). While certain issues related to GSDR policy make convenient access to equipment difficult, privatization is being tentatively encouraged by the GSDR. There exists some modicum of private-sector involvement in the farm-supply sector in the Lower Shebelli Region, including several competent, local mechanic shops. To develop greater indigenous operations and maintenance capabilities, technical training programs should be designed to encourage involvement of these groups in any equipment maintenance for the SWMP.

Water-quality and soils issues pertaining to pumped irrigation for agriculture were examined. While there are deficiencies in the water-quality and soils data bases for the Lower Shebelli Region, field sampling and subsequent analysis of both river and groundwater confirm other researchers' contentions that groundwater is generally far too saline to be considered seriously for long-term irrigation. However, at both Somali

National University's Faculty of Chemistry and the National Soils Laboratory at Afgoi, the institutional capability does exist to further extend this limited data base.

The adaptive research component of the SWMP should have a strong soil/water chemistry emphasis, including more extensive water and soils sampling and analysis in the PPAs. A drainage engineer with experience in salt-flushing should be included on the research team to investigate the extent of required drainage. Without adequate drainage, low yields and eventual land abandonment will continue to be major causes of low crop yields in the PPAs.

The decision to include water-lifting strategies in the SWMP will require additional study and investigation. These efforts should be carefully coordinated with plans for rehabilitation of the existing irrigation infrastructure. Additional water-lifting requirements may become evident once rehabilitation is complete and water flows at farmers' fields are evaluated. If the current emphasis on annual crops is changed to include some perennials, then groundwater pumping (which is strongly discouraged in this report) or additional seasonal off-stream storage must be considered.

Thus, the project design team should first identify precise applications required in the rehabilitation effort. It should then establish a timetable and terms of reference for studies to determine design water-lifting requirements and the appropriate choice of pumping technologies, based on the tentative conclusions in this report. Concurrently, farming systems research on small farm budgets should determine the marginal benefits of pumped irrigation and the subsequent feasibility of designing water-lifting into the physical rehabilitation component.

The ARD team was asked to suggest scopes of work for inclusion in the PP design. Summarized below are the activities the authors feel the project design team should consider in preparing terms of reference for the adaptive research component of the project:

- evaluate existing available water supplies in the PPAs (both groundwater and water from the Shebelli River), in light of all projects, both planned and currently under development in the river basin, including consideration of the possibility of dams constructed in other countries which may affect water availability in the PPAs;

- investigate the "marginality" of additional irrigation input--among other things, this would include estimating present and future demand for additional irrigation input, estimating the profitability of increased irrigation input, and comparing net benefits from additional irrigation input with those which might be obtained from increased use of other inputs;

- estimate the impact of marginal output associated with increased irrigation input on market prices for farm production;

- examine the feasibility of diesel-pump performance improvement programs based on operator training and pump-performance monitoring and evaluation;

- identify specific locations/applications for water-lifting systems, identify technically viable water-lifting technologies on a site-by-site basis, and evaluate particular benefits/economies associated with each;

- conduct on-site testing and evaluation at existing installations for technically viable water-lifting technologies (in particular, medium-scale diesels)--data collection efforts should focus on recurrent operations and maintenance costs associated with various alternatives, since these are the most variable and site-dependent components of diesel-pump life-cycle costs;

- evaluate the impact of import duties, taxes, subsidies and government procurement policies on the choice of water-lifting technology;

- evaluate the training/transactions costs associated with public- versus private-sector ownership and examine possible alternatives to ownership, such as equipment leasing;

- determine appropriate values/fees for pumped irrigation water, and evaluate methods for their collection;

- install and collect data from a six-station anemometry (wind measurement) network in the Lower Shebelli Region to provide design and estimated cost data for wind-pumped drainage systems;

- perform a local epidemiological study to determine the incidence of water-borne diseases in the PPAs and the relationship between those diseases and the possible use of extensive off-stream (particularly seasonal) storage basins in project rehabilitation;

- initiate a concerted program to extend the existing water-quality and soils data bases in the PPAs, integrating widely scattered data, as well as bringing to bear the expertise of existing institutions; and

- investigate the requirements for drainage and salt-flushing in the PPAs, in terms of both current and future cropping patterns and irrigation practices.

2.0 INTRODUCTION

2.1 Purpose

In late 1985, ARD was asked to undertake a comparative evaluation of pumping and water-lifting systems in rural Somalia under the auspices of USAID/Somalia's Comprehensive Groundwater Development Project. ARD has done related water-pump evaluation studies in Botswana, Malaysia and Yemen to determine and compare the technical, financial/economic, institutional and social aspects of a variety of pumping systems. The initial focus was on equipment options for borehole pumping of village water supplies for domestic use and stock watering in rural Somalia. After a trip to Somalia in late 1985, ARD's senior engineer produced an initial reconnaissance report (McGowan, 1985). This served as the basis for a second visit in May/June 1986 to develop an implementation work plan to install, test and evaluate a number of diesel, wind and photovoltaic (PV) borehole pumps in the Bay Region. The proposed effort was not undertaken due to time and logistic constraints, but ARD was asked by the mission to refocus its efforts on the Lower Shebelli Region in an issues-oriented study of water pumping to increase the agricultural production of small farmers in the Lower Shebelli Region.

2.2 Shebelli Water Management Project

The Lower Shebelli Region is one of two major agricultural areas in Somalia (see Figure 2-1). While certain areas in the region have been under irrigation for quite some time, dramatic expansion of the irrigated area occurred in the late 1920s. Somali farmers and Italian colonists undertook initial construction of what became a series of barrage dams and network of primary, secondary and tertiary canals in the area between Genaale to the north, Shalambood to the southeast, Mokoyjaale to the southwest and Qorioley to the northwest (see Figure 2-2).

The primary objective of USAID/Somalia's agricultural development program is to increase short- to medium-term output in the agricultural and livestock sectors. Since supplemental irrigation is critical to much of Somalia's agricultural production (particularly in the Lower Shebelli Region), AID sought to address the need for more reliable irrigation through implementation of the SWMP. As currently conceived, the project has three major components:

- adaptive research to address some of the significant gaps in agricultural production data for Somalia;

- river basin management for the Shebelli River, which is particularly important because of the various

Figure 2-1. Map of Somalia

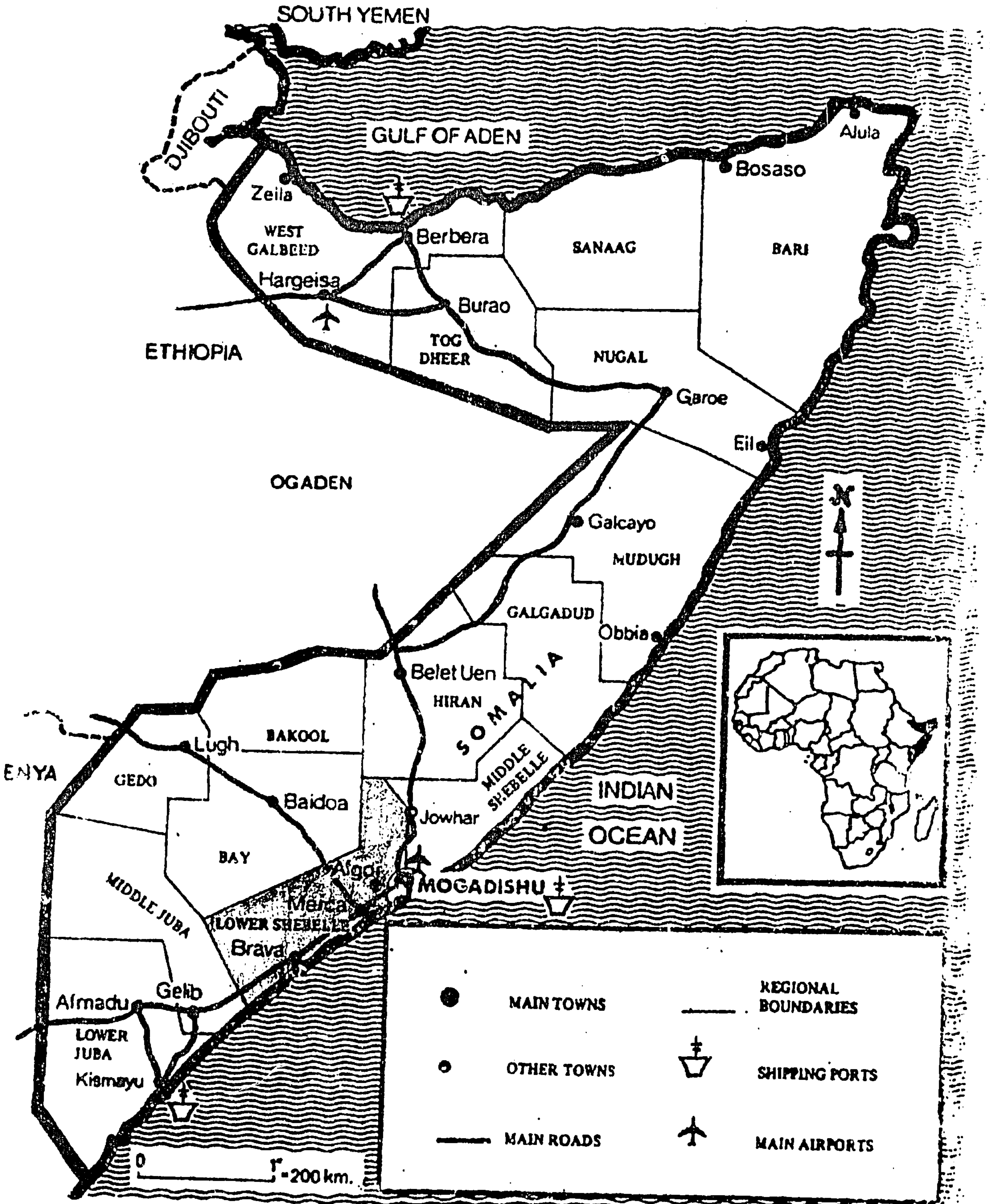
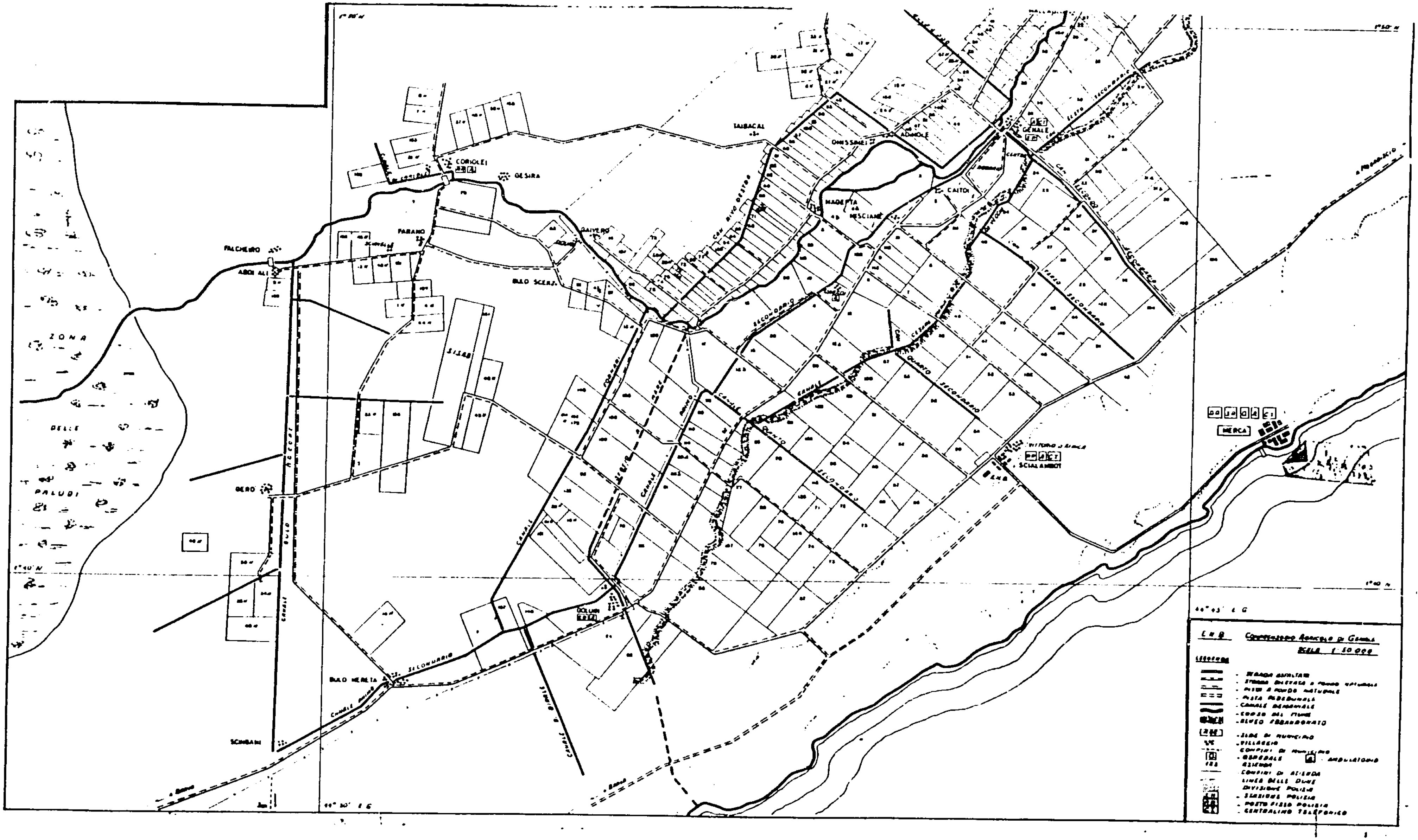


Figure 2-2.

Genaale-Shalambood-Qorioley Area



irrigation rehabilitation or development projects that are either already in progress or under consideration by different donor organizations; and

- rehabilitation of civil works, including barrage dams, primary and secondary canals, and possible development of additional off-stream storage reservoirs to increase the operating efficiency of the irrigation network.

Several donor groups have focused their efforts on development and/or rehabilitation of irrigated areas in the Lower Shebelli Region. Over the past 10 years, a number of references that are very useful for the design of SWMP have resulted from donors' project planning efforts. One of the more valuable outputs of the ARD team's efforts was the collection of all the relevant references that are likely to be needed by the SWMP design team. To avoid repetition in this report of information in those references, the reader is directed to specific sections of the most useful documents, as appropriate.

Prior to the ARD team's visit to Somalia, its primary references were the TAMS 1986 interim report, titled GENALE IRRIGATION REHABILITATION PROJECT, FEASIBILITY STUDY. Of secondary importance (since it focused on the Bay Region) was the draft final report from Louis Berger International on the Comprehensive Groundwater Development project. Upon arrival in Mogadishu, the team obtained the studies of primary importance to the current effort from a variety of sources at MOA and donor agencies, including:

- SHABELLE WATER STRATEGY STUDY (Lahmeyer International of West Germany, 1986, in draft with eight appendices), henceforth referred to as the Lahmeyer International report, funded by the German Agency for Technical Cooperation (GTZ) as a feasibility study for the irrigation rehabilitation of a specific area, in the context of the entire Shebelli River Basin;

- GENALE-BULO MARERTA PROJECT, VOLUME I, MASTER PLAN, MAIN REPORT, Sir M. MacDonald and Partners, Ltd. (MMP), of Cambridge, England, 1978--a broad-ranging study of irrigation in the Lower Shebelli Region; and

- SOMALIA--GENALE IRRIGATION REHABILITATION PROJECT, SUPPORTING DOCUMENT FOR PROJECT BRIEF, prepared by a team from the World Bank and Food and Agriculture Organization (FAO) of the United Nations that visited the area in September 1983--this is an excellent quick-reference summary document for the project.

In addition, a variety of other reports of topical interest are referenced throughout this report.

2.3 Scope of Work

ARD was asked by USAID/Somalia to undertake a study of the irrigation water-pumping aspects of the planned project and also suggest scopes of work (SOWs) for the SWMP design team to include in the PP. The SOW for the ARD team initially included the following tasks:

- collect, analyze and evaluate all available data on water-supply pumping systems (e.g., PV, wind, diesel and any other systems) that may exist in the Lower Shebelli Region;
- in collaboration with USAID/Somalia agriculture and engineering offices, formulate appropriate plans and SOW(s) for the next logical phase(s) of this activity in the Lower Shebelli Region; and
- prepare a comprehensive report on comparative pumping systems in the area.

The first half of the ARD team--Mr. McGowan and Mr. Johnston, an engineer and agricultural economist, respectively--arrived in Somalia in August 1986. To broaden the perspective of the team on irrigation-specific issues, ARD also proposed the inclusion of two additional team members:

- a sociologist with experience in the social and institutional aspects of irrigation (Dr. Waldstein); and
- a water-quality specialist (Mr. Speed), who could examine both ground- and river-water samples to determine the effects of water quality on pumping equipment (e.g., corrosion) and agricultural production. Dr. Tillman would then review and evaluate the data collected for inclusion in the report.

To determine the physical constraints under which irrigation pumps would operate, and to examine the broader issues of water management, soil and water quality, cropping patterns, and the prioritization of agricultural production constraints, field trips included the visual examination of the following physical structures:

- the four barrage dams upon which irrigation networks in both PPAs depend, namely those at Genaale, Gayweerow, Qorioley and Falkeerow;

- the relevant primary canals feeding the project areas--the First Secondario, Dhamme Yassin, Wadajir and Bokori;

- the major secondary canals in the Shalambood PPA (there were no large secondaries in Faraxanne), the Second, Third and Fourth Secondario canals; and

- at each project site, the team followed one secondary canal from its headgate on the primary canal down through all the minor headgates to the fields that it feeds--in the Faraxanne area, the secondary canal chosen was unnamed (on the team's maps), but came off the Bokori along the western-most edge of the project boundary, and in Shalambood, the Fourth Secondario from just north of Shalambood to the Dhamme Yassin was selected.

In addition, at each site, the soil was cursorily examined for salinity and texture, cropping patterns were noted, any pumps the team found were examined and photographed, and conversations were initiated with any farmers or laborers encountered.

3.0 GENERAL CONDITIONS IN THE PROPOSED PROJECT AREAS

This section gives an overview of conditions in the PPAs to provide a context for examining pumping as an issue in the design of SWMP. To avoid repetition of information that is given in considerably more detail in the primary references already noted (see Section 2.2), the descriptions are necessarily brief.

3.1 Existing Infrastructure

3.1.1 Physical Characteristics

A general description of the irrigation network in Somalia's Lower Shebelli Region is available in several references (MMP, Lahmeyer International, TAMS), so only a brief discussion of the major civil works that directly affect the PPAs is provided in this section. On the Lower Shebelli River between the towns of Genaale and Qorioley, there are three barrage dams, located at Genaale, Gayweerow and Qorioley. There are also three primary canals with headgates located immediately upriver of the Genaale barrage--the Primo Secondario, the Dhamme Yassin and the Asayle. The Asayle is no longer operational.

The Primo Secondario and Dhamme Yassin canals are the main sources of irrigation water for the eastern side of the Lower Shebelli River Valley between Genaale to the north, Buulo Mareerta to the south and Shalambood to the east (see the map provided in Figure 2-1). The Second, Third, Fourth and Fifth Secondario canals run northwest to southeast from the Dhamme Yassin. The gross irrigable area fed by the northern three secondary canals is approximately 6,255 hectares (TAMS, 1986) and the location of the Shalambood project, the first of two areas being considered for rehabilitation.

Approximately 15 kilometers downstream from Genaale is the Gayweerow barrage, not currently in use for reasons that are only briefly mentioned in the major references. It was designed to deliver water into the lower end of the Primo Secondario canal, but according to local farmers and MOA officials, the slope is incorrect, which results in water from the Primo Secondario flowing back into the river. 25 kilometers downriver from Genaale is the Qorioley barrage. The last barrage of interest on the river is located at Falkeerow. Approximately two kilometers downstream from the Gayweerow barrage are located the headgates of the Wadajir canal, one of the two primary canals running through the Faraxanne PPA. The headgates of the second primary canal intersecting the Faraxanne project, the Bokori, are located about three kilometers upstream from the Falkeerow barrage. The Wadajir canal runs into the Primo Secondario between Golweyn and

Buulo Mareerta, and the Bokori runs into it three kilometers below Buulo Mareerta.

There is no network of major secondary canals in the Faraxanne area like those along the Dhamme Yassin serving Shalambood. Italian large landholders initially settled and developed both the Faraxanne and Shalambood areas, but poor groundwater quality (which is required for perennial fruit irrigation during the dry season) eventually forced the abandonment of fruit farms in Faraxanne. Widespread production of irrigated annual crops in the Faraxanne area has developed much more recently than Shalambood.

3.1.2 Current Cropping Patterns

Cropping patterns vary somewhat between the two study areas. In Shalambood, there are several very large farms belonging to SomalFruit, with primary crops (in descending order of importance) of bananas and other fruits, such as papaya, lemons and grapefruit, maize and small vegetable plots (tomatoes, sweet peppers, groundnuts, beans, onions, lettuce and occasionally beets), watermelon and coconuts. In Faraxanne, while some areas were planted in fruit, the most common crop was maize, with small vegetable plots that were apparently largely for personal consumption. Smallholders grow only annual crops.

One farmer that the team visited near Jeerow (just south and west of the Faraxanne project boundary) had 10 hectares of grapefruit (1,000 trees) as well as some papaya, guava and mango groves, and several hundred hectares of irrigated maize. He had constructed a 13-hectare reservoir to store irrigation water primarily for use in the dry season. He was in the process of preparing an additional 40 hectares to plant 4,000 more grapefruit trees. He estimated the reservoir would be more than adequate, assuming that all the fruit trees were irrigated once a month during the dry season after the river dried up.

While farmers with access to the canal network generally feel there is sufficient water for annual crops, perennial crops normally require groundwater pumping. The only instances in which this is not true are where private reservoirs are filled from canals during the high-water seasons and then just enough water is pumped from storage during the dry months to keep the trees alive.

There is some question as to which crops the USAID project would support. The project identification document (PID) specifically states that the focus of USAID/Somalia's irrigation rehabilitation effort is to be directed toward import substitution (i.e., primarily cereal crops). However, several individuals interviewed by the team, both farmers and MOA personnel, felt that growing maize would not pay for expensive irrigation projects and efforts should focus on extending the production of cash crops. This reflects the recommendation of the World Bank's 1981 agricultural sector development study that Somalia should concentrate on growing crops for export. The team heard differing opinions about whether Somalia is actually self-sufficient in cereal crop production. Apparently, Somalia exported maize and sorghum before 1965, but only in the last two years has domestic demand been met, according to MOA planners.

In practical terms, AFMET agricultural researchers stated that they were encouraging the planting of rice, sunflowers (which have a better yield than sesame, but require higher input costs) and groundnuts, and that rice was a better crop than maize for the region. However, due to traditional tastes, it was unlikely that people would move away from maize as the main cereal crop. Sesame requires a low level of agricultural inputs (one-third the cost for maize), but a quintal of sesame is three times the price of maize. While maize yields in Somalia can approach 35 quintals per hectare under good conditions, in reality, they seldom approach even 10 quintals per hectare under normal irrigated conditions (since other inputs are often insufficient).

3.1.3 Irrigation-Related Institutions and Practices

Several Somali national institutions are already active in the Shalambood irrigation area in supporting smallholder agriculture. MOA's Department of Land and Water Resources (DLWR) cleans the primary canals and makes equipment available for cleaning the secondaries. ONAT, a division of MOA, makes tractor services available to independent smallholder aziendas (farms) for a fee. The tractor usually comes and plows all of the land at an azienda, rather than doing each family holding individually, and the foreman of the azienda then assesses each family for its share of the charge.

AFMET has a network of contact farmers throughout the PPAs. Several people interviewed by the team mentioned general adoption of selected seeds and planting distances recommended by AFMET, and they have noted improvements in their yields after following the AFMET program. However, they complain that the costs of inputs are rising faster than the ADC producer price. Given this record in the area, it seems desirable to build a role for AFMET into the proposed project.

ADC is the buyer of choice for locally produced maize. During September 1986, when the field study for this report was conducted, the official ADC producer price for maize was So. Sh. 1,500 per quintal, while the free market price was 1,400 to

1,450. There is no information on the amount of marketable production that ADC absorbs.

UQIB still holds title to about 1,150 hectares of land in the Shalambood irrigation area. Recently, this land was divided among the smallholders who had been the work force there. They now work their plots as independent farm families. The cooperative supports them with access to machine services and inputs on credit. The smallholders are supposed to reimburse the cooperative after they sell their maize to ADC. This is the first year for the system, and since ADC has not yet bought the maize, the credits have not yet been repaid. The Agricultural Crash Programme project plays exactly the same role as UQIB for the smallholders on whom 650 hectares of its land have devolved. The only difference is that it is not clear to what degree the cost of machine services is covered by the project and to what extent it is furnished on credit.

MOA representatives in the area felt that the three major irrigation concerns are that:

- virtually all of the canals are seriously in need of more frequent periodic maintenance;
- given current cropping patterns, the river is high enough in much of the PPAs so that most irrigation does not require extensive pumping; and
- the barrages were under-designed and, in their current state of disrepair, are insufficient for as extensive a network of gravity-fed irrigation as might be possible.

MOA is responsible for the maintenance of all the barrages and primary canals, but that work is frequently done as an emergency response, rather than on a preventive basis. The government is also responsible for the primary and secondary canal gates and associated machinery, which are expensive and often cannot be manufactured locally. While the gates on the primary canals were all imported, secondary headgates that were manufactured locally were considered to be of substandard quality, as they rusted out rapidly and required replacement too frequently.

The regional MOA office annually submits a budget for canal maintenance that it feels is a minimum requirement, and routinely, none of the funding is received from the central government except when there is an emergency situation, such as a river embankment collapse or canal breach with consequent flooding. It is often the case that most, if not all, of the available canal excavation equipment is used extensively by SomalFruit, and canals which are not of particular concern to them do not necessarily receive the maintenance attention they need. Estimates of how often canals require de-silting varied from every two months to once a year. The MOA representative felt that a continuous program of excavation was needed for the area at a cost of about So. Sh. 10 million per year, which would cover river embankment, cleaning canals and the occasional digging of new canals, as necessary.

While MOA does not formally charge farmers for canal maintenance (such as it is), people are required to contribute food and fuel to MOA canal maintenance crews working on their stretches of major secondary canals. If people do not contribute, theoretically, they receive no water. In fact, no one ever refuses to pay and it unthinkable that some accommodation not be worked out to cover cases where someone is not able to pay. There is also a difference in the tax rate for unirrigated or rain-fed versus irrigated land, So. Sh. 10 compared to 20 per hectare, respectively. However, these taxes are not always collected on a regular or equitable basis, and land at remote sites is often not taxed at all. Although all land is formally owned by the government, farmers with over 100 hectares (particularly banana plantations) routinely pay the land-use tax, farmers with 10 to 100 hectares sometimes pay, and small farmers, who are by far the largest group in terms of population, often feel they have no money to pay the tax at all.

There is currently no formal water law in Somalia. National water legislation may be necessary before user fee collection can be initiated (some is currently under consideration). While it is logical that water users should pay fees, in fact, it may be a difficult concept to easily disseminate, since people are historically unaccustomed to paying any fees for water. While user fees (particularly if levied on a volumetric basis, although this is problematic at best due to measurement difficulties) will presumably reduce current wasteful irrigation practices, the farmers must understand that water allocations are limited, especially during the dry season.

With regard to land tenure, all land is owned by the government. To secure use of a particular piece of land, a farmer goes to the district MOA office and fills out an application specifying the size of the parcel and names of the users (presumably registered) along all the parcel's boundaries. Next, a letter is obtained from the local police verifying the claims in the application and that no one else is currently using the property, and a notice of intent to secure a use permit is publicly displayed for a month. The district officer and regional MOA commissioner then sign a letter granting permission to the farmer to use the land, and that form is forwarded to the Minister of Agriculture for final signing before the farmer formally has access to the land. When the entire process (which normally takes one to two months) is successfully completed, the farmer has use of the land for 50 years. However, if at any time during that period the land remains unused for two consecutive years, it reverts to the available land pool and other farmers are then free to apply for a use application.

In terms of management, the common element among all the plantations is a distinction between owners and workers. Some plantations are privately held, others owned by local cooperatives, some by national cooperatives and still others by national institutions. All use hired laborers, many of whom are actually resident on the plantation, who have no rights to the land. Land rights are vested in the plantation owner, whoever or whatever it may be.

The bulk of land in the PPAs is under the control of smallholders who are de facto owners of the land they cultivate, although few have registered title to the land they farm. The average smallholder family cultivates 1.0 to 1.5 hectares. Smallholders have grouped themselves into water-user associations of 100 to 150 families. Each association is headed by a foreman and farmers' committee. They schedule irrigation maintenance, assess members for the cost of paid services, oversee water distribution and adjudicate disputes.

The dominant private-sector institution in terms of irrigation water pumping in the Lower Shebelli Region is SomalFruit, a marketing and production organization that is jointly owned by an Italian company (60 percent) and the GSDR (40 percent). SomalFruit is not only the principal marketing and production agency for most of the banana crop, but also the primary source for much of the area's mechanized farming equipment (e.g., pumps, canal excavators, bulldozers and tractors). While most of the tractors rented by small farmers come from ONAT, SomalFruit is apparently the sole source of irrigation pumps, other than international donor agencies that provide pumps through various GSDR projects.

Farmers mentioned to the team that before 1960, the irrigation system functioned reasonably well. An arrangement had been made between large Italian landowners and local farmers and villagers that during the dry season, water allocations would be prioritized as follows:

- human consumption,
- stock watering, and
- maintenance irrigation of cash crops.

This arrangement was apparently strictly enforced by a group of private "canal police," and social pressures were strong enough to ensure reasonable compliance. Since independence, this has not been the case. Government officials control the primary canals, so in some instances, cooperatives and/or state farms have been given privileged access to dwindling water supplies at the end of the dry season when availability becomes most problematic.

3.2 Major Constraints to Increased Agricultural Production

The purpose of this section is to provide a brief overview of production constraints facing farmers in PPAs, which will afford a broader perspective for evaluation of the relative importance of irrigation issues.[1] Production constraints can be grouped into three major categories:

- natural resource constraints,
- physical constraints, and
- institutional constraints.

3.2.1 Natural Resource Constraints

Soil fertility in the PPAs is moderate to low. The soils are classified as vertisols which are characterized by their high content of fine-textured, heavy "cracking" clays. These soils are sticky and plastic when wet and hard when dry. Tillage activities are generally confined to very short periods after rains. While most soils in the area are at least moderately suitable for irrigation, profile and drainage deficiencies are evident. Poor aggregate stability, slow infiltration rates, and salinity hazards affect a significant portion of soils in the area.

The climate in the PPAs can be classified as tropical and semiarid. It is characterized by consistent temperatures in the $72^{o}F$ to $88^{o}F$ range, uniformly high humidities, and wind speeds averaging two to five miles per hour year round. Annual rainfall averages 400 to 500 millimeters, with roughly 60 percent of this total concentrated in the months April through July. Plant water

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[1]For a complete discussion of constraints and institutions involved, see the World Bank 1983 Identification Mission's Genale Irrigation Rehabilitation Project--Supporting Document for Project Brief, USAID Agricultural Extension and Farm Management Project's Farming Systems in the Lower Shebelli Region, March 1985; Lahmeyer International's Shebelle Water Strategy Study, Appendix C; TAMS' Genale Irrigation Rehabilitation Project, Feasibility Study.

losses due to transpiration often exceed water uptake, leading to retarded growth and reduced yields.

Irrigation water resources in the PPAs are limited to the Shebelli River and groundwater. Water is supplied from the river in two high-flow periods, i.e., the Gu flood in April-May, and the Der flood in August. The Gu flood is short-lived, unreliable, and often associated with high salinity levels and debris. Discharge during the Der flood is consistently high and of acceptable quality. Low flows may persist from the time Der floods subside (December-January) until the rise of the next Gu flood in April-May. In some years, the river actually dries up for one or two months. Groundwater supplies in the PPAs consist of an extensive aquifer from which the present abstraction is considerably less than the estimated recharge. However, earlier studies have shown that groundwater supplies are highly saline, even in the highest-quality area associated with the Primo Secondario Canal. MMP reported:

> If crops were irrigated solely from groundwater, yields would be practically zero except for highly tolerant crops such as cotton. With only supplementary use of groundwater (20 percent of the total supply) crop yield reductions of around 25 percent are still expected, and with more sensitive crops such as citrus, up to 50 percent reductions may occur. (p. 2.8)

Thus, the lack of usable groundwater is a major constraint to expansion of irrigated crops in general. Given the seasonality in river water supplies, the lack of usable groundwater also limits substitution of perennial crops for annual crops, since perennial crops require year-round irrigation.

3.2.2 Physical Constraints

One of the biggest constraints to increased agricultural production is farm size. Typical landholdings in the PPAs average less than two to three hectares. Farming units of this size simply do not generate cash revenues sufficient to purchase modern farming inputs. Even if they did, the "lumpiness" of many farm inputs would still create difficulties.[2]

Mechanization is widely employed in land preparation, but hand labor is used in virtually all other farming activities. Small farmers often rent tractors and farm implements from ONAT,

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[2]For example, choice of diesel pumps is limited to those capacities offered by manufacturers, none of which may be economically suited for a small farming operation.

the government agency, but also from the private sector. Family labor is often inadequate to meet total labor requirements, particularly those associated with weeding and harvesting activities. Farmers vie for limited supplies of hired labor, creating seasonal shortages and inflated labor prices.[3] These factors effectively limit farming unit size in the PPAs. To the extent that labor constraints affect the timeliness of farming operations, they may also lead to lower yields.

Recent surveys conducted by AID's Agricultural Extension and Farm Management (AEFM) project suggest that other physical constraints include machinery, fuel, improved seeds, insecticides and fertilizers. Research efforts, while far from conclusive, suggest that small farmers could expect rather dramatic yield increases with only moderate increases in the use of these inputs, particularly improved seeds and fertilizer. The authors believe that increased use of these inputs would produce far greater benefits than additional irrigation input (see Section 5.2). Their limited use is primarily due to limited supplies, high prices, inadequate credit facilities and lack of technical expertise.

Road and communication networks in the PPAs represent an additional constraint to increased agricultural production (and marketing). Compared with other areas of Somalia, the PPAs is well served by roads. There is a surfaced road from Mogadishu to Shalambood, and additional surfaced roads connecting Shalambood with Genaale, Qorioley and Golweyn. On the other hand, these roads have not been well maintained and are beginning to deteriorate badly. Similarly, earth tracks are extensive in the PPAs but poorly maintained. These tracks quickly become impassable when wet.

Telecommunications within the study area are poor. There are exchanges at Genaale, Qorioley and Shalambood, but these are often unreliable. Farmers do not appear to have access to printed communications, although limited use of radios is in evidence. In general, the lack of a communications infrastructure contributes to a poorly informed agricultural community. This situation has an obvious effect on barrage dam gate and water management at all the primary and secondary canals. The communications issue should be addressed by the project as part of its river basin planning component.

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[3]Some studies have dismissed the labor constraint issue on grounds that the Shebelli River Basin is one of the most densely populated areas in Somalia. This overlooks the fact that a great deal of the population is neither mobile, nor skilled in agricultural production.

3.2.3 Institutional Constraints

Institutional weaknesses have made it difficult for farmers to procure production inputs. Domestic production of farm inputs is limited and economically inefficient.[4] Imports are scarce and often beyond the financial means of small farmers. Distribution of inputs through government channels is untimely and often politically motivated. While parastatal organizations struggle with bureaucratic "red tape" and its attendant inefficiencies, farmers are forced to turn to the private sector in search of farm inputs.

Private-sector involvement in farm input supply varies by commodity. The private sector is not able to expand its involvement in markets which are either dominated by one or two large entities (particularly monopolistic public entities), or too limited to be financially attractive (see Lahmeyer International's SHEBELLE WATER STRATEGY STUDY, Appendix C, pp. C-46 to C-48). Under these circumstances, the private sector cannot be relied upon to aid in overcoming chronic shortages of fertilizers, improved seeds, small-scale farm implements and agricultural chemicals.

The scarcity of agricultural credit represents yet another important institutional weakness. Small farmers in the PPAs typically experience difficulties in financing production inputs, a situation which might be partially alleviated by greater access to credit. Marketing associations, water-user groups and other cooperative organizations evidently provide credit to farmers on a very limited scale. Time allocated for the current reconnaissance effort did not permit investigation of the credit terms available.

Both the Commercial and Savings Bank of Somalia (CSBS) and the Somali Development Bank (SDB) provide credit to the agriculture sector; however, their agricultural lending activities are limited in both scope and effectiveness. Branch offices are not convenient to small farmers (particularly the SDB, with only two branches, neither of which is in the PPAs). Interest rates are rather high (currently ranging from 14 to 15 percent), and repayment schedules often do not match the timing of expected cash inflows.

Given farmers' cash-flow problems and very limited access to institutional credit, it is obvious that other credit arrangements are being made. Unfortunately, very little is known about private credit sources in the PPAs. SomalFruit, a joint venture between Somalia (40 percent) and a group of Italian

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[4]Urea production at the plant near Mogadishu is a case in point.

investors (60 percent), provides credit in kind to farmers in return for labor and/or contracted banana production. Details of these and other private credit arrangements could not be readily ascertained.

Farmers in the PPAs generally lack the knowledge and technical skills required for modern (and more productive) farming activities. Assistance is required in identifying and promoting:

- alternative crops,
- optimum planting dates,
- improved planting and cultivation practices,
- effective crop rotations,
- optimum input levels,
- more efficient irrigation practices, and
- improved storage and marketing practices.

Research and extension relevant to the PPAs are primarily the responsibility of two government institutions--the Central Agricultural Research Station (CARS) at Afgoi, and the Agricultural Farm Management and Extension (AFMET) Center near Genaale. Both institutions have been criticized in previous studies. While weaknesses obviously exist, the authors are encouraged to find that such institutions are in place, staffed, and at least marginally functional. Poor management rather than lack of equipment and skilled manpower seems to be the major problem.

3.3 Differences Between Shalambood and Faraxanne

During discussions of pumping issues with farmers and government officials, many individuals suggested that there are significant differences between the Shalambood and Faraxanne PPAs which should be considered in selecting the area for irrigation rehabilitation efforts. It must be emphasized that these comments are based only on observations made during three field trips and on discussions with about 20 farmers in the area, and should not be construed as definitive characterizations of the two areas. The following differences were noted:

- In the Shalambood area, there are generally more smallholders (with less than three hectares) than in Faraxanne, despite the several very large banana farms in the southern part of the project area.

When the Italians left after World War II, their holdings were split among many smallholders. One person estimated the average holding along the Fourth Secondario (in Shalambood) to be about 20 jibals (16 jibals are equivalent to one hectare).

- Soil fertility in Faraxanne is considered better than that in Shalambood, due to soil composition and less intensive cropping history. Visible salt deposits were more noticeable on lands adjacent to the Fourth Secondario than on land adjacent to the Bokori.

- In the Faraxanne area, the authors saw many fields of sesame planted for the upcoming Der season, but there seemed to be very little sesame planted in Shalambood. One farmer speculated that this might be due to poor soil fertility.

- It was suggested that the water supply in the Dhamme Yassin was insufficient to meet the irrigation demands on the areas served. However, the secondary canals in Shalambood cover the project area quite well. There were no major secondaries observed in Faraxanne during the field visits (at least along the sections of the Bokori visited by the authors), nor were any indicated on the available maps.

- Groundwater in the Faraxanne area was generally considered far inferior in terms of salinity to that commonly available in Shalambood. One farmer said that until the late 1960s there were about 15 Italian-owned banana farms in the Faraxanne area that pumped groundwater from deep boreholes (static heads averaging 80 to 100 meters). These were abandoned due to excessive salinity. Good groundwater was felt to be restricted to an area between Buulo-Mareerta on the south, a point about halfway between Buulo-Mareerta and Jeerow to the northwest, and then following up the east-central side of the valley (Golweyn-Shalambood-Genaale) approximately along the Primo Secondario canal.

- In spite of the better groundwater in Shalambood, farmers said that the generally saline soil, low fertility, labor shortages, etc., could not justify the additional cost of pumping groundwater in Shalambood.

- Based on observations and interviews with farmers, typical maize yields were noticeably lower in Shalambood than Faraxanne. This was particularly true in the areas in along the Fourth Secondario where salt deposits were visibly apparent on the soil surface. Farmers quoted typical maize yields in Shalambood of five to six quintals/ha compared to 10 to 15 quintals/ha in Faraxanne. This assumed the standard smallholder conditions of little or no fertilizer, but sufficient water for the standard two irrigations.

- Farmers mentioned that the Bokori and Wadajir primary canals in Faraxanne were "insufficiently sloped" so that excessive sedimentation necessitated cleaning the canals every four months.

- While no obviously marshy areas were observed in Faraxanne, there were several such areas in Shalambood where drainage appeared to be a problem. Local farmers said the fields in question would be planted after the water was dissipated at the end of the Der season.

- The road network in Faraxanne is decidedly inferior to that in Shalambood. This definitely restricts market access for locally grown produce.

Finally, it should be mentioned that the MOA's vice minister of planning said that he felt both areas were desperately in need of rehabilitation, and that AID should consider broadening the focus of the project to address the needs of both areas.

4.0 GENERAL IRRIGATION ISSUES

4.1 Demand for Additional Irrigation Water

Any serious discussion of irrigation rehabilitation (and related pumping issues) must first address the issue of demand for irrigation input. In the PPA, this demand is partially satisfied by existing infrastructure. The real issue, then, is demand for additional irrigation input. The magnitude and seasonality of this "marginal" demand is of great importance. Generally, current demand for additional irrigation input is thought to be small, and limited to three or four months of the year.

Given a desire to see the SWMP's recurrent costs met locally, it becomes very important to distinguish between farmers' "wants/needs" and their "effective demand" for additional irrigation input. Effective demand can be described as the irrigation input farmers collectively require, and for which they are willing and able to pay.

The sociocultural sensitivities associated with Somalia's scarce water resources suggest that it might be wise to think in terms of demand for water delivery services rather than demand for water per se. This subtle but significant distinction was made by several farmers contacted during this reconnaissance. Generally, they indicated a willingness to pay for services associated with receiving additional irrigation input, but not for the water itself. There are two primary issues involved:

- irrigation in the PPA is basically a supplementary activity, which is of major importance in understanding the demand for irrigation input; and
- attempts to recover costs associated with additional irrigation input should be promoted as fees for water delivery services rather than for water per se.

4.2 Irrigation Water Availability and Delivery Capability

Groundwater and the Shebelli River represent the only natural supplies of irrigation water in the PPA. Previous studies suggest that supplies of usable groundwater may be limited both in quantity and geographic distribution (see MMP, 1978). Available evidence suggests that much of the usable groundwater supply in the PPA has been tapped by the larger farms producing perennial crops (particularly bananas). Potential for expansion of groundwater irrigation, especially for small farmers, is thought to be quite limited.

All irrigated farms in the PPA are served to some degree by the area's gravity-fed irrigation system. Water currently available to the system is seasonal and depends upon total flow at the PPA as well as efficiency of water delivery. River flow is not significantly affected by rainfall in the PPA since roughly 90 percent of the Shebelli River's discharge is derived from catchment areas in Ethiopia. Flow at the PPA is affected by offtake upstream. The timing and magnitude of upstream offtake become critical during periods of negligible rainfall. Barrages at Genaale, Qorioley, and Falkeerow were designed to smooth out variations in flow. However, these barrages are in various states of disrepair and their operation is poorly coordinated. Nonetheless, they continue to be marginally functional due to the inventive use of local materials for temporary repairs.

Unfortunately, major reductions in flow tend to coincide with periods of negligible rainfall in the PPA. River levels typically fall below those required to feed the gravity-flow network, creating serious water shortages on farmers' fields. Even in periods of adequate flow, inefficiencies (particularly the very heavy siltation) within the irrigation network limit the supply of water to farmers' fields. Previous studies have cited numerous factors responsible for overall irrigation efficiencies estimated at 20 percent, e.g., siltation and weediness of canals, seepage, and inadequate drainage. MMP went on to caution that even with overall efficiencies of 45 percent, the existing river flow and irrigation network in the PPA could support only limited expansion of annual crops, and even that only in the Der season (see MMP, 1978: Section 3.3). Any expansion of perennial crops was strongly discouraged. The primary issue is:

- irrigation supplies in the PPA are limited, particularly during the Gu season months of June and July--project efforts should be focused upon improving the quality and efficiency of irrigation in areas already under production.

4.3 Optimal Resource Allocation

Even if there is effective demand for additional irrigation input (and corresponding ability to meet that demand), one should consider whether an investment in additional irrigation capacity represents an optimum allocation of resources. At the micro level, targeted farmers should ask whether expenditures for additional irrigation input will yield greater net benefits than equal expenditures for other inputs. There is some evidence to suggest that this may not be the case.

Annual crop production in the PPA depends heavily on rainfall. Irrigation is supplemental, and many farmers in the PPA have access to at least limited quantities of irrigation water. Comparatively speaking, other inputs such as improved seed, fertilizer and insecticides, are used much less intensively. Therefore, one might expect that the marginal output associated with additional units of other inputs might be greater than that associated with additional irrigation input. Still, one must consider the marginal costs involved with specific inputs. Preliminary investigation suggests that the marginal cost of additional irrigation input will be quite high.

At the macro level, the questions become more complex. Specifically, how do net benefits from the proposed project compare with those which might be obtained from the same investment in alternatives such as energy, transportation or communications? Similarly, how do net benefits from the proposed project compare with those which might be obtained from the same investment in another geographic area? These issues deserve serious consideration. At best, one can point to studies such as MMP's, which used financial and economic analyses to rank various irrigation projects in the Lower Shebelli region. The main issue is:

- various input combinations can be used to produce a given level of output--the decision to promote additional irrigation input should be consistent with the principles of "input substitution" and "least-cost input combination."

4.4 Capital Versus Recurrent Costs

Many donor investments have become unproductive because funding was not made available for recurrent inputs, even when investment in these inputs was more profitable than investment in new capital inputs. Since the problem stems from poor policy choices by both developing countries and donors, future investments (such as the SWMP) are likely to suffer the same fate unless existing policies are modified to deal effectively with the problem of recurrent costs.

Developing countries' policy failures can be grouped into three broad categories:

- inability to raise adequate revenues;
- misallocation of public resources between capital and recurrent budgets, or among expenditure categories within the recurrent budget; and
- project design or public policy failures that reduce the likelihood of project success.

AID's Bureau of Program and Policy Coordination has recommended four basic responses to the problem of recurrent costs (USAID, 1982):

- improve project design;
- encourage policy reform;
- partial funding for recurrent costs under narrowly defined conditions; and
- reallocation of assistance when the host government refuses to take appropriate action on project design and policy reform.

A particularly thoughtful paper on the appropriate choice of small-scale pumping technologies (Barnett, 1985) provides useful insight into recurrent costs as a project design issue. Barnett emphasizes the importance of carefully specified objectives. If the real objective is donor "visibility," project planners should not be surprised when projects fail to achieve success. Useful analysis of recurrent cost problems requires answers to three important questions:

- who pays for what;
- what are the real opportunity costs for each group; and
- to whom do benefits accrue, and in what form are they received, i.e., cash or imputed values?

Recurrent cost problems are likely to occur unless project objectives are clearly stated, GSDR policies are consistent with project design, and "players" and their roles are clearly defined.

4.5 Management Issues

There are two levels of management issues concerning irrigation development in the PPA--main system management and on-farm management.

In terms of main system management, the Shebelli River provides the water to irrigate approximately 50,000 hectares along its banks. Most of this irrigation has developed in an ad hoc, uncoordinated manner. The degree to which irrigation systems on the river have reached the limits of the available water resource is unknown. Even if they have, there is no mechanism for preventing further expansion of irrigation. Several major and/or irrigation rehabilitation development projects are planned or being undertaken currently. The synergetic impact of these projects does not appear to have been evaluated carefully. The objective of main system management is to develop a mechanism for coordinating irrigation activity with the potential of the resource. The issues involved include:

- establishing the aggregate annual water needs of irrigation works on the Shebelli;
- comparing those needs with the river's annual flow;
- setting up priorities for water distribution in low-flow years;
- regulating the growth in demand for Shebelli water for irrigation; and
- operating and maintaining the system's head-works and primary channels.

At the field level, farmers confront a range of social and technical challenges to use available irrigation water effectively. They have to operate and maintain the field portions of the system, and must also be able to cultivate cost-effectively in a demanding technical context. This often requires a level of social organization that is not necessary under rain-fed agricultural conditions. The issues here are:

- incentives for irrigated agriculture--i.e., why would a family want to put all the required effort into agriculture;
- at what levels are families willing to contribute in labor or cash to system operation and maintenance;
- what organizations are responsible for coordinating operation and maintenance at the field level;
- what is the legal mechanism through which families hold their rights to irrigated land; and
- what role do national-level institutions and policies play in management support and technical assistance in irrigated areas?

4.6 Role of Pumping in PPAs

At present, the only pumps used in the project area are used by plantations and state farms. The river feeds the field channels by gravity through a network of primary and secondary canals. Plantations and state farms use pumps occasionally, at low river flows, to pump water into the canals that feed their fields. However, every year during the dry season, they pump groundwater from one to three wells per azienda onto banana and grapefruit fields. The pumping issue is, therefore, in current practice, closely tied to the issue of annual versus perennial cropping.

Clearly, pumping has a positive cost/benefit ratio in production of perennial crops. The question remains of what advantage pumping would give producers of annual crops. The vast majority of the aziendas in the project zone produce only annual crops. A second and separate question would be the cost and benefits, in economic terms, of such a role for pumping.

Producers of annual crops use the gravity-fed irrigation system merely to supplement the rainfall on their fields. One informant pointed out that in a good Gu season (i.e., with sufficient rainfall), people do not irrigate at all after they plant their maize. Even in a normal season, they irrigate only two or three times. As things now stand, pumping irrigation water for annual crops (from a river to a primary or secondary canal) is necessary only in exceptionally dry years when the number of irrigations has to rise to compensate for the low rainfall and when the level of the river falls to the point where the water is not flowing through the system in sufficient quantities to satisfy all the demands by gravity.

Another question is the extent to which people would shift some of their fields to perennial crop production if they could pump water during the dry season. The probability is that the shift would be insignificant. River flows are too low during the dry season for dependable irrigation of perennials. Moreover, the plots of the smallholders are too small, for the most part, to subdivide and get high enough perennial crop production to make the investment worthwhile. Most people need their whole plot for subsistence production.

The social organization already exists to pay the costs of pumping at the head of the secondary canals. The social organization also exists to operate and finance pumping at the tertiary level. The critical question is going to be willingness to pay. People in the area are already paying for maintenance of the system. Will they be willing to pay to amortize pumpsets they need for only a few days every few years? Section 5.0 examines the technical and financial economic context in which these questions can be addressed.

In summary, the primary pumping issues are:

- at present, almost all pumping in the PPA is for perennial fruit crops grown on the large plantations;

- very few, if any, annual crops are supported by pumped irrigation; and

- it is problematic whether small farmers will consider it worthwhile to pay the additional costs of pumping water for annual crops when other production inputs (e.g., fertilizer, pesticides, good seed, etc.) are perceived as greater constraints.

5.0 PRELIMINARY SCREENING OF PUMPING ALTERNATIVES

This section discusses the engineering and economic criteria used to perform preliminary screening on the various irrigation pumping system options. Most of the options have been eliminated purely on technical grounds. The remainder are then reviewed within the economic context of the SWMP, with particular attention paid to the position of pumped irrigation water in the hierarchy of required agricultural production inputs.

5.1 Engineering Criteria

This subsection discusses the technical aspects of irrigation water pumping/lifting as it pertains to SWMP's design. The existing uses of pumps in the PPAs are listed, then additional applications that may be designed into the project are discussed briefly. Technical selection criteria for pumps are then given, and these criteria are applied to each system type considered to have potential application in the PPAs. Finally, a matrix summarizing the potential applications and limitations of each system type is presented. The information in this section was derived primarily from:

- two field trips to the PPAs and nearby areas;
- one field trip to the Afgoi area;
- a pump survey carried out by a Somali engineer on contract to the consultants; and
- the Lahmeyer International report's Appendix D, and the MMP primary references.

To determine existing conditions in the PPAs, the authors conducted a survey of pumps used by area farmers for irrigation water lifting. A copy of the survey form is given in Appendix B. The MOA's renewable energy coordinator, Abdiqani Fara, who had conducted a related survey on energy use in agriculture for the MOP's Energy Department, to conduct a survey of the two areas to locate and record data for all of the pumps that he could find. During the authors' field visits, they recorded the location and description of any pumps encountered. There were also some data available from the primary reference materials, particularly the Lahmeyer International report.

For any pumpsets encountered, the following data were recorded, if available:

- pump type, make, model, country of manufacture, rated power input, rated flow rate (rare), and head;

- engine type, make, model, country of manufacture, rated power output and whether the pump and/or engine were portable (an important factor depending upon application); and

- application (pumping from river to canal, reservoir to canal, borehole to canal, etc.).

At most of the pump sites examined, operations personnel were able to give at least minimal information on use patterns. While this information is necessarily incomplete and subjective, in many cases, it is all that is available. Maintenance and operating records are not generally kept. However, some operators were able to give estimates of fuel consumption, number of hectares serviced (by crop), annual pump use profiles, and information on local serviceability.

While the survey is not conclusive, the authors asked nearly every farmer and MOA representative they spoke with whether they knew of any pumps in the immediate area and for any descriptions they might have. There were actually very few pumps used in the PPAs (with the exception of the banana plantations along the southern border of the Shalambood PPA), mainly due to the fact that much of the area was able to be gravity-irrigated. Detailed descriptions of the pumps recorded are given in Appendix C.

5.1.1 Water-Lifting Applications

Existing irrigation pump applications vary considerably in the Lower Shebelli Region. Pumps tend to be much more common in the more northerly areas around Afgoi than in the Genaale-Shalambood-Qorioley area. The level of the river in the Genaale-Shalambood-Qorioley area is above the surrounding fields, so most irrigation is by gravity. In the Afgoi area, the river is below the surrounding countryside, so water must be pumped from the river into the canals and fields. Since the ARD team was specifically directed to confine its data collection and analysis activity to the two PPAs (Shalambood and Faraxanne in the Genaale-Shalambood-Qorioley area, where the majority of annual crop irrigation was by gravity), it was a relatively easy task to visit and catalog most of the irrigation pumps in those two areas.

Current pump applications in the PPAs (and in the nearby areas, since so few pumps are used in the PPAs per se) are listed below, ordered from most to least common application:

- irrigation of perennial fruit crops (usually bananas, but also other crops such as papaya, grapefruit, mangoes, etc.), primarily during the dry season, but on a year-around basis on some farms--

this can be either groundwater pumping (usually borehole-mounted, vertical-turbine pumps) or low-head, high-volume river water pumping with centrifugal suction pumps from the river into canals or directly to fields;

- provision of late Der season second irrigations of sesame and vegetable crops by pumping either from the lowered river into secondary or tertiary canals, or from off-stream seasonal storage reservoirs into distribution canals; and

- pumping from primary or major secondary canals to fields on an April to November basis (e.g., near Buulo Mareerta) to support perennial fruit and annual crops.

For surface water pumping, the most common type of pump in the PPAs (but not areas such as Afgoi, where the situation is quite different) is a shaft-driven, centrifugal, single-stage, belt-driven pump with twin parallel discharge pipes. The pumps are driven either by fixed-mounted diesel engines or tractor PTOs, depending on the need for portability for use at multiple sites and access to equipment. In the Shalambood project area, by far the majority of pumps (vertical turbines) were used by the banana plantations for pumping groundwater during the dry season.

Groundwater pumping was much more prevalent in the Shalambood area. Around Faraxanne, the farmers with whom the ARD team spoke all felt that the local groundwater was not suitable even for maintenance irrigation of cash crops (fruits or vegetables) during the dry season. Just south of Faraxanne, near Buulo Mareerta, one farmer (320 hectares) supports his fruit trees during the dry season by pumping groundwater with vertical turbine borehole pumps, from average static heads of about 50 to 60 meters. He had originally owned another 100 hectares near Faraxanne, which he planned to put into perennial fruits. After drilling five 80-meter wells, he was forced to abandon his plans due to excessively saline groundwater (see Section 7.2). Besides salinity, another problem with groundwater use is the significant cost of drilling a well (farmers quoted typical prices of So. Sh. one million for boreholes).

At some of the newer (or recently revived) projects, large diesel generators are being used to provide electricity to run pumps. Examples include the Libya-Somalia (LibSoma) project near Afgoi, and the Buulo-Mareerta project on the right bank of the Shebelli above Qorioley (neither of these sites is within the PPAs). At the LibSoma project, a $1.1 million system consisting of two 375-kW Cummins diesel-driven generators provide electricity to a bank of six large (75-kW) electric motors, each driving a single-shaft-driven centrifugal Mono pump for a combined output of 7.2 cubic meters per second. Water is pumped directly from the river to a primary canal, which serves 2,400 hectares. The pumpsets are mounted on sliding racks so that variations in river water levels can be accounted for, allowing the pumps to take water with lower silt levels from the upper section of the river profile as the depth of flow varies.

The Buulo-Mareerta (Qorioley) project does not yet have any pumps installed. At the Weidleplan-engineered site east of Qorioley, diesel generators will be used to drive electric submersible pumps to pump water from an off-stream storage reservoir to an elevated primary canal. Similar pumps are to be used for two planned pumped-drainage sites.

Besides the applications discussed above, several other possible pumping applications may be incorporated into the eventual SWMP design, including:

- pumping from river to main canal during low-water periods, then gravity-distributed to secondaries or directly to fields;

- gravity flow from river through main to secondary canal, then pumped to fields above the grade of secondary canal;

- pumping from primary to secondary canals, particularly during low-water periods when the secondary could be temporarily dammed, and then water pumped into it so that the higher head would allow gravity distribution from that point downstream;

- pumped drainage--there appeared to be no drainage civil works whatsoever in the PPAs, but increased use of irrigation will likely aggravate existing drainage problems, thereby necessitating drainage (pumped or otherwise); and

- pumping either to or from off-stream (seasonal or night) storage reservoirs (two examples of pumping to tertiary canals from gravity-filled seasonal storage basins were noted near Faraxanne)--filling storage basins during high river flow periods (Hagai and Der) shows promise of cost-effective seasonal storage for use during low- or no-flow periods in the Jibal and early Gu seasons (depending on the as yet undetermined rehabilitation scheme for civil works, this may be SWMP's principal pumping application).

One issue raised on several occasions was the legal aspect of pumping relatively saline drainage water back into irrigation canals or into the river. Several respondents said it was an ostensibly illegal practice. An MOA representative said that while it was not actually illegal, it was discouraged by the MOA. The actual impact of pumping drainage water into a canal would, of course, depend on the flow rates in both the canal and the drainage system, and these are both unknowns at present.

Irrigation methods vary by crop. The types of irrigation methods currently in common use included controlled flooding, furrow and bunding. Smaller farmers use bunding in maize fields. Bananas are planted in furrowed fields, then are bunded into jibal-sized areas (25 meters by 25 meters) after they begin to mature. Some large farmers use suction hoses to run water from ground-level head ditches into their fields. Watering is typically done on an eight- to 12-day schedule year-round, depending on rainfall.

Several respondents suggested that in almost all banana plantations near Shalambood, there would be salinity problems after two to three years because of irrigation with groundwater. Bananas are a three-year crop in Somalia (compared to five years elsewhere) and yields are half of international standards due to water and subsequent soil salinity. For bananas, this is exacerbated by furrow irrigation which, while producing water savings of up to 50 percent over flooding methods, concentrates salinity in the plants' root genes. Papaya is also planted and kept in furrows.

Trickle irrigation, while used at the agricultural experiment station in Afgoi, has found little acceptance. This is due to cost, the farmers' lack of familiarity with the equipment, and probable clogging problems because of suspended solids (in river water) or high levels of groundwater (see Section 7.2).

Although there is an experimental drip irrigation system at the AFMET research farm in Afgoi, drip irrigation does not yet seem to be a reasonable option in the project areas for several reasons (these conditions would also argue against extensive use of sprinklers):

- Typically, there are very high levels of suspended solids in river water. If groundwater is used (as for perennial fruit crops), then dissolved solids become a problem--mainly because of high levels of bicarbonates, which tend to clog up the discharge nozzles.

- While much more efficient than other methods, drip irrigation requires a considerably greater initial capital investment and level of infrastructural support (i.e., for system design, equipment procurement, spare parts supply, etc.) than furrowing or flooding methods. It does, however, have the potential for much lower labor costs than are associated with these other methods.

- The small-diameter tubes and nozzles used require that the head pressure on the system be great enough and correctly controlled to ensure sufficient, properly distributed flow throughout the system. Not only does this require additional design expertise, but it either increases energy demand for pumps (if pumps are used) or requires that gravity-delivered water be from a higher-head source.

5.1.2. Pump/Engine Options

Prior to the ARD team's arrival in Mogadishu, representatives from S&T/EY and REDSO wrote a memorandum which sought to more precisely define the types of pumping systems on which the ARD team should focus. These included:

- central, small generator/mini-grids with electric pumps (for drainage only);
- central, small mini-grids, for drainage and canal feed pumps;
- one-farmer diesel pumpsets for the sale of water to other farmers; and
- individual, small "portable" systems.

In conversations with the USAID/Somalia agriculture office, it was suggested that, where appropriate, other alternatives (such as wind and solar pumping) should also be given at least preliminary consideration to determine whether they should be investigated in more detail. The mission engineer also suggested that heavy-oil, slow-speed diesels, should be considered. He reasoned that since heavy oil was a by-product of the Gesira Refinery, and much of it is being exported because there is little domestic demand, it might be cost-effective for use in irrigation pumpsets.

Based on pumping systems currently being used in the PPAs, on alternatives used in similar projects, and on the suggestions made by the mission, REDSO and S&T/EY personnel, the following types of systems have been considered in this discussion:

- stand-alone, direct-drive standard diesel pumps;

- single standard diesel generator driving a single electric pump;

- single standard diesel generator driving a series of electric pumps (i.e., mini-grid);

- heavy-oil diesel pumps;

- wind pumps;

- solar photovoltaic (PV) pumps;

- very low-head (less than two meters) micro-hydroelectric generation, with electric pumps; and

- hand-operated pumps.

Petrol- (gasoline) driven engines were not considered, in the direct-drive or electric generator configuration, largely due to their usually high-speed (i.e., short-lived) operation, the fact that very few if any units are currently being used in Somalia, and primarily, the difficulty of assuring a dependable supply of petrol for such a critical load.

5.1.3 Equipment Selection Criteria

The major criterion used to eliminate the more inappropriate systems is load matching. The pump and prime mover must be able to match the demand profile, so that the required volume of water is available at the proper time. This is a function not only of the capacity of the system (output at a given head or lift), but also of on-demand pumping capability, and the probable availability of fuel or renewable energy resource(s). Several system options can be quickly dismissed on this basis. Other important selection criteria include:

- reliability of equipment (often directly proportional to design complexity and extent of existing field application);

- typical water availability of each system option (and seasonal dependence, if applicable);

- frequency and complexity of maintenance, level of technical skills (or additional training) required, and existence of local spare parts inventories; and

- potential for standardization of equipment (to minimize parts inventory and technical training requirements).

The precise selection of pumping options is not possible at this stage in project design, since the civil works rehabilitation planning has not yet taken place. However, certain applications can still be eliminated at this point. First, pumping from the river to primary canals, which requires very large-capacity pumps, (such as the bank of six generator-driven electric pumps at the LibSoma project) is unlikely to be required because of the river elevation at the PPAs. The same is true for primary to secondary canal pumping. The most probable applications are pumping to or from off-stream storage, and pumped drainage.

If a pump is to be used to pump back into a secondary canal from a gravity-filled off-stream storage reservoir, typical pump capacity can be determined by estimating the flow rate in the secondary canal. Given typical secondary canal dimensions (and typical siltation blockages) dimensions, pump capacities will be on the order of 1,000 to 1,500 cubic meters per hour. At a typical pump efficiency of 60 percent, assuming a two-meter head, they will require an engine with a continuous rated shaft output of about 20 to 30 horsepower. Depending, of course, on the eventual design and dimensions of the off-stream storage reservoirs, this should be considered a lower limit for required pump capacities. Recently cleaned canals will be able to carry 7,000 cubic meters per hour or more, requiring up to 100-HP engines. The ability of the various system options to meet this minimum capacity requirement will be discussed in each of the following sections.

Diesels (Various Configurations)

Diesels are the standard prime mover in most of the developing world, and Somalia is no exception. Diesel engines are normally characterized by:

- low capital costs, yet relatively high recurrent costs;
- local familiarity with operation and maintenance, due to existing infrastructural support networks (of widely varying quality), including availability of trained mechanics, spare parts supplies, reliability and availability of fuel transport, and seasonally variable but often annually monotonically increasing fuel costs (which in many developing countries, Somalia in particular, is seemingly independent of decreases in world oil prices);
- on-demand pumping capability (as opposed to, for example, wind or solar pumps, which are dependent

upon the availability of the inherently variable renewable energy resources);

- commonly available equipment of essentially unlimited capacity in terms of both head and flow rate, which can be, but all too often are not, well-matched to site-specific loading conditions, except for very small loads (less than two to three kW); and

- requirement that an attendant be present during operation.

The variable that is most difficult to quantify in determining the cost of pumping with diesels is the local operation and maintenance cost. To get a qualitative feel for the magnitude of these costs, the ARD team visited local engine repair shops, talked with farmers who used diesels, and visited several equipment dealers, nearly all of whom, except for the largest, SomalFruit, are located in Mogadishu.

SomalFruit is the largest supplier of pumping equipment in the Genaale-Shalambood-Qorioley area. The authors spoke with several SomalFruit staff about their operations. Diesel engines used for water pumping are typically overhauled about every eight years. Sometimes, instead of overhauling old pumps, new ones are purchased, and the used pumps are sold to local farmers. The plantation manager for each field has responsibility for keeping records of all production costs, including pump maintenance, fuel consumption, etc., but the ARD team was not given access to these records, so the level of detail and reliability of the data are unknown. Because of the often high variability in diesel maintenance costs from one area to another (particularly another country), extrapolating data from another area can lead to large errors in comparative cost analysis.

Fuel availability is particularly problematic in much of Somalia. One large SomalFruit farmer said that it has happened where he was unable to obtain diesel fuel for his pumps for an entire month. Given that bananas normally are irrigated every eight to 15 days (and other common fruits somewhat less often), this could be disastrous. Of similar concern, and closely related to availability, is the highly variable cost of diesel fuel. The official price in 1984 was So. Sh. 20 per liter, yet the common price last year was often So. Sh. 50 to 60 per liter on the parallel market. Occasionally, fuel is simply not available at any price.

Portability is another important consideration. A farmer below Golweyn who has 400 hectares (300 of which are currently fallow due to labor and water shortages) uses two pumps for canal-to-field water delivery. However, he must move them around to accommodate all his crops. The fact that they can be driven by a tractor PTO is critical. Pumping 24 hours a day, each of the dual-discharge 200-mm discharge diameter pumps can irrigate approximately four hectares. His 60-HP Fiat tractor engine consumes about 100 liters of fuel in the process.

One field engineer emphasized the importance of equipment portability, saying that since most pumps and engines in the Qorioley district are repaired at either ONAT or private workshops in Shalambood, he felt that weight was an important constraint engine size. No engine (or pump) should be heavier than a large group of people could pick up and physically place in the back of a truck. He estimated this limit to be about 600 to 700 kilos, or approximately the weight of a 40-HP diesel engine.

To support equipment standardization (thus simplifying training, spare parts inventory, and user familiarity problems for the support infrastructure), Italian diesel engines and pumps should be considered. This is the only widely supported equipment in the Lower Shebelli Region. As part of its evaluation of local equipment use, the ARD team visited all known pump suppliers. They supported Italian equipment almost exclusively. The suppliers' inventories were low, byt they can order equipment from a variety of manufacturers, including OM, Carari, Adim, Grezina, Fassrica, Lambordhini, Rovatte and Rotos (all in the 17- to 80-HP range). Several of these makes are also handled by SomalFruit. One supplier also handled Indian diesel pumpsets.

Mini-Grids

A single-station generating plant driving a series of remote-sited pumps offers several possible advantages, including single-point operation and fuel storage, and the potential for concentrating all of the available, competent maintenance mechanics at a single installation. While there are no current plans to develop a local grid in the Lower Shebelli Region, some experience in local grid use will come from the current installation of a system in Baidoa, which consists of two 1.6-MW light diesels. The donor (the Finnish government) is including 10 years of operation, maintenance and spare parts support. A second system (location unknown) will consist of two 1.2-MW light-diesel generators. Indigenous experience in the use of such systems is non-existent. It has been suggested that a smaller version of such an installation could be used to drive electric irrigation pumps in the PPAs. This would presumably be similar to the LibSoma installation.

All of the above comments on diesel engines apply to this discussion of mini-grids as well, since it is assumed that a diesel-driven generator would be used to supply electrical energy to the pumps. Most of the remarks in this section apply to power distribution and the electric pumps themselves. While there seem to be few electric pumps in Somalia, experience elsewhere indicates that grid-connected electric pumps require somewhat less maintenance than diesel direct-drive pumps. This is particularly true for submersible electric pumps, which are not subject to animal damage, theft or vandalism. Electric pumps are normally characterized by:

- relatively low capital equipment costs and, exclusive of the electrical supply source itself, fairly low operation and maintenance costs (generator maintenance costs could be considerable);

- in Somalia, lack of an adequate infrastructural support network to provide access to equipment, purchasing credit, spare parts, or system design, installation, maintenance and repair services;

- on-demand pumping capability;

- commonly available equipment of essentially unlimited capacity (for all practical purposes) in terms of both head and flow rate, which can be well-matched to site-specific loading conditions (although all too often it is not); and

- electronic controls, which allow for unattended operation (reducing operations costs).

In spite of the apparent advantages of using electric pumps per se, there are several reasons why single direct-drive units at each pump site would be a preferable choice to the local deployment of a mini-grid. From an energy-efficiency perspective, while a larger diesel engine (e.g., in a mini-grid) would normally run at a higher efficiency than a smaller one (e.g., for a single diesel directly driving a centrifugal pump), the mini-grid arrangement would involve three additional sources of power loss:

- the conversion losses from mechanical shaft power (diesel engine output) to electrical power in the generator;

- transmission line losses; and

- conversion losses from electrical power back to mechanical shaft power (in the electric motor) to drive pumps on each branch of the grid.

From system cost and reliability perspectives, while a single large generator of, for example, 250 kVA costs less than 10 smaller 25-kVA generators, a mini-grid would also require extensive investment in poles, transmission lines, and step-down transformers. Also, the mini-grid would require the installation of a backup generator identical to the primary generator (i.e., 250 kVA). The backup would be used in the event of failure of the primary, or during the performance of regularly scheduled maintenance. In the single-unit/single-site case, it would also be necessary to have one or two backup diesel engines to fulfill the same role, but the (presumably portable) backup could be used at any of the 10 sites, thereby reducing the backup unit cost per site. Therefore, the backup cost would be considerably more expensive for the mini-grid.

Reliability is a closely related issue. In a system with a centralized power source (as has been amply demonstrated by the national grid in Mogadishu), when a single source is providing power to multiple end-users and the source goes down, the entire system is down. In the case of the decentralized system, if one unit goes down, the other nine are still running. This will no doubt be a critical difference in rural Somalia.

Using diesel generators and electric rather than direct-drive pumps not only tends to reduce the efficiency of the pumpset, but also adds another component (the generator) to the system. This decreases reliability (one more part to break down), increases the size of required spare parts inventories, and makes more demands on the limited number of trained technicians and the range of their skills. In general, it is advisable to keep systems as simple as possible for cost, maintenance and manpower reasons.

There is at least one possible reason why it might be worthwhile to consider a local mini-grid. Studies in northern India (Bhatia, 1984) comparing on-site PV power generation for pumping with typical grid extension costs showed that the major obstacle to cost-effectiveness for grid extension was the typically very low capacity factors at which the grid extensions operated. Eleven kVA lines to villages typically had 10 to 15 percent capacity factors. A mini-grid used primarily for driving electric irrigation pumps also would likely have a very low capacity factor, since the irrigation water demand profile would be seasonally dependent. This low capacity factor would tend to increase the unit cost of delivered water, since the capital cost of the equipment would be amortized over a smaller volume of water pumped.

If this were the case, an argument could be made to spread system costs over a larger user base. The mini-grid power could be made available to nearby villagers for any number of other purposes, such as village lighting or light industrial purposes.

However, once people become accustomed to having access to the electricity, it might become difficult to simply shut off the power to the village when it was necessary to run the irrigation pumps. Since the focus of the project is on irrigation, not integrated rural development, this should be carefully considered prior to allowing outside access to project-generated power.

In summary, in the context of an integrated rural development project, it certainly makes technical and economic sense to spread the cost and responsibility for system operation and maintenance over a broader use base. However, as a policy question, it is unclear whether rural electrification is, or ought to be, a goal of SWMP.

On the practical side, to determine whether any local infrastructure existed to support the operation and maintenance of mini-grids in the PPA, the ARD team visited several sites where small diesel generators were being used for power generation. None of these small grids (most of which were owned by private entrepreneurs) involved water pumping. They were also on a considerably smaller scale than that which would probably be necessary for the irrigation pumping capacity for SWMP. Detailed descriptions the two mini-grids are given in Appendix C.

Heavy-Oil Diesel Engines

Residual fuel (heavy) oil-fired diesel engines were suggested as a possible substitute for the standard light diesel fuel used in most of the diesel engines in Somalia. Heavy oil is a by-product of the Gesira Refinery, and was primarily intended for use as the major input into the nearby 150 ton/day urea plant. The heavy oil is usually exported if the urea plant is not working at full capacity. Since the price for urea produced at the plant ($200/ton) is approximately double the average world price, the plant's use schedule is somewhat variable.

A refinery process balance study would be necessary to define actual heavy-oil availability. A Somali engineer who had worked at the urea plant knew of no one in the country who was using heavy fuel oil-driven diesels (except for some of the older Russian tractors, which are increasingly falling into disuse since parts are no longer available). Even the central generating plants driving the national electric grid use light diesel. GSDR plans for increasing the plant capacity factor, or possible other plans for using the heavy oil by-products, were not determined. However, the variability of the heavy oil supply, due to the intermittent operation of the urea plant, would be a distinct disadvantage in considering its use for a load as critical as irrigation pumping.

In spite of the fact that it would certainly be useful to provide a local market for the heavy oil, there are several distinct disadvantages to using it for irrigation pumping purposes:

- From the perspective of procuring U.S.-manufactured equipment, the smallest heavy oil-fired diesel engines available are in the 1,500- to 2,000-HP range. The probable load range of engines used for SWMP pump applications is 20 to 50 HP.

- Heavy oil has certain characteristics that make its use for small-scale operations somewhat problematic, including: lower calorific value and volatility compared to light diesel; the frequent need for heating prior to use, due to its high viscosity; treating to neutralize acid and other chemical impurities; centrifuging; and filtering to remove other impurities. Such treatment equipment would be difficult to justify economically for the relatively small irrigation pumping load (likely less than 500 kW total).

- The sulfuric acid commonly found in heavy oil accelerates corrosion of diesel fuel injection nozzles and other internal parts, significantly increasing maintenance frequency.

- Necessary treatment depends on the source of the particular batch of fuel, so that chemical analysis of each batch is required for proper treatment prior to use.

- Heavy oil would have to be carefully segregated from light diesel. This would entail incremental costs for both storage and transportation.

Since the proper-sized equipment is not commercially available (in the United States, at any rate), and local spare parts inventories and trained technicians to support the equipment do not exist in Somalia, heavy oil-fired diesels do not appear to be a proper choice for further consideration as a pumping option in the Shebelli rehabilitation scheme. In general, given the limited technical resources in Somalia, policy decisions should encourage rather than discourage standardization of pumping equipment where possible.

Wind Pumps

Wind pumps have been used in Somalia for many years, primarily for borehole water pumping. Italian colonists used wind machines for pumping water, apparently as far back as the beginning of the century. Overall success has been variable. While a quite favorable wind regime exists in much of Somalia (particularly in the coastal regions), little attention has been paid to minimal maintenance requirements, so that one primarily finds non-functioning windmills in many areas of the country, including the Lower Shebelli Region.

Wind pumps are normally characterized by:

- high capital equipment costs, yet relatively low recurrent costs for operation (no fuel requirements), maintenance and repair;
- in Somalia, a minimal local infrastructural support network--while several hundred machines have been installed, there has been no apparent provision for necessary maintenance capability or maintaining spare parts inventories, which is why most of the existing wind pumps do not work;
- limited capacity based on commercially available machines' rotor diameter and commonly encountered wind regimes (less than five HP under favorable wind conditions);
- no on-demand pumping capability (requiring large storage capacity);
- mechanical controls, which allow for unattended operation;
- eventual possibility of local manufacture; and
- apart from their limited capacity, wind pumps are not portable, so that units would have to be purchased for each pumping station.

An assessment of the strength of the wind energy resource is essential before seriously considering the technical or economic feasibility of a particular application. While there has been some effort on the part of Somali National University's Faculty of Engineering to develop a wind resource assessment map for Somalia, funding (from the Italian government) has been cut and the activity is stagnant. The MOP's Energy Planning Unit has submitted a proposal to USAID in the amount of So. Sh. 2.9 million for funding. Should this effort prove fruitful, several of the anemometers (wind-measuring instruments) should be sited within the Lower Shebelli Region to establish the local wind regime characteristics. With the wind regime characteristics and pumping head as inputs, computer models (such as that developed by Wyatt and Hodgkin, 1985) can be used to predict wind-pump output for most of the standard reciprocating-piston machine designs.

Because of the limited capacity of wind pumps (maximum of about 1,500 m^3/day assuming a typical average windspeed in the PPA of about four meters per second, a two-meter pumping head, and a rotor with a 6.2-meter diameter), their application in the SWMP would probably be restricted to situations where water is pumped into a storage reservoir that is above-grade, or pumped drainage. The reservoir could then be used to deliver water by gravity distribution on an on-demand basis whenever other sources were unavailable. The limited capacity of wind pumps requires an often large, expensive storage capacity. Thus, since water demand for all but the smallest irrigation requirements is greater than the capacity of commercially available wind pumps, it is unlikely that wind pumps will find much application for irrigation water supply. Depending on the eventual rehabilitation design of SWMP's civil works, the only likely application for wind pumps in Somalia would be low-capacity, intermittent-load pumped drainage.

Solar PV Pumps

Solar pumps have been used in Somalia with variable success, primarily for village water supplies (especially in the refugee camps) and stock watering. The use of early-design equipment often resulted in systems that worked for only a short time after installation. While this is not characteristic of most commercially available PV pumping equipment, several GSDR officials now view PV pumps with some degree of caution. Solar pumps are characterized by:

- high capital equipment costs, yet relatively low recurrent costs of operation (no fuel requirements), maintenance and repair;

- in Somalia, a minimal local infrastructural support network--while about 60 PV pumps have been installed, there has been no apparent provision for necessary maintenance capability or spare parts inventories (thus more than half of the PV pumps are no longer functioning);

- limited capacity of commercially available equipment (up to 2.2 kW peak, capable of providing an average of about 550 m^3/day at two meters head), given typical solar radiation levels in Somalia;

- no on-demand pumping capability (although either hydraulic or electrical storage can be used to broaden range of application);

- low portability, even for two-kW installations;
- electronic/mechanical controls, which allow for unattended operation;
- susceptibility to vandalism (thrown stones break module glazing); and
- very high reliability of power supply.

Because of their capacity limitations, solar pumps are not applicable for flood, or surge irrigation schemes because of the inherently high flow rates required. They are unlikely to be cost-effective or appropriately load-matched for the relatively high pressure requirements of most sprinkler systems. Commercially available units are capable of delivering high enough flow rates for furrow or trickle irrigation schemes (where application efficiencies are typically greater), but only for very small plots (less than about two hectares) and even then could approach cost-effectiveness only for high-value cash crops.

Renewable energy-driven pumps, such as solar PV or direct wind pumps (i.e., not wind turbine electric generators) are practically restricted to the low-capacity range of less than three horsepower, and are not on-demand applications. Examples of this are slow-filling from primary or secondary canals to elevated off-stream storage (for gravity distribution back into the canals on-demand), or for low-capacity pumped drainage. However, for the >20-HP capacity required for off-stream storage to secondary canal application, they cannot be considered a viable option.

A rule of thumb for estimating the relative costs of low-capacity water pumping with wind and PV systems is the following:

> For areas with relatively high solar radiation conditions (annual average of >20 $MJ/m^2/day$, equivalent to Somalia or Botswana), wind pumping is cost-competitive with solar pumping at sites with average windspeeds greater than or equal to three meters per second.

Since annual average windspeeds in the PPAs appear to be greater than four meters per second (and nearly seven meters per second during some seasons), wind pumping will be less expensive than solar pumping (and cost-competitive with diesel) for low-capacity, intermittent loads such as pumped drainage.

Based on preliminary meteorological data in the PPAs, highest windspeeds occur in the months June through September. This should be considered when the demand profiles is established. A relatively small investment in properly sited anemometers (10-meter height) would add significantly to the system design data base for using wind pumps in the PPAs.

Micro-Hydroelectric Generation

Standard micro-hydroelectric[5] generators convert the potential energy of water falling through a given pressure head to generate electricity. Power output is directly proportional to the water flow rate, head (here, mainly elevation) and overall system efficiency. Usually, civil works construction (a small diversion dam, at minimum) is required. This serves both to increase head and to provide storage to smooth the supply curve.

The topographical conditions in the Lower Shebelli Region do not lend themselves to standard micro-hydro configurations. River slopes are generally too gentle to allow installation of more cost-effective, higher-head installations. However, if a sufficient water flow rate is available, a larger (albeit more expensive) turbine can, to some extent, make up for inadequate elevation head. For a river installation, a small diversion dam would have to be constructed, at minimum. Since raising the level of the river in this area to any significant degree would involve flooding the banks, additional dikes would have to be built to contain storage, further increasing the civil works costs. Other potential problems involve the river's high silt load, which could lead to the need for frequent dredging of the sedimentation basin upstream of the turbine, scouring of the turbine itself, and possibly early turbine replacement.

Rather than installing a diversion dam on the river, a second option is to install the turbine at the outlet of a large, seasonal, off-stream storage reservoir. The basin would be filled during high-water flow periods during the Hagai and Der seasons, then stored until the Jilaal and early Gu seasons. The stored water would then be released through the turbine (at a higher-elevation head, since the river level would have dropped). However, given the still limited head (one to two meters, maximum), the volume of water required would probably not be adequate to meet the assumed power requirements for downstream pumping.

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[5]The term "micro-hydroelectric" is usually understood to mean a design rating of less than 100 kW. The present case, where loads on the order of 250 to 500 kW are assumed, is formally known as the mini-hydroelectric range. For continuity, however, the term micro-hydroelectric will continue to be used in this discussion.

As a rough example to indicate the potential limits of power generation in a micro-hydro installation on the Shebelli, assume the following:

- the irrigation pumping load consists of six 60-HP electric motors, each pumping from a gravity-filled, off-stream storage reservoir back into a main canal during a low-water period (say, the late Der in November--by no means the worst case) because rains were insufficient, requiring a second maize irrigation);

- due to the local topography, elevation drop through the turbine is restricted to a very low-head (0.5 meters), but high-flow, design;

- the generating system efficiency, including the water turbine, generator, and transmission losses to the electric pumpset at each site. is 50 percent (a typical value); and

- according to one reference (TAMS, 1985), the mean monthly river flows at Audegle (just upriver from the PPA) are as follows (the months given are only those during which pumping is likely to be required):

June	July	Nov	Dec	Jan
45.6 m^3/sec	33.1	58.7	31.3	12.5

The flow rate required to drive those six pumpsets is given by the power equation:

$$P_{req'd} = (9.81) x (Q) x (h) x (E_{sys})$$

where $P_{req'd}$ = required power to the pumpsets
9.81 = gravitational constant
Q = water flow rate in m^3/sec
h = available head in meters
E_{sys} = generating system efficiency, including transmission losses

Solving this equation for the required flow rate gives 109 m^3/sec, which is nearly twice as much water as is in the entire river, based on the average mean monthly flows given above. If a one-meter head could be built up (by building up the river banks), the entire river would still have to run through the turbine. This is a very unlikely design. While higher flows do occur in other months, using micro-hydro is problematic due partially to the load mismatch between high water levels and the pumping demand profile.

A possible solution to this problem would be a load management scenario in which the pump loads could be brought on-line in stages rather than simultaneously, thereby reducing peak demand. Such an installation might provide power for pumped drainage in which the supply and demand profiles match, but the cost would likely be excessive compared to other options, such as diesel.

An alternative system option is a "run-of-the-river" turbine. These are essentially raft- or barge-mounted submerged "windmills", usually similar to a vertical-axis Darrius-design windmill. The kinetic (velocity) rather than potential (elevation) energy of the water is converted to shaft output, in this case, to an electrical generator. Run-of-the-river turbines eliminate the need for potentially costly civil works. While their size is theoretically unlimited, existing designs are limited to about one kW, far below project design requirements. Since no storage is used, they are also restricted to the medium to peak river-flow periods. Run-of-the-river turbines would, therefore, not be useful for off-stream storage pumping during low river-flow periods. However, they might provide a source of power for pumped drainage.

An FAO project to demonstrate and evaluate several small run-of-the-river turbines in Somalia (in the Shebelli River, actually) is in the planning stage. The results of this program should be monitored by USAID/Somalia's engineering office.

If installed in the Shebelli River, micro-hydro equipment--whether a diversion dam with a standard turbine, or a run-of-the-river, raft-mounted system--would be susceptible to damage by both flood-stage high flows (since the river levels vary so widely and unpredictably) and river-borne debris. The ARD team observed several barrage dam gates that had been damaged severely by trees or large limbs crashing into them at flood stage.

Micro-hydroelectric units have a cost-related problem common to all RET systems. It is difficult to amortize the usually high initial capital cost of the system over the very intermittent load profile usually characteristic of irrigation water-lifting. For diesel pumps, recurrent costs (for fuel consumption, periodic maintenance and operator labor charges), are directly proportional to operating time. These recurrent costs typically represent 60 to 70 percent of life-cycle costs. For RET systems, recurrent costs are relatively independent of operating time (except for cylinder or pump replacement itself). Most of the cost of these units is the initial capital cost of the power source (the solar modules, windmill, or civil works and turbine for micro-hydro). Therefore, unit costs of pumped water tend to be lower with diesel and other less capital-intensive pumping systems than with RET systems under intermittent, on-demand loading conditions.

Since any of these scenarios are variations of the mini-grid discussed earlier, all of the remarks about mini-grids apply here as well. Given the topographical conditions in the PPAs and the mismatching of energy supply and pump demand profiles, it is unlikely that micro-hydroelectric generation is a more cost-effective power source than stand-alone diesels for irrigation water-lifting.

Hand-Operated Pumps

Hand-operated pumps are characterized by:

- very low capital and recurrent costs;
- easy installation, operation and relatively easy maintenance;
- very limited capacity (less than about five cubic meters per day); and
- possibility of local manufacture (at least 10 hand pumps have been manufactured in Mogadishu already).

Obviously, hand pumps have only extremely limited application for micro-irrigation, and even then only for delivering water from a canal directly onto a small field. Various types of hand-operated pumps (rower pumps, the standard reciprocating-piston variety such as the Dempster or the India Mark II, rotary pumps such as the Mono, etc.) have been used in several countries for micro-irrigation.

Summary

The pump-selection matrix given on the following page summarizes the applications, advantages and disadvantages of using all of the different pumping options discussed in this section.

In summary, it appears that stand-alone, standard diesel pumpsets are the best choice of equipment, given the site-specific constraints of the project and the probable primary applications (storage to canal, pumped drainage) for which pumping may be required. The only exception to this is the use of mechanical wind pumps for intermittent drainage pumping, depending on whether existing equipment can meet the eventual project design capacities.

If diesel pumpsets are used, it is important to provide infrastructural support, i.e., training of maintenance technicians, guaranteeing an adequate supply of spare parts and, Pump Selection Matrix

System (1)	Application (2)	Advantages (3)	Disadvantages (4)
A	1,2,3,4,5,6*	a,c,g,i	b,e,f,h
B	1,2,3,4,5,6*	a,c,g	b,e,f,h
C	1,2,3,4,5,6*	a,c,g	b,e,f,h
D	1,2,3,4,5,6*	a,c,g	e,f,g,h,i
E	2,3	b,f,j	a,c,e,g,i
F	4	b,d,f	a,c,e,g,i
G	6	a,b,f,g,h,j	c
H	2,3,4,5,6	a,c,g	b,d,e,f,g,h,i

Notes:

(1) System Types

- A: stand-alone direct-drive standard diesel
- B: stand-alone diesel generator w/single electric pump
- C: large diesel generator w/series of electric pumps (mini-grid)
- D: heavy oil-fired diesel
- E: wind pump
- F: solar PV
- G: hand pump
- H: high-speed petrol pump (direct-drive or generator)

(2) Applications

1. river to canal
2. groundwater lifting from boreholes
3. canal to reservoir
4. reservoir to distribution network
5. primary to secondary (or secondary to tertiary)
6. tertiary to small field

* indicates that these systems would likely be very oversized for size of demand

(3) Advantages

a. low installed cost
b. low recurrent costs
c. essentially unlimited capacity
d. high reliability
e. high water availability
f. low O+M demands (skilled mechanics, parts procurement, etc.)
g. on-demand capability
h. local maintainability (spare parts, technicians, design)
i. local familiarity with equipment
j. possibility of local manufacture

(4) Disadvantages

a. high installed cost
b. high recurrent costs
c. limited capacity
d. problematic reliability (complex design, short-lived components)
e. water availability contingent upon uncontrollable factors (such as fuel supply, seasonally-dependent road access, variable energy resource base, etc.)
f. high maintenance demands (highly skilled technical personnel, difficult to procure parts, not field repairable, etc.)
g. long or otherwise problematic procurement
h. high maintenance requirements (cost/frequency)
i. high foreign exchange requirements for imported equipment

as much as possible, using standardized equipment. Given existing conditions in Somalia, at least the last two of these points could best be addressed by using Italian equipment, which could be purchased through or, at a minimum, supported by SomalFruit.

5.2 Financial/Economic Criteria

5.2.1 Scope of Analysis

This subsection provides a brief examination of financial and economic factors that will affect decisions concerning water-lifting strategies associated with the Shebelli Water Management project. Since it is quite possible that the project's civil works rehabilitation component will modify existing water-lifting requirements, it would be premature (and highly speculative) to perform detailed macro- or micro-level analyses of investment in water-lifting technologies. Hence, the following discussion addresses only qualitative macroeconomic issues, and focuses on several critical inputs into the micro-level analysis.

Water-lifting technologies are not widely used in the PPA. As a result, their general profitability is not readily evident. Unfortunately, the value of existing data is limited by the site specificity of water-lifting analysis. Furthermore, there is less than total agreement on such critical issues as appropriate means for valuing irrigation water, the Shebelli River's total capacity for irrigation, the supply and distribution of usable groundwater, and current irrigation practices and efficiencies.

These limitations notwithstanding, it should be possible to establish a basis for further investigation of water-lifting issues. The decision to employ a water-lifting technology depends largely on expected changes in profit, so only anticipated changes in income and expenses need be considered. Sufficient data are available to estimate expected changes in small farmers' incomes. It is also possible to estimate marginal irrigation requirements for small farmers. Costs for delivering these requirements are site-specific, and estimates are not readily available. Thus, the procedure here will be to calculate a break-even cost for additional units of irrigation water. This estimate can be evaluated relative to per-unit delivery costs identified in previous research efforts. While this should provide the basis for a preliminary screening of water-lifting alternatives, site testing and data collection should precede further analysis of pre-screened alternatives.

Profitability is but one criterion in selecting financially viable water-lifting technologies. All too often, cash-flow considerations are overlooked in the analysis of small farm investments. These considerations are examined in the following discussion in conjunction with institutional factors affecting the financial and economic viability of various water-lifting technologies.

5.2.2 Representative Small-Farm Cropping System

To calculate a break-even cost for additional units of irrigation water, it is necessary to define a representative small-farm cropping system in the PPA. Data reported in previous studies provide some guidance for this exercise.

Crop production in the PPA relies heavily on rainfall distribution--irrigation is basically a supplementary activity (MMP, 1978: 5.2). On-site inspection and interviews with farmers suggest that irrigation requirements are largely met by the existing gravity-fed irrigation infrastructure. MMP estimated full irrigation availability for May and August through mid-January, limited availability in June and July, and no availability from mid-January through April (1978: 5.12). Most sources agree that current overall irrigation efficiencies are on the order of 20 percent (MMP, 1978: 4.4; TAMS, 1986: V-24).

AID's Agricultural Extension and Farm Management (AEFM) project recently directed farm surveys in the Qorioley and Merka districts of the Lower Shebelli Region (Boateng et al., 1986). Since these districts include or border much of the PPA, the survey results are of great value in defining a representative small-farm cropping system.

Of the farmers surveyed by the AEFM project, 90 percent reported landholdings of less than five hectares. Landholdings among small farmers average roughly two hectares. These holdings are typically divided among two or three non-contiguous fields. A large majority of farmers practice mono-cropping. All small farmers seem to produce maize in the Gu season and sesame in the Der season. More than 60 percent of those surveyed produce an additional maize crop in the Der season. Various sources agree that irrigated yields are on the order of 10 to 15 quintals per hectare for maize and 2.5 to 4.5 quintals per hectare for sesame (see MMP, Lahmeyer International, TAMS). Crops grown on a more limited scale include tobacco, tomatoes, cowpeas, groundnuts and watermelon.

Existing literature is in general agreement concerning the predominant cropping system found in the PPA. Land-use intensity is thought to average 50 percent. One study attributes this relatively low figure to labor constraints associated with weeding activities (see Lahmeyer International, 1986: C-19, Appendix C). The typical production pattern involves 100 percent maize in the Gu season, and a 40 percent/60 percent combination of maize and sesame in the Der season. Overall cropping intensity is roughly 100 percent (i.e., 200 percent cropping intensity on land under production multiplied by 50 percent land-use intensity).

The information presented above provides the basis for the assumptions shown below. Collectively, this set of assumptions defines a representative small-farm cropping system in the PPA:

- landholdings of two hectares, 50 percent idle at all times;
- 100 percent maize production in the Gu season and a 40 percent/60 percent combination of maize and sesame in the Der season;
- Gu season maize yields of 12.5 quintals/ha, Der season maize yields of 14.4 quintals/ha, and sesame yields of 3.5 quintals/ha (note: Gu season maize yields are assumed to be lower due to deficits in irrigation requirements);
- irrigation exclusively from the river, i.e., no groundwater irrigation;
- full irrigation availability in May and August through mid-January, 50 percent availability in June and July, no availability from mid-January through April; and
- overall irrigation efficiency of 20 percent.

5.2.3 Break-Even Analysis

An earlier study estimated monthly net irrigation requirements for various crops grown in the PPA (MMP, 1978: 5.8, Table 5.2). Net irrigation requirements were defined as gross crop water requirements (in millimeters) minus effective rainfall. Monthly requirements were weighted to allow for the spread of the planting season. These estimates were used in conjunction with the assumptions listed above (Section 5.2.2) to project gross irrigation deficits. Table 5-1 summarizes these deficits for a representative small farm in the PPA. These deficits, totaling over 7,000 cubic meters annually, are a crude but useful measure of water lifting potential.[6]

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[6] Admittedly, this ignores potential for lifting drainage water. However, drainage requirements are not generally known. Furthermore, estimating returns to this activity would be extremely difficult given current data limitations.

Table 5-1. Deficit in Gross Irrigation Requirements for Representative Small Farm in the PPA (in cubic meters)

Crop	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Jan	Feb	Mar	Total
Maize			2600	2500									5100
Sesame										2300			2300
Total			2600	2500						2300			7400

Source: Sir M. MacDonald and Partners, Ltd. (1978), and calculations based on assumptions listed in Section 5.2.2.

The next step is to estimate marginal returns associated with increased irrigation input. Marginal returns are a function of marginal output and prices. Data limitations make it difficult to identify the stage of the production function in which small farmers are currently operating. Yield constraint computations reported by Lahmeyer International (1986: Appendix C, Annex C-16) suggest that inadequate or improperly timed irrigation can reduce yields by 10 to 25 percent. Since current deficits are minor in relation to total net irrigation requirements, it should be reasonable to assume yield increases in the PPA of no more than 15 percent.[7]

The foregoing suggests that increases in aggregate output will be small in relation to total domestic supply. Therefore, marginal output prices might be expected to remain constant. An informal survey of farm prices in the PPA suggests that So. Sh. 1,500 per quintal and So. Sh. 6,000 per quintal are representative farm-level prices for maize and sesame, respectively. Table 5-2 illustrates the calculation of marginal revenue for a representative small farm in the PPA.

[7] Der season maize yields would not be expected to increase, since 100 percent of net irrigation requirements are met by existing irrigation infrastructure.

Table 5-2. Marginal Revenue Associated with Additional Irrigation Input on a Representative Small Farm in the PPA*

Crop	Area Cropped	Yields: with additional input	Yields: without additional input	Yields: marginal	Price	Marginal Revenue
	(hectares)	(quintals/hectare)			(So.Sh./quintal)	
Gu maize	1.0	14.4	12.5	1.9	1500	2850
Der maize	0.4	**	13.3	---	1500	---
Sesame	0.6	4.0	3.5	0.5	6000	1800
Total	2.0	---	---	---	---	4650

* Calculations based on assumptions given in Table 4-1.
** No additional irrigation input required.

The final step in this process is calculation of a "break-even" cost for additional units of irrigation water. The break-even cost calculated below represents the maximum amount that a representative small farmer could afford to pay for additional units of irrigation water. It is important to understand that this is the maximum amount that could be paid for all costs associated with using additional units of irrigation water (including the major expense of canal maintenance), not just those associated with water lifting.

$$\text{Break-even cost} = \frac{\text{So. Sh. } 4{,}650}{7{,}400 \text{ cubic meters}}$$

$$= \text{So. Sh. } 0.63/\text{cubic meter}$$

As one might expect, the break-even cost is sensitive to expected yield increases and overall irrigation efficiencies. Table 5-3 provides a range of estimates for various combinations of these factors.

Table 5-3. Break-Even Cost Estimates for Various Yield Increases and Overall Irrigation Efficiencies (in So. Sh./m^3)

Yield Increase	Overall Irrigation Efficiency 10%	20%	35%	45%
5%	0.11	0.22	0.39	0.50
15%	0.31	0.63	1.10	1.41
25%	0.53	1.06	1.87	2.40

Table 5-3 shows that with higher irrigation efficiency, farmers can afford to pay more for a given quantity of water, since less water is being wasted. It reinforces the importance of irrigation efficiency to the cost of water delivery and suggests that the most cost-effective approach to system rehabilitation might be implementation of a series of strategies to increase irrigation efficiency (e.g., through training farmers in proper irrigation practices). This reflects the "pragmatic rehabilitation" approach suggested by other researchers (Keller et al., 1986), namely that the biggest bottlenecks in the system should be addressed first.

Little quantitative field data exist that would allow the computation of typical break-even water costs for pumped irrigation in Somalia. There is a dearth of field data on recurrent costs of diesel (the only technically viable high-capacity system option--see Section 4.2) operation and maintenance in Somalia, particularly for relatively large capacity (30- to 100-HP) irrigation pumps. Economists for the AID Comprehensive Groundwater Development project have developed estimated water-pumping costs for borehole pumping in the Bay Region (Louis Berger International, Inc., 1986). These estimates were based on known capital equipment and installation costs. However, the recurrent costs of operation and maintenance were extrapolated since the pumps had only recently been installed, and very little maintenance cost data were available. The Somali Unit for Research on Emergencies and Rural Development (SURERD) has also performed preliminary analysis, but with only rudimentary cost data (SURERD, 1985). The pump field-testing and evaluation program that ARD initially proposed to the mission would have determined some of these cost parameters (McGowan, 1985), but this activity was not implemented.

The only detailed field data currently available for comparison come from field tests performed over the last several years in Botswana (McGowan and Hodgkin, 1985). These data must be used with considerable caution, however, since operation and maintenance costs are not readily transferable from one country to another. Sources of error include, but are not limited to:

- varying local fuel and labor costs;
- the degree to which an existing support infrastructure affects life-cycle costing (e.g., a strong maintenance infrastructure that insures the timely performance of periodic preventive maintenance will reduce pumping costs); and
- local equipment costs, which can vary considerably depending on government import duties, source of equipment, etc.

Given these caveats, the break-even water costs calculated from measured field data in Botswana were in the range of $0.002-0.008 per cubic meter. Under current foreign exchange rates, this would correspond to So. Sh. 0.17-0.67 per cubic meter. This means that, assuming the yield increases in Table 5-3 are reasonable, the estimated water-pumping costs for diesels fall within the realm of possible cost-effectiveness.

For example, assume the mean water-pumping charge (from the Botswana results) of So. Sh. 0.44 per cubic meter approximately reflects existing conditions in Somalia. Then, for the Somalia base case assumption of 20 percent irrigation efficiency and 15 percent yield increase due to additional irrigation inputs (i.e., break-even cost of 0.63), after pumping charges the farmer would have:

$$\text{So. Sh. } 0.63-0.44 = \text{So. Sh. } 0.19/m^3 \text{ of water}$$

remaining to pay for associated irrigation costs such as canal maintenance. If actual pumping costs in Somalia turn out to be greater than in Botswana (as they likely will, given higher fuel and spare parts costs, fewer trained mechanics, etc.), this margin can quickly become negative. Since the farmer has no choice but to invest in canal maintenance, the cost-effectiveness of pumped irrigation becomes less likely.

The foregoing, admittedly incomplete analysis should not be taken to conclude that investments in mechanical water lifting should be avoided absolutely. It does, however, show that existing information does not allow a final conclusion to be drawn. Therefore, during the first phase of the project, it is important that a study to measure the actual costs of diesel pumping in the PPA be undertaken before finalizing any physical rehabilitation design that includes pumping.

5.2.4 Cash-Flow Considerations

While profitability is important in selecting financially viable water-lifting technologies, it is by no means the only criterion. In light of AID's emphasis on recurrent cost recovery, small-farm cash-flow problems deserve careful consideration.

Recurrent costs consist of fixed costs (e.g., payment on a loan for purchasing pumping equipment) plus variable costs (e.g., fuel, parts and labor costs of operation and maintenance). Variable costs are those which vary with the level of production or use. If no financing is involved, capital costs are typically incurred at the time of initial investment. Recurrent cost problems arise when financing for fixed and variable costs is lacking.

The pumping equipment considered for this project will not normally be owned by a single individual. Rather, it will be owned and operated either by groups of individuals (e.g., farming cooperatives) or government agencies. A crucial social issue related to equipment ownership is that users should feel responsible for maintaining the machinery. All too often, if equipment is not owned by its users, the machinery does not receive proper care. Furthermore, users feel that if the equipment belongs to the MOA, there is nothing to prevent MOA from moving it elsewhere.

It seems reasonable to assume that initial investments in water-lifting technology (i.e., 30-HP or greater units, which will be used to benefit groups of small farmers) may be provided by foreign donors.[8] Responsibility for recurrent costs associated with these investments is less evident. However, GSDR budget constraints and a gradual shift to privatization suggest that users may be increasingly called upon to bear these costs. Presumably, then, additional income arising from water-lifting schemes would benefit farmers rather than the government.

In such situations, cash flows accruing to users may have a significantly higher opportunity cost than that assumed for initial investment funds.[9] If this is true, and if it is not properly accounted for in the original investment analysis, then

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[8]Small farmers in the PPA simply do not have access to capital, foreign exchange or foreign markets. Furthermore, foreign donors typically prefer to finance these "visible" and administratively less cumbersome capital expenditures.

[9]For example, financing for capital expenditures may be relatively abundant as a result of foreign aid contributions. Resources for meeting recurrent costs can be scarce since they typically come from local sources. The situation is exacerbated by the tendency in both public and private sectors to be inflexible in separating capital and recurrent budgets.

cash flows are likely to be siphoned off to higher-order uses, thus creating a serious recurrent cost problem.

One must consider that benefits accruing to user groups may be other than cash. This is particularly true in the case of small farmers, who typically market no more than 30 percent of their farm production (see Lahmeyer International, 1986: C-20, Appendix C). Table 5-4 on the following page shows an annual cash budget for crop production activities on a representative small farm in the PPA. It illustrates the break-even nature of small-farm crop production activities. In all likelihood, small farmers in the PPA currently earn insufficient cash to pay for costs associated with planned water-lifting schemes.

As shown in Table 5-4, small farmers in the PPA typically incur cash expenses for items such as seed, hired labor, tractor and machinery hire, fertilizer, and insecticide. Major cash outlays are required in the periods April-June, August, and October-December. These are in direct proportion to labor requirements, which constitute an estimated 65 to 75 percent of total production costs (see TAMS, 1986: IV-31). On the other hand, Gu season crops are marketed in August, and Der season crops in January and February. Marketed surpluses, to the extent that they occur, may not be sold for some time. Proceeds from crop sales are often needed to finance the next season's crops, as well as to meet family living expenses. Needless to say, serious cash-flow problems already exist among small farmers in the PPA.

Table 5-1 indicated that irrigation deficits typically occur in the months of June, July and January. Thus, water-lifting costs might be expected to further concentrate major cash outlays during periods when cash inflows would not normally be available.[10] Furthermore, it was assumed that foreign donors would finance initial investment in water-lifting technologies. In the future, if farmers were responsible for periodic payments to principal and interest (in addition to the recurrent costs of operation and maintenance), cash-flow problems would probably become insupportable.

5.2.5 Institutional Factors

Many institutional factors will influence not only the decision to employ water-lifting technologies, but also decisions concerning the choice among alternative technologies. The focus

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[10] This assumes that water-lifting is confined to "on-demand" situations. In reality, one cannot eliminate the possibility that water will be lifted to storage during other periods of the year.

Table 5-4. Annual Cash Budget for Crop Production on a Representative Small Farm in the PPA*

Item	Gu Maize	Der Maize	Sesame	Total
Yield (quintals/hectare)	12.5	14.4	4.0	
Area (hectares)	1.0	0.4	0.6	
Actual yield (quintals)	12.5	5.8	2.4	
Marketed surplus (quintals)**	3.8	1.7	1.0	
Price (So. Sh./quintal)	1,500	1,500	6,000	
Cash revenue (So. Sh.)	5,700	2,550	6,000	14,250
Cash Expenses (So. Sh. per annual crop)				
Seed	500	200	324	1,024
Land preparation	1,750	700	600	3,050
Fertilizer	1,000	400		1,400
Pesticide	1,080	432		1,512
Irrigation***				
Machinery	408	163		571
Casual labor	2,100	840	1,008	3,948
Shelling	620	248		868
Miscellaneous	500	200	300	1,000
Total Cash Expenses	7,958	3,183	2,232	13,373
Net Cash	-2,258	-633	3,768	877

*Source: Lahmeyer International, 1986, and calculations based on assumptions listed in Section 5.2.2 of this report.

**Assumes 30 percent of maize production and 40 percent of sesame production are sold for cash.

***Gravity irrigation only. Costs are included in casual labor.

here is on those factors which have obvious financial and economic implications.

SWMP should strive to develop a self-sustaining irrigation network in the PPA. Equipment provided by the project will require parts and service, and it will eventually have to be replaced. Among other things, users groups must be able to generate sufficient revenues, obtain credit and foreign exchange, import equipment and parts on favorable terms, purchase fuel (if and when required) at reasonable prices, and, to the extent possible, service and repair all equipment locally.

This reconnaissance effort suggests that water-lifting applications will be primarily limited to cooperative schemes, e.g., a group of farmers sharing in the operation and maintenance of a pumping installation feeding a larger secondary canal from an off-stream storage facility. Responsibility for recurrent costs associated with this activity should be clearly delegated, either to the government or, more likely, to private-sector user groups, due to GSDR budget constraints and a general policy shift to greater privatization.

Private-sector success in meeting recurrent costs associated with water lifting will depend upon two important factors. The first is a willingness and ability among farmers to organize user groups. This matter is discussed in detail in Section 6.3 of this report. The second factor, discussed below, involves the ability to generate sufficient revenues to meet recurrent costs.

Successful user groups must be able to generate sufficient revenues to cover the initial investment (if not provided by donor agencies) and recurrent costs associated with water lifting. It will be difficult, if not impossible, to assess fees on a volumetric basis due to measurement difficulties. Some variation of fee assessment based on per-hectare charges would seem to be much more practical. This would have the effect of forcing large landowners to lease sections of unused land. It would also provide no incentive to farmers for increasing the efficiency of water application. As noted earlier, it is desirable to think in terms of fees assessed for water delivery services rather than for water per se.

Obviously, farmers will pay no more for water delivery services than they hope to gain from them. Thus, a logical departure point in establishing per-hectare fees would be the marginal revenue associated with eliminating the deficit in net irrigation requirements (although this is obviously crop-dependent). From Table 5-2, it is clear that a representative small farmer in the PPA could afford to pay no more than So. Sh. 4,650 per hectare for additional irrigation input.

The TAMS study estimated that 3,500 hectares in the PPA are devoted to irrigated annual production (1986: IV-10). Thus, in the entire PPA annual user fees could total no more than So. Sh. 16.28 million ($195,000 at official exchange rates).[11] Again, it is important to remember that these fees would have to cover all costs associated with additional irrigation input, not just those directly related to water lifting. Admittedly, these figures are of limited value, but they do suggest that financial considerations may limit the scale of water-lifting schemes in the PPA.

Somalia's foreign exchange difficulties are well documented. For all practical purposes, small farmers in the PPA have no access to Somalia's limited supply of foreign exchange. Large commercial farmers and equipment dealers suggested that it is often difficult to obtain foreign exchange even through black market channels. It is to these large farmers and dealers that small farmers must normally turn for imported equipment such as tractors, implements and pumps. The Lahmeyer International study reported that the private sector, consisting of four major importers, dominates the market in irrigation pumps (1986: Appendix C, Annex C-9). Because of the historical Italian colonial influence, the majority of pump imports are of Italian origin. This fact should be given serious consideration when choosing water-lifting equipment for the PPA.

Official GSDR policy provides for duty exemptions on agricultural equipment imported by farmers. However, it seems that the MOA will grant an exemption only after the equipment has arrived in country, and then only if documents show that the equipment was consigned to the purchasing farmer. Dealers, on the other hand, must pay duty on imported agricultural equipment.[12] In effect, farmers who purchase agricultural equipment from dealers must pay import duties, since dealers typically will not import equipment in a farmer's name.

The cash-flow problems faced by small farmers were demonstrated earlier. The introduction of water-lifting technologies may further exacerbate those problems. Greater access to credit would no doubt be helpful, but there is concern that farmers do not generate sufficient income to meet borrowing

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[11] This ignores fees which might be assessed on some 270 hectares of irrigated perennial crops. On the other hand, it probably overestimates fee collections, because not all land suitable for irrigated annual cultivation will be under production in any given year.

[12] One source in the Ministry of Finance reported duties of 50 percent on imported agricultural equipment. Conversations with several dealers in Mogadishu suggest that the rate is often "negotiable."

commitments due both to the fungibility issue and to their serious cash-flow situation (Table 5-4 illustrates this point rather graphically). Furthermore, Somalia's agricultural credit institutions are limited in both scope and effectiveness (see Lahmeyer International, 1986: C-57, C-58; and TAMS, 1986: VI-22 through VI-26). SWMP planners may want to consider working with these institutions to insure that credit in support of water-lifting technologies is available. Furthermore, the unit costs of what appear to be the least-cost alternative--stand-alone diesel pumps--can approach So. Sh. one million for a standard six-cylinder engine and pump. Only the wealthiest farmers or cooperative groups could afford this.

Trained manpower will be required to operate and maintain water-lifting equipment. Training costs associated with water-lifting technologies would be difficult to estimate since they depend upon the scale of investment and the choice of technology. These costs could possibly be addressed by donor support, possibly through the assistance of private voluntary organizations (PVOs). The following brief discussion merely demonstrates that training costs associated with each technology are likely to vary.

This reconnaissance effort suggests that the scale of water-lifting investment in the SWMP will be limited. The final technology choice cannot be predicted on the basis of current information. However, standard (i.e., not heavy-oil) diesel-powered pumps have been successfully employed in the PPA for many years. As a result, there are institutions and at least some modicum of trained manpower capable of supporting this technology. This should provide a relatively low-cost base for training additional manpower.

An example of indigenous technical expertise are the local ONAT workshops. ONAT is the major source of rental equipment, such as tractors, bulldozers and excavators. It also does considerable repair work on this equipment, and sometimes builds and repairs pumps and engines. ONAT has built copies of the dual-discharge canal pumps that are so common in the area. From their appearance, it seems that the performance of these copies is not quite the same standard as the originals. However, they do work, and the local manufacturing capability (estimated by the Shalambood ONAT workshop manager to be about six units per year) assures at least some long-term repair capacity for similar pumps in the area.

The same is not true for renewable energy technologies (RETs), such as wind and solar pumps. Generally speaking, these technologies have seen minimal use in the PPA (the ARD team saw several old wind pumps that were no longer functional and no PV pumps). While several individuals have had some experience in wind-pump installation, in general, institutions and trained manpower to support these technologies are virtually non-existent. On the other hand, RETs are relatively simple to operate and maintain and would probably require less intensive training.

Availability and reliability of energy sources are critical factors in the choice of water-lifting technology. The current reconnaissance effort suggests that diesel (and possibly solar or wind pumps for intermittent pumped drainage) is the only technically viable alternative at the present time. The generally accepted method for evaluating the financial and economic viability of system options is to discount costs and benefits in calculating the net present value of life-cycle cash flows.

Previous studies have shown conventional diesel power to be cost competitive in spite of the substantial savings in fuel costs associated with wind and solar power (Barnett, 1985: 11). In fact, it is surprising how little discounted life-cycle costs have been affected by fuel expenses.[13] Of greater significance are the magnitude and distribution of life-cycle costs. RETs generally have greater initial costs and lower operating costs than their fossil-fuel counterparts. Thus, RETs tend to be adversely affected in the discounting process. In fact, the higher the discount rate used, the less favorable RET alternatives appear.

Obviously, the choice of discount rate will greatly influence the outcome of any comparative analysis of alternative technologies. Some have questioned the validity of discounted cash-flow analysis in evaluating water-supply projects. Barnett dismisses this notion by pointing out:

> In general, if it is believed (and a plausible case can be made) that the use of renewable sources of energy produces benefits (or avoids costs) that are greater than (or different from) the benefits of using non-renewable resources, then they should be accounted for in the valuation of benefits rather than by abandoning the idea that resources have an opportunity cost over time. (1985: 11)

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[13] On the other hand, statistics from the GSDR's MOP indicate that fuel prices have increased more than tenfold since early 1983. Given Somalia's balance-of-trade problems, limited foreign exchange reserves, and dependence on foreign oil, the situation is not likely to improve in the future. Under these circumstances, technologies requiring fossil fuels should be considered with caution.

In the present case, the opportunity cost of cash for small farmers appears to be quite high (15 to 20 percent). Financial and economic analysis of alternative technologies should account for this fact, regardless of how it affects the outcome. Failure to do so may lead project planners to "build-in" recurrent cost problems. Advantages peculiar to specific technologies should be accounted for in the valuation of benefits and costs.

In summary, the ARD team's reconnaissance effort leads to the following conclusions:

- it appears that additional irrigation water input is not the most critical constraint to agricultural production in the PPA, and that marginal benefits from increased irrigation input will be limited, both in absolute terms and relative to marginal benefits from increased use of other agricultural inputs;

- water-lifting applications in the PPAs will be primarily limited to cooperative schemes (e.g., groups of farmers sharing in the operation and maintenance of systems designed to pump water from off-stream storage into a secondary canal for their joint use);

- given existing cropping patterns, small farmers in the PPA currently do not appear to generate sufficient cash to pay for water-lifting schemes;

- water-lifting costs might be expected to concentrate major cash outlays, exacerbating existing cash-flow problems;

- even stand-alone diesel-powered pumps (the system of choice based on technical criteria) probably cannot be justified without major improvements in overall irrigation efficiencies; and

- a study to quantify the actual costs of diesel pumping for irrigation in the PPAs should be undertaken before the design of the project's physical rehabilitation is finalized.

6.0 SOCIAL ISSUES

The social/institutional backdrop of the Shalambood PPA has been evolving over the last 50 to 75 years. The most recent steps in that evolution took place only this year. On the surface, the project area appears to be a patchwork of smallholders working their own land; of large, privately held, commercial estates; of cooperatives; of state farms; of projects; and of medium-sized commercial farms. To understand the overall social/institutional pattern of the area it is necessary to reconstruct this evolution.

6.1 Brief History of the Shalambood PPA

Introduction

The population of the Shalambood area has always been much more heterogeneous than the picture of Somali society given by the standard ethnographic literature. It has been an area of settled agriculture for hundreds of years. The Somali groups originally from the area gradually absorbed other agricultural peoples who moved to the area into Somali society. During the prosperous period of riverine agriculture in the nineteenth century, the local Somali landowners settled numbers of slaves of diverse origins as clients on their lands. Liberating the slave populations played an important role in the early stages of Italian presence in the lower Shebelli. As I. M. Lewis has described (1980: 13), "In general, three classes of landholders are recognized: putative descendants of the original groups, long-standing accretions, and finally, recently adopted clients." The lower Shebelli is one area in Somalia where common residence and common landholding have taken precedence over kinship.

The Italian colonial powers felt pressure for the colony to generate the revenues to pay for its administration. They soon began to focus on the development of the farmland of the lower Shebelli as revenue-producing enterprises. The colonial government granted concessions to Italian entrepreneurs and companies to establish plantations primarily to grow bananas for export. Throughout the colonial period, however, the plantation owners found the recruitment and maintenance of adequate labor a major problem.

> Despite salaries which were not low, voluntary recruits were hard to come by, and those who were induced to work for the Italian farmers had to be supervised by guards otherwise they simply stopped work or fled. The tradition of largely compulsory labor recruitment, mainly from the sedentary Bantu

> tribes of the riverine regions, continued throughout much of the Italian colonial period. (Lewis, 1980: 92-3)

The importance of discussing Italian colonial agricultural policy in this report is for the insight it gives into the present organization and performance of cultivators in the project area. The present organization of most of the farming units in Shalambood is a lineal descendant of the system put in place in the Italian estates of the 1920s and '30s.

> By 1924 . . . the system of cooperative "collaboration" by which labourers were established in cultivating settlements within the (first plantation's) lands was extended to all employees and began to prove successful. Each worker was allocated one hectare of land, of which half was for his own use, while the remainder was to be worked by him for the company at rates which varied according to the yield produced. On this basis a comprehensive labor code was elaborated under which recruits from different tribes and areas were grouped together in cultivating villages on the consortium according to their ethnic and tribal origin. (Lewis, 1980: 94-5)

By the late 1920s, the colonial government decided to create a vast irrigation project for plantation cultivation centered at Genaale. The conditions of employment were modeled on those described above.

> Yet, however generous these conditions appeared to the Italian settlers and companies, there was marked reluctance on the part of many cultivating tribesmen to leave their lands and homes, neglecting their own subsistence farming, to work, virtually as prisoners, for foreign masters. Consequently, in good seasons, especially, when there was plenty of work at home, the Italian concessionaries at Genaale continued to be confronted with the problem of a reluctant and generally inadequate labour force which they overcame, with the connivance of the Administration, by forced recruitment. The consequent forages which were undertaken, to collect workers from the Baidoa and Bur Hacaba regions for this purpose, are still bitterly remembered. (Lewis, 1980: 95)

Field Divisions at Shalambood PPA

The Genaale Barrage, which has made the irrigation system in Shalambood possible, dates from 1926. In-field interviews with several foremen dated the development of the field works in Shalambood to 1935-36. At that time the area bounded by the upstream edge of the project zone, the Fifth Secondario, the Dhamme Yasin canal, and the paved road from Shalambood to Mogadishu was divided into 63 aziendas or plantations, almost all owned by Italian entrepreneurs or commercial firms.

The map in Figure 6-1 records the divisions of these 63 aziendas. Each azienda has been numbered for easy reference. This organization of the land, which dates from the colonial era, has continued into the present. It is the key to understanding the different types of tenure and land use currently in practice in the area.

Labor Force in the Shalambood Irrigation Works

The present labor force in the irrigated area is heterogeneous. It has come in several different waves.

The oldest group is the residents of Shalambood and Genaale, themselves. As mentioned above, they are, themselves, heterogeneous groups in terms of their origins. Residents of both towns walk from their homes into the fields. There are, consequently, few settlements in the irrigated areas near the two towns. Moreover, the few settlements that exist there are small and fully occupied only seasonally. There are more private plantations and state farms near Genaale than near Shalambood. Consequently, Genaale residents tend to be casual day labor on these estates while Shalambood residents tend to be smallholders on their own plots. This generalization is, however, only a generalization.

A number of aziendas, numbers 9 through 23 on the map (Figure 6-1), were too far from Genaale or Shalambood to rely on labor from the towns. A labor force was, therefore, brought in from the Bay region to work these estates. This labor force remains in settled villages, in general, on the aziendas in which it has a share of the land. Laborers from the Bay Region also live on the private plantations that they currently staff in the area. The latters' conditions of employment are the same as during the colonial era. They are paid to work a plot for the plantation owner. In addition, they have a small plot of their own, the production from which is entirely their own to dispose of. These migrants from the Bay Region are still in contact with their families from home. Children from Shalambood spend time in the households of relatives from the Bay Region. Relatives from

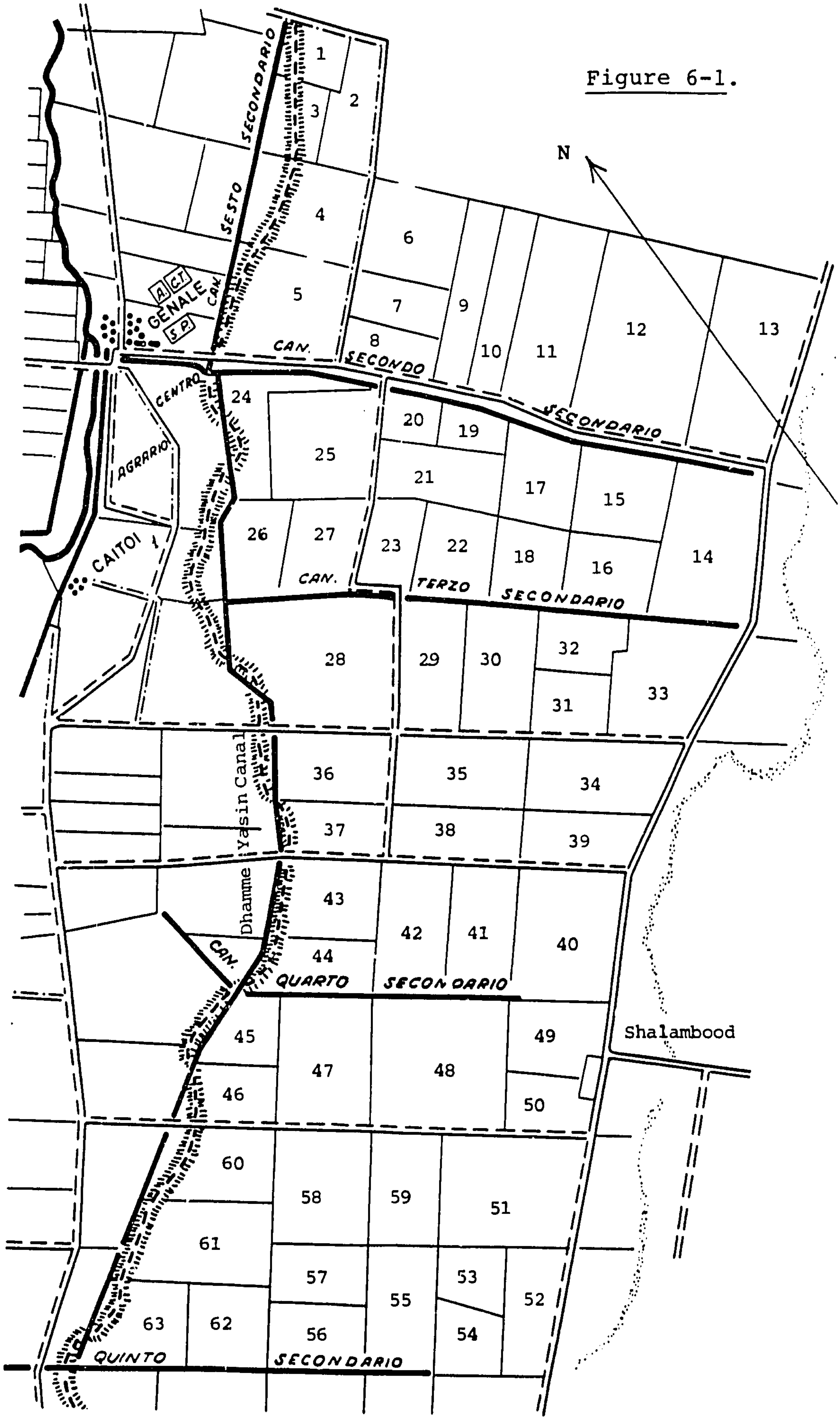
Figure 6-1.
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A.C.T.
S.P.
CAN.
CAN. SECONDO SECONDARIO
CENTRO AGRARIO
CAITOI
CAN. TERZO SECONDARIO
Dhamme Yasin Canal
CAN. QUARTO SECONDARIO
Shalambood
QUINTO SECONDARIO
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the Bay Region come to Shalambood to lend a hand in the irrigation works there.

A third segment of the labor force came in the early to mid 1970s with the creation and operation of two Agricultural Crash Programme project farms in the project area. The Agricultural Crash Programme project recruited its volunteers principally among the urban unemployed. The Agricultural Crash Programme project, therefore, introduced people to irrigation in Shalambood from a wide range of backgrounds from all over the country. The Agricultural Crash Programme project scaled back its operations drastically in 1977-78, with the advent of the Ogaden War, but kept a core group of volunteers on its land.

The final components of the work force in the proposed project area have come as a result of Agricultural Crash Programme project activities. In 1983, the project distributed its remaining lands then under cultivation to the remaining volunteers cultivating it. The following year it began to distribute its other land, which had gone back to bush in the previous five years, to several different groups. These include war veterans and war widows, government and party officials who lost their jobs with shrinking budgets, and a group of well-placed individuals who got grants of land directly through the Ministry of Agriculture in Mogadishu and about whom the authors have almost no other information.

6.2 Landholding and Management on Aziendas

During the 1960s, plantation agriculture was in decline. One informant cited a drop in the water levels in the river as an important factor. More importantly, however, the cost of labor apparently shot up after independence. Labor became hard to get. Rising labor costs put a squeeze on profits. One by one azienda owners departed for Italy and left their foremen in charge. This was the first step in their abandonment of their aziendas. Their personal financial loss was not very great since they were all heavily indebted to the banks.

The foremen of the aziendas ran them, in the owners' absence, on the system developed by the owners. As it became clear that the owners would not be returning, the foremen took plots for themselves and began to lease out the rest of the azienda to the workers or to others who were willing to pay. The rent, at the time, was one quintal per hectare or two shillings per jibal (a jibal measures 25 meters by 25 meters). The last of the Italian azienda owners left shortly after the inception of the military government in 1969. Only four aziendas in the project area have been cultivated continuously as plantations throughout this period. These include aziendas number 28 and 36 on the map (Figure 6-1).

Autonomous water-user groups date from the late 1960s. The estate owners had left by that point. The impetus for forming the groups must have come from the foremen. The labor and cash contribution to maintain the works would have been a condition of his renting out the land. To this day the head of the water-user groups is called the foreman. The system put in place by the azienda owners has, therefore, survived a transitional period and is now reproduced by the smallholders themselves.

As part of the Land Law of 1975, the Ministry of Agriculture determined that there were no valid claims to ownership of many of the aziendas in the project zone. It annulled the right of the foremen to collect rent on the land and awarded plots to the families cultivating them. It appears that many foremen lost the leadership of the water-user groups at this time. Very few of the former foremen are still active in managing the water-user groups as near as the authors can determine. The present group leaders have, however, served an apprenticeship of a number of years. At least 12 aziendas are now owned and operated entirely by the smallholders. There are probably a few others, on which the authors were not able to get information, that are also smallholder owner-operated.

In the period between the abandonment of the aziendas and the Land Law giving tenure to those who cultivated the land, various Somali institutions and private parties paid off the bank debts on a number of other aziendas and installed themselves as azienda owners. In this way the Agricultural Crash Programme project acquired 12 aziendas; AFMET acquired four; UDHIS, the general union of cooperatives, three; UQIB, the association of agricultural cooperates, five; and other national cooperatives, three.

Many of the aziendas that were taken over by Somali institutions are now in various stages of devolution to ownership and management by the smallholder labor force that occupies them. Thus, in this past year, UQIB has subdivided its aziendas and distributed the lands to farmers according to the size of their families. It still provides some support services to them, however. The Agricultural Crash Programme project has distributed all of its lands over the past three years. It gave 650 hectares to various groups of smallholders.

The national cooperative aziendas are growing perennial crops, chiefly bananas, on a commercial basis for sale mainly through SomalFruit. The UDHIS aziendas are doing the same. In addition, there are six or seven aziendas that are owned by private parties, commercial establishments or local cooperatives that are producing perennial crops on the same basis. The largest of these is a 280-hectare azienda, number 28 on the map (Figure 6-1).

The table in Appendix D presents, azienda by azienda, the authors' information on the size, management status and number of smallholder families of each of the 63 aziendas in the project area. There are clearly a number of information gaps, but the table is complete enough to illustrate what has been happening in the area. There are doubtless many inaccuracies in the table. Future teams will have to double-check the area and status of each azienda and determine how many families have cultivation rights on each. The table is most useful as a first attempt at creating a framework for analyzing land distribution and the organization of its use within the project area.

In summary, as the table in Appendix D shows, there are a number of different groups in the proposed Shalambood project area in terms of how the group originated, current status of access rights and current organization. Table 6-1 presents this information for all of the aziendas for which it is available.

Table 6-1. Current Distribution of Landholding by Type

Landholding Status	Number Aziendas Known	Hectares Known	Number Families Known	Average Hectares/ Family
Smallholders:				
independent	13	744[1]	617	1.2
cooperative	4	825[1]	697	1.2
Plantations:				
privately held	4	412[2]	n.a.	n.a.
private cooperative	2	150[2]	n.a.	n.a.
state cooperative	6	655[1]	n.a.	n.a.
state farms	5	400[1]	n.a.	n.a.
Agricultural Crash Programme project:				
smallholders	3	350[3]	350	1.0
excess employees	2	300[4]	60	5.0
others	7	unknown[4]	unknown	10-15(?)
Miscellaneous:				
Shalambood	1	30+	n.a.	n.a.
in dispute	2	n.a.	n.a.	n.a.
Unclear	1	n.a.	n.a.	n.a.

[1]Data based on five aziendas.
[2]Data based on two aziendas.
[3]Data based on three aziendas.
[4]This land no longer organized by azienda.

The table on the preceding page accounts for the current use of 50 of the 63 aziendas. Most of the remaining 13 aziendas are probably controlled by smallholders in one arrangement or another. Meanwhile, it is important to point out that the majority of the labor force on the plantations and state farms are housed on the aziendas concerned and work on the sharecropping basis established in the colonial era. In addition to working a field for the estate, each family has a plot on the estate whose production reverts entirely to it.

An irrigation project designed to improve the performance of the irrigation system in the Shalambood area must resolve a number of issues. The rest of this section of the report will identify and discuss social and institutional issues. Resolution of these issues will, in most cases, have to await the research and deliberations of a project design team.

6.3 Beneficiary Contributions to System Operation and Maintenance

At present, all of the aziendas are maintaining the tertiaries that bring water to their fields. There are two systems for maintaining the tertiaries. The aziendas that are dedicated to production of annual crops recruit labor from the families cultivating there to clean the tertiaries. Aziendas where perennial crops are grown routinely assign the job of cleaning the tertiaries to their paid workforce. In either case the tertiaries are generally cleaned out twice a year, just before each cultivation season begins.

The people farming the annual cropping aziendas constitute a water-user association. The management committee of the association, known as the farmers' committee, usually determines when the cleaning will be done. The committee informs the member families of how much labor it will have to supply, where and when. The amount of labor is usually a function of the size of people's holdings. People with very small holdings usually are not asked to contribute any labor. People with very large holdings are asked to contribute more labor than average.

Most aziendas are fed by three or four tertiaries. People are generally asked to clean the section of the canal that runs along their parcels. It usually takes a gang of 15 to 20 workers working two days a week about a month to clean the length of a tertiary within the azienda. The length cleaned can easily exceed a kilometer.

In principle, the government is responsible for maintaining the secondary canals. In practice, maintenance of the secondaries is carried out by several different institutions.

The practice along the Third Secondario in Shalambood is representative. There is a constant information-sharing, consultative process among the heads of the 16 aziendas that receive water from the canal. Six of these aziendas are growing perennial crops. The other 10 are growing annual crops only. When the public consensus demands it, the leader of the group goes to the leaders of each azienda to collect an assessment. The leader has been chosen for his MOA connections. The aziendas that do only annual cropping each paid So. Sh. 3,000 in July as their share of the cost of excavating the Third Secondario. This figure is very low when compared with that reported from the Fourth Secondario. One explanation is that the perennial croppers may be subsidizing the annual croppers by allocating assessment charges according to ability to pay. When the money is collected, the leader of the group goes to the MOA to request the use of its equipment. The ministry lends the equipment at no charge. The money collected is to pay for the fuel and for an incentive to the equipment drivers to work well for a full day.

During the past Jilaal season, January or February, a general committee of farmers' committees on the Fourth Secondario assessed each of the 12 aziendas that get water from the canal a sum of So. Sh. 10,000 to clean the canal. Again, the MOA supplied the equipment. The fuel and incentives for the drivers came to So. Sh. 110,000.

SomalFruit and UQIB have reportedly been performing the same service under similar conditions along the Second Secondario.

Within each annual cropping azienda, it is the responsibility of the foreman and members of the farmers' committee to assess the farmers for their share of the azienda assessment.

6.4 <u>Water-User Associations</u>

Each of the aziendas that does annual cropping only is, in effect, a water-user association, although not named as such. Each association is governed by a farmers' committee. The head of the committee and chief executive officer of the association is known, in a legacy from the colonial period, as the foreman. Water distribution and maintenance of the canals are his responsibility. The authors suspect that he generally has one of the largest holdings on the azienda, but they were not able to confirm this.

The farmers' committees are self-perpetuating bodies which renew their ranks from rank and file association members that distinguish themselves by their leadership qualities and performance in the system. The number of members on the farmers' committees varies somewhat, as shown in Table 6-2.

Table 6-2. Membership in Farmers' Committees

Azienda number	13	39	47	29	49	40	12	14
Hectares		149	158	150	70	217	430	150
Families	170	176	161	82	66	134	427	150
Committee members	9	7	9	7	7	7	14	5

A year ago the aziendas along the Fourth Secondario organized a committee to take charge of maintenance along the canal. This year they have been drawing farmers along the Third Secondario into the committee. The committee is known as the Committee of Farmers of Shalambood. The general committee has seven members, four from aziendas along the Fourth Secondario and three from aziendas along the Third Secondario. The combined group now includes 24 aziendas. Eighteen of them are doing annual cropping only, six are plantations of one sort or another doing perennial cropping. The purpose of this organization is to coordinate, collect money and make arrangements for maintenance of the secondaries.

6.5 Farmer Motivation

This level of farmer organization, participation and performance is not often found in local irrigation systems in Africa and Asia. The question arises, therefore, of why the farmers are responding as they are. What are the incentives?

As pointed out by the WMSII team, the reason people are working in groups is a function of the high silt content of Shebelli River water. The only practical way to keep the irrigation works functioning under these conditions is for people to work cooperatively to maintain public goods. Without cooperative labor, the resource will become increasingly unavailable.

This response explains only why, when people value irrigated cultivation, they organize to maintain it. It begs the question of why irrigation is so important to them that they make the effort. The question is important to get some measure of how people might respond to changes wrought by a project.

Access to the irrigation works is far and away the most important economic resource at the disposal of the farmers in the proposed project area. The opportunity cost of any other economic activity is too high to be competitive. People do very little rain-fed agriculture outside the irrigated area.

They keep some livestock. The Utah State University farming systems study found that 86 percent of the farm families in the area have livestock of one sort or another (Boateng et al., 1986: 76). The role of cattle and small ruminants in the farming systems of the irrigated area is an issue that the project design team will have to consider. When people accumulate a little cash, their first investment is generally the purchase of livestock. During cultivation seasons, they send their cattle outside the area, in the care of their sons or hired herders. Sheep and goats are usually left in the village. After harvest people like to bring their livestock into the fields to graze on the stubble. It is often the most nutritious feed the livestock will get for several months. People, therefore, have an interest in maintaining the irrigation system in order to maintain their livestock interests.

There are three other questions concerning incentives for irrigated cultivation in the Shalambood area. The first is the impact on production of the freeing up of the grain markets in the past two years. Logically, freeing up the grain markets should be a spur to greater maize production. Several groups of farmers mentioned that they have begun using selected seed and some fertilizer in the last two years but they did not link this use to the jump in the producer price of maize. They noted that the cost of production, including these recently adopted inputs, has been going up more rapidly than the producer price. They are concerned about this. The Utah State farming system study confirms: "Cost of production has increased more than the increase in the sale price of the produce, considering the increasing cost of insecticides and fertilizer, as well as the cost of labor in 1985" (Boateng et al., 1986: 61).

A second issue is the impact of the closure of the Saudi meat markets to Somali cattle in the last two years. No informant saw any linkage between irrigated production and the livestock markets. Farmers in the irrigated areas around Shalambood must be such small-scale livestock holders that the vicissitudes of the international markets have only a marginal impact on their farming system strategies. They are raising livestock mainly as an investment. In the absence of any better investment opportunities, the market price of livestock has minimal effect on their behavior.

A final issue is the impact of the expansion of SomalFruit in the area. SomalFruit is recruiting more and more outgrowers in the area and is supplying inputs and services on credit to assure banana production for export. To what degree does the SomalFruit program compete with annual cropping for land, labor and water? Under what conditions would aziendas growing only annual crops become outgrowers for SomalFruit? To what degree would people be inclined to convert annual cropping land to perennial cropping land with improved performance of the irrigation system?

6.6 Role of Kinship in Resource Allocation

Section 6.1 makes the point that access to resources in the Shalambood irrigated area is held by a heterogeneous group of people. Kinship did not play a critically determinant role in access to resources even before the advent of the colonial powers. In the 50 years since the works were developed, several different groups have moved into the area and laid claim to a share in the resource. These claims have been based on economic transactions, not on kinship.

It is, therefore, the authors' opinion that kinship is not an important factor in the allocation of resources in the proposed project area. It need not be a major consideration in the design of the project.

6.7 Security of Tenure

People hold their rights in the irrigation works through several different mechanisms. The owners of the aziendas doing perennial cropping have certificates of title registered with the Ministry of Agriculture. These certificates give them exclusive rights to the land for 50 years in the case of the private enterprises and in perpetuity in the case of the cooperatives and state enterprises.

The national association of agricultural cooperatives (UQIB) and the Agricultural Crash Programme project hold the title certificates for the smallholders who have recently received shares of their former lands.

The smallholders of the independent aziendas generally do not have certificates guaranteeing their rights to the land they cultivate. There are exceptions, but in general the process of acquiring a certificate is too long, cumbersome, expensive and arcane for a family with one or two hectares to pursue. In addition, Somali law automatically gives rights in the land to the people who are cultivating it. People, therefore, feel fairly secure in their tenure. However, the dispute over control of azienda 33 could undermine this confidence if it is decided in favor of the private claimant as opposed to the independent smallholders.

The GSDR collects a land tax of So. Sh. 10 per hectare for irrigated land. The tax collector for the area is based in

Genaale. Those whose land is registered pay directly to him. For the taxes on the independent smallholder aziendas, he contacts the head of the farmers' committee, who allocates and collects the tax from the cultivating families.

Perhaps one component of the proposed project would be to facilitate the registration of the irrigated lands in the name of the families cultivating there.

6.8 Perennial Versus Annual Cropping

This is one of the most important issues in the conceptualization of the project. Expressed differently, the issue becomes plantations versus smallholders. Only the plantations, either privately held, held by cooperatives or run by the government as state farms, grow perennial crops. Only smallholders grow annual crops exclusively.

The issue is very complicated because plantations and smallholders are scattered throughout the area. There is no zone devoted exclusively or even predominantly to perennial cultivation. Therefore, improvements in the technical efficiency of the irrigation system will benefit both types of cultivation.

The resolution of this issue will probably be that project components focused on improvements in public goods or public welfare, such as increasing technical efficiency of the irrigation system or improving public health, would not discriminate between perennial and annual crops.

The project should otherwise, probably, not promote perennial cropping either by plantations or smallholders. On the one hand, this conclusion comes from equity considerations. On the other hand, focusing on annual cropping to the virtual exclusion of perennial cropping aims at building the new project on the present system. The present system is a low-cost supplemental irrigation system. It does not pretend at full water control. But the cost of cultivation under this system is within the ability of the smallholders to pay. Finally, considerations of groundwater hydrology also militate against a project promoting perennial crop cultivation.

Other components, such as agricultural extension and community development, could and should, therefore, focus on aziendas doing annual cropping exclusively. Even these components must not, however, ignore the fact that on many plantation aziendas, the labor force cultivates its own family plots as smallholders, in addition to working the commercial fields of the plantation. Is there not some way of working with these people as well?

6.9 Potential Role for the Private Sector

The private sector is already active in the Shalambood area in several areas, and there is a broad mix of private-sector operators in the zone. Small-scale private-sector actors as owner-operator firms include families that do annual cropping exclusively. Boateng et al. (1986: 91) show that average independent smallholders put aside about two-thirds of their maize crop for family consumption and market one-third. Maize is marketed on the open market, although at present, ADC (a para-statal marketing agency) is the preferred client purely for price reasons. The same independent smallholders are growing sesame, watermelons, tomatoes and vegetables, mainly for the open market.

Regardless of the size of their holding, cultivators in Shalambood sell tomatoes, watermelon and vegetables through the wholesale market. The market meets under a tree alongside the paved road, 100 yards from the town's retail market. Market activity begins after noon and peaks around 4:00 p.m. People bring their produce in by cart, donkey or bicycle.

The study team spent an hour or so at the market on Sunday, 14 September 1986. During that time, people only brought in tomatoes. The peak of the tomato season had just passed and prices had begun to rise. About two-thirds to three-quarters of those bringing in tomatoes were women. The team suspects that these women had grown the tomatoes on family land on their own time and the revenue from sales belongs to them, not the family. However, this suspicion could not be confirmed.

Tomatoes are sold at auction in the wholesale market. The produce is received in the market by a broker, who is a licensed member of the national brokers guild. The seller establishes a floor price with the broker before bidding begins. All sales are cash, and the seller receives 96 percent of the price. Two percent goes to the broker and two is set aside for taxes. All of the tomato buyers at the Shalambood wholesale market were women. They apparently load their purchases onto buses and bush taxis to take them to market in larger towns in the area. Jaffee (1984) has described a similar system that operates in the Afgoi area.

There is no evidence that buyers give production credits to producers for any annual crop. Nor is there any indication of the establishment of long-term business relations between particular buyers and producers. Finally, there is no evidence that wholesalers buy crops in the field before harvest or at the farm-gate during harvest. All transactions appear to be for cash and take place in town.

Other small-scale, owner-operated firms are active in support of annual crop production. Boateng et al. (1986: 21) point out that 97 percent of farmers in the area call on tractor services to prepare their land--94 percent have to rent tractors. Among the aziendas doing annual cropping in the proposed project area, tractors are hired by each azienda and individual families are assessed their share of the cost. They can hire tractors from ONAT, the para-statal agricultural supply organization, at So. Sh. 346 per hour plus fuel plus an incentive to the driver. TAMS (1986: IV-51) estimates that the demand for ONAT tractor services is three to 10 times their availability. Consequently, most aziendas go to private tractor owners. They pay about double the ONAT hourly rental rate, although the latter probably approaches the private-sector cost when fuel charges and incentives are taken into account.

Small- and medium-scale private-sector firms dominate all aspects of pumping operations. This includes buying and selling pumps and spare parts, installation, operation, maintenance and repair. Pumps sales and service provide a livelihood for several businesses in the town of Shalambood. The clients for these pump sales and service businesses are all cultivating perennial crops in the area.

Lahmeyer International (1986: Annex C-9) indicates substantial private-sector involvement in farm input supply in the lower Shebelli region. However, it appears that, for the most part, families doing annual cropping in the proposed project area get their agricultural inputs through AFMET, the Agricultural Crash Programme Agency, or the national association of agricultural cooperatives (UQIB). This is an issue that should be examined more closely to establish the role of the private sector in input supply with more confidence. One discouragement to a major private-sector role in agricultural input supply is the difficulty that smallholders have in acquiring production credits.

The largest private-sector firms in the proposed project zone are privately held plantations that are growing perennial crops and, of course, SomalFruit, a joint stock corporation that assembles banana shipments, exports them to Italy and distributes them there. The plantations do not cultivate perennials exclusively. For two where the evaluation team was able to get data, perennials covered about 10 and 20 percent of the arable land. About 25 percent of the land was under annual crops. The rest was either fallow or under development. The plantations all grow bananas for SomalFruit, which provides its growers with a number of cultivation services and inputs aimed chiefly at banana production, but that often serendipitously support annual crop production as well. SomalFruit provides such production support on credit, which the growers repay through deductions from the receipts for their banana deliveries.

One possible opportunity for private-sector involvement in supplying pumping equipment would be equipment leasing. Because of the high cost of investing in equipment, farmers are often forced to do without. A leasing arrangement (particularly for technologies with high initial costs, such as wind or solar pumps) would tend to spread these costs out over a longer period. A maintenance contract could be supplied as well, wherein the lessor agrees to provide expected periodic maintenance for a fixed fee during the rental period. Obviously, the social issues involved in such arrangements would require further study. Alternative formulations of such arrangements and their respective merits appear worthy of further examination.

6.10 Training Needs

Pumping will probably not play a major role at the field level in the proposed project area unless a decision is made to promote perennial cropping or unless extensive off-stream storage is designed into the rehabilitation component. Thus, training needs for pump operation, maintenance and service will be minimal. It is still possible to pump at the head of the main canals to increase flows throughout field channels. Similarly, pumping may play an important role in drainage and storage. In either case, training needs will be limited to a half-dozen operators and an equal number of mechanics.

Smallholders on the aziendas could use some extension training to increase the efficiency of their water use. AFMET already has fruitful contacts with smallholders. It might be possible to develop a special irrigation extension program within AFMET. The program would be staffed with about 25 extension agents, specifically trained to identify and analyze inefficiencies in on-farm water management and recommend remedial practices.

There are a number of trained technicians for the maintenance and repair of diesel engines and the standard pumps used in the area. However, the same problems encountered in most African countries (e.g., obtaining adequate supplies of spare parts, poorer farmers not having access to technicians, etc.) were a common complaint. Since the maintenance and repair expertise resides largely within SomalFruit, it is primarily used to service the machinery of large banana farmers. While a cadre of trained technicians exists within organizations such as ONAT and AFMET workshops, they are largely devoted to keeping tractors and farm implements in shape and are not able to spend much time on pumps.

A significant contribution to developing a pump maintenance infrastructure would be to support training programs for local mechanics specifically for the purpose of servicing pumps.

However, whether or not farmers other than those who already have access to SomalFruit mechanics would stand to benefit by this is questionable. Furthermore, if GSDR employees are the focus of training programs, it should be noted that other donor projects in Somalia (e.g., the USAID Groundwater Development project) have found technical training programs particularly problematic because of extremely low GSDR employee compensation levels. There is little incentive for technically trained personnel to remain within the government when opportunities exist for employment in the private sector.

A final area where training may play a role is in irrigation system management. Several technicians will have to be trained to analyze river flows, and program and operate civil works on the river and main canals to distribute water equitably and efficiently.

6.11 Expressed Needs

The two biggest problems cited by local people are poor drainage and waterlogging of the fields. These problems can cost people their entire crops from certain fields during particularly rainy years. In addition, waterlogging is a problem outside the fields. Water often overflows the canals and transforms roads into a mire. Transportation within the irrigated area, particularly getting crops to market, becomes an almost insurmountable problem.

People also feel that the canals at all levels cannot cope with the volumes of water farmers need in the fields. They feel the secondaries and tertiaries, in particular, should be enlarged. They suspect the problem is aggravated by high infiltration rates on the canal banks. People also complain about the continuous effort required to keep the canals clear of silt. Canal maintenance is a constant problem.

Finally, credit is a problem. People feel that selected seed and fertilizer have increased their production. They need access to cheap credit to be able to employ other inputs. In the meantime, they have noticed that the cost of inputs is rising faster than the producer price. This is especially true for the cost of labor. They would like ADC to raise its producer price more rapidly.

6.12 Information Gaps

First and foremost, there is a need for a local epidemiological study to gain an understanding of the incidence of waterborne diseases in the proposed project area. More detailed information on the present role of women in the irrigation system would be helpful in planning and implementing a project in the area.

It would also be useful to review the table in Appendix D and Table 6-1 concerning landholding and management on the aziendas for information gaps. The important issues are the area of each azienda, number of families cultivating there and the azienda's management status (plantation, state farm, cooperative or smallholder owner-operated).

Finally, the TAMS (1986) study had a team of enumerators collect quantitative data on socioeconomic life in the proposed project area. If available, these data could give some useful background information on the people in the area.

7.0 WATER-QUALITY AND ENVIRONMENTAL ISSUES

Planning exercises for irrigation projects are rarely remiss in assessing water quantities available for cropland application under different cropping and economic scenarios. Yet, in most semiarid environments, including Somalia, the quality of irrigation water quality causes equally serious constraints to irrigated agriculture. Clearly, application of large volumes of inferior-quality irrigation water does not produce desirable agricultural yields. If this were so, ocean or brackish water could easily alleviate global irrigation water needs.

In the Shebelli PPA, irrigators currently apply water of inferior quality to cropland, which results in declining yields and subsequently, land abandonment. The dangers of this practice have been described in numerous reports generated by visiting international agricultural experts and government officials. There are also sufficient data on water quality to reveal the dangers of low-quality irrigation water. Results of various water-quality studies are summarized in reports (listed in the bibliography) by FAO, the Japanese International Cooperation Agency, Lahmeyer International, Faillace and Faillace, and Hussein and Ahmed.

While the data complied in these references are mostly non-systematic and discontinuous, they are sufficient to accurately portray the magnitude of water-quality problems within the Shebelli River system. If these data are considered in concert with soil data in the same references, a rationale for moderate to severe soil salinization effects in the PPA emerges. Data from these references, corroborated by tests performed during this consultancy, clearly demonstrate a pressing need for additional expertise in irrigation water quality and management in project design phases for Lower Shebelli agricultural projects, especially those related to irrigation development or rehabilitation.

7.1 Existing Water-Quality Data

The components of the water-quality terms of reference were interrelated in intent and practice. Cooperating Somali institutions, including the Faculty of Agriculture and the Faculty of Chemistry of the Somali National University and the National Soils Laboratory at Afgoi, provided references and valuable field assistance as well as full cooperation with laboratory facilities. The National Soils Laboratory and the Faculty of Chemistry Laboratory in Mogadishu are capable of conducting water-quality analyses on a continuing basis, although clearly, at present. the Faculty of Chemistry has a wider array of laboratory equipment and a larger staff of trained personnel.

As noted previously, compilations of water-quality data from surface and groundwater analyses are deficient due to a lack of continuity, reliability, consistency and standardization. Samples are often taken on an ad hoc basis by a variety of technicians and analyzed by different methods for different purposes. Until recent efforts by Faillace, data have not been standardized, nor stored in a managed data storage and retrieval system. Yet references demonstrate a remarkable consistency of findings, which should have significant implications for irrigation planning and development in both river valleys of Somalia.

7.2 Field Sampling

The field sampling was not intended to be either comprehensive or systematic, in that it was subject to vagaries of time, logistics, personnel and good fortune. Data were to be used to corroborate and/or validate results from other studies. A set of 35 samples were collected from the two PPAs, 11 from the Faraxanne area and 25 from the Shalambood area. In the Faraxanne area, one sample was taken from the Shebelli River, another from a pond adjacent to the Wadajir Canal, five from irrigation canals and three from wells. In the Shalambood area, two river samples, 13 irrigation canal samples and nine well samples were collected. Samples were analyzed in the field with portable test kits for pH, temperature and conductivity (EC). The remaining parts of each sample were taken to the Faculty of Chemistry Laboratory at the Somali National University and analyzed for turbidity, dissolved oxygen (d/o), total dissolved solids (TDS), settled solids, suspended solids, hardness, and ions of calcium (Ca), magnesium (Mg), Sodium (Na), Potassium (K), Chlorine (Cl), bicarbonates (HCO3), sulfates (SO4), phosphates (PO4) and nitrates (NO3). All samples were collected and analyzed in September 1986. Table 7-1 summarizes the locations and types of the 35 samples.

The analysis data, summarized in Table 7-2, corroborate results from previous studies when normal seasonal variations are considered. Of the various parameters measured, three are of considerable significance to water use for agriculture or domestic supplies. They are total dissolved solids (TDS), electrical conductivity (EC) and hardness. To a lesser degree, suspended solids (SS) and sodium absorption ratios (SAR) have implications in the PPAs.

In the PPAs, river water is diverted or pumped into distribution canals for furrow or basin irrigation. During the driest part of the year, January to March, the river normally ceases flow, or is so reduced in flow that irrigation water is not available. Some irrigators supplement irrigation water supplies from groundwater using dug or drilled wells. Domestic

Table 7-1. Water Sample Locations and Rates

Sample Number	Date	Location	Type
1	9/86	Qorioley (bridge)	river water
2	9/86	Cabdi Cali	irrigation
3	9/86	Cabdi Cali	well
4	9/86	Faraxanne	irrigation
5	9/86	Jeerow	irrigation
6	9/86	Faraxanne	well
7	9/86	Aduma	well
8	9/86	Wadajir Canal	irrigation
9	9/86	Wadajir Canal (Madhuulow)	irrigation
10	9/86	Wadajir Canal (Madhuulow)	irrigation
11	9/86	Primo Secondario Canal	irrigation
12	9/86	near Primo Secondario	well
13	9/86	near Primo Seondario	irrigation
14	9/86	Primo Secondario Canal	irrigation
15	9/86	Mushani	well
16	9/86	Primo Seondario Canal	irrigation
17	9/86	Shebelli (Primo Secondario)	river water
18	9/86	Genaale Barrage	river water
19	9/86	Fourth Secondario (tertiary)	irrigation
20	9/86	Dhamme Yassin Canal	irrigation
21	9/86	Genaale	well
22	9/86	Genaale	well
23	9/86	Genaale	well
24	9/86	Second Secondario	irrigation
25	9/86	near Second Secondario	irrigation
26	9/86	near Second Seondario	well
27	9/86	Third Secondario Canal	irrigation
28	9/86	Third Secondario Canal	irrigation
29	9/86	near Third Secondario	well
30	9/86	Fourth Secondario Canal	irrigation
31	9/86	Fourth Secondario Canal	irrigation
32	9/86	Fifth Secondario Canal	irrigation
33	9/86	near Fifth Secondario	well
34	9/86	Fifth Secondario Canal	irrigation
35	9/86	Shalambood	well

Table 7-2. Water-Quality Data

Sample Number	pH	EC (mS/cm)	TDS (mg/L)	Turb (NTU)	SusS (mg/L)	Hardness (mg/L)	SAR Ca,Mg/Na
River							
1(F)	7.3	359	392	164	4300	200	0.42
17(S)	7.4	416	264	85	1948	220	0.35
18(S)	7.5	420	228	45	2760	260	0.06
Irrigation water							
2(F)	7.4	357	308	177	528	240	0.32
4(F)	7.5	359	340	31	172	240	0.35
5(F)	7.5	373	288	181	2140	220	0.27
8(F)	6.8	371	244	180	1320	240	0.32
9(F)	7.5	378	340	49	96	240	0.32
11(F)	7.6	362	296	54	124	260	0.006
13(S)	6.5	375	356	156	2500	220	0.007
14(S)	7.4	412	368	113	2756	200	0.077
16(S)	7.4	405	992	143	1652	240	0.006
19(S)	7.5	384	324	184	524	200	0.35
20(S)	7.6	390	312	195	604	180	0.007
24(S)	7.4	400	304	252	956	196	0.43
25(S)	7.5	381	360	316	1072	120	0.36
27(S)	7.6	403	340	230	692	204	0.35
28(S)	7.5	423	240	270	320	208	0.35
30(S)	7.7	382	308	255	1272	200	0.007
31(S)	7.7	371	352	329	2368	200	0.35
32(S)	7.6	378	190	261	2052	180	0.37
34(S)	7.6	380	160	339	1208	200	0.45
Wells							
3(F)	7.3	2181	2912	2	60	1622	1.7
6(F)	7.8	915	924	3	32	600	1.3
7(F)	7.7	2559	3232	2	56	1922	4.7
12(S)	7.8	3182	1012	6	264	1982	4.7
15(S)	7.4	2823	3920	4	140	1681	5.0
21(S)	7.8	2002	3295	2	88	1501	2.0
22(S)	8.2	3116	3280	8	288	581	18.1
23(S)	7.9	4533	5220	1	128	757	5.1
26(S)	8.2	2417	3570	19	112	1742	3.2
29(S)	7.9	1926	2440	6	1172	1782	2.6
33(S)	7.6	1926	2550	3	96	1581	1.2
35(S)	7.7	1501	1550	286	2116	801	2.9
Pond							
10(F)	7.8	973	1184	8	160	641	0.20

Underlining indicates unacceptable level.

water is also taken from a mixture of sources, both river points and wells. Thus, a discussion of water quality for agriculture and domestic use is necessary for the PPAs.

Salinity, reflected by EC and TDS values, is a critical issue for irrigation in the PPAs. The USDA classification for agricultural water uses an EC of 750 micromhos as an upper limit for agricultural waters without restrictions. Above that level, consideration must be given to soil drainage characteristics or saline-resistant crops. In the Lower Shebelli Region, salinity levels in irrigation water are exacerbated by the extremely poor drainage of the heavy clayey soils.

During the September sampling period, EC values for the river and irrigation samples were between 357 and 423 micromhos, well within the safe range. These results are similar to other studies which report safe levels during most of the year. During the first flush caused by March-April rains, EC values can skyrocket, exceeding 2000 micromhos for brief periods. Irrigators in southern Somalia are aware of this flushing effect and normally suspend irrigation during this period.

Of considerable significance, however, are the EC values for groundwater, taken from the 12 wells in both areas. These values, ranging from 915 to 4,533 micromhos, indicate severe salinity problems if this water should be used for irrigation. Water with an EC above 1,500 micromhos must be used with extreme caution, involving both drainage and saline-tolerant crops. Above 2,500 micromhos, the water simply should not be used for agriculture. The results of this survey confirm results from other studies which have cautioned against the use of groundwater for supplemental irrigation water.

During this survey period, it was possible to collect data on other wells in the PPAs from other references (Faillace and Faillace, 1986). The data for these wells and 12 sampled in this survey are presented in Table 7-3. The data are not encouraging for the use of groundwater for supplemental irrigation in that only three tests produce EC values suitable for banana irrigation. Anecdotal information from local water users indicates a "sweet-water" zone for groundwater extraction between Buulo Mareerta and Shalambood along the Primo Secondario Canal. The limited data available did not confirm the existence of this water.

Of greater importance, but not tested in this sampling period, is the accumulation layer of salts leached from the surface. Studies by MMP indicate that this layer is only slightly deeper than 50 centimeters from the surface with EC values in excess of 20,000 micromhos (FAO, 1985). A rising water table caused by overapplication of irrigation water can easily bring these salts to plant root zones resulting in crop reduction

Table 7-3. PPA Well Data

Well Location Name-Number	Type Dug/Drill	Depth (m) Well/Water	Date Tested	EC micromhos/cm
Waagade-M93	dug	14/1.3	4/85	1896
Waagade-M94	drill	60/na	4/85	1920
Buulo Shiik-M111	drill	60/na	1/78	4900
Buulo Mareerta-M119	drill	60/na	4/85	2390
Shalambood-M121	drill	60/4.4	1/78	3100
Jooriow-M125	drill	86/na	4/85	2508
Beled Amin-M128	dug	na/3.3	4/83	2980
Meteriko-M131	dug	20/6.3	no date	1280
Basiglio-M133	drill	60/na	4/85	2380
Basiglio-M138	drill	60/na	4/83	2499
Basiglio-M139	drill	80/3.8	4/83	2430
Basiglio-M140	dug	9/4.7	4/83	3200
Basiglio-M143	drill	na	4/85	1820
Basiglio-M146	drill	98/na	2/85	1986
Basiglio-M147	drill	na	4/85	2750
Golweyn-M193	dug	15/4.4	1/78	4008
Golweyn-M198	drill	59/9	4/85	3580
-- -M200	drill	72/na	4/85	1760
Abid Ali	drill	15/3.5	9/86	2181
Farano Balli	dug	4/3.3	9/86	916
Buulo Mereta	drill	40/7	9/86	3182
Ugadi village	drill	11/9	9/86	2823
Plantation 33	drill	60/10	9/86	2417
SomalFruit	drill	45/10	9/86	1502
Aduna-M30	dug	10/7	9/86	2559
Cabdimoule-M36	dug	6.5/5.7	4/85	5040
Genaale-M36	drill	80/2.5	4/85	2980
3 wells	drill		9/86	2002
	drill		9/86	3116
	drill		9/86	5500
Mushaani-M38	drill	70/3	4/85	1950
Tawakal-M40	dug	4/3.8	4/85	2190
Mushaani-M41	drill	60/8	4/85	2000
Mushaani-M41	drill	60/8	6/85	1680
Mushaani-M41	drill	60/8	9/86	3525
Genaale-M51	drill	60/na	4/85	2800
Genaale-M53	drill	60/na	4/85	2830
Mushaani-M57	dug	10.5/1.4	1/78	8575
drilled 1981	drill	65/45	9/86	2105
Mushaani-M60	dug	6/na	4/85	4890
Mushaani-M61	drill	na	4/85	1775
Majarto-M66	dug	13/2	1/78	2613
Mushaani-M70	dug	5.5/1.5	1/78	3103
Mushaani-M72	dug	3.1/1.8	1/78	7200
Mushaani-M74	drill	35/na	4/85	1910
Buulo Shiik-M89	drill	120/21	9/81	5100
Waagade-M90	dug	5.6/3.7	4/85	4060
Waagade-M91	drill	59/na	4/85	2310
Waagade-M92	drill	66/na	4/85	1920

or loss. This salt accumulation layer will also create restraints on deeper-rooted crops, such as perennials. Agricultural projects in the PPAs must assess the extent and locations of these salt accumulation layers and devise means of flushing or draining the salts if perennials are to be cultivated extensively.

The high salinity of groundwater and soils do indicate a critical need for additional research on the drainage characteristics of PPA soils. Drainage engineers will need to collect additional soils data before efficient systems can be designed to drain or flush salts from the different soil layers. Further research is needed on salt-tolerant crops or varieties which could be introduced in this region. It is likely that both surface flushing and subsurface drainage will be needed to address expanded use of groundwater resources for supplemental irrigation.

The high suspended-solid levels in river water will continue to plague irrigators in the PPAs. These suspended solids do not harm crops, but impose the necessity of continuous canal cleaning and limit potentials for sprinkler or trickle irrigation. The high level of sediments will clog sprinklers or drip devices unless extensive and expensive filtering systems are employed. The fine silts cannot be effectively removed through settling basins and will require frequent cleanings of mechanical filtering systems.

Water with hardness values greater than 180 mg/liter are considered to be very hard. Each of the 35 samples in this survey exceeded this figure, and the groundwater samples were dramatically high. Hard water is preferable to soft water for irrigation, but the groundwater values are excessive. Water of this hardness may cause deposition in pipes used for irrigation or domestic water. Such hardness may also create problems with sprinkler or drip orifices through clogging. Without annual profiles on water-quality changes, it is difficult to predetermine if clogging of piped systems will occur due to high mineral content. It should be noted that the groundwater hardness values exceed standards set by the World Health Organization for drinking water, although no definite health hazards are defined.

The sodium absorption ratio (SAR) is an important indicator of agricultural water quality. Sodium ions cause clay particles to disperse, which decreases soil permeability. If irrigation water has a high ratio of calcium and magnesium ions to sodium ions, the SAR value is low and soil permeability is less affected. The SAR values calculated from the ionic analyses of the current survey period were all very low and do not indicate any threat of soil alkalization. These findings are consistent with values reported from other studies. The FAO report does mention increasing SAR values since 1978, but this is not a point of significant concern.

Data collected during this survey are not sufficient for sweeping generalizations or extensive analysis. However, they are adequate to confirm previous work and to underscore a need for a more extensive and systematic study of water quality of surface and groundwater sources as an integral part of agricultural development in the PPAs. A comprehensive study of the agricultural limitations of water quality is crucial in determining crop selection and cropping strategies in the Lower Shebelli region.

7.3 Conclusions and Recommendations

First, Somalia clearly has the capacity for sophisticated water chemistry analysis within Somali National University's Faculty of Chemistry. This facility should be strongly supported for further work in Shebelli Valley agricultural projects. At the same time, the National Soils Laboratory at Afgoi should also be upgraded to the point that both soil and water chemistry can be at par with the Faculty of Chemistry Laboratory. The university laboratory should function as a training institution using real field experiences, as in agricultural projects, to train technicians for other national laboratories.

Second, at present, there are deficiencies in water-resource (including water-quality) data bases in Somalia. Technical assistance is required to establish criteria, design and management of a water-resources data base. This data base will aid in standardizing future data collection and reporting. Much of the existing data are unreliable or difficult to use because they have not been collected or recorded in a systematic fashion.

Third, agricultural research for PPAs should include a strong component on soil/water chemistry. An annual profile of changes in groundwater chemistry at different depths should be established and mapped in both areas. The existence of a "sweet" groundwater zone should be confirmed or denied by further testing. Further, the depth and range of the salt accumulation zone needs additional clarification and mapping. Thus, the presence of a soil/water chemist on an agricultural research team is necessary to strengthen the laboratories, define and implement a field program to assess groundwater quality and salt accumulations, and define and implement a national (or project-level) water-quality data base.

Fourth, a drainage engineer with experience in salt flushing should also be included in an agricultural research team. Without proper drainage systems and periodic salt flushing, irrigators in the PPAs will continue to be plagued with reduced yields or land abandonment owing to increasing soil salinities. This person should be prepared for extensive fieldwork because data on Shebelli Valley soils need to be supplemented by additional field studies.

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APPENDIX A

Individuals Contacted

USAID/Somalia

Lou Cohen, mission director
Dale Pfieffer, deputy director
William Darkins, project officer
Ray Carpenter, ADO
Roger Garner, Office of Agriculture
Dan Vincent, Engineering
Sally Patton, environmental officer
Martin Wulfe, energy advisor, Ministry of Planning
Frank Proscella, livestock specialist
Stanley Andrews

Other AID Personnel

Deborah Prindle, project backstop officer, AID/Washington
C. Anthony Pryor, REDSO energy officer
Sam Schweitzer, S&T/EY, AID/Washington
Janine Finnell, S&T/EY, AID/Washington

GSDR

Mohamed Abdi Noor, vice minister for planning, MOA
Said Bille, former governor of Lower Shebelli Region
Abukar Osman Abikar, director of planning, MOA
Abdiqani Fara, renewable energy coordinator, MOA
Yusuf Mohamed Fara, regional coordinator, Lower Shebelli Region, MOA
Adan Abdulahi Aw-Hassan, regional director, AFMET, Genaale
Abdilatif Hagi Abdullahi, general manager, GBMIP, MOA
Dr. A. H. Abdulahi, director, GBMIP, MOA
Mohamud Mohamed Ali, director, DLWR
Abdulahi Sheihk, director, Technical Department, MOA
Ahmed Atchi, acting director, DLWR, MOA
Osman Balley, department head, Soils Department, Faculty of Agriculture, Somali National University
Mohamed Abdulgadir, microbiologist, Faculty of Agriculture, Somali National University
Abdul Rahman, project manager, National Tsetse Fly and Trypanosomiasis project
Abdul Kafar, water quality specialist and assistant lecturer, Chemistry Department, Somali National University,
Andres Saava, water resources advisor from FAO, MOP
Current governor of Lower Shebelli Region
AFMET research agronomist, Genaale

Regional party secretary, Shalambood
ONAT regional director, Shalambood
ONAT workshop manager, Shalambood

Contractors and PVOs

James Merryman, anthropolgist, ARD, JESS project
Nancy Merryman, anthropolgist, ARD, JESS project
E. Drannon Buskirk, chief of party, ARD, JESS project
Weidelplan engineers
Dennis Hattem, civil engineer, SCF Qorioley
Charisse Adams, administrative coordinator, SCF
Frances Reimer, community project coordinator, SCF
Ali Omar, AT Laboratory director, SCF, Qorioley
Ali Hussein Fara, surveyor, SCF, Qorioley
Harun Agrar, irrigation engineer, SCF, Qorioley
Christopher Cassidy, agricultural coordinator, SCF
Jack Keller, irrigation engineer, WMSII
Tom Weaver, agricultural economist, WMSII
John Mayo, irrigation engineer, CH2MHill
Bob Cummings, Mono pump engineer

Other Individuals and Groups

Mr. Rumennaggen, director, National Water Data Center, FAO
Dick Cummer, surface water hydrologist, National Water Data Center
Osman Verdure, farmer, Jeerow
Yusuf Sheik, SomalFruit, acting director, Shalambood
Phillip Winter, REDCO, regional rep for ARCO Solar
Sharif Noor, storeowner with diesel/electric mini-grid, Merka
Mohamed Amalow, farmer, Haduuman
Ron Matlin, Tri-Solar Corporation, United States
Aweys Warsame Yusuf, Assistant Lecturer, Faculty of Engineering, Somali National University
Seventeen members of the CRASH cooperative, Shalambood
Many other farmers and laborers in Shalambood and Faraxanne

APPENDIX B

Sample Data Collection Forms for Pump and Small-Farm Budget Surveys

Farmer's Name: Location: Season: ________

Crop 1: ___________ (type of crop)
Hectares Irrigated: ___ ha Hectares Rainfed: ___ ha
Approx. Yield (quintals/ha): ___ (irrig.) ___ (rainfed)

Crop 2: ___________ (type of crop)
Hectares Irrigated: ___ ha Hectares Rainfed: ___ ha
Approx. Yield (quintals/ha): ___ (irrig.) ___ (rainfed)

Crop 3: ___________ (type of crop)
Hectares Irrigated: ___ ha Hectares Rainfed: ___ ha
Approx. Yield (quintals/ha): ___ (irrig.) ___ (rainfed)

Crop 4: ___________ (type of crop)
Hectares Irrigated: ___ ha Hectares Rainfed: ___ ha
Approx. Yield (quintals/ha): ___ (irrig.) ___ (rainfed)

Hectares Fallow: ___ ha Total Hectares Under Cultivation: ___ ha
Total Hectares: ____ ha

Source of Water: __Canals	___ Groundwater (Pump One)	___ Rain Only (Pump Two)
Type of Pump and Engine:		
Year of Installation:		
Size (kW or Hp):		
Country of Origin:		
Use Schedule (months):		
Hours Operated per Day:		
Days Operated per Month:		
Size of Fuel Tank:		
How many hrs between filling?		
Estimated Fuel Use (liters/hr)?		

Cost of Fuel/liter: _____ (max) When? ________ (month)
_____ (min) When? ________ (month)

Sources of fuel:
% of fuel from official source: ____%
% of fuel from other source: ____%

Who has repaired your pumps in the last three years?

Where do you obtain spare parts (minor and major parts)?

Does anyone in the area use or has used any other than standard diesel pumps (electric, windmill, heavy diesel, etc.)? What kind?

Farm Prices (So.Sh./quintal)

	Der Season 1985	Gu Season 1986
Maize	________	________
Sesame	________	
Groundnuts	________	
Tobacco	________	________
Others:		
________	________	________
________	________	________
________	________	________

Typical Yields (quintals/hectare)

Maize	________	________
Sesame	________	________
Groundnuts	________	________
Tobacco	________	________
Others:		
________	________	________
________	________	________
________	________	________

Typical Labor Costs (So.Sh./person-day)

Land Preparation	________	________
First Weeding	________	________
Second Weeding	________	________
Third Weeding	________	________
Irrigation	________	________
Harvesting	________	________
Other: (________)	________	________

Input Prices (So.Sh./hectare)

	Local Market	Official Market
Diesel Fuel	________	________
Seeds/seedlings		
Maize	________	________
Sesame	________	________
Other	________	________
Fertilizer		
#1(________)	________	________
#2(________)	________	________
#3(________)	________	________
Insecticide		
#1(________)	________	________
#2(________)	________	________
#3(________)	________	________

Typical Tractor Charges (So.Sh./hectare) 1985-86 seasons
(Please indicate whether prices are with or without fuel)

	ONAT	Private
Levelling	________	________
Disc Plowing	________	________
Harrowing	________	________
Furrowing	________	________
Bunding	________	________

APPENDIX C

Pump Descriptions

A sample of the data collection form used in the pump survey can be found in Appendix B.

A group of farmers in the Faraxanne area estimated that there were between 150 and 200 pump installations in the area between Genaale on the north, Shalambood on the east, Golweyn (near Buulo-Mareerta) on the south, and Qorioley on the west, about 70 of which were Italian diesels obtained (often on credit) through SomalFruit, through which most of the spare parts and mechanics were also obtained. Typical of the pump types observed during field trips and recorded in the pump survey are the following:

Pump Type #1

Pump: Portable (movable) submersible, centrifugal turbine, single-stage, shaft-driven, approx. 600-mm impeller diameter, dual discharge (250-mm diameter, 5-m length), of Italian origin, 20 years old, purchased through SomalFruit.

Motor: Belgian 60-HP diesel engine, fuel use approximately 40 liters/day over 12- to 13-hour pumping day, 20 years old.

Application: Pumping water from secondary canal to distribution ditch through approximately 0.5-m head. Used to irrigate about 50 ha bananas every 10-15 days (depending upon precipitation) from April to November.

Location: Beynah Barre farm near Buulo Mareerta.

Pump Type #2

Pump: Shaft-driven, vertical-turbine borehole pump pumping from about 45-m static head, 73-m borehole depth, 200-mm discharge.

Coverage: Maximum of 30 ha. Italian orgin (Milano).

Make: Roto. Purchased from SomalFruit.

Motor: Tractor PTO belt-driven, normally by a 60-HP Fiat-Allis.

Application: Groundwater pumping during dry season (approximately November to April).

Location: Beynah Barre farm near Buulo Mareerta. There were four similar, active borehole pumps on the farm.

Pump Type #3

Pump: Single-stage, dual-discharge pump similar to that described in #1 above, Tamaco (Italian) Company, available in 200/250-mm discharge sizes.

Cost for 250-mm size: So. sh. 495,000. Also, 315-mm PVC pipe sells for So. sh. 1,555/meter.

Motor: tractor or fixed-mounted diesel, often Italian-made Grezina 70-HP engines, or fixed-mounted Adim diesel (Italian) Model 1056P Version 4257.

Source: SomalFruit Company quote.

Location: widespread, but particularly on banana plantations.

Pump Type #4

Pump: Dual-discharge pump described in #1 above, 200-mm discharge, 3- to 5-m head depending on level of reservoir, rated output: 1500 liter/sec.

Motor: 36-HP Lambordhini (Italian) diesel engine. On-site, Italian Adim 1053P 60-HP diesels.

Application: Pumping from reservoir to field canals at SCF irrigation project in Qorioley. Two units at one reservoir site (irrigating 120 ha), six units at second site (irrigating 200 ha).

Pump Type #5

Pump: Dual-discharge pump described in #1 above, but locally manufactured by ONAT in Shalambood. Available in 100/150/250-mm discharge sizes.

Manufacturing capacity: Up to six units per year.

Cost: So. Sh. 200,000. Typical head range: 1-5 m.

Motor: Tractor (often Italian Samat 60 HP) PTO or fixed-mounted diesel.

Fuel consumption: About 40 liters of diesel over 12- to 14-hour period.

Application: Varies, but large (>100 ha) banana plantations would normally use four or more pumps, smaller (<30x<100-ha) farms would normally have only one unit.

Pump Type #6

Pump: Surface-mounted centrifugal suction pump, 600-mm impeller diameter, East German manufacture, new units and spare parts no longer available.

Motor: 70-kW tractor PTO or fixed-mounted diesel.

Application: Pumping from river to primary, or primary to major secondary canal. Only know of five units in area (Genaale-Shalambood-Qorioley).

Pump Type #7

Pump: Surface-mounted centrifugal suction pump, 600-mm impeller diameter, Veb Kombinat of East German manufacture, new units and spare parts no longer available. 300-mm discharge rated at 745-1240 m3/hr.

Motor: 65-kW tractor PTO or fixed-mounted diesel.

Application: Pumping from river to primary canal in Afgoi area near LibSoma project. Double set, one no longer functioning (drive shaft and several injectors missing).

Pump Type #8

Pump: Shaft-driven vertical-turbine borehole pump, installed in 1985, Italian origin, manufactured by ROTOS/AIF.

Motor: Six-cylinder, 120-HP Lambordhini diesel.

Application: Groundwater pumping, operated 23 hours/day, 30 days/month to irrigate 130 hectares of bananas at Sherkada Beeraha Shalambood Cooperative. Two very similar pumpsets were also installed at Azienda 33 in Shalambood, and on a banana farm in Faraxanne. Four other identical sets at other aziendas in Shalambood.

APPENDIX D

Current Status of Aziendas in Shalambood PPA

Azienda Number	Area (Hectares)	Number of Families	Management
1-8			Information on these aziendas is poor. At least three are private plantations and another is run by a cooperative for a total of approximately 450 hectares.
9-10	175	128	Cooperative of smallholders created by UQIB in 1986.
11	190	140	Cooperative of smallholders created by UQIB in 1986.
12	450	427	Cooperative of smallholders created by UQIB in 1986.
13-16			Agricultural Crash Programme project land divided among various classes of smallholders in 1983.
17			No information.
18			A local cooperative is trying to arrange taking over this land but the Ministry of Agriculture has not yet certified it.
19-23	400		This is an AFMET demonstration farm. It is run as a state farm with some resident sharecropping labor and some casual labor from Genale.
24-26			This land is run by UDHIS as a state farm. It produces mainly bananas for export through SomalFruit.
27			No information.
28	280		This is a plantation growing perennial crops commercially. The work force, originally from the Bay Region, lives in a village on the azienda and has a sharecropping arrangement with the owners.
29	150	82	Owner-operated by an association of smallholders living in Shalambood.

Azienda Number	Area (Hectares)	Number of Families	Management
30			Owner-operated by an association of smallholders living in Shalambood.
31			Owner-operated by an association of smallholders living in Shalambood.
32			Owner-operated by an association of smallholders living in Shalambood.
33	This azienda is in dispute. Ownership is claimed by a Somali private citizen. He says he got rights directly from the Italian owner of the colonial era. The claim is being contested by smallholders living in Shalambood and working the land.		
34	A Somali-owned private plantation.		
35	150	82	Owner-operated by independent smallholders living in Shalambood.
36	132	Land owned by national cooperative, the Cadaanka Aslubta Somaaliyeet, which operates it as plantation producing crops on commercial scale, including bananas for export through SomalFruit.	
37	Privately held plantation. Labor provided by 34 families from Bay Region settled in two villages on plantation. They work on the Italian established system of plantation plots and laborers' plots. Plantation produces crops on commercial scale, including bananas for export through SomalFruit.		
38	Owner-operated by independent smallholders living in Shalambood.		
39	149	176	Owner-operated by independent smallholders living in Shalambood.
40	217	134	Owner-operated by independent smallholders living in Shalambood.

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Azienda Number	Area (Hectares)	Number of Families	Management
41			Owner-operated by independent smallholders living in Shalambood.
42			Owner-operated by independent smallholders living in Shalambood.
43			Owned by national cooperative.
44			Owned by national cooperative, which has organized it as state farm and produces crops on commercial scale, including bananas for export through SomalFruit.
45-46	150		Owned by a cooperative of people in trades and professions living in Shalambood. Run as plantation producing crops on commercial scale, including bananas for export through SomalFruit.
47	158	161	Owner-operated by independent smallholders living in Shalambood.
48			Owner-operated by independent smallholders living in Shalambood.
49	70	66	Owner-operated by independent smallholders living in Shalambood.
50			Entire azienda has been absorbed into town of Shalambood.
51			Owner-operated by independent smallholders living in Shalambood.
52-54			No information.
55-63			Area covers over 1,000 hectares. From 1970 to 1978 it was location of two Agricultural Crash Programme project camps. Project has carved out 300-hectare farm and given it to 60-family cooperative of supernumerary government and party officials. It has also carved out 200-hectare farm and given it to an association of 200 families of former Agricultural Crash Programme project volunteers. Rest of land granted by Ministry of Agriculture in 10- to 15-hectare blocks. Authors have no information on how the latter are organized.

APPENDIX E

Notes on Existing Local Grids

Sharif Noor, a storeowner in Merka, has a 32-kW Italian Cavi diesel generator, which is used to power lights and some machinery (espresso maker, coffee grinder, ice cream maker) in a mini-grid in the vicinity of his store. He provides electricity to 10 other shops in the area (a single 220-volt 20-W light each), to two local mosques (a total of seven lights), and to his own home (total of 12 lights in his shop and home). He is always able to buy fuel at the official rate of So. Sh. 22 per liter. Presumably, this favorable arrangement has something to do with his providing electricity free to his neighbors and the mosques. If he runs out of fuel, the mosques have no lights. The price for his unit was So. Sh. 700,000, which includes So. Sh. 160,000 in tariff duty. Normal tariffs for this type of equipment are levied at a rate of 100 percent of the value.

The brand new (eight months old) generator, rated at 31.2 kVA, only had 3,880 hours on it thus far. Output is three-phase 380 (two legs for 220). Fuel consumption is about 35 liters over a typical 11-hour day. The approximately 12-gauge wire to the other individual shops is So. Sh. 22 per meter, and the mains wire is So. Sh. 300 per meter. Mr. Noor estimated that for all breakers, wiring, switches, etc., he paid So. Sh. 55,000 for all hookups. The shops are an average of 20 to 30 meters away, and the mosques are about 100 meters from the installation. He said that another person, who owns a 50-kW generator, sells power to people on Merka, and that he had seen several other smaller generators (two to five kW, presumably Honda or similar petrol) in town.

The operations and maintenance requirements at this site are:

- uses 10 kilos of oil every 10 days at a cost of So. Sh. 180/kilo, oil filter is cleaned every 10 days, and oil filter is replaced every 20 days (So. Sh. 500 each);

- the diesel fuel filter is replaced every 30 days; and

- the drive belts are replaced every six months (So. Sh. 1,200 each, but unlike other replacement parts, not usually available at SomalFruit).

Another entrepreneur in Merka, Ahmed Mohamed, has an AIFO/FIAT/OM 20-kW generator of Italian origin. It is three-phase, 380-volt, 50 Hz, and was purchased secondhand. The generator powers 50 fluorescent lights (220 volt, 20 watt) and a

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5.5-kW induction motor in a carpenter shop. He charges his users So. Sh. 250 per light per month. Depending on loading conditions, fuel consumption ranges from 10 to 20 liters over the daily four-hour operating period. The generator has been operating for one month.

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