The SSE Program

Review of the Um Ja Wasir Project

Implemented by ADRA

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EXECUTIVE SUMMARY

The Um Ja Wasir project is being implemented by ADRA to support nomads of the Hawaweer tribe. The present report presents a review of the recent development of the project, with special emphasis on the project's contribution to fulfilling the overall objectives of the SSE program, the data monitoring within the project, and the project's economic and financial viability.

The Hawaweer nomads were severely hit by the droughts in the 1980s. ADRA supplied food aid to the nomads, and later started to develop an irrigated agricultural project. Phase 0 of the project, which was developed in the late 1980s, involved four wells supplying water for a total of 40 farms. Funds for phase 1 were granted by NORAD in 1995, involving 6 new wells supplying a total of 72 farms. On its field visit, the review team found that the targets for 1995 by and large had been achieved, and that the funds granted had been spent according to the intentions.

The objectives of the SSE program are related to environmental rehabilitation and food security. A significant improvement is taking place within the limited project area, but attention has to be directed to the fact that there is limited knowledge about the characteristics of the aquifer, salinity problems might be experienced in the future, and sand movements are not yet under control. A minor survey on food security was carried out by the review team, showing that the food security situation among the farming families had been improved since the start of the project, but there is still a food shortage during the winter season.

An extensive monitoring program is suggested by the review team. The monitoring should include climatological data, yields of the field crops, fuel consumption of the irrigation pumps, water supply to the different crops, and costs of field preparation, fertiliser, and seed inputs. Also the ground water level and the soil salinity should be monitored.

Farm budgets and economic analysis of the project has been carried out by the review team. The build-up of a revolving fund will be an important test on the economic viability of the project. It is suggested that a revolving fund from a water tariff paid by the individual farmers will finance an increasing share of new extensions of the project, so that the need for NORAD funding will diminish for every new phase. After phase 4, new extensions should be funded exclusively from the project's own revolving fund.

Marketing of agricultural products and women's participation have been identified by the review team as two subject areas that should receive more attention in the future.

It is recommended that the project management should emphasise monitoring of ground water level, soil salinity, climatological data, cropping pattern, the use of irrigation water, fuel consumption, and yield. It is also recommended that windbreaks should be established. The food shortage in the winter season should be addressed. A water tariff should be implemented to secure the build-up of a revolving fund. A marketing strategy and a strategy for women's involvement should be worked out.

The review team suggests that the project should be evaluated when application is received for phase 2 of the project. Such an evaluation should have special emphasis on the build-up of revolving funds, environmental impacts, effect on food security, and gender aspects.

1 INTRODUCTION

The Um Ja Wasir project has been set up by ADRA to support nomads of the Hawawir tribe. The project provides water for irrigated agriculture by drilling deep wells and lifting the water with diesel engine driven turbine pumps. The pilot stage (phase 0) of the project was implemented in 1992 with four wells, while a a phase 1 with six additional wells has been started in 1995. Phase 1 is fully financed by NORAD under the SSE funds. ADRA plans for phases 2, 3 and 4 to be launced in 1998, 2001 and 2004 respectively.

A team was set up by NORAGRIC in November 1995 to review the project. The team consisted of Fred H. Johnsen (NORAGRIC), Åge Rønningen (RBConsult) and Johannes Deelstra (JORDFORSK).

According to its terms of reference, the team shall assess the recent development of the Um Ja Wasir project. The extent to which the project follows the intention of the SSE program is particularly in focus. The team shall also evaluate to what extent the recommended monitoring of the Um Ja Wasir project has been followed up and recommend any necessary changes in the monitoring system.

The team's key contacts during the review visit in Sudan were:
Ronald Kuhn, Director of ADRA Sudan
Fadul Bashir, project manager, Um Ja Wasir project
Jan Nielsen, technical adviser, Um Ja Wasir project
Bjørn Klausen, Director of ADRA Norway

The following documents were important sources for this review:

- Expanded development of the Small Scale Irrigated Farming Project Um Ja Wasir, Wadi Al Magaddam, Sudan. Project proposal submitted by ADRA Sudan, revised version October 1993.
- ADRA´s application for NORAD support 1995, with appendixes (revised version, 28 December 1994)
- Åge Rønningen and Johannes Deelstra´s comments to ADRA´s application (dated 14 January 1995)
- Mohamed S. Awadalla: Final Land Use and Soil Survey Report of Umm gawasir Agricultural Project (the new extension) (not dated)
- Baseline Study of Socio-economic and Environmental Characteristics of the Um Gawaseer Project Area Conducted Jointly by ADRA/Sudan and Soil Conservation, Land Use Planning, Water Program Administration (Ministry of Agriculture, Sudan) and Andrews University, Dept. of Behavioral Sciences, Berrien Springs, Mi. USA July/August 1995.

The team would like to thank all ADRA´s personnel for co-operating with us and making a considerable effort to supply us with data as well as catering for us during our field trip.

2. PROJECT BACKGROUND, OBJECTIVE AND HISTORY

2.1 Background

Wadi Al Magaddam has traditionally been the homeland of two nomadic tribes, of which the larger is the Hawaweer. The Hawaweer depended mainly on camels, sheep and goats, but to a limited extent they also practised crop production. During the droughts of the past couple of decades most of the families lost their livestock. It is estimated that about 20,000 families of the Hawaweer tribe have been displaced in the Nile area, while only about 6,000 families remain in the wadi.

During the drought in the 1980s a high malnutrition rate was identified among the nomadic children. In this period, ADRA supplied food aid to the nomads. As relief operations phased out in 1986, ADRA was requested by the government of Sudan to take up rehabilitation among the nomads. It was clear that the nomadic tribes in the Northern Province, such as the Hawaweer, who had been forced away from their ancestral land by drought, suffered the greatest losses. ADRA's assistance to this group continued in the form of health care and small enterprise development.

Searching for a way to develop the home areas of the Hawaweers, ADRA soon focused on the area Um Ja Wasir. This area has ground water of good quality and sufficient quantity, it is situated along a major desert route between Khartoum and the Northern State, the soil fertility is relatively good and the nomads were used to practising rainfed agriculture in this area during years with good rainfall.

2.2 Project objective

The objective is to implement an irrigated agricultural project which is sustainable and which can be reproduced other places under desert conditions. After some initial phases, the project is supposed to continue expanding on the basis of a revolving fund without further external funding.

2.3 Phase zero of the project

The planning of the first phase of the Um Ja Wasir project started in 1986. By May 1990 four wells with solar pumps were constructed. The solar pumps did unfortunately not yield enough irrigation water and in 1991 they were replaced by diesel pumps. The first commercial crop was produced in the winter season 1992. Since then, the project has produced one winter crop and one summer crop every year. The first phase of the project now includes 40 farmers who cultivate an area of 2 feddan (0.8 ha) each.

2.4 Phase one of the project

The first proposal for an extended project was formulated in 1992. This proposal went through several revisions and was finally submitted to NORAD in December 1994 and accepted. Phase one involves the construction of 6 wells with pumps having a larger capacity than the original four. A total of 72 farms of 4 feddan (1.6 ha) each will be irrigated by the project. The intention is to implement another three equally large phases in year 1998, 2001 and 2004 respectively. If successful, a revolving fund will finance an increasing share of the investments over time and after phase 4 further expansions should be fully financed by the revolving fund.

2.5 Project progress in 1995

ADRA´s application has six indicators on achievement of targets for 1995. By the end of November 1995, the status of those indicators is as follows:

- **Six pumps installed and in operation.**
  This has been achieved.

- **72 farms shall have at least 1 feddan ready for planting, while some have had one crop and are ready for the next.**
  All farms have been allocated to farmers and the farmers seemed to have land ready for planting. However, the pumps were not installed early enough to allow any of the farmers to harvest one crop in 1995.

- **All families have had some training in agriculture and irrigation.**
  An extensionist has been employed to assist the project manager on this task, and the training seems to be proceeding well.

- **Data collection and monitoring has taken place since the start of the project, and can be documented.**
  Data collection and monitoring is in progress. One person has been employed to take care of this particular task. For details, see chapter 4.

- **A council/board has been established to manage a joint fund for purchases, maintenance and extensions of the project.**
  A farmers committee for phase 1 has been established.

- **Family income and costs shall be within the budgets.**
  There is not yet any family income, because the first crop is about to be planted now (winter season). Project costs have been kept within the budget.

From this we can conclude that the targets for 1995 have by and large been achieved.

3 THE PROJECT'S CONTRIBUTION TO FULFILLING SSE OBJECTIVES

3.1 Environmental rehabilitation

The aim of the project is to resettle members of the Hawaweer tribe in the Um JA Wasir area. To this end an agricultural project is initiated which utilises ground water. As a source of irrigation water, the rich aquifer underlying the Wadi al Muqaddam is used. The total estimated quantity under the project area is estimated at 200 km^3 (2×10^{11} m^3). This amount equals approximately 4 times Egypt's yearly water use of the Nile river. Little is known however about the hydraulic characteristics of the aquifer. Its utilisation must therefore proceed with the greatest care and be kept under constant monitoring.

Agricultural production in the scheme will reduce the pressure on the original grazing lands of the Hawaweer tribe and also provide income and improve food security.

Investigations carried out by the Land Use, Soil Conservation and Water Programming Administration in 1995 showed that the soils are very suitable for agriculture. An advantage of the project will be an increase in organic matter and nitrogen content of the soil through mixing of plant residues in the soil and the introduction of leguminous crops in the plant rotation.

The same investigation concluded that the quality of the irrigation water is good for irrigation. However, the presence of a heavy clay layer in the soil profile might create problems with salinity in the future.

Positive results of the present pilot scheme can mean a further expansion of the area under irrigated agriculture, thereby contributing to a further rehabilitation of the original grazing lands.

One of the main problems the project is facing is the frequent exposure to sandstorms. Sand dunes are formed and have a tendency to move into the Um JA Wasir project. To safeguard a long life of the project, wind breaks have to be established on the windward site of the project. Both the old and the new project have to be provided with wind breaks as soon as possible. The project team is aware of this problem and is planning the establishment of windbreaks according to a design proposed by the Land Use, Soil Conservation and Water Programming Administration.

3.2 Food security

Phase 1 is in its early implementation stage, thus no evaluation can be done on its impact on food security. On one hand the cropping schedule assumes a good proportion of food crops, therefore one would assume the food security to improve. On the other hand, a large amount of cash has to be paid by the farmers in order to maintain the project and build up the revolving fund. A lot of this cash has to be obtained by selling food. On this basis one cannot be certain about the food security impact, consequently this impact needs to be monitored when phase 1 has been in progress for some time.

A simple food security assessment was made in phase 0 by the review team (appendix 1). Ten farmers were interviewed about the number of months of food shortage before and after the project. The results give an average reduction of food shortage months for the farm families from 6.4 before the project to 4.2 with the project, that is a reduction by 2.2 months. One should be careful about drawing strong conclusions on the basis of such a limited number of interviews. It seems fair, however, to conclude that the food supply has improved, but that there are still food security problems among the farm families in phase 0.

The food shortage occurs particularly in the winter months. It seems as the winter crop (mainly wheat) is enough to support the family during the summer, while the summer crop (mainly sorghum) is not quite enough to support the families during the winter.

One explanation to the winter food shortage, offered by the project manager, is that sorghum is partly used for fodder, and partly sold, so that too little sorghum is kept for home consumption. A grinding mill for sorghum at the project site might be helpful in giving the farmers better opportunities for keeping sorghum for home consumption rather than selling it.

4 PROJECT MONITORING

4.1. Monitoring in 1994 and 1995

During the years 1994 and 1995 monitoring of the agricultural activities were carried out on a limited scale. The main work during the summer season of 1995 has been the installation of 6 pumps together with the preparation of agricultural land. Land levelling and canal construction was completed when the review team visited the project site. Irrigation of the winter crops had been started.

One of the important tasks in the new project has to be the monitoring of all relevant agricultural activities. The main objectives of this monitoring is to obtain real figures on costs and benefits of irrigated agriculture under conditions prevailing in the desert.

To be able to carry out these monitoring activities, the project team has been expanded by one expatriate staff and 2 Sudanese agricultural engineers, directly employed by ADRA. In addition, 2 agricultural engineers were seconded to the scheme by the ministry of agriculture.

4.2. Needs for future monitoring

With the start of the winter season a start has to be made with the monitoring and data collection program.

In this respect the following activities should be monitored:
* climatological data
* yields of the field crops
* fuel consumption of the irrigation pumps
* water supply to the different crops
* cost of field preparation, fertiliser and seed inputs

Climatological data collection.

The irrigation water requirement of the different crops is decided by a combination of the prevailing climatological conditions and the irrigation efficiency.
A meteorological station has been erected at the project site in 1995. In the autumn a start has been made with the collection of data. The readings are carried out twice daily, at 8:00 and 20:00 hrs. resp. Below an overview is given of the parameters which are measured.

- maximum and minimum temperature
- dry and wet temperature.
- soil temperature at 5, 10, 20, 50 and 100 cm below soil surface(bss).
- wind speed
- pan evaporation
- Piche evaporation
- rainfall

All the parameters are read twice a day. Contrary to the routine practised by the project, however, the minimum temperature should be measured only in the morning and the maximum temperature in the evening.

A shield should be build around the thermometers, measuring the soil temperature, to prevent sand blasting of the glass.

Every month, 10-day averages should be calculated in addition to the monthly average for all the parameters. In addition, the reference crop evaporation should be calculated.

Irrigation water application.

The project is supplied with irrigation water from 6 wells. Each well consists of a diesel engine and a turbine pump. Details on pump characteristics are supplied in Appendix 2.1.

The pumps discharge into a stilling basin from which the water is diverted into the irrigation canals. It is important that all the operational hours of the pump and the discharge it is delivering are recorded.

At different rpms (revolutions per minute), the pump delivers different amounts of water. To be able to know this amount of water, the outlet of the each basin should be provided with a discharge measurement structure. The installation of such structures has been discussed with the project team. [1]

Water delivery and fuel consumption are to be monitored accurately as they are key factors in the project economy. Each time the pumps are set in operation the following should be recorded/monitored:

* date and time
* the number of pumping hours (hour display at the start of operation)
* the rpm's the engine is operating at
* the discharge of the pump(the discharge measurement structure)
* fuel consumption(whenever fuel is added this should be recorded)
* which crops are irrigated

Any change in pulley or conveyer belts has to be recorded as this has effect on the output of the pump. In addition, any other operation or maintenance should be recorded.

For the field recordings it is most likely convenient to have a logbook at the pump site. From this logbook the operation of the wells can be summarised in weekly/monthly sheets which provide easy access to information on fuel consumption and water delivery to crops.

[1]Design proposals have been forwarded to ADRA-Sudan in the beginning of December.

Crop water requirements

On the basis of the actual climatological data, collected at the project site, the water requirements for the different crops have to be calculated. This can be done by using the CROPWAT program. This is a simple model, prepared by FAO, which is available at the project site(including the manual).

Additional information, needed to carry out the calculations is available in the FAO publication "Crop water requirements", Irrigation and Drainage Paper no. 24.

The following parameters should be monitored for both the summer and winter crops.

* *cropping pattern for the command area per pump*
* *planting, sowing and harvesting dates*
* *irrigation dates.*
* *irrigation application time for the different crops.*

Fuel consumption

The fuel consumption of the diesel engines constitutes a major part of the total project costs. A detailed monitoring of the fuel consumption of each pump is required.

The fuel consumption can be estimated based on the water requirements of the crops. During the review mission in November 95, updated climatological data were obtained for the Karima station for the period of 1961 to 1990. On the basis of the updated data the reference crop evapotranspiration(ET_0) was calculated and new estimates have been made of the water requirements for the different crops. A complete listing of the results is presented in Appendix 2.3.

The fuel consumption is a function of the energy required to lift the ground water. Fuel consumption for the project is estimated in Appendix 2.4.

Crop yield

The crop water requirements are based on the potential crop water evaporation. Maximum yields will be obtained when this water requirement is fully covered.

However, often it pays to deviate from this rule and irrigate according to an evaporative demand, less than the potential. Savings in water, obtained in this way, might be utilised in expanding the area under irrigation. It is difficult to estimate the optimum irrigation water supply.

On the other hand, one has to be careful not to reduce the irrigation water supply too drastically, because this will lead to reductions in yield. An indication of yield response to irrigation levels is presented in appendix 2.5.

It is proposed to carry out yield estimates for the major crops grown in the project. Sampling can be carried out by harvesting and weighing the produce of a number of 1 x 1 m sites in different plots. In this case one has to be aware of the different harvesting strategy for alfalfa. Sampling is important as they are the only reliable basis for the calculation of the farmers income or the benefit of the irrigation project.

Ground water

Ground water levels should be monitored at least once a month. It was proposed by AWASCO(1994) to install 3 observation wells. In addition, open wells in the surrounding should be monitored. The review team was informed that one observation well will be established in December. It is proposed that investigations are carried out on whether it is possible to observe ground water in existing wells in the scheme. Observation of ground water is important as the quantity of it may at least theoretically restrict the lifetime of the project.

Soil salinity

The Land Use, Soil Conservation and Water Programming Administration has prepared a Final Land Use and Soil Report of the Um Ja Wasir project. The main conclusion of the report is that soils and ground water are suitable for irrigation. However, the report does state that soil salinity problems might occur in the future due to a heavy clay layer at a depth of 80 - 100 cm below soil surface.

Monitoring of the soil salinity shall also be carried out in the future. The project manager informed that an agreement has been made with the Administration that soil sampling for salt analysis will be carried out both after the winter season and summer season.

5. ECONOMIC/FINANCIAL ASSESSMENT

5.1 General

The proposed project now comprises a series of three year phases. Each phase includes the drilling of 6 wells, installation of pumps and equipment for irrigation, and the administration and investments required to start off 72 families (approximately 600 people) as farmers in the project area.

Phase 1 of the project, which ADRA ha got financing for, started in 1995, and will last to the end of 1997. By November 1995 all six wells are in operation and 72 farmers have been selected and have started farming. ADRA is responsible for the administration of the project. It is assumed that there will be an evaluation of the project towards the end of Phase 1, and that the outcome of this evaluation will determine the continuation of NORAD support to the project.

In the following, the beneficiaries who started farming in phase 1 are defined as group 1, the ones starting in phase 2 are defined as group 2, etc.

5.2 Cost and income data

Based on ADRA's revised estimates of costs and incomes the tables 1 to 8 in appendix 3 have been established.

- Table 1 shows estimated annual income for one farm (4 feddan - 16,800 m2).
- Tables 2, 3 and 4 shows ADRA's estimated costs for Groups 1, 2 and 3 respectively.
- Tables 5 to 8 contain economic analyses for Groups 1 to 4 respectively.

Tables 1 to 4 in appendix 3 are data provided by ADRA and updated according to discussion with ADRA in Khartoum in November 1995.

In Tables 5 to 8 ADRA's figures have been used to analyse each phase in terms of costs, income and the requirement for financial support and principles for operating a revolving fund.

5.3 Criteria for the economic analysis

1) *For each group the long term income should meet the long term costs. Income and costs are expressed as Present Value of cost and income streams over 20 years, using 6% discount rate.*

This does not yield a positive net present value without some subsidy. Referring to Table 5.1 (appendix 3): Total costs exceed total income (PV(6%)) by 3,014 - 2,544 = 470 (1000 USD). To get a balance NORAD grant funding of USD 500,000 is provided, corresponding to PV(6%) of 489 (Table 5.2). This means in principle that if NORAD provides a subsidy (grant financing) of USD 500,000 (corresponding to the cost of ADRA project organisation and most of the initial purchase of vehicles) the assumed income from farming will meet the cost of farming including the total cost of water. For the next groups, the costs of ADRA, project organisation and vehicles will be less and the requirement for NORAD subsidy will be reduced as shown in Tables 6.2, 7.2 and 8.2 in appendix 3.

(2) *The income from farming should meet farming costs including the initial investment in the water wells.*

Tables 5.2, 6.2, 7.2 and 8.2 in appendix 3 show 'Farmers' cash flow. Total income covers direct farming costs including fuel for the water pumps, a reasonable family income and a 'contribution to the revolving fund' which can be regarded as a repayment of the initial investment in the wells and pumps. The amounts shown for 'contribution to revolving fund' is in total for 20 years (Present Value) the same as Present Value of wells investment in Tables 5.1, 6.1, etc. This contribution builds up over the first five years and is even negative the first two years when the farmers' income is small.

(3) *The financing of the initial years of each group's establishment is facilitated by funds provided by NORAD as a revolving fund. Each group will have to regard this as a loan to be repaid for use when establishing the next group.*

Tables 5.2, 6.2, etc. (appendix 3) show the operation of a revolving fund for each group of farmers. The costs to be covered by this revolving fund are the ADRA project administration and the initial investments in wells, vehicles, etc. Financing is provided by NORAD grant and by farmers' contribution as shown. Present value (6%) of costs (952) corresponds approximately to present value of financing (489 + 482) in Table 5.2.

The NORAD input to the revolving fund is required to cover the situation where the costs are mainly incurred in the first years and the income is spread more evenly over a number of years. As shown in Tables 5.2, 6.2, etc. each group will 'repay' this NORAD input to be used in the financing of the next groups' establishment.

Table 5.2 in appendix 3 shows funds available 'from previous phases'. This means that the farmers established during the initial pilot project should start paying a contribution to cover the initial investment in their wells and pumps. It does not seem fair that new farmers should pay this contribution and the original group not.

(4) *In economic terms the project will be sustainable and replicable provided*

- *the initial costs of organising and establishing the project (ADRA project costs and an initial investment in vehicles, etc.) are met from external grant financing.*
- *external funds are provided for a revolving fund, i.e. to be regarded as a loan to each group which will be repaid and used for establishing the next groups.*
- *the assumptions regarding costs and income prove realistic.*
- *a mechanism can be established for sustaining the value of farmers' income during inflation.*

5.4 Required external financial input

The external support consists of a grant subsidy and a revolving fund. The required funding by NORAD according to Table 5, 6, 7 and 8 is presented in Table 1. The total funding requirement is being reduced over time, indicating that an increasing share of the project investments can be covered by the funds from the water tariffs paid by earlier groups of farmers. After the fourth phase, it is assumed that further extensions can be fully financed by the farmers themselves.

Table 1. Required funding by NORAD for the four phases of the Um Ja Wasir project (in thousand US$).

Phase	Grant funding	Revolving fund	Total
1	500	400	900
2	300	300	600
3	200	150	350
4	50	250	300
Total	1,050	1,100	2,150

Compared to the analysis made one year back the grant requirement has increased from USD 780,000 to USD 1,050,000. The total requirement in NOK (About NOK 13.5 million) is about the same due to the decreased value of USD.

In the updated estimates ADRA has reduced their figures for assumed future income, especially the income expected from dates from year 5 onwards. The analysis shown here has used income figures which are 5 % higher than ADRA's estimate. This is necessary in order to show a satisfactory economic development. The alternative is to look for corresponding reductions in project costs.

5.5 Economic risks

The main uncertainty in the initial phase of the project is the operation of the revolving fund. The long term viability of the project concept depends largely on the success of the revolving fund, and special attention must be given to this aspect during monitoring and evaluation. The question of sustaining the value of income earned at one point in time until it is to be used for paying for say water pumps at a later time will be crucial.

6 OTHER ISSUES

6.1 Marketing

Our small farm survey (appendix 1) revealed that the most common way of getting cash is to sell a goat. This may be a sufficient strategy as long as the cash requirements are modest. However, the revolving funds will require considerable amounts of cash to be earned by farm production. There is hardly a local market for the production that will come if the project is successful. A marketing strategy is therefore needed.

Such a marketing strategy may involve transport facilities to carry the products to the market. Storage facilities may also prove very beneficial, because the seasonal variation in crop prices is considerable. An other possibility is simple processing, e.g. pressing oil seeds.

We are not in a position to indicate which products to market and how and where to market them. It is important, however, to point out the need for a marketing strategy. For such a strategy to be efficient, it is necessary to take some common decisions on what, where, and when to market.

5.2 Gender issues

The project has a strong male bias. All the employees of the project are men, and all the farmers who have been allocated land are men. Agricultural extension and other project activities also seems to be exclusively directed towards men.

During the project visit from NORAGRIC in 1993 it was suggested to employ a female extensionist with special responsibility in securing women's participation in the project. The project management first responded positively to the idea, and specifically included this item in the application for phase 1 of the project extension. So far, however, no attempt seems to have been made to employ a female extensionist, and our discussions with the project management in November 1995 gives no reason to believe that such an attempt will be made in the future.

Traditionally, caring for the animals is the women's responsibility among the Hawaweer nomads. If a project component were to be designed to empower women, a livestock component seems to be an obvious choice.

7 CONCLUSIONS AND RECOMMENDATIONS

7.1 Conclusions

The review team found that the project is technically progressing by and large according to its schedule. The funds granted by NORAD for 1995 have been spent according to the intentions. Six new wells have been drilled, the pumps have been installed and the farms were about ready to start planting at the time of the field visit in November 1995.

The general objectives of the SSE program are environmental rehabilitation and food security. A very spectacular environmental improvement has taken place within the relatively small project area. Some environmental issues like the sand movements, possible future salination of soils, and the limited knowledge about the size of the aquifer that the project is based on, need to be addressed. The review team found that the food security problem among the farming families in phase 0 of the project has been reduced, but not eliminated.

In order to make the experiences from phase 1 of this project useful for further project phases and for other future irrigation projects in arid climates, monitoring is crucial. Some monitoring has been going on in 1994 and 1995. The review team suggests that monitoring should be emphasised strongly, and specific recommendations have been made on which parameters to monitor.

The build-up of a revolving fund by contributions from the farmers is an essential element of the project, and the success or failure of this revolving fund can be seen as a test of the economic viability of the project. The review team found that the project costs had been kept well within the budgets, while earlier estimates of incomes seem to be too optimistic. Revised financial and economic assessments have been made by the review team.

The review team has identified marketing and gender issues as two items which have to be addressed more specifically in the future.

7.2 Recommendations to the project management

1. The extent of ground water resources for the project is unknown. Observation of the ground water level is therefore important and has to be initiated as soon as possible.

2. Irrigation water is of good quality. However, under the prevailing dry conditions, soil salinity levels should be monitored continuously.

3. Climatological data should be monitored to obtain accurate data on the reference crop evaporation.

4. The cropping calendar and cropping pattern for both the summer and winter season should be known.

5. Information should be obtained on irrigation application times and irrigation intervals for the different crops.

6. Fuel consumption by the diesel engines and water supply to the different crops should be monitored as they constitute the major cost component in the project.

7. Yield estimates for the major crops grown in the project area should be carried out.

8. To safeguard the lifetime of the project, windbreaks should be established.

9. The recommended distribution of land between crops in the summer season should be reconsidered in order to address the food shortage in the winter season which has been identified among the farmers in phase 0 of the project.

10. Farmers contribution to a revolving fund must be emphasised strongly, and should be collected in the form of a water tariff.

11. A marketing strategy for surplus agricultural produce should be worked out.

12. A strategy for women's involvement in the project activities should be worked out.

7.3 Recommendations to NORAGRIC / NORAD

Based on observation, we don't find any reason for NORAGRIC or NORAD to take any immediate action. A new review with paticular emphasis on the monitoring of technical, environmental, economic and social data should be carried out around the turn of the year 1996/97.

When application is made for phase 2 of the project, we recommend that the project should be evaluated. Such an evaluation should particularly focus the following aspects:

1. The build-up of revolving funds from water tariffs up to that time, and the prospects for future build-up.
2. Environmental impacts, including the risk of depleting the water resource, the risk of salination, and the sand movements.
3. Effect of the project on food security.
4. Gender aspects.

Appendix 1

Farm survey in Um Ja Wasir November 1995

A 1.1 Introduction

A mini-survey was carried out among the farmers in the first phase of the Um Ja Wasir project. These farmers have been cultivating irrigated farms of 2 feddan (approximately 0.8 ha) each for about 3 years.

A 1.2 Materials and methods

Ten farmers were interviewed, 2-3 from each of the four plots within the pilot project. The farmers were selected on random while we walked through the area (that means no random sampling in the strict scientific sense of the word). An interpreter was used for translating from English to Arabic and vice versa.

The farmers were interviewed by using a check-list focusing the following items:
- Household size
- Months of food shortage with the project
- Months of food shortage before the project
- Sources of cash
- General comments about the project and suggestions for improvement

The results have been recorded and tabulated, and the effect on food security has been calculated as change in number of months of food shortage. The sample size was considered to be too limited for statistical testing.

A 1.3 Results

The responses to the questions on household size and length of food shortage period with and before the project are summarised in table 1. "Individual food shortage months" are calculated by multiplying the number of food shortage months by the number of household members.

Based on the "total" row in the table, the following can be calculated:
Average individual food shortage months with project = 352/84 = 4.19
Average individual food shortage months before project = 536.5/84 = 6.39
Average individual reduction of food shortage months = 184.5/84 = 2.20

The project (phase 1) includes 40 households, consequently the survey included 25% of these households. Thus, an estimate of the total annual reduction of individual food shortage months within the project area is:
184.5 * 4 = 738 food shortage months.

Table 1. Food security assessment in Um Ja Wasir, Sudan

Respon-dent no.	Plot no.	House-hold size	Months of food shortage now	Months of food shortage before project	Individua l food shortage months with project	Indivi-dual food shortage months before project	Increase (+) or decrease(-) in indivi-dual food shortage months
1	4	7	3	6	21	42	- 21
2	4	9	3	6	27	54	- 27
3	4	8	3	7	24	56	- 32
4	3	9	4	8	36	72	- 36
5	3	7	4	6	28	42	- 14
6	2	10	2.5	4	25	40	- 15
7	2	11	12	9	132	99	+ 33
8	2	6	4.5	4.5	27	27	0
9	1	8	4	8	32	64	- 32
10	1	9	0	4.5	0	40.5	- 40.5
Total	-	84	-	-	352	536.5	- 184.5

The respondents where asked how they get cash when needed. In cases where they referred to loans from relatives, this was not taken as the final answer. Instead they were asked how they get cash to pay back their loans. The frequency of mention of various answers is given in table 2.

Table 2. Sources of cash in Um Ja Wasir, Sudan. Simple counts. (The total is 11 because one of the farmers mentioned two sources of cash)

Source of cash	Number
Selling animals	6
Cutting wood for sale as firewood or charcoal	2
Selling crops	2
Taking casual work by the Nile	1
Total	11

When asked about general opinions most farmers expressed satisfaction with the project. They generally regarded the project as very helpful in providing food for themselves and fodder for their animals. One of the farmers expressed that one great benefit of the project was that it helped him and his family to get settled. Another farmer expressed that though his herd had been reduced from 30 animals before the project to 10 animals now, he considered his situation to be greatly improved. One farmer out of the ten who were interviewed expressed that his situation was worse now than before the project started.

Most farmers had suggestions for improvements. The frequency of mention of various suggestions is given in table 3.

Table 3. Suggestions for improvements in the project in Um Ja Wasir, Sudan. Simple counts.

Suggestion	Number
Need support for agricultural inputs, spares for pumps etc.	6
Need assistance to stop sand movements	5
More timely tractor ploughing	1
Need of more land	1
Need supply of food and other basic needs	1
Total	14

A 1.4 Discussion

This mini-survey includes only a small number of interviews, therefore any interpretation or conclusion must be drawn with great caution.

There is quite convincing evidence that the project has improved the food security of the farm households (Table 1). On the other hand, most farmers still experience a food shortage in parts of the year, particularly in the winter season. This indicates that while the winter crop gives sufficient food during the summer period, the summer crop which is harvested in the autumn fails to give enough food during the winter.

The responses to how the farmers get cash (Table 2) indicate that these nomads have not turned to cash croppers. Their most important supply of cash seems still to be the animals, and for many of them the crop production produces cash only indirectly by providing fodder for their animals.

On the general questions about suggestions for improvements (Table 3), the answers regarding agricultural inputs, spareparts and basic household needs should probably not be taken too seriously. The farmers assumed that we represented an aid organisation, and it seems obvious that they will ask for more aid. These are things that should now be their own responsibility, according to the project design. Sand movements, however, is an issue that has to be addressed by the project management.

Appendix 2

Technical notes on project monitoring

A 2.1 The diesel pumps

The project is supplied with irrigation water from 6 wells. Each well consists of a diesel engine and a turbine pump. At the end of the drilling of each well, the capacity of the wells was established through pumping tests. The pumping tests were carried out by the drilling company in the presence of a hydrogeologist from the ADRA office at Khartoum. Some key figures of the pumps and wells are shown in table 1.

Table 1; Pump characteristics.

Pump	Static water level (m b.s.s.)	Draw down (m)	Daily capacity (m^3/s)	Discharge (l/s)	Energy require ments (kW)
1	26.8	8.4	4368	50	13.15
2	26.75	9.71	4368	50	13.12
3	26.94	14.2	3600	41	10.84
4	26.63	16.9	3600	41	10.71
5	26.68	12.03	3272.7	38	9.95
6	26.65	13.8	4368	50	13.01

The diameter of the wells is 15 inches.

The wells are supplied with Nemitsas pumps(Limasol, Cyprus) while the engine type is Andrychow(Polen).

The engines are provided with easily readable displays for the recording of the revolutions per minute(rpm). In addition, the engines are provided with a recorder for the cumulative hours of operation.

A 2.2 Generally on crop water requirements

On the basis of the cropping pattern, planting and sowing dates and the reference crop evapotranspiration, the crop water requirements can be calculated(ET_c). Comparison of the crop water requirements with the total amount of irrigation water supplied by the pumps(V_{tot}), gives information on the overall project efficiency(e_p).

$$e_p = ET_c / V_{tot}$$

Water losses in the scheme occur at different levels. At Um ja Wasir the most likely losses of irrigation water appear in the canal and on the field

during application of the irrigation water.

After leaving the pump, the water enters the irrigation canal(V_p). Due to losses in the canal the discharge decreases and the amount of irrigation water reaching the farmers(V_f) becomes less over the length of the canal. Losses in the canal system are expressed through the field canal efficiency. Comparing the amount of water reaching the farmers plot with the amount of water delivered by the pump gives information on the canal efficiency(e_c).

$$e_c = V_p/V_f$$

When applying the irrigation water to the crops in the basin, different amounts infiltrate at the beginning and end of the basin due to different application times. Part will percolate beyond the root system of the crop and will therefore not be used in the crop evapotranspiration. The losses in the field are expressed through the application efficiency(e_a) and is equal to the actual crop-evapotranspiration(ET_a) divided by the total amount of water delivered to the basin(V_b)

$$e_a = ET_a/V_b$$

The overall irrigation efficiency is equal the product of the field canal efficiency and the field application efficiency.

Valuable information can be collected during summer and winter time which will provide information on the canal - and application efficiency.

1. Observations should be made on the irrigation application time at different places in the scheme. A factor which greatly influences the application time is the water loss in the irrigation canal. When less irrigation water is available at the end of the canal, the application time will increase which has a negative effect on the irrigation application efficiency.

2. If the application time differs a lot between two plots, situated at the beginning and end of the canal resp., the canal losses are most likely significant. In this case, efforts should be made to estimate the canal losses and ways to decrease these should be considered.

A 2.3 Water Requirements Of The Different Crops Grown At Um Ja Wasir.

The crop water requirements for the different crops, grown at Um Ja Wasir, have been calculated. The main cropping pattern for the project is shown in table 2. 0.5 feddan will be grown with vegetables, both during the winter - and summer season. Of course a variety of vegetables are possible. Only for the calculation of the crop water requirements it is assumed that these are onions and tomatoes respectively.

The calculation of the crop water requirements is based on the climatological data obtained at Karima. During the stay of the review team in Sudan, new updated data were obtained for the period 1961 -1990. On the basis of these data, a new calculation was carried out of the reference crop evapotranspiration(ET_0). The total yearly ET_0 is slightly less compared to previous calculations carried out by the review team (Å. Rønningen, J.Deelstra, April 94). The results of this calculation are shown in table 3.

Tables 4 through 10 represent the calculations of the crop water requirements for the different crops grown in the project. It should be understood that these figures represent the net irrigation requirement. To cope with the canal- and application losses, a larger amount should be supplied at the pumps. Often one assumes an overall irrigation efficiency in the order of magnitude of 50%. This means that the gross irrigation water requirement is approximately twice as large.

Table 2; Cropping pattern at Um Ja Wasir.

Crop	Area (%)	Planting	Harvesting
Full Misri	25	7 November	27 February
Wheat	50	15 November	15 March
Alfalfa	13	1 January	31 December
Onion	13	1 December	1 April
Sorghum(grain)	50	15 May	25 August
Sorghum(fodder)	25	15 May	25 September
Tomato	13	7 June	17 September

Table 3; Reference crop evapotranspiration, ET_0(mm/day), based on Karima climatological station.

Month	Max. Temp C	Min. Temp C	Hu-mid. %	Wind km/day	Sun-shine hours	Sol.Rad. MJ/m /day	ETo-PenMon mm/day
January	28.0	11.9	30	386	10.2	20.7	7.2
February	30.5	13.5	23	425	10.6	23.1	8.7
March	34.7	17.3	19	386	10.3	24.5	9.8
April	38.8	21.5	17	386	10.8	26.2	11.2
May	42.0	25.1	16	386	10.6	25.7	12.0
June	43.4	26.9	17	347	10.4	25.1	11.7
July	41.9	27.0	24	309	10.4	25.1	10.5
August	41.4	27.1	29	309	9.7	24.3	10.1
September	42.1	27.1	22	347	9.4	23.3	10.9
October	39.2	23.8	23	347	10.3	23.2	10.1
November	33.2	18.0	29	390	10.1	21.0	8.7
December	29.4	13.8	33	390	9.3	19.0	7.3
YEAR	37.1	21.1	24	367	10.2	23.4	3597.0

Table 4: Crop water requirements of full misri.

Month	Dec	Stage	Coeff Kc	Etcrop mm/ day	Etcrop mm/ dec
Nov	1	init	0.35	3.21	9.6
Nov	2	init	0.35	3.04	30.4
Nov	3	init	0.35	2.88	28.8
Decl	1	in/de	0.46	3.52	35.2
Dec	2	deve	0.70	5.03	50.3
Dec	3	deve	0.96	6.94	69.4
Jan	1	de/mi	1.12	7.97	79.7
Jan	2	mid	1.15	8.03	80.3
Jan	3	mid	1.15	8.70	87.0
Feb	1	mi/lt	1.12	9.17	91.7
Feb	2	late	0.97	8.47	84.7
Feb	3	late	0.74	6.77	47.4
Total net irrigation requirement.					694.4
Total gross irrigation requirement					1388.8

Table 5: Crop water requirements of wheat

Month	Dec	Stage	Coeff Kc	Etcrop mm/ day	Etcrop mm/ dec
Nov	2	init	0.50	4.34	21.7
Nov	3	init	0.50	4.11	41.1
Dec	1	init	0.50	3.85	38.5
Dec	2	deve	0.62	4.45	44.5
Dec	3	deve	0.85	6.13	61.3
Jan	1	deve	1.08	7.68	76.8
Jan	2	mid	1.20	8.38	83.8
Jan	3	mid	1.20	9.08	90.8
Feb	1	mid	1.20	9.86	98.6
Feb	2	mi/lt	1.15	10.04	100.4
Feb	3	late	1.00	9.09	90.9
Mar	1	late	0.80	7.55	75.5
Mar	2	late	0.60	5.88	29.4
Total net irrigation requirement					853.3
Total gross irrigation requirement					1706.6

Table 6; Crop water requirements of sorghum(grain).

Month	Dec	Stage	Coeff Kc	Etcrop mm/ day	Etcrop mm/ dec
May	2	init	0.40	4.86	24.3
May	3	init	0.40	4.79	47.9
Jun	1	deve	0.51	5.99	59.9
Jun	2	deve	0.73	8.45	84.5
Jun	3	deve	0.94	10.62	106.2
Jul	1	mid	1.05	11.45	114.5
Jul	2	mid	1.05	11.06	110.6
Jul	3	mid	1.05	10.90	109.0
Aug	1	late	0.94	9.56	95.6
Aug	2	late	0.72	7.19	71.9
Aug	3	late	0.50	5.15	25.8
Total net irrigation requirement					850.1
Total gross irrigation requirement					1700.2

Table 7; Crop water requirements of sorghum(fodder).

Month	Dec	Stage	Coeff Kc	Etcrop mm/ day	Etcrop mm/ dec
May	2	init	0.40	4.86	24.3
May	3	init	0.40	4.79	47.9
Jun	1	deve	0.51	5.99	59.9
Jun	2	deve	0.73	8.45	84.5
Jun	3	deve	0.94	10.62	106.2
Jul	1	mid	1.05	11.45	114.5
Jul	2	mid	1.05	11.06	110.6
Jul	3	mi/lt	1.03	10.66	106.6
Aug	1	late	0.96	9.75	97.5
Aug	2	late	0.87	8.66	86.6
Aug	3	late	0.78	7.99	79.9
Sep	1	late	0.68	7.37	73.7
Sep	2	late	0.59	6.59	65.9
Sep	3	late	0.50	5.40	27.0
Total net irrigation requirement					1085.0
Total gross irrigation requirement					2170.0

Table 8; Crop water requirements of alfalfa.

Month	Dec	Stage	Coeff Kc*	Etcrop mm/ day	Etcrop mm/ dec
Jan	1	init	0.75	5.32	53.2
Jan	2	init	0.75	5.24	52.4
Jan	3	init	0.75	5.67	56.7
Feb	1	init	0.75	6.16	61.6
Feb	2	init	0.75	6.55	65.5
Feb	3	init	0.75	6.81	68.1
Mar	1	init	0.75	7.08	70.8
Mar	2	init	0.75	7.35	73.5
Mar	3	init	0.75	7.69	76.9
Apr	1	deve	0.75	8.04	80.4
Apr	2	deve	0.75	8.38	83.8
Apr	3	deve	0.75	8.60	86.0
May	1	deve	0.75	8.86	88.6
May	2	deve	0.75	9.11	91.1
May	3	deve	0.75	8.98	89.8
Jun	1	deve	0.75	8.84	88.4
Jun	2	deve	0.75	8.74	87.4
Jun	3	deve	0.75	8.46	84.6
Jul	1	mid	0.75	8.18	81.8
Jul	2	mid	0.75	7.90	79.0
Jul	3	mid	0.75	7.79	77.9
Aug	1	mid	0.75	7.63	76.3
Aug	2	mid	0.75	7.49	74.9
Aug	3	mid	0.75	7.73	77.3
Sep	1	mid	0.75	8.09	80.9
Sep	2	mid	0.75	8.36	83.6
Sep	3	mid	0.75	8.10	81.0
Oct	1	late	0.75	7.80	78.0
Oct	2	late	0.75	7.59	75.9
Oct	3	late	0.75	7.23	72.3
Nov	1	late	0.75	6.87	68.7
Nov	2	late	0.75	6.51	65.1
Nov	3	late	0.75	6.17	61.7
Dec	1	late	0.75	5.78	57.8
Dec	2	late	0.75	5.42	54.2
Dec	3	late	0.75	5.41	54.1
Total net irrigation requirement					658.9
Total gross irrigation requirement					1317.8

* Compared to previous calculation the crop coefficient, Kc, has been reduced from 0.9 to 0.75. After cutting the crop, the crop coefficient is 0.1 while just before harvesting this will reach as high as 1.1. By reducing the crop coefficient, a better representation of the average condition of the crop coefficient for alfalfa is obtained. Because of this reduction the crop evapotranspiration is reduced compared to previous calculations.

Table 9; Crop water requirements of onion(dry).

Month	Dec	Stage	Coeff Kc	Etcrop mm/ day	Etcrop mm/ dec
Dec	1	init	0.70	5.39	53.9
Dec	2	init	0.70	5.05	50.5
Dec	3	in/de	0.72	5.19	51.9
Jan	1	deve	0.78	5.56	55.6
Jan	2	deve	0.87	6.05	60.5
Jan	3	de/mi	0.93	7.03	70.3
Feb	1	mid	0.95	7.80	78.0
Feb	2	mid	0.95	8.29	82.9
Feb	3	mid	0.95	8.63	86.3
Mar	1	mi/lt	0.93	8.78	87.8
Mar	2	late	0.87	8.53	85.3
Mar	3	late	0.79	8.10	81.0
Total net irrigation requirement					844.2
Total gross irrigation requirement					1688.4

Table 10: Crop water requirements of tomato.

Month	Dec	Stage	Coeff Kc	Etcrop mm/ day	Etcrop mm/ dec
Jun	1	init	0.70	8.25	24.7
Jun	2	init	0.70	8.16	81.5
Jun	3	in/de	0.72	8.12	81.2
Jul	1	deve	0.81	8.80	88.0
Jul	2	deve	0.94	9.90	99.0
Jul	3	de/mi	1.05	10.94	109.4
Aug	1	mid	1.10	11.19	111.9
Aug	2	mid	1.10	10.99	109.9
Aug	3	mi/lt	1.06	10.95	109.5
Sep	1	late	0.90	9.71	97.1
Sep	2	late	0.65	7.24	50.7
Total net irrigation requirement					962.9
Total gross irrigation requirement					1925.8

Table 11; Monthly water requirements for the different crops(mm/day)

Crop	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1	8.2	8.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.0	5.2
2	8.4	9.7	4.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.8	4.8
3	5.4	6.5	7.4	8.3	9.0	8.7	8.0	7.6	8.2	7.5	6.5	5.5
4	6.2	8.2	8.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	5.2
5	0.0	0.0	0.0	0.0	3.2	8.4	11.1	7.3	0.0	0.0	0.0	0.0
6	0.0	0.0	0.0	0.0	3.2	8.4	11.1	8.8	6.5	0.0	0.0	0.0
7	0.0	0.0	0.0	0.0	0.0	8.2	9.9	11.0	5.7	0.0	0.0	0.0

1;full misri,25%. 2; wheat, 50%. 3; alfalfa, 12.5%. 4; onion, 12.5%. 5; sorghum(grain), 50%.
6; sorghum(fodder), 25%. 7; tomato,12.5%.

Table 12; Net and gross irrigation water supply in liter per second per hectare(l/s/ha)

SQ_l	7.7	8.7	4.2	1.0	3.5	8.4	10.6	8.2	3.3	0.9	3.0	5.0	mm/d
SQ_n	0.89	1.01	0.49	0.12	0.41	0.97	1.22	0.95	0.39	0.11	0.35	0.58	l/s/ha
SQ_g	1.78	2.02	0.98	0.24	0.82	1.94	2.44	1.90	0.78	0.22	0.77	1.16	l/s/ha
Ar	100.0	100.0	58.3	12.5	62.5	100.0	100.0	100.0	45.8	12.5	70.8	100.0	%

SQ_l - weighed monthly crop irrigation requirement
SQ_n - net irrigation amount per hectare(24 hrs per day irrigation)
SQ_g - gross irrigation amount per hectare (24 hours per day irrigation)
Ar - area under irrigation(%)

A 2.4 Fuel consumption.

The fuel consumption is a function of the energy required to lift the groundwater. The capacity (Q)of the pumps varies from roughly 40 - 50 l/s while the static water level(h) in the wells is 27 m below the soil surface.

To be able to lift this amount of water, the netto energy requirement(E_n) is

$E_n = Q \times h \times g$ ($g = 9.81\ m^2/s$)
$E_n = 50 \times 27 \times 9.81 = 13244$ Watt (1 horse power = 0.734 kW)
$E_n = 18$ hp

The efficiency of the pump is estimated at 50% while an additional loss of 10% is assumed in the transfer of power from the diesel engine to the pump.

The total energy requirement of the engine is therefore

$E_g = 18/(0.5 \times 0.9) = 40$ hp

The fuel consumption is estimated at 200 gr of diesel fuel per horse power per hour. The specific weight of diesel fuel is estimated at 0.9 kg. The hourly fuel consumption(F_h) is therefore

$F_h = 40 \times 0.2/0.9 = 8.8$ liters

On the basis of the gross irrigation requirement(SQ_b , table 11), the monthly fuel consumption can be calculated.

Table 13; Fuel consumption per pump and for the whole project.

Month	SQ_g (l/s/ha)	Q_b (m^3/day)	P_{hrs} (day)	Fuel/month (pump)	Fuel/month (scheme)
Jan	1.78	3230	17.9	4895	29368
Feb	2.02	3665	20.4	5017	30103
Mar	0.98	1778	9.9	2695	16169
Apr	0.24	435	2.4	639	3832
May	0.82	1488	8.3	2255	13529
Jun	1.94	3520	19.6	5163	30975
Jul	2.44	4427	24.6	6710	40257
Aug	1.90	3447	19.2	5225	31348
Sept	0.78	1415	7.9	2076	12454
Oct	0.22	399	2.2	605	3630
Nov	0.77	1397	7.8	2049	12294
Dec	1.16	2105	11.7	3190	19139
Total					243098

The amount of water , which has to be delivered per pump(Q_b), is equal to

Q_b = area x day x SQ_b = $50 \times 0.42 \times 24 \times 3600 \times SQ_b$

In calculating the pumping hours per day, it is assumed that the pump discharge is set to 50 l/s. The pumping hours per day(P_{hrs}) is the equal to

$P_{hrs} = Q_b \times 1000 / (50 \times 3600)$

The fuel consumption for each pump and the whole scheme per month is presented in the last two columns of table 2. These figures are based on a fuel consumption of 8.8 liters/hour.

A 2.5 Crop yield response to irrigation levels

FAO, in "Yield response to water", Irrigation and Drainage paper no. 33, expresses the relation between yield and water requirement in the following way,

$(1 - Y_a/Y_p) = k_y (1 - E_a/E_p)$ in which

Y_a - actual crop yield
Y_p - potential crop yield
E_a - actual crop evaporation
E_p - potential crop evaporation
k_y - yield response factor

A tentative watering schedule for wheat, prepared by the project, is as follows. A total of eight irrigations is practiced. During the first irrigation 600 m^3/feddan is supplied, during the second 400 m^3, during the third watering 300 m^3 and from the fourth until the eighth 250 m^3 is supplied. The total supply per feddan will be 2550 m^3 which is equal to 607 mm.

On the basis of the climatological data of Karima meteorological station the calculated potential crop evaporation for wheat is 853 mm.

The yield response factor for wheat for the whole growing season is, k_y, varies from 1 - 1.15. The effect of an under irrigation on the yield of wheat can then be calculated as

$(1 - Y_a/Y_p) = k_y \times (1 - 607/853) = 0.28 - 0.33$

One will obtain a yield which is approximately 70% of the potential one. No comparison is made for the other crops but also for those crops there is a tendency to under irrigate. One should be careful practicing under irrigation because this might have serious effects on the yield.

Appendix 3

Financial and economic calculations

Table 1 - Estimated annual income per farm (£S - November 1995)

	Plot size (feddan)	Season	Estimated yield	Yield per year	Selling price (Ls)	Calculated Sum per year	Assumed (*) income per fam./year (Ls)
Alfalfa + date palm seedlings	0.50	All year around	1 bundle/hod/cutting x 50 hods x 10 cuttings	500	500	250,000	200,000
Beans	0.50	Winter	3 sacks/0.5 feddan	3	30,000	90,000	72,000
Onion	0.50		1 sack/hod x 50 hods	50	7,000	350,000	280,000
Potato	0.25		5 sacks	5	10,000	50,000	40,000
Wheat	2.00	Winter	10 sacks/feddan x 2 feddan	20	18,000	360,000	288,000
Other crops:							
- Water melon		Winter	10 hods x 6 plants x 3 fruits = 180 fruits	180	200	36,000	
- Cucumber		Winter	10 hods x 2 kg x 8 pickings = 160 kg	160	200	32,000	
- Tomato		Winter	10 hods x 8 kg x 8 pickings = 640 kg	640	200	128,000	
- Other crops (spices)		Winter	20 hods			84,000	
Sum						280,000	100,000
Plant sorghum (green fodder)	3.00	Summer	A-grains: 4 sacks x 3 feddan	12	10,000	120,000	
			B-fodder: 3 feddan x 100 hods x 10 bundles	3,000	175	525,000	
						645,000	516,000
Onion	0.50	Summer	50 sacks	50	8,000	400,000	320,000
Sum, 1st year (**)							1,816,000
Soft date plant intercropped with alfalfa (from year 5)		All year around	20 trees x 50 kg (from year 5)	1,000	300	300,000	240,000

(*) Assumed income taken as 20% less than calculated, and even less for 'other crops'

(**) Income assumed to increase by 15% from year 2

Farm size: 4 feddans (16,800 m2) 1 feddan = 100 hods

Um Jawasir Development Programme
Group 1, Cost assumptions (USD - November 1995)

	Cost per month	1995	1996	1997	1998	1999	2000
Personnel							
Technical advisor (expat.)	4,200	20,000	50,000	50,000			
Project Director (local)	625	6,500	7,500	7,500			
Field Manager	500	5,000	6,000	6,000			
Data Monitor	500	5,000	6,000	6,000			
Logistics	400	4,000	4,800	4,800			
Field Extensionist	333	4,000	4,000	4,000			
Mechanic/Pump Operator	333	4,000	4,000	4,000			
Driver	250	3,000	3,000	3,000			
Driver	250	3,000	3,000	3,000			
Support labour		2,000	2,200	2,200			
1% cont./rounding		500	1,500	1,500			
Sum		57,000	92,000	92,000	-	-	-
Operating/support costs:							
Accounting/secretarial	250	6,000	6,000	6,000			
Consultants		10,000	10,000	10,000			
Base/endline surveys		5,500		4,000			
Training (internal)		1,400	1,000	1,000			
Training (external)		6,000	6,000	6,000			
Int'n travel (Norway)		5,700	5,000	5,000			
Office supplies/exp.		3,600	3,000	3,000			
Misc. supplies		3,000	1,000	1,000			
1% cont./rounding		800	1,000	1,000			
Sum		42,000	33,000	37,000	-	-	-
Agricultural wells (6 Nos.)							
Well (40 years techn. life time)		110,000					
Pump (10 years tlt.)		60,000					
Engine (5 years tlt.)		80,000					80,000
Clearance/transport		30,000					
Office/resthouse/furniture		10,000					
Maintenance/repairs (5%/year)			15,000	15,000	15,000	15,000	15,000
1% cont./rounding		4,000	-	-	-	-	-
Sum		294,000	15,000	15,000	15,000	15,000	95,000
Vehicles and equipment							
Vehicles (4 years techn. life t.)		68,000					
Trailer		2,400					
Donkeys and carts		3,000					
Tractor implements		4,000					
Irrigation supplies		15,000	30,000				
Fuel tanks		8,000					
Tools		7,000					
Office equipment		5,000					
Weather station		2,000					
Veh. spares/maint.		7,200	7,000				
Repair govt. truck		5,000	500				
1% cont./rounding		1,400	500	10,000	8,000	8,000	8,000
Sum		128,000	38,000	10,000	8,000	8,000	8,000

Table 2/1

Um Jawasir Development Programme
Group 1, Cost assumptions (USD - November 1995)

	1995	1996	1997	1998	1999	2000
Agricultural inputs						
Seeds and seedlings	13,500	13,500	13,500	13,500	13,500	13,500
Seeds and seedlings (dates)	6,500					
Shelter belt establishment	-	10,000				
Goats/sheep impr. stock	-	13,500				
Fertiliser/chemicals	3,000	7,500	7,500	7,500	7,500	7,500
Fuel and oils	21,000	60,000	60,000	60,000	60,000	60,000
1% cont./rounding	1,000	1,500	1,000	1,000	1,000	1,000
Sum	45,000	106,000	82,000	82,000	82,000	82,000
Summary of costs						
Personnel	57,000	92,000	92,000	-	-	-
Operating/support costs	42,000	33,000	37,000	-	-	-
Agricultural wells (6 Nos.)	294,000	15,000	15,000	15,000	15,000	95,000
Vehicles and equipment	128,000	38,000	10,000	8,000	8,000	8,000
Agricultural inputs	45,000	106,000	82,000	82,000	82,000	82,000
Sum	566,000	284,000	236,000	105,000	105,000	185,000
ADRA, Sudan - 4% overhead	23,000	11,000	9,000			
Total costs	589,000	295,000	245,000	105,000	105,000	185,000
Farming income						
Basic income (6 wells/72 fam.)	40,000	174,312	174,312	174,312	174,312	174,312
Productivity increase (+15%)			26,147	26,147	26,147	26,147
Dates						23,040
Total	40,000	174,312	200,459	200,459	200,459	223,499
Family expenses (USD 950 per family per year)						
72 families	40,000	70,000	70,000	70,000	70,000	70,000

Assumed for fuel and oils:

Diesel for six pumps:	As calculated in chapter 4:		243,000 litres/year
	243,000 ltr/4.5 =	54,000 gallons x USD 1 =	USD 54,000 per year
	+ lubricants etc.		USD 6,000 per year
	Total estimate		USD 60,000 per year

Table 2/2

Um Jawasir Development Programme
Group 2, Cost assumptions (USD - November 1995)

	Cost per month	1998	1999	2000	2001	2002	2003
Personnel							
Technical advisor (expat.)	4,200	50,000	20,000				
Project Director (local)	625	7,500	7,500	7,500			
Field Manager	500	6,000	6,000	6,000			
Data Monitor	500	6,000	6,000	6,000			
Logistics	400	4,800	4,800	4,800			
Field Extensionist	333	4,000	4,000	4,000			
Mechanic/Pump Operator	333	4,000	4,000	4,000			
Driver	250	3,000	3,000	3,000			
Driver	250	3,000	3,000	3,000			
Support labour		2,200	2,200	2,200			
Contingencies/rounding		1,500	1,500	1,500			
Sum		92,000	62,000	42,000	-	-	-
Operating/support costs:							
Accounting/secretarial							
Consultants							
Base/endline surveys							
Training (internal)							
Training (external)							
Int'n travel (Norway)							
Office supplies/exp.							
Misc. supplies							
Contingencies/rounding		21,000	15,000	15,000			
Sum		21,000	15,000	15,000	-	-	-
Agricultural wells (6 Nos.)							
Well (40 years techn. life time)		110,000					
Pump (10 years tlt.)		60,000					
Engine (5 years tlt.)		80,000					80,000
Clearance/transport		30,000					
Office/resthouse/furniture							
Maintenance/repairs (5%/year)			15,000	15,000	15,000	15,000	15,000
Contingencies/rounding		4,000	-	-	-	-	-
Sum		284,000	15,000	15,000	15,000	15,000	95,000
Vehicles and equipment							
Tractor - vehicle replacement		20,000	20,000				
Trailer		3,000					
Donkeys and carts		3,000					
Tractor implements							
Irrigation supplies		15,000	30,000				
Fuel tanks							
Tools							
Office equipment							
Weather station							
Veh. spares/maint.		8,000	8,000	8,000	8,000	8,000	8,000
Repair govt. truck							
Contingencies/rounding		1,000	-	-	-	-	-
Sum		50,000	58,000	8,000	8,000	8,000	8,000

Table 3/1

Um Jawasir Development Programme
Group 2, Cost assumptions (USD - November 1995)

	1998	1999	2000	2001	2002	2003
Agricultural inputs						
Seeds and seedlings	13,500	13,500	13,500	13,500	13,500	13,500
Seeds and seedlings (dates)	6,500					
Shelter belt establishm.		10,000				
Goats/sheep impr. stock	-	13,500				
Fertiliser/chemicals	3,000	7,500	7,500	7,500	7,500	7,500
Fuel and oils	21,000	60,000	60,000	60,000	60,000	60,000
Contingencies/rounding	1,000	1,500	1,000	1,000	1,000	1,000
Sum	45,000	106,000	82,000	82,000	82,000	82,000
Summary of costs						
Personnel	92,000	62,000	42,000	-	-	-
Operating/support costs	21,000	15,000	15,000	-	-	-
Agricultural wells (6 Nos.)	284,000	15,000	15,000	15,000	15,000	95,000
Vehicles and equipment	50,000	58,000	8,000	8,000	8,000	8,000
Agricultural inputs	45,000	106,000	82,000	82,000	82,000	82,000
Sum	492,000	256,000	162,000	105,000	105,000	185,000
ADRA, Sudan - 4% overhead	20,000	10,000	6,000			
Total costs	512,000	266,000	168,000	105,000	105,000	185,000
Farming income						
Basic income (6 wells/72 fam.)		174,312	174,312	174,312	174,312	174,312
Productivity increase (+15%)			26,147	26,147	26,147	26,147
Dates						23,040
Total		174,312	200,459	200,459	200,459	223,499
Family expenses (USD 950 per family per year)						
72 families	40,000	70,000	70,000	70,000	70,000	70,000

Assumed for fuel and oils:

Diesel for six pumps:	As calculated in chapter 4:		243,000 litres/year
	243,000 ltr/4.5 =	54,000 gallons x USD 1 =	USD 54,000 per year
	+ lubricants etc.		USD 6,000 per year
	Total estimate		USD 60,000 per year

Table 3/2

Um Jawasir Development Programme
Group 3, Cost assumptions (USD - November 1995)

	Cost per month	2001	2002	2003	2004	2005	2006
Personnel							
Technical advisor (expat.)							
Project Director (local)	625	7,500	7,500	7,500			
Field Manager	500	6,000	6,000	6,000			
Data Monitor	500	6,000	6,000	6,000			
Logistics	400	4,800	4,800	4,800			
Field Extensionist	333	4,000	4,000	4,000			
Mechanic/Pump Operator	333	4,000	4,000	4,000			
Driver	250	3,000	3,000	3,000			
Driver	250	3,000	3,000	3,000			
Support labour		2,200	2,200	2,200			
Contingencies/rounding		1,500	1,500	1,500			
Sum		42,000	42,000	42,000	-	-	-
Operating/support costs:							
Accounting/secretarial							
Consultants							
Base/endline surveys							
Training (internal)							
Training (external)							
Int'n travel (Norway)							
Office supplies/exp.							
Misc. supplies							
Contingencies/rounding		15,000	15,000	15,000			
Sum		15,000	15,000	15,000	-	-	-
Agricultural wells (6 Nos.)							
Well (40 years techn. life time)		110,000					
Pump (10 years tlt.)		60,000					
Engine (5 years tlt.)		80,000					80,000
Clearance/transport		30,000					
Office/resthouse/furniture							
Maintenance/repairs (5%/year)			15,000	15,000	15,000	15,000	15,000
Contingencies/rounding		4,000	-	-	-	-	-
Sum		284,000	15,000	15,000	15,000	15,000	95,000
Vehicles and equipment							
Vehicle replacement		20,000	20,000				
Trailer							
Donkeys and carts		3,000					
Tractor implements							
Irrigation supplies		15,000	30,000				
Fuel tanks							
Tools							
Office equipment							
Weather station							
Veh. spares/maint.		8,000	8,000	8,000	8,000	8,000	8,000
Repair govt. truck							
Contingencies/rounding		1,000	-	-	-	-	-
Sum		47,000	58,000	8,000	8,000	8,000	8,000

Table 4/1

Um Jawasir Development Programme
Group 3, Cost assumptions (USD - November 1995)

	1998	1999	2000	2001	2002	2003
Agricultural inputs						
Seeds and seedlings	13,500	13,500	13,500	13,500	13,500	13,500
Seeds and seedlings (dates)	6,500					
Shelter belt establishm.		10,000				
Goats/sheep impr. stock	-	13,500				
Fertiliser/chemicals	3,000	7,500	7,500	7,500	7,500	7,500
Fuel and oils	21,000	60,000	60,000	60,000	60,000	60,000
Contingencies/rounding	1,000	1,500	1,000	1,000	1,000	1,000
Sum	45,000	106,000	82,000	82,000	82,000	82,000
Summary of costs						
Personnel	42,000	42,000	42,000	-	-	-
Operating/support costs	15,000	15,000	15,000	-	-	-
Agricultural wells (6 Nos.)	284,000	15,000	15,000	15,000	15,000	95,000
Vehicles and equipment	47,000	58,000	8,000	8,000	8,000	8,000
Agricultural inputs	45,000	106,000	82,000	82,000	82,000	82,000
Sum	433,000	236,000	162,000	105,000	105,000	185,000
ADRA, Sudan - 4% overhead	17,000	9,000	6,000			
Total costs	450,000	245,000	168,000	105,000	105,000	185,000
Farming income						
Basic income (6 wells/72 fam.)		174,312	174,312	174,312	174,312	174,312
Productivity increase (+15%)			26,147	26,147	26,147	26,147
Dates						23,040
Total		174,312	200,459	200,459	200,459	223,499
Family expenses (USD 950 per family per year)						
72 families	40,000	70,000	70,000	70,000	70,000	70,000

Assumed for fuel and oils:

Diesel for six pumps:	As calculated in chapter 4:		243,000 litres/year
	243,000 ltr/4.5 =	54,000 gallons x USD 1 =	USD 54,000 per year
	+ lubricants etc.		USD 6,000 per year
	Total estimate		USD 60,000 per year

Table 4/2

Um Ja Wasir - Economic Analysis (1000 USD)

Phase/year		Family years	Project organisation/investments: ADRA incl. expat. costs	Project org./ support	Wells investments	Vehicles/ equipment	Direct farming costs: Fuel for water	Wells maint.	Vehicles op /maint.	Seeds and other	Net project costs	Family-costs	Tot. proj costs	105 % Assumed income (*)	Yearly 'balance'
	1995	20	43	79	294	128	21			24	589	40	629	42	-587
I	1996	72	61	75		30	60	15	8	46	295	70	365	183	-182
	1997	72	59	79			60	15	10	22	245	70	315	210	-105
	1998	72					60	15	8	22	105	70	175	210	35
II	1999	72					60	15	8	22	105	70	175	210	35
	2000	72			80		60	15	8	22	185	70	255	234	-21
	2001	72					60	15	8	22	105	70	175	234	59
III	2002	72					60	15	8	22	105	70	175	234	59
	2003	72					60	15	8	22	105	70	175	234	59
	2004	72					60	15	8	22	105	70	175	234	59
IV	2005	72			140		60	15	8	22	245	70	315	234	-81
	2006	72					60	15	8	22	105	70	175	234	59
	2007	72					60	15	8	22	105	70	175	234	59
	2008	72					60	15	8	22	105	70	175	234	59
	2009	72					60	15	8	22	105	70	175	234	59
	2010	72			80		60	15	8	22	185	70	255	234	-21
	2011	72					60	15	8	22	105	70	175	234	59
	2012	72					60	15	8	22	105	70	175	234	59
	2013	72					60	15	8	22	105	70	175	234	59
	2014	72			-100	-30	60	15	8	22	-25	70	45	234	189
Sum		1,388	163	233	494	128	1,161	285	154	466	3,084	1,370	4,454	4,365	-89
PV(6%)		823	153	220	482	130	690	167	91	292	2,193	821	3,014	2,544	-470
PV(10%)		622	147	212	474	130	523	125	69	230	1,857	626	2,483	1,899	-584
USD/fam /year			186	267	585	157	839	203	111	355	2,663	997	3,660	3,090	-570

Based on ADRA budget figures November 1995
Figures in USD at November 1995 value (USD 1 = 750 SDP)
Family costs. A reasonable income per family as estimated by ADRA
PV(6%). Present value for discount rate 6% p.a.
USD/fam.yr Discounted 'average' cost per family per year

(*) Assumed income 5% more than estimated by the project in November 1995. Alternatively, the project costs must be reduced by 5%.

Table 5.1 - Estimated costs and income Group 1 - 6 wells - 72 families

Um Ja Wasir - Economic Analysis (1000 USD)

Phase/year		Family years	Farmers' cash flow: Assumed income	Contrib. to revolv. fund	Direct farming costs	Family costs	Balance/ contingency	Group 1 - Revolving fund: Org./investm. costs	NORAD grant	Farmers' contrib.	Balance per year	NORAD rev.fund (*)	From prev. phases	Group 1 balance
	1995	20	42	-45	45	40	2	544	350	-45	-239	250	-	11
I	1996	72	183	-20	129	70	4	166	100	-20	-86	100	10	35
	1997	72	210	30	107	70	3	138	50	30	-58	50	20	47
	1998	72	210	35	105	70	-	-		35	35	-50	30	62
II	1999	72	210	35	105	70	-	-		35	35	-50	30	77
	2000	72	234	60	105	70	-1	80		60	-20	-50	30	37
	2001	72	234	60	105	70	-1	-		60	60	-100	30	27
III	2002	72	234	60	105	70	-1	-		60	60	-100	30	17
	2003	72	234	60	105	70	-1	-		60	60	-100	30	7
	2004	72	234	60	105	70	-1	-		60	60	-	30	97
IV	2005	72	234	60	105	70	-1	140		60	-80	-	30	47
	2006	72	234	60	105	70	-1	-		60	60	-50	30	87
	2007	72	234	60	105	70	-1	-		60	60	-100	30	77
	2008	72	234	60	105	70	-1	-		60	60	-100	30	67
	2009	72	234	60	105	70	-1	-		60	60	-100	30	57
	2010	72	234	60	105	70	-1	80		60	-20			37
	2011	72	234	60	105	70	-1	-		60	60			97
	2012	72	234	60	105	70	-1	-		60	60			157
	2013	72	234	60	105	70	-1	-		60	60			217
	2014	72	234	60	105	70	-1	-130		60	190			407
Sum		1.388	4,365	935	2,066	1,370	-6	1,018	500	935	417	-400	390	
PV(6%)		823	2,544	482	1,241	821	1	952	489	482	19	-97	251	
PV(10%)		622	1,899	324	947	626	3	911	482	324	-105	20	195	
USD/fam yr			3,090	585	1,507	997	1	1,156	594	585	23	-118		

(*) Negative figures denotes funds that can be made available for the next group's investments

Table 5.2 - Assumed financing - Group 1

Um Ja Wasir - Economic Analysis (1000 USD)

Phase	Year	Family years	Project organisation/investments: ADRA incl. expat. costs	Project org./ support	Wells investments	Vehicles/ equipment	Direct farming costs: Fuel for water	Wells maint.	Vehicles op./maint.	Seeds and other	Net project costs	Family-costs	Tot. proj costs	105 % Assumed income (*)	Yearly 'balance'
	1998	20	70	63	284	50	21			24	512	40	552	42	-510
II	1999	72	30	57		50	60	15	8	46	266	70	336	183	-153
	2000	72	6	57			60	15	8	22	168	70	238	210	-28
	2001	72					60	15	8	22	105	70	175	210	35
III	2002	72					60	15	8	22	105	70	175	210	35
	2003	72			80		60	15	8	22	185	70	255	234	-21
	2004	72					60	15	8	22	105	70	175	234	59
IV	2005	72					60	15	8	22	105	70	175	234	59
	2006	72					60	15	8	22	105	70	175	234	59
	2007	72					60	15	8	22	105	70	175	234	59
	2008	72			140		60	15	8	22	245	70	315	234	-81
	2009	72					60	15	8	22	105	70	175	234	59
	2010	72					60	15	8	22	105	70	175	234	59
	2011	72					60	15	8	22	105	70	175	234	59
	2012	72					60	15	8	22	105	70	175	234	59
	2013	72			80		60	15	8	22	185	70	255	234	-21
	2014	72					60	15	8	22	105	70	175	234	59
	2015	72					60	15	8	22	105	70	175	234	59
	2016	72					60	15	8	22	105	70	175	234	59
	2017	72			-100	-30	60	15	8	22	-25	70	45	234	189
Sum		1,388	106	177	484	70	1,161	285	152	466	2,901	1,370	4,271	4,365	94
PV(6%)		823	104	168	472	70	690	167	89	292	2,020	821	2,841	2,544	-297
PV(10%)		622	102	162	464	71	523	125	67	230	1,690	626	2,316	1,899	-417
USD/fam /year			126	203	573	86	839	203	108	355	2,453	997	3,450	3,090	-360

Based on ADRA budget figures November 1995
Figures in USD at November 1995 value (USD 1 = 750 SDP)
Family costs: A reasonable income per family as estimated by ADRA
PV(6%) Present value for discount rate 6% p.a.
USD/fam.yr Discounted 'average' cost per family per year

(*) Assumed income 5% more than estimated by the project in November 1995. Alternatively, the project costs must be reduced by 5%.

Table 6.1 - Estimated costs and income **Group 2 - 6 wells - 72 families**

Um Ja Wasir - Economic Analysis (1000 USD)

Phase/year		Family years	Farmers' cash flow: Assumed income	Contrib. to revolv. fund	Direct farming costs	Family costs	Balance/ contingency	Group 2 - Revolving fund: Org./investm. costs	NORAD grant	Farmers' contrib.	Balance per year	NORAD rev.fund (*)	From prev. phases	Group 2 balance
	1998	20	42	-45	45	40	2	467	300	-45	-212	200	50	38
II	1999	72	183	-20	129	70	4	137	-	-20	-157	100	50	31
	2000	72	210	30	105	70	5	63	-	30	-33	-	50	48
	2001	72	210	35	105	70	-	-		35	35	-150	100	33
III	2002	72	210	35	105	70	-	-		35	35	-150	100	18
	2003	72	234	60	105	70	-1	80		60	-20	-100	100	-2
	2004	72	234	60	105	70	-1	-		60	60	-50	-	8
IV	2005	72	234	60	105	70	-1	-		60	60	-50	-	18
	2006	72	234	60	105	70	-1	-		60	60	-150	50	-22
	2007	72	234	60	105	70	-1	-		60	60	-150	100	-12
	2008	72	234	60	105	70	-1	140		60	-80	-	100	8
	2009	72	234	60	105	70	-1	-		60	60	-150	100	18
	2010	72	234	60	105	70	-1	-		60	60	-50	-	28
	2011	72	234	60	105	70	-1	-		60	60	-	-	88
	2012	72	234	60	105	70	-1	-		60	60	-	-	148
	2013	72	234	60	105	70	-1	80		60	-20	-	-	128
	2014	72	234	60	105	70	-1	-		60	60	-	-	188
	2015	72	234	10	105	70	49	-		10	10	-	-	198
	2016	72	234	10	105	70	49	-		10	10	-	-	208
	2017	72	234	10	105	70	49	-130		10	140		-	348
Sum		1,388	4,365	785	2,064	1,370	146	837	300	785	248	-700		
PV(6%)		823	2,544	429	1,239	821	55	781	300	429	-52	-380		
PV(10%)		622	1,899	296	945	626	32	745	300	296	-149	-242		
USD/fam.yr			3,090	521	1,505	997	67	948	364	521	-63	-462		

(*) Negative figures denotes funds that can be made available for the next group's investments

Table 6.2 - Assumed financing - Group 2

Um Ja Wasir - Economic Analysis (1000 USD)

Phase/year		Family years	Project organisation/investments: ADRA incl. expat. costs	Project org./ support	Wells investments	Vehicles/ equipment	Direct farming costs: Fuel for water	Wells maint.	Vehicles op./maint.	Seeds and other	Net project costs	Family-costs	Tot. proj. costs	105 % Assumed income (*)	Yearly 'balance'
	2001	20	17	57	284	47	21			24	450	40	490	42	-448
III	2002	72	9	57		50	60	15	8	46	245	70	315	183	-132
	2003	72	6	57			60	15	8	22	168	70	238	210	-28
	2004	72					60	15	8	22	105	70	175	210	35
IV	2005	72					60	15	8	22	105	70	175	210	35
	2006	72			80		60	15	8	22	185	70	255	234	-21
	2007	72					60	15	8	22	105	70	175	234	59
	2008	72					60	15	8	22	105	70	175	234	59
	2009	72					60	15	8	22	105	70	175	234	59
	2010	72					60	15	8	22	105	70	175	234	59
	2011	72			140		60	15	8	22	245	70	315	234	-81
	2012	72					60	15	8	22	105	70	175	234	59
	2013	72					60	15	8	22	105	70	175	234	59
	2014	72					60	15	8	22	105	70	175	234	59
	2015	72					60	15	8	22	105	70	175	234	59
	2016	72			80		60	15	8	22	185	70	255	234	-21
	2017	72					60	15	8	22	105	70	175	234	59
	2018	72					60	15	8	22	105	70	175	234	59
	2019	72					60	15	8	22	105	70	175	234	59
	2020	72			-100	-30	60	15	8	22	-25	70	45	234	189
Sum		1,388	32	171	484	67	1,161	285	152	466	2,818	1,370	4,188	4,365	177
PV(6%)		823	31	162	472	67	690	167	89	292	1,938	821	2,759	2,544	-215
PV(10%)		622	30	156	464	68	523	125	67	230	1,609	626	2,235	1,899	-336
USD/fam./year			37	196	573	82	839	203	108	355	2,354	997	3,351	3,090	-261

Based on ADRA budget figures November 1995
Figures in USD at November 1995 value (USD 1 = 750 SDP)
Family costs: A reasonable income per family as estimated by ADRA
PV(6%) Present value for discount rate 6% p a.
USD/fam yr Discounted 'average' cost per family per year

(*) Assumed income 5% more than estimated by the project in November 1995. Alternatively, the project costs must be reduced by 5%.

Table 7.1 - Estimated costs and income Group 3 - 6 wells - 72 families

Um Ja Wasir - Economic Analysis (1000 USD)

Phase/year		Family years	Farmers' cash flow: Assumed income	Contrib. to revolv. fund	Direct farming costs	Family costs	Balance/ contingency	Group 3 - Revolving fund: Org./investm costs	NORAD grant	Farmers' contrib.	Balance per year	NORAD rev.fund (*)	From prev. phases	Group 3 balance
	2001	20	42	-45	45	40	2	405	200	-45	-250	150	150	50
III	2002	72	183	-20	129	70	4	116	-	-20	-136	-	150	64
	2003	72	210	30	105	70	5	63	-	30	-33	-100	100	31
	2004	72	210	35	105	70	-	-		35	35	-100	50	16
IV	2005	72	210	35	105	70	-	-		35	35	-50	50	51
	2006	72	234	60	105	70	-1	80		60	-20	-150	150	31
	2007	72	234	60	105	70	-1	-		60	60	-200	150	41
	2008	72	234	60	105	70	-1	-		60	60	-50	-	51
	2009	72	234	60	105	70	-1	-		60	60	-250	150	11
	2010	72	234	60	105	70	-1	-		60	60	-100	50	21
	2011	72	234	60	105	70	-1	140		60	-80	-	-	-59
	2012	72	234	60	105	70	-1	-		60	60	-	-	1
	2013	72	234	60	105	70	-1	-		60	60	-	-	61
	2014	72	234	60	105	70	-1	-		60	60		-	121
	2015	72	234	60	105	70	-1	-		60	60		-	181
	2016	72	234	60	105	70	-1	80		60	-20		-	161
	2017	72	234	60	105	70	-1	-		60	60		-	221
	2018	72	234	60	105	70	-1	-		60	60		-	281
	2019	72	234	60	105	70	-1	-		60	60		-	341
	2020	72	234	60	105	70	-1	-130		60	190		-	531
Sum		1,388	4,365	935	2,064	1,370	-4	754	200	935	381	-850		
PV(6%)		823	2,544	482	1,239	821	3	699	200	482	-17	-565		
PV(10%)		622	1,899	324	945	626	5	664	200	324	-141	-433		
USD/fam.yr			3,090	585	1,505	997	3	849	243	585	-21	-686		

(*) Negative figures denotes funds that can be made available for the next group's investments

Table 7.2 - Assumed financing - Group 3

Um Ja Wasir - Economic Analysis (1000 USD)

Phase/year		Family years	Project organisation/investments: ADRA incl. expat costs	Project org./ support	Wells investments	Vehicles/ equipment	Direct farming costs: Fuel for water	Wells maint.	Vehicles op /maint.	Seeds and other	Net project costs	Family-costs	Tot. proj. costs	105 % Assumed income (*)	Yearly 'balance'
	2004	20			284	25	21			24	354	40	**394**	**42**	-352
IV	2005	72				70	60	15	8	46	199	70	**269**	**183**	-86
	2006	72					60	15	8	22	105	70	**175**	**210**	35
	2007	72					60	15	8	22	105	70	**175**	**210**	35
	2008	72					60	15	8	22	105	70	**175**	**210**	35
	2009	72			80		60	15	8	22	185	70	**255**	**234**	-21
	2010	72					60	15	8	22	105	70	**175**	**234**	59
	2011	72					60	15	8	22	105	70	**175**	**234**	59
	2012	72					60	15	8	22	105	70	**175**	**234**	59
	2013	72					60	15	8	22	105	70	**175**	**234**	59
	2014	72			140		60	15	8	22	245	70	**315**	**234**	-81
	2015	72					60	15	8	22	105	70	**175**	**234**	59
	2016	72					60	15	8	22	105	70	**175**	**234**	59
	2017	72					60	15	8	22	105	70	**175**	**234**	59
	2018	72					60	15	8	22	105	70	**175**	**234**	59
	2019	72			80		60	15	8	22	185	70	**255**	**234**	-21
	2020	72					60	15	8	22	105	70	**175**	**234**	59
	2021	72					60	15	8	22	105	70	**175**	**234**	59
	2022	72					60	15	8	22	105	70	**175**	**234**	59
	2023	72			-100	-30	60	15	8	22	-25	70	**45**	**234**	189
Sum		1,388	-	-	484	65	1,161	285	152	466	2,613	1,370	**3,983**	**4,365**	382
PV(6%)		823	-	-	472	64	690	167	89	292	1,743	821	**2,564**	**2,544**	-19
PV(10%)		622	-	-	464	64	523	125	67	230	1,419	626	**2,045**	**1,899**	-146
USD/fam./year			-	-	573	78	839	203	108	355	2,116	997	**3,114**	**3,090**	-24

Based on ADRA budget figures November 1995
Figures in USD at November 1995 value (USD 1 = 750 SDP)
Family costs A reasonable income per family as estimated by ADRA
PV(6%): Present value for discount rate 6% p a.
USD/fam yr: Discounted 'average' cost per family per year

(*) Assumed income 5% more than estimated by the project in November 1995. Alternatively, the project costs must be reduced by 5%.

Table 8.1 - Estimated costs and income Group 4 - 6 wells - 72 families

Um Ja Wasir - Economic Analysis (1000 USD)

Phase/year		Family years	Farmers' cash flow: Assumed income	Contrib. to revolv. fund	Direct farming costs	Family costs	Balance/ contingency	Group 4 - Revolving fund: Org./investm. costs	NORAD grant	Farmers' contrib.	Balance per year	NORAD rev.fund (*)	From prev. phases	Group 4 balance
	2004	20	42	-45	45	40	2	309	50	-45	-304	250	100	46
IV	2005	72	183	-20	129	70	4	70	-	-20	-90	-	50	6
	2006	72	210	30	105	70	5	-	-	30	30	-150	150	36
	2007	72	210	35	105	70	-	-		35	35	-200	200	71
	2008	72	210	35	105	70	-	-		35	35	-150	50	6
	2009	72	234	60	105	70	-1	80		60	-20	-200	250	36
	2010	72	234	60	105	70	-1	-		60	60	-150	100	46
	2011	72	234	60	105	70	-1	-		60	60	-100	-	6
	2012	72	234	60	105	70	-1	-		60	60	-40	-	26
	2013	72	234	60	105	70	-1	-		60	60	-	-	86
	2014	72	234	60	105	70	-1	140		60	-80	-	-	6
	2015	72	234	60	105	70	-1	-		60	60	-	-	66
	2016	72	234	60	105	70	-1	-		60	60	-60	-	66
	2017	72	234	60	105	70	-1	-		60	60	-60	-	66
	2018	72	234	60	105	70	-1	-		60	60	-60	-	66
	2019	72	234	60	105	70	-1	80		60	-20	-	-	46
	2020	72	234	60	105	70	-1	-		60	60	-60	-	46
	2021	72	234	60	105	70	-1	-		60	60	-60	-	46
	2022	72	234	60	105	70	-1	-		60	60	-60	-	46
	2023	72	234	60	105	70	-1	-130		60	190		-	236
Sum		1,388	4,365	935	2,064	1,370	-4	549	50	935	436	-1,100		
PV(6%)		823	2,544	482	1,239	821	3	503	50	482	28	-668		
PV(10%)		622	1,899	324	945	626	5	474	50	324	-101	-494		
USD/fam.yr			3,090	585	1,505	997	3	611	61	585	34	-812		

(*) Negative figures denotes funds that can be made available for the next group's investments

Table 8.2 - Assumed financing - Group 4