Irrigation Manual
Module 11

Financial and Economic Appraisal of Irrigation Projects

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List of abbreviations

AfDB	African Development Bank
AF	Present worth of annuity factor
Agritex	Department of Agricultural Technical and Extension Services (Zimbabwe)
B/C	Benefit/Cost
CF	Compounding factor
c.i.f.	cost, insurance and freight
CRF	Capital recovery factor
DF	Discount factor
f.o.b	free on board
Forex	Foreign exchange rate
FV	Future Value
GMB	Grain Marketing Board
IFAD	International Fund for Agricultural Development
IRR	Internal Rate of Return
IMF	International Monetary Fund
NGO	Non Governmental Organization
NPV	Net Present Value
OER	Official Exchange Rate
PV	Present value
SER	Shadow Exchange Rate
US$	United States Dollar
WB	World Bank
ZW$	Zimbabwe Dollar

Chapter 1
Project planning

Agricultural development is a process that takes place through changes in production techniques and methods on the different farming units, both large-scale and small-scale. The changes in the different units will depend on the challenges facing them and will occur through:

- New production inputs used by farmers
- New methods of production, for example the introduction of irrigation
- New marketing opportunities, for example the opening of the export markets for horticultural producers

Changes do not always bring positive benefits to the farmer. They have to be analyzed and measured against the prevailing situation. Choices should be made between alternative plans and ideas. Farmers, investors and society all need an objective way of making these analyses and choices.

Resources are limited and all organizations and institutions have to make choices regarding the allocation and investing of human and financial resources in development projects. Project appraisal helps to determine if the investment is viable, usually according to quantitative financial and economic criteria. Projects may be financed by the government, donor agencies, farmers, or a combination of these three.

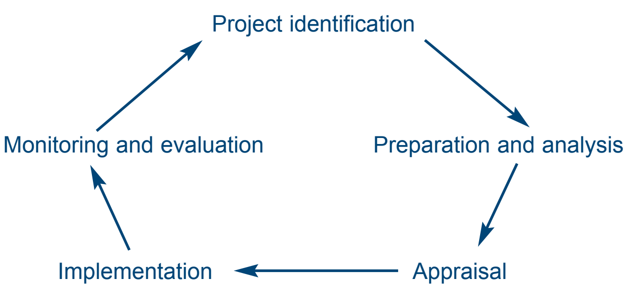
A project is a specific investment activity in which financial resources are used over a specified period of time with the expectation of a greater flow of benefits to an individual or a community. A common feature of all projects is that they can be planned, financed and implemented. During planning the costs and returns of a project are estimated. For this purpose the unit market costs, the estimated yields and market prices are used. For any project, the geographical location is determined and the people whom it intends to reach are identified in advance. The activities to be carried out, and their financing, are organized in sequence. Even the key stakeholders who will participate in the project execution are specified.

For a layperson, a project starts when physical items can be observed on a site. Thus, when they see a team of surveyors placing landmarks to demarcate suitable plots for farming, they might believe that the project is starting. However, by then project planners might have already been working for a long time. A project has a long way to go from its conception to its implementation. While some activities in the field take place during project preparation, it is mainly during implementation that most of the activities and supplies (vehicles, machinery, equipment, building and personnel) can be seen on the project site.

A project is a continuous process involving sequential steps that form a kind of cycle, usually called 'the project cycle'. The sequence is as follows:

- Identification
- Preparation and analysis
- Appraisal
- Implementation
- Monitoring and evaluation

The project cycle



1.1. Project identification

Project ideas originate from various circumstances. A project may be designed to address an identified constraint in the community or to exploit an opportunity. Ideas of pursuing an irrigation project may be prompted by the following:

- Low yields due to poor rainfall patterns
- Low incomes from rainfed crop production
- Presence of water resources and irrigable land
- Market opportunities due to proximity to a large market (consumer and/or industrial, for example a processing factory)

Well-informed technical specialists, local communities, local leaders and farmers are the most common sources of project ideas. While performing their professional duties, technical specialists will have identified many areas where they feel new investment might be profitable. Local communities may also be consulted both to identify and to confirm the need for the projects. Local leaders will generally have a number of suggestions about where investment might be carried out, because of the requests they had from members of the community on various constraints they are confronted with. Individual farmers in the community may also come up with ideas for their own projects.

Project identification aims at undertaking a preliminary assessment of a project idea before important planning resources, like money and skills, are utilized in detailed project design and appraisal. It involves the development of the concept and crystallizing ideas. Project identification is initiated when farmers, extension workers, or NGO or donor agency staff point to a prospective project. A quick assessment, which includes visiting the potential site(s), is done to determine whether developing a project would be feasible. In the case of an irrigation project, identification would include a first rough examination of available water resources (including quantity and quality) and irrigable land (size, types of soils, topography, etc.). If the outcome is positive and the project is deemed suitable for financing, a detailed project preparation and appraisal of the viability of the project is made.

1.2. Project preparation and analysis

Once a project has been identified, a process of progressively more detailed preparation and analysis of project plans begins. This process includes all the work necessary to bring the project to the point at which a careful review or appraisal can be undertaken. Then, if it is determined to be a good project, implementation can begin.

Typically, the first step in project preparation and analysis is to undertake a feasibility study that will provide enough information for deciding whether to begin more advanced planning (see also Module 1). The feasibility study should clearly define the objectives of the project. It should explicitly address the question of whether alternative ways to achieve the same objectives may be preferable. This stage is concerned with the study of a limited number of project alternatives and will enable project planners to exclude poor alternatives. The feasibility study forms the basis for detailed project design (Module 7, 8, 9) and involves a detailed analysis of the following:

- ❖ Technical aspects
- ❖ Financial aspects
- ❖ Commercial aspects
- ❖ Community participation
- ❖ Organization and management
- ❖ Socio-economic benefit-cost analysis
- ❖ Environmental impact
- ❖ Political and cultural risks
- ❖ Sustainability and replicability

Project preparation ends with the production of a project proposal indicating what resources will be required to implement the project activities. The proposal will contain an action plan detailing the stage-by-stage implementation of the project. The proposal will also show who will be involved and how.

1.2.1. Technical study

The technical study is a key area in project design. It is concerned with assessing the technical feasibility. For example, a project aiming at growing wheat in an arid area without irrigation may not be technically feasible. In the case of irrigation development, technical feasibility considers whether the irrigation system and crops under consideration are adapted to the following characteristics at the site:

- ❖ Land topography
- ❖ Soils: soil texture, consistency, structure, profile and depth, salinity and drainage
- ❖ Water resources: accessibility, quantity and quality
- ❖ Climate and crop: top or root watering crops, shallow rooted crops, etc.
- ❖ Capital and labour: availability and cost
- ❖ Energy: availability and cost

The first three issues, i.e. the natural resources assessment, are dealt with in Module 2. Modules 3 and 4 cover agronomic and climatic aspects respectively.

1.2.2. Financial analysis

The financial analysis of a project aims at assessing the financial effects the project will have on farmers, public and private firms, government operating agencies and anybody else who may be participating in it. It establishes the magnitude of costs of capital investments and production and weighs these against future financial benefits of the project. Investment costs include the costs for land purchase and development, civil works, procurement of equipment and technical skills. Production costs cover items such as materials, inputs, energy, repair and maintenance and labour. Besides the cost estimates, the financial study will look at possible financing sources, including the terms and conditions of financing.

The financial study is the basis for working out the budget requirements of the project. At the same time an assessment of project outputs and returns will be made. These will be the basis for evaluating the project's profitability and viability. Several methods for assessment of the profitability are available. The most common ones use the following indicators: Net Present Value (NPV), Benefit/Cost (B/C) ratio, Internal Rate of Return (IRR) and Payback Period (see Section 2.6).

1.2.3. Commercial study

Commercial appraisal is important because it enables the project planner to predict the potential income and costs that are the basis for assessment of financial results. It deals with the analysis of the markets for inputs, materials, labour and products or outputs. The sources of inputs, their prices and the management of their supply is essential at this stage. The price for inputs and outputs is used as the basis for calculating projected income, future earnings and cash flows. It is important that projection of prices, yields and outputs be as realistic as possible in order not to lead to a waste of resources.

As far as costing is concerned, it is advisable to use current prices and to include quantity and price contingencies. Sensitivity tests to check the effect of changes in prices, yields and outputs on project benefits should also be done. Sensitivity analysis is discussed in more detail in Chapter 4.

1.2.4. Community participation analysis

A participation analysis involves engaging the community in discussions in order to find out their views and interests as far as the proposed project is concerned. It also helps develop a feeling of ownership of the project in the community. The study looks at answering for example the following questions:

- ❖ What the community is willing to contribute to the project (in cash or kind)?
- ❖ What managerial capabilities exist in the community?
- ❖ What skills training the community will require in order to fully benefit from the project?

Consultations also need to include other stakeholders such as suppliers, government officials, politicians and lenders. Their roles and responsibilities in the planned project need to be clearly defined.

1.2.5. Project organization and management

Without adequate organization and management, no project can produce the expected results. It is thus essential that a detailed analysis of project organization and management be made. This will look into the establishment of a functional organizational and/or management structure showing lines of responsibilities, communication and activities to be undertaken. Analysis of the organization and management of a project should be seen as very important because only adequate management will result in efficient project implementation, greater project benefits and, eventually, harmonious development. The study will also assess the need for training and institutional capacity building.

1.2.6. Economic and social cost-benefit analysis

Economic analysis of a project aims at assessing the additional income to the nation and the community resulting from project implementation. When analyzing the economic benefits, the question to answer is: Is the proposed project good from the viewpoint of national development interest?

Social cost-benefit analysis is one of the techniques that have been developed to assess what costs and benefits accrue to the community at large. The technique identifies the effects of the project on the economy as a whole by setting out and evaluating the social costs and benefits of investment projects. This comparison of costs and benefits helps to decide whether the project should be undertaken. The aim is to measure the losses and the gains in the economic welfare of the society in which a project is implemented. This involves several issues: 1) establishing the appropriate price of inputs and outputs; 2) the valuation of the outputs of services; 3) the valuation of indirect effects called 'externalities'. For example, externalities of irrigation projects may include pollution of domestic water sources, loss of grazing land, loss of vegetation, etc.

It is difficult to compare costs and benefits because the prices used are distorted by inflation, foreign exchange and price controls. If the government fixes a minimum wage for labour for instance, yet at the same time there are many unemployed people, the real wage is less than the fixed wage. This means that workers could accept the same jobs for lower pay, if no regulation against that existed. The difficulties attached to the valuation of costs and benefits have led to the use of what is called adjusted price, shadow price or accounting price (see Section 3.1). This price better reflects the true social or economic values. In agricultural projects, for example, a generally accepted advice is to use the farm-gate price for product output and the official exchange rate for foreign exchange and market prices. The unskilled labour price or wage should be reduced or reasonably shadow-priced below the normal wage rate, while skilled labour should be shadow-priced above its wage to reflect its scarcity.

Besides the benefits offered by the project output (crops produced, revenues received, etc.) there are many other economic benefits of a project. The most obvious ones are employment at community level, food security, foreign exchange earnings, access to new technology and a better standard of living for the community served by the project.

1.2.7. Environmental impact assessment

In most countries an environmental impact study is now a pre-requisite for project financing. The environmental impact of a project refers to the effect of a project on the world of natural flora and fauna (biodiversity), water and human beings existing in the project area.

The environmental effects of a project can best be illustrated by large dam construction. The construction of a large dam may aim at providing water for domestic use, for electricity generation, or for production by means of irrigation. Such undertakings result in incremental socio-economic benefits to project communities. The benefits may be ‘increased produce’ and ‘increased income’ to the farmers. But these benefits can be counter-balanced by undesirable events caused by the project. For example, when a dam covers a forest or other vegetation, water movement can be impeded laterally as well as vertically and this can lead to anaerobic decomposition. Other effects of a large dam may be the displacement of communities.

Assessment of the likely impact of a proposed irrigation scheme on the environment involves establishing whether the project will:

- ❖ Affect sensitive biological areas susceptible to erosion or pollution, such as wetlands and fresh drinking water sources
- ❖ Contribute to a change in soil structure or fertility
- ❖ Contribute to salinization of soils or to waterlogging
- ❖ Have a large impact on the availability of surface water or groundwater
- ❖ Contribute extensively to pollution of land and water
- ❖ Affect areas with unique or sensitive species of vegetation
- ❖ Involve an increase in the use of chemicals such as fertilizers and pesticides
- ❖ Involve a risk of unintentional spreading of pollution beyond the project area through air, water or the food chain
- ❖ Involve unskilled people handling hazardous chemicals

Project planners must indicate the appropriate measures for the protection of the ecology. But, most importantly, they should inform the project participants about the possible environmental effects on the communities of the project area. They must be aware that authorities can refuse to give permission for implementation of projects that will have a disastrous impact on the people intended to be served. This is the best way of ensuring not only the protection of present targeted communities, but also the survival of future generations.

1.2.8. Political and cultural risk assessment

There is need to align the project objective with national development strategies and policies. Project objectives should not contradict government goals. It is important for planners to assess trends in the political system as well as the stability of the social environment. The cost of investing may be high if the political system is unstable or is implementing policies that do not protect investors.

At the local level, project objectives should be in line with the cultural practices of the area. There will be need, at this level, to generate political goodwill by sensitization and awareness creation.

1.2.9. Project sustainability analysis

The concept of project sustainability is based on the belief that project implementation should result in benefits that have a lasting effect. Ideally, a project should not exhaust available resources like raw materials, inputs and skilled labour. In this way, continuity in production of goods and services remains possible and project implementation does not over-exploit resources that will be needed by future generations.

In sustainability analysis, the planner should make sure that the proposed project meets specific conditions in respect of sustainability. A project is sustainable if it does not result in exhaustion or degeneration of natural resources. In addition, it should preserve the national environment and ensure the continuity of the production process in the future. Continuity of the production process can be obtained by making participants more self-reliant (through a programme of local/national human resources capacity building) in the management of the project once external project assistance in terms of funds and management skills has stopped. A complimentary strategy to achieve project sustainability is to use appropriate technology and locally available resources.

The various studies (technical, financial, environmental, etc.) will allow the planners to examine the pros and cons of different options, for example a sprinkler versus surface irrigation system. The analysis looks at the different costs and benefits, associated with each alternative, and allows for the selection of the most worthwhile option while less promising alternatives are eliminated. Once studies have indicated which proposed project would be likely to be worthwhile, detailed planning and analysis may begin.

This is the stage at which detailed studies commence, such as a detailed soil survey, hydrological analyses (Module 2), the thorough examination of cropping patterns (Modules 3 and 4), estimates of labour and other inputs, the detailed farm budgets, etc. Detailed planning may take time, particularly for complex agricultural projects. It may also be quite expensive. In agriculture, preparing a detailed project plan may well cost 7-10% of the total project investment (Gittinger, 1992). However, thorough preparation increases a project's efficiency and helps ensure its smooth implementation.

The project may be prepared by a multi-disciplinary team, assembled for the purpose and given sufficient time and resources. This task may be undertaken by the private sector (consulting firm), the public sector (relevant government department) or by both. Disciplines represented in the preparation of a feasibility study for an irrigation project may, for example, be irrigation engineering, soil science, crop production, agricultural economics and sociology.

1.3. Project appraisal

After a project has been prepared, a critical review or an independent appraisal usually needs to be conducted. This provides an opportunity to re-examine every aspect of the project plan in order to assess whether the proposal is appropriate and sound before large sums of money are committed to it. It will also look at whether the time frame proposed for implementation is realistic.

The appraisal process builds on the plan, but it may involve gathering new information if the specialists on the appraisal team feel that some of the data are questionable or some of the assumptions faulty.

1.4. Project implementation

Implementation starts when the final appraisal report has been approved and when financing agreements have been concluded. It involves:

- Preparation of an action plan and budget for the project
- Mobilization of resources (human, material and management) and assigning of responsibilities
- Mobilization of farmers to participate fully in the project right from the start
- Initiation of fieldwork, for example laying out of engineering works, crop production, etc.

Project implementation must be sufficiently flexible to take into account changed circumstances, which are difficult to predict. For example, price changes may necessitate different cropping patterns or adjustments in inputs.

1.5. Monitoring and evaluation

Monitoring takes place throughout project implementation and helps management to keep track of project progress. Monitoring reports provide the bulk of the information required for evaluating a project. Monitoring can also be used to improve the management of the irrigated plot in terms of which agronomic technologies to use, the allocation of resources and decisions on what to produce.

Evaluation assesses whether:

- Project objectives have been met
- Activities have been implemented as planned
- Anticipated benefits have been achieved

The analyst looks systematically at the elements of success and failure in the project experience to learn how to better plan for the future. Evaluation is not limited to completed projects. It is a most important managerial tool in ongoing projects and rather formalized evaluation may take place several times during the lifetime of a project. It may be undertaken when the project is in trouble, as the first step in a re-planning effort. Often a mid-term evaluation takes place and evaluation should be undertaken when a project is terminated or is well into routine operation.

Many different people may participate in the evaluation. Project management will be continuously evaluating its experience as implementation proceeds. The sponsoring agency, perhaps the operating ministry, the planning agency, an external assistance agency, may undertake evaluation. In large projects, the project's administrative structure may provide for a separate evaluation unit responsible for monitoring the project's implementation and for bringing problems to the attention of the project's management.

In many instances project management or the sponsoring agency will want to turn to outside evaluators. Whoever does the evaluation will want to read the relevant documents carefully and then have extensive conversations with those who have had a part in the project, such as planners, project managers, operating staff, participating farmers, or local people affected by the project.

Monitoring the technical and financial performance of an irrigation scheme is dealt with in Module 14. This Module will describe in detail in the following chapters the process of carrying out financial and economic appraisals, using Mutange drag-hose sprinkler irrigation scheme as a working example.

Chapter 2
Financial analysis

Analyzing the financial benefits of an irrigation project involves looking at the project at two levels: the farmer level and the scheme level. At farmer level, we look at production levels, labour requirements and net income 'with' and 'without' the project. At scheme level, we look at costs incurred in constructing, operating and managing the whole scheme. Scheme-level costs are then compared with estimated income from the whole scheme (all irrigators) to assess the financial benefits of investing in irrigation.

2.1. Farm income analysis

In analyzing a project, the underlying assumption we make is that, for a farm or farming community, the objective will be maximization of the income that the families will earn as a result of participating in the project. To achieve the objective, we must analyze the resource use, the income generated by the operation of the project and the investment. This section deals with the first two aspects, while the investment aspects will be dealt with in Section 2.2.

The resources used consist of land, water, labour and inputs. The tools to evaluate these resources are cropping patterns, labour requirements and crop budgets.

2.1.1. Cropping patterns

When an irrigation project is introduced, the area for irrigation might be taken from the participating farmers' landholdings being used for rainfed cultivation. If the farmers become full-time irrigators, they might commit all their rainfed land. This means that by switching to irrigation the income that used to come from this rainfed land is lost and the income from irrigation is gained. In order to assess the impact of this, we have to establish what was grown on the rainfed land and look at the new cropping pattern for the irrigated area. Where the land was previously unutilized or is reclaimed, the 'without-project' situation would be zero.

The 'without-project' situation

Table 1 lists the cropping pattern for a proposed drag-hose sprinkler scheme, called Mutange irrigation scheme, that farmers practice on their land under rainfed conditions. The scheme has 210 farmers, each farmer having on average 3 ha of rainfed plots. The calculated average yields are also shown in Table 1. Farmers will be expected to give up an average of 0.5 ha each towards irrigation development and retain 2.5 ha for rainfed crop production.

Table 1

Current cropping pattern under rainfed conditions of farmers participating in Mutange irrigation scheme

Crop	Area planted (ha)	% of total area planted (%)	Average yield (tons/ha)
Grain maize	1.10	36.7	1.1
Sorghum	0.15	5.0	0.8
Pearl millet	0.05	1.7	0.9
Groundnuts	0.70	23.3	1.4
Cotton	1.00	33.3	1.0
Total	**3.00**	**100.0**	

The 'with-project' situation

To estimate the benefits of the project, a cropping pattern for the irrigated area is proposed. In proposing a cropping pattern, several factors have to be taken into consideration:

- The farmers' wishes and aspirations
- Marketing aspects (consumer and/or industrial)
- Government regulations
- Agronomic aspects
  - soils
  - climatic conditions
  - crop water requirements
  - rotational considerations
- Access to inputs
- Financial considerations
- Labour requirements

Farmers will have some idea of what they want to grow, stemming from their knowledge of the area and of what is especially in demand in terms of their household requirements or the market. This might or might not coincide with what is feasible, since the proposed crops should be in accordance with the agronomic conditions above. But whatever is proposed will have to be approved by the farmers.

One of the major aspects of choosing a cropping pattern under irrigation is to determine whether there is a market for the crops. The production structure has to fit the market, and possible markets and their supply and demand have to be determined. In doing this, it is important to look into the following elements:

- How big is the market now and what will be its size in the future?
- What sort of competition exists in the market? Do a few big suppliers or many small ones dominate it?
- How far is the market from the scheme? Are there suitable marketing channels available?
- What sort of price variations can be expected? Is the price very sensitive to supply variations?
- What sort of storage and packaging facilities are necessary to enter the market and are they available?
- Can the scheme act as a reliable and continuous supplier and thus improve the competitive position?
- Is there a specific niche that the scheme has good possibilities of exploiting?
- What are the options for hedging, i.e. delivering on contract?
- Are the farmers capable of organizing the marketing, which means organizing the harvesting, preparing and packing the produce and organizing the transport?

Though not all these questions may be answered satisfactorily, it is important that they at least are considered when the proposed cropping pattern is worked out. The larger the scheme the more crucial it is to have a clear view of exactly how the marketing is going to take place. One general rule normally applies: the safer the market the lower the price.

Marketing arrangements, such as contracts with private companies, cooperatives or farmers' associations where prices and volumes are agreed upon early in the season, provide a ready market for some crops but the prices paid result in moderate returns. On the other hand, there is very little risk involved compared with selling on the open market.

The availability of inputs is a factor that influences the implementation of the actual cropping pattern. It may be difficult, however, to take this into account when preparing the feasibility study as supply situations change continuously.

In choosing the crops, it should also be considered whether the most profitable ones fulfil other requirements that include:

- Reliable demand
- Local consumption potential
- Food security

Lastly, the labour requirements will have to be determined in order to establish whether the farmers can provide the extra labour needed. Section 2.1.2 will elaborate on this.

Having taken all these factors into consideration, a proposed cropping pattern can be established. Table 2 gives an example for Mutange proposed irrigation scheme. The total area is 105 ha with 210 farmers, each with 0.5 ha under irrigation.

Table 2
Proposed cropping pattern for Mutange irrigation scheme (105 ha, 200% cropping intensity)

Crop	Area planted (ha)	% of total area
Grain maize	42	40
Sugar beans	42	40
Groundnuts	21	20
Green maize	42	40
Wheat	42	40
Cabbages	21	20
Total	**210**	**200**

Yield estimates should be based on experience from various irrigation schemes. In some countries, government agricultural departments produce farm viability models detailing potential yields under various conditions. Where available, these data can be used to estimate potential yields for a planned scheme.

In estimating yields for grain maize it is assumed that the farmers in Mutange irrigation scheme will obtain good yields early in the project, as they are familiar with the agronomic practices of this crop. For the other crops, a learning process should be assumed so that yields are estimated at 70% of the target yield in year 1 and increase to reach 100% from year 4 onwards. The estimated yields for Mutange proposed irrigation scheme are listed in Table 3.

2.1.2. Labour requirements

The labour requirements are calculated on a crop-by-crop basis and added up to estimate the total requirements in any given situation. Where an exhaustive survey on labour requirements on smallholder irrigation schemes has been carried out, this provides the data associated with various operations in the proposed scheme. For our example of Mutange proposed irrigation scheme, labour requirements for each crop have been estimated on the basis of information from the Farm Management Handbook (Agritex, 1993).

Table 3
Estimated yields in Mutange irrigation scheme

Crop	Unit	Year 1	Year 2	Year 3	Year 4
Grain maize	tons/ha	4.2	6	6	6
Sugar beans	tons/ha	1.4	1.6	1.8	2
Groundnuts	tons/ha	2.5	2.8	3.2	4
Green maize	cobs/ha	31 500	36 000	40 500	45 000
Wheat	tons/ha	3.5	4	4.5	5
Cabbages	heads/ha	28 000	32 000	36 000	40 000

When calculating the requirements for each crop, not only the total requirements but also the distribution over the cropping period will have to be established so that the labour requirements in the peak periods can be determined. Labour requirements for the common irrigated and rainfed crops are listed in Appendix 1. They indicate the number of labour days required for individual activities such as manuring, planting, irrigation, etc.

When looking at the labour requirements associated with the project, two main questions have to be addressed:

- ❖ What are the additional labour requirements that the project will induce?
- ❖ Will the farmers involved be able to cope with the total labour requirements in the 'with-project' situation?

To answer these questions, it is important to assess total labour requirements for the 'without-project' situation and compare the figure to the 'with-project' situation. Total labour requirements for the project are compared with the total labour available so that periods of labour shortage can be identified.

The main activities on any given farm can be categorized as:

- ❖ Cropping
- ❖ Other on-farm activities

As for cropping, socio-economic surveys on the project community will have established the rainfed cropping pattern, including the crops grown and the respective areas cropped (Table 1). By applying the estimated labour requirements for the rainfed crops on a monthly basis, the total labour requirements for the rainfed crops can be determined.

For the other on-farm activities, usually no surveys have been carried out to determine the labour required for such tasks as:

- ❖ Cooking
- ❖ Firewood collection
- ❖ House construction and repair
- ❖ Looking after cattle
- ❖ Social activities

As these activities have not been quantified, some allowance must be made to cater for the labour needed. This is done through not counting children aged below 18 years as available labour during the school year, although they will be available for these tasks after school hours (at least primary school children). Furthermore, it is assumed that the labour day is only 8 hours although farmers would be able to work longer hours in the field. Also 20 workdays per month are assumed, which is roughly equal to a 5-day working week. Table 4 shows the use of labour in the 'without-project' situation.

Table 4
Household labour requirements for a rainfed area of 3 ha: 'without-project' situation in Mutange irrigation scheme

Crop	Area (ha)	Labour requirements (labour days)												
		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Grain maize	1.10	9.3	15.1	6.1	24.2	12.2	13.4	14.6				18.2	18.4	**131.5**
Sorghum	0.15	0.9	0.0	0.0	0.0	5.2	8.9					0.4	0.9	**16.4**
Pearl millet	0.05	0.3	0.0	0.0	0.0	1.7	3.0					0.1	0.3	**5.5**
Groundnuts	0.70	0.8	8.6	24.2	8.5	2.7						0.2	10.2	**55.3**
Cotton	1.00	10.1	5.3	27.6	96.7	7.7						12.4	22.1	**181.9**
Total requirement		**21.4**	**29.0**	**57.8**	**129.4**	**29.6**	**25.3**	**14.6**	**0.0**	**0.0**	**0.0**	**31.4**	**52.0**	**390.6**
Available labour		90.0	60.0	60.0	90.0	90.0	60.0	60.0	90.0	90.0	60.0	60.0	90.0	**900.0**
Hired labour		0.0	0.0	0.0	39.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**39.4**

Available labour used in the example is based on the following, which has derived from the baseline socio-economic survey carried out during the initial stages of project formulation:

- ❖ Average family size of 9 people
- ❖ Average family composition:
  - – three adults (> 18 years)
  - – three school going children (9-18 years)
  - – three small children (< 9 years)
- ❖ Adults provide 20 labour days per month
- ❖ School children provide 20 labour days during school holidays
- ❖ Children below 9 years provide no labour

Table 4 suggests that there is a labour shortage in the project area in the 'without-project' situation in April, which is the cotton picking time. Labour has to be hired to make up for the shortfall. It is estimated that about 30 days will be hired for cotton and 10 for groundnuts in the month of April (see Table A2-26 and A2-27 in Appendix 2).

The 'with-project' situation includes the 0.5 ha irrigated area and the 2.5 ha rainfed land that the farmers will have after joining the scheme. In the case of full-time irrigators, no rainfed cropping is assumed. It is further assumed that, apart from the cropping, the other activities remain constant as compared to the 'without-project' situation.

Using the irrigated cropping pattern, as presented in Table 2, the 'with-project' labour requirements can be calculated (Table 5). Comparing it with the available labour, we can establish the amount of labour that needs to be hired.

The available labour is estimated as an average figure, based on the assumptions on household composition made above. This ignores the variation that will exist between farms. Accordingly, there may be a need to estimate what proportion of the families will not be able to meet the labour requirements. If this proportion is significant, it might be advisable to look for a less labour intensive cropping pattern or perhaps put forward some conditions concerning the size of families selected for irrigation or ensure that the cash income generated from irrigation is large enough to hire the extra labour. If the calculation shows that there is need for hired labour during certain months, some thought should be given as to whether this labour will be available.

For Mutange, both the 'without-project' (Table 4) and the 'with-project' (Table 5) situations demand that labour be hired in April when the labour requirements exceed the average labour available per family. The amount of additional labour required in the 'with-project' situation compared to the 'without-project' situation is 51.7-39.4=12.3 labour days, which is limited. It may therefore be assumed that the farmers will be able to provide enough labour to operate the scheme successfully, either by working slightly longer hours and/or working on some weekends.

2.1.3. Gross margin analysis

Crop budgets contain the evaluation of gross margins per hectare for the different crops. Gross margin is the income generated from a production activity and is equal to the difference between the total gross income and the total variable costs. Table 6 provides an example of a crop budget for irrigated cabbages. Gross margin for the most common irrigated and rainfed crops are given in Appendix 2.

Table 5

Household labour requirements for an irrigated area of 0.5 ha (200% cropping intensity) and a rainfed area of 2.5 ha: 'with-project' situation in Mutange irrigation scheme

	Area	Labour requirements (labour days)												
Crop	(ha)	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Grain maize, irrigated	0.20	2.1	3.2	0.7	6.8	0.9	0.9	0.9				5.8	5.9	**27.3**
Sugar beans, irrigated	0.20	6.4	6.6	4.1	5.3	4.2	1.6							**28.1**
Groundnuts, irrigated	0.10	2.9	5.0	3.8	0.8						3.6	3.1	1.6	**20.7**
Wheat, irrigated	0.20					4.5	6.1	2.8	3.7	2.8	20.2			**40.0**
Green maize, irrigated	0.20								5.8	5.9	2.1	2.8	5.3	**21.9**
Cabbages, irrigated	0.10			0.2	4.0	3.3	2.3	2.0	4.4					**16.2**
Grain maize, rainfed	1.00	8.5	13.8	5.5	22.0	11.1	12.2	13.3				16.5	16.7	**119.6**
Groundnuts, rainfed	0.50	0.6	6.2	17.3	6.1	1.9						0.2	7.3	**39.5**
Cotton, rainfed	1.00	10.1	5.3	27.6	96.7	7.7						12.4	22.1	**181.9**
Total requirement		**30.5**	**40.0**	**59.1**	**141.7**	**33.6**	**23.1**	**19.0**	**13.9**	**8.6**	**25.9**	**40.8**	**58.9**	**495.2**
Available labour		90.0	60.0	60.0	90.0	90.0	60.0	60.0	90.0	90.0	60.0	60.0	90.0	**900.0**
Hired labour		0.0	0.0	0.0	51.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**51.7**

Table 6
Gross margin budget for irrigated cabbage for a 1 ha plot

	Quantity	Unit	Unit cost	Year 1	Year 2	Year 3	Year 4
Area (1)		ha		1.00	1.00	1.00	1.00
Saleable yield (2)		heads/ha		28 000	32 000	36 000	40 000
Saleable harvest (3) = (1) x (2)		heads		28 000	32 000	36 000	40 000
Price (4)		US$/head		0.27	0.27	0.27	0.27
Gross income (5) = (3) x (4)		**US$**		**7 560.00**	**8 640.00**	**9 720.00**	**10 800.00**
Variable costs:			US$	US$	US$	US$	US$
Land preparation	1.00	ha	38.18	38.18	38.18	38.18	38.18
Seed	0.45	kg	18.18	8.18	8.18	8.18	8.18
Fertilizer:							
Compound S	1 000	kg	0.67	670.00	670.00	670.00	670.00
Ammonium nitrate	400	kg	0.37	148.00	148.00	148.00	148.00
Transport of inputs to farm	1.4	ton	18.18	25.45	25.45	25.45	25.45
Chemicals:							
Endosulfan 35MO	2	litre	24.12	48.24	48.24	48.24	48.24
Dichlorvos	1	litre	76.36	76.36	76.36	76.36	76.36
Dimethoate	0.75	kg	15.45	11.59	11.59	11.59	11.59
Seasonal loan interest (6%)		US$		61.56	61.56	61.56	61.58
Hired labour	90	days	3.09	278.10	278.10	278.10	278.10
Transport of output/harvest		1000 heads	36.36	1 018.08	1 163.52	1 308.96	1 454.40
Total variable costs (6)				**2 383.74**	**2 529.18**	**2 674.62**	**2 820.06**
Gross margin (7) = (5) - (6)		**US$**		**5 176.26**	**6 110.82**	**7 045.38**	**7 979.94**

The various components in the table are described below.

Yield, harvest and price

The basis for estimating the total income earnings from production are the harvest (= yield x area) and the unit price that farmers are likely to obtain, taking into account the season and the local market conditions. Multiplying the harvest and the estimated unit price gives the estimated gross income.

The estimated yields for Mutange irrigation scheme are presented in Table 3. For horticultural crops, the marketable or saleable harvest takes into account losses that might occur since it is unlikely that the entire crop can be marketed. Losses can be due to poor harvesting methods or they can occur during storage and problems in marketing (for example not providing sufficient transport and not reaching the market at the right time). The exact rate of loss will vary depending on the type of crop and the distance to market. If a crop is highly perishable and is grown in a remote area with unreliable transport facilities, then higher losses should be anticipated compared to a crop that stores well in a scheme that is favourably located in respect of transport and market.

The prices used in crop budget estimates and investment calculations can stem from different sources:

- ❖ Suppliers of agricultural inputs
- ❖ Marketing boards
- ❖ Prices observed in local markets

Input suppliers' prices are used directly. Blend prices, which are average prices for various grades of the same product (see below), are used for crops sold to marketing boards. For freely marketed crops, major markets may be monitored closely to provide average prices for each month.

Gross income

The gross income is the total value of production from an enterprise. It includes sales plus value of retained produce for consumption at home (farm) and any by-products with value, such as retentions for livestock feed:

- ❖ Gross income of marketed output = marketed output (quantity) x market blend price (US$/unit quantity)
- ❖ Gross income of retained output = output retained (quantity) x farm gate price (US$/unit quantity), where farm gate price is the value the produce would have fetched if sold

- Total gross income = gross income of marketed output + gross income of retained output

Where there are differentials between grades for the marketed output, a blend price is calculated as shown in the following example for cabbages:

Grade	% of total quantity	Price (US$/ head)	Average price (US$/head)
Good quality crop	60	0.35	(60/100) x 0.35 = 0.21
Average quality crop	20	0.20	(20/100) x 0.20 = 0.04
Poor quality crop	20	0.10	(20/100) x 0.10 = 0.02
Total	100		0.27

Thus, in our example the average market price or blend price of one head of cabbage would be: US$0.27.

Variable costs

Variable costs are the costs that:

- Can be directly allocated to a particular enterprise in a production season
- Tend to change with the size of the enterprise and the scale of production
- Can be avoided if management so decide, for example by not harvesting a crop the labour cost for harvesting, fuel and overtime costs are saved

The variable costs included in our crop budget are:

- Land preparation (hired labour or equipment)
- Planting material (for example seed)
- Fertilizers (both organic and inorganic)
- Chemicals (pesticides, insecticides, herbicides)
- Transport of inputs
- Interest on seasonal loan, if money for inputs is borrowed
- Casual labour for weeding, harvesting, etc.
- Packing material
- Transport of outputs
- Marketing costs

Household labour is not costed in this case. The gross margin for each enterprise is assumed to be the return to family labour and capital.

Expenses for *land preparation* should be indicated if help is brought in from outside, for example contract ploughing, and costed on a per hectare basis. If the farmers themselves do land preparation, it should not be included as a cash expenditure as the purpose of this analysis is to establish the return to the resources of labour and capital invested by the farmer.

For *planting material, fertilizers and chemicals*, the rates recommended from research and extension are applied and valued at the most recently available prices. In the budget of the example of cabbage above, it is assumed that the increasing yields over the first four years of the project are not dependent on the input of seed, fertilizers and chemicals, but solely on the improvement in cultural practices and management, such as correct and timely application of fertilizers and chemicals.

The expenses for *transport of inputs* will vary according to the quantities of input and the price that would be charged to the project site. The quantities are given and can easily be summarized, but the transport costs from prospective transporters need to be established.

Interest on seasonal loan is calculated as a percentage of the total cost of the inputs (land preparation, seed, fertilizers, chemicals and transport of inputs to the farm). Calculations in Appendix 2 show the interest used per year as 12%. It is assumed that the farmers will pay back the loan after each season of approximately six months. Thus, a seasonal interest rate of about 6% is applied. It is assumed that the transport cost of output can be covered from savings and proceeds from sales, thus no seasonal interest is charged on the transport of output.

Hired labour cost is included in the crop budget if there is a disparity between available household labour and required labour during the production period of the crop.

Packing material should be included in the crop budget to an extent that is deemed realistic. For cabbages, no cost for packaging was included as the crop is assumed to be sold by the 'head'. For crops like potatoes, dry onions and carrots, which are normally sold by the pocket, an allowance for packing will have to be made. This is done by dividing the harvest by the weight of the standard unit. For example, for grain maize, the standard weight is a 50 kg bag. If the marketed harvest in one year is 3 tons for 1 ha, then 3 000/50 = 60 bags are required.

As far as the *transport of output* is concerned, some output will be sold locally at the farm-gate, with little or no transport costs involved, and some will be sold in markets further away as local markets normally cannot absorb the total output from the scheme. Accordingly, assumptions would have to be made as to what proportion of the crop will be sold where. One would normally apply the transport charges to the nearest major market outlets. Then a calculated price per ton for local transporters could be applied.

Marketing costs are usually included in the crop budget. These refer to expenses that are connected with the marketing itself, such as fees for market stands, personal transport for farmers to the market and/or marketing fees charged by wholesalers (where wholesalers sell on commission, for example).

A small allowance (2%) is usually added to the costs, for unforeseen miscellaneous expenses.

Gross margin

The gross margin of an enterprise is the difference between the total gross income earnings and the total variable costs. This is then the estimated gross return to the labour and capital that a farmer has invested for a unit land area of the particular crop. The gross margin is usually expressed on a per hectare basis to allow for comparison of different crops. The gross margin of different enterprises on the farm can be added up to come up with a whole farm margin.

Standard crop budgets or viability models for various crops are usually produced by government research and/or extension departments and can be used to make rough estimates of enterprise performance. Examples of these crop budgets are listed in Appendix 2. Adjustments need to be made to these standard crop budgets depending on specific conditions on the ground, such as soil quality, temperatures, farmer management levels, etc.

When the crop budgets for all crops have been made, the whole plot gross margin for the irrigated area and any income foregone in the rainfed land can be estimated. As an example, the gross margin of the 0.5 ha irrigated land with a cropping intensity of 200% is listed in Table 7 and the income forgone on the 0.5 ha rainfed land is given in Table 8.

The gross margin of the 0.5 ha irrigated plot (200% cropping intensity) multiplied by the number of plots in the scheme (210) is used in the scheme investment analysis to approximate the 'with-project' benefits of the irrigation scheme (Table A2-3) (Section 2.2). The gross margin for the rainfed plot foregone (0.5 ha) multiplied by the number of farmers (210) is used in the farm investment analysis to approximate the 'without-project' benefits (Table A2-2).

Table 8

Gross margin for the rainfed area of 0.5 ha foregone due to transformation into irrigation, at Mutange irrigation scheme

Crop	Area		Gross margin
	(%)	(ha)	(US$)
Maize	20	0.10	25
Groundnuts	40	0.20	108
Sorghum	30	0.15	30
Pearl millet	10	0.05	12
Total	**100**	**0.50**	**176**

2.2. Scheme investment analysis

The scheme investment analysis looks at the scheme income based on the gross margins, investment costs and the operation and maintenance costs. The analysis seeks to compare the anticipated 'with-project' situation to the 'without-project' situation for the duration of the project. The analysis seeks to judge the likely incremental benefits to project participants and the incentive for farmers to participate in the project, thus looking at the attractiveness of the project to the participating farmers. The analysis also indicates the contribution of the various agencies to the project in terms of finance and technical assistance.

The farm investment analysis utilizes the information collected from the farmers to determine the 'without-project' income levels, compares them with the 'with-project' income levels and determines the difference, the incremental income or net benefits. It should be noted that this only looks at the irrigation project. The spillover effects on the rainfed land and livestock are not considered.

Table 7

Gross margin for the irrigated area of 0.5 ha (200% cropping intensity) at Mutange irrigation scheme

Crop	Area		Gross margin (US$)			
	(%)	(ha)	Year 1	Year 2	Year 3	Year 4
Grain maize	40	0.2	102	193	193	193
Sugar beans	40	0.2	171	213	255	297
Groundnuts	20	0.1	99	121	149	205
Wheat	40	0.2	230	280	331	382
Green maize	40	0.2	1 031	1 193	1 355	1 518
Cabbages	20	0.1	518	611	705	798
Total	**200**		**2 151**	**2 611**	**2 988**	**3 393**

Since the analysis follows discounted cash flow analysis, the time-adjusted cash flows are utilized. This means that the accounting convention that assumes that every transaction falls at the end of the accounting period (end of every year in our case) is used. This means that the initial investment is considered to take place at the end of the first year of the project. Year 2 is the first accounting period in which increases in operating costs as well as increases in income occur. An exception to this will be if the project involves the construction of a dam. Then the projected construction period will have to be taken into account.

2.2.1. Investment

Investment refers to the initial costs of construction of the irrigation scheme. The cost items included depend on the type of system. The investment cost estimates for Mutange proposed drag-hose sprinkler irrigation scheme are listed in Table 9. If houses and toilets are constructed for the project, they should also be included in the calculation of the initial costs to field edge (head works and conveyance system) and the infield works.

Table 9

Investment cost estimate for Mutange irrigation scheme (105 ha)

Description	Estimated Cost (US$)	
	Whole scheme	Cost per ha
Head works	89 257	850
Infield Works	330 605	3 149
Fence, roads and drains	87 706	835
Initial land clearing	20 634	197
Housing and sanitation	126 098	1 201
Equipment and materials	363 624	3 463
Contingencies	72 985	695
Total	**1 090 909**	**10 390**

2.2.2. Land

Where land for irrigation development is purchased, this major item of cost must appear in the investment analysis. Similarly, where land for irrigation has to be rented, the rental appears as a cost in the investment analysis. However, in most of the East and Southern Africa sub-region, land has no significant market value attached to it, due to lack of title deeds for smallholder farms. Thus the cost of land is not included in this working example.

2.2.3. Operating costs

The operating expenditure is calculated for the costs of equipment utilized in making the investment functional and would include the ones described below.

Replacement costs

These are the costs incurred to replace specific items. In the example of Mutange irrigation scheme (Table 10), the following assumptions about the replacements are made:

- All hoses and valves should be replaced every 5 years
- All sprinklers and tripods should be replaced every 10 years
- The pumping unit should be replaced every 15 years

Table 10

Replacement costs for Mutange irrigation scheme

Item	Replacement period (year)	Cost of replacement (US$)
Hoses and valves	5	24 936
Sprinklers and tripods	10	52 161
Pumping unit	15	59 520

Energy costs

This depends on the elevation of the water source relative to the elevation of the scheme, which determines whether water should be pumped in order to reach the scheme, and on the irrigation system used (surface or pressurized). In the case of an overhead or pressurized irrigation system, energy costs used in the appraisal are estimated on a per crop basis (assuming crop water requirements, pumping head and conveyance needs). Mutange irrigation scheme has a pressurized irrigation system (drag-hose sprinkler). Engineers designing the irrigation scheme could provide the figure for energy requirements of the system. Fixed charges, levied by the power authority, can also be included in the energy cost. Where the source of fuel is diesel or petrol, the energy cost is the estimated cost of diesel or petrol that the farmers will be expected to pay.

Repair and maintenance costs

These costs are usually assumed to depend on the cost of the equipment utilized. Thus a percentage of the cost of equipment (normally ranging from 1.5-5%) is taken as repair and maintenance costs per year. Real costs can be used if known from other similar schemes. In the case of Mutange irrigation scheme, the repair and maintenance costs are assumed to be 3% of the investment cost per year.

Technical support

In large irrigation schemes, government may commit at least one full-time agricultural extension officer to advise farmers on their agricultural activities. The cost of this technical expertise (mainly salary) is included in the analysis of the project.

Water charges

These are the charges payable to whoever supplies water, for example the national water authority. Where water is purchased, the water charges should be indicated as a cost. In the case of Mutange, water charges are not included.

2.2.4. Other costs and/or benefits

Sunk cost

Sunk cost is the cost incurred in the past that cannot be retrieved as a residual value from an earlier project. A sunk cost has no opportunity cost, as the assets represented by the sunk cost have no alternative use. A sunk cost is therefore not included in the outflow when projects are analyzed. This can be the case if the project is a rehabilitation of a previously operated irrigation scheme and a dam was constructed to provide water for the previous irrigation scheme. Then the dam is considered a sunk cost. This is the case for Mutange irrigation scheme.

Residual value

This is the value of the asset remaining unused at the end of a project. The asset can be termed a residual asset. In project analysis the residual value is generally added to the benefit stream at the end of the project. Salvage value or scrap value are forms of residual values that refer to the estimated value of the asset at the end of the project period. In our analysis we assume this value to be zero as the project period will be the same as the estimated lifetime of the irrigation system.

Drought relief

If the irrigation scheme is in a drought-prone area and is financed by the government, a further benefit should enter into the calculations, namely the saved drought relief expenditure. However, for reasons of simplicity, this has been omitted in the Mutange example.

2.3. Setting up the investment budget

Having assessed the costs and benefits, the budget of the Mutange irrigation scheme can be set up. Table 11 lists the budget items. The calculation would be different if the cost of acquiring land and building a dam were included. For reasons given in the previous section, it was decided not to include them. The tables in Appendix 3 provide more details.

Before the budget can be evaluated and the viability of the project assessed, the problems of comparing costs and incomes from different time periods and how to summarize the viability using simple indicators have to be dealt with. For this the project period needs to be known and the time value of money needs to be estimated, which includes determining the discount rate, compounding, discounting and the present values of equal income streams. This process will be explained below.

2.4. Project period

If the project centres on one major asset, for example the irrigation system, the project period will be the estimated life of this asset, which is usually 20 years for irrigation equipment. If a dam were constructed in connection with the scheme, then the time horizon would be extended to cover the expected lifetime of the dam (usually 30 years). For external funding, however, the project period is currently shorter, about 3-5 years.

2.5. Time value of money

When the costs and benefits of a project are spread over time, the problem arises of how to compare future income with present income. To be able to do this, the value of future income has to be reduced to its present worth. This is based on the principle that a dollar buys more today than it buys tomorrow.

2.5.1. Determining the discount rate

The factor used to reduce projected future income or to accumulate loans taken now, is the discount rate or interest. There are two main explanations for interest:

- *Time preference:* Having money in your hand today is better than having it in your hand a year from now, when its value may have been eroded by inflation. Uncertainty about the future also results in preference for money today rather than in the future.
- *Opportunity cost of capital:* If you lend out money, you give somebody else the opportunity to invest the money productively while foregoing the possibility of doing this yourself. There is an opportunity cost to lending out your capital. This should be covered by the interest charged.

The actual interest rate that is used is influenced by the above-mentioned as well as by the following factors:

- *The capital market rate:* What is the going rate for loans? Government and Central Bank regulations will have a significant influence on this rate.

Table 11

Investment budget for Mutange irrigation scheme (US$): financial analysis (all investment costs included)

Year	Investment cost	Replacement cost	Energy cost	Repairs and maintenance	Technical support	Without-project benefit	With-project benefit	Net benefit
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
1	1 090 909		0	0	0	36 878	0	-1 127 787
2			22 126	32 727	14 545	36 878	451 663	345 387
3			22 126	32 727	14 545	36 878	548 352	442 077
4			22 126	32 727	14 545	36 878	627 446	521 171
5			22 126	32 727	14 545	36 878	712 469	606 193
6		24 936	22 126	32 727	14 545	36 878	712 469	581 257
7			22 126	32 727	14 545	36 878	712 469	606 193
8			22 126	32 727	14 545	36 878	712 469	606 193
9			22 126	32 727	14 545	36 878	712 469	606 193
10			22 126	32 727	14 545	36 878	712 469	606 193
11		77 097	22 126	32 727	14 545	36 878	712 469	529 096
12			22 126	32 727	14 545	36 878	712 469	606 193
13			22 126	32 727	14 545	36 878	712 469	606 193
14			22 126	32 727	14 545	36 878	712 469	606 193
15			22 126	32 727	14 545	36 878	712 469	606 193
16		84 456	22 126	32 727	14 545	36 878	712 469	521 737
17			22 126	32 727	14 545	36 878	712 469	606 193
18			22 126	32 727	14 545	36 878	712 469	606 193
19			22 126	32 727	14 545	36 878	712 469	606 193
20			22 126	32 727	14 545	36 878	712 469	606 193
21			22 126	32 727	14 545	36 878	712 469	606 193
Total	**1 090 909**	**186 489**	**442 527**	**654 545**	**290 909**	**774 428**	**13 739 429**	**10 299 643**

(7) = income foregone on rainfed land

(9) = (8) - (7) - (6) - (5) - (4) - (3) - (2)

- *The rate of inflation:* The lender will want to be covered for expected inflation. Accordingly, high inflation means higher interest rates.
- *Uncertainty:* If there is great uncertainty about the country's economic or political future, the interest rates rise to compensate for the perceived risk.
- *Institutional arrangements:* There might be a government policy to provide funding for specific purposes, such as smallholder irrigation, at concessionary interest rates.
- *The farmer's personal attitude to different investment opportunities:* Are they, for example, prepared to accept 12% interest as a reasonable return on their money or do they want more than 12%? What is their preference for an extra dollar sooner versus an extra dollar they might receive much later?

For the financial analysis, the discount rate is the cost of borrowing money, which is the interest that the lender is charging in order to be compensated for foregoing the use of the money now.

For a project funded through borrowed money and farmers' equity (the difference between assets and liabilities), the discount rate should be the weighted average of the interest on borrowed funds and the farmers' minimum acceptable rate of return. An example of minimum acceptable rate of return could be risk-free fixed deposits.

The discount rate can be expressed as follows:

Equation 1

$$\text{Discount rate} = \frac{\text{(borrowed funds x interest)}}{\text{total funds}} + \frac{\text{(equity x return on equity)}}{\text{total funds}}$$

2.5.2. Compounding

Compounding is the process of calculating the accumulation of money at a certain interest rate to arrive at the value of the money in future.

Consider a farmer who borrows US$1 000 on 31 December 2001 at 10% interest. Assuming that there are no installments on the loan, then a year later the amount owed will be US$1 000 x 1.10 = US$1 100. If the loan accumulates for another four years, additional interest will be added as outlined in Table 12.

Table 12

Compounding of a loan of US$1 000 over 5 years at an interest rate of 10% per year

Year	US$ at year start	Multiplying factor (10% interest)	US$ at year end
2001			1 000
2002	1 000	1.10	1 100
2003	1 100	1.10	1 210
2004	1 210	1.10	1 331
2005	1 331	1.10	1 464
2006	1 464	1.10	1 611

At the end of 5 years the debt will have accumulated to US$1 611. From Table 12, the following formula for compounding a 5-year loan can be derived:

Debt after 5 years = US$1 000 x 1.10 x 1.10 x 1.10 x 1.10 x 1.10 = US$1 000 x 1.10^5

The general formula is:

Equation 2

$$FV = PV \times (1 + i)^n$$

Where:

FV = Future value (total amount payable)

PV = Initial amount borrowed (present value)

i = Interest rate

n = Number of years

$(1 + i)^n$ = Compounding factor CF

The higher the interest rate charged the higher the total amount payable. For example, the total amount payable on a loan of US$1 000 borrowed over 5 years at 20% interest rate is $1000 \times (1 + 0.20)^5 = 1\,000 \times 2.488 =$ US$2 488, compared to US$1 611, if borrowed at 10% interest rate (Table 12). Table A4-1 (Appendix 4) provides compounding factor values over a period of 40 years for different interest rates.

2.5.3. Discounting

The reverse of compounding is discounting, which is the process of finding the present worth or present value (PV) of a future value (FV). Discounting is used to establish what the income earned in future will be worth today.

Compounding →

Present value (PV) ⇄ Future value (FV)

← Discounting

So, reversing the example in Table 12, we can calculate what is the present value (PV) of US$1 611 received 5 years from now. The general formula then becomes:

Equation 3

$$PV = FV \times \frac{1}{(1 + i)^n}$$

Where:

$$\frac{1}{(1 + i)^n} = \text{Discounting factor DF}$$

Table 13

Discounting of a loan of US$1 000 received 5 years from now at an interest rate of 10% per year

Year	US$ at year end	Dividing factor (10% interest)	US$ at year start
2006	1 611	1.10	1 465
2005	1 465	1.10	1 331
2004	1 331	1.10	1 210
2003	1 210	1.10	1 100
2002	1 100	1.10	1 000
2001	1 000		

Table 13 can be interpreted as follows: receiving US$1 611 on 31 December 2006 is worth the same as receiving US$1 000 now. In other words, an offer of US$1 611 in 5 years' time is as attractive as an offer of US$1 000 now. This is the justification for discounting. It enables flows of different years to be compared with the present flows. Table A4-2 (Appendix 4) provides discount factor values over a period of 40 years for different interest rates.

In the appraisal of an irrigation project discounting is important, because it allows for comparison of income and cost streams that are realized over several years in the life of the project.

2.5.4. Present value of future equal income streams

In appraising a project, one may also have to deal with future equal or even income streams. The present value of an equal income stream of $1 000 per year is calculated in Table 14.

Table 14

Discounting an equal annual income (US$1 000/year) over a 5-year period at 10% discount rate

Year	Amount received US$	Discount factor (10% interest)	Discounted amount US$
2001	1 000	0.9091	909
2002	1 000	0.8264	826
2003	1 000	0.7513	751
2004	1 000	0.6830	683
2005	1 000	0.6209	621
Total	**5 000**		**3 790**

Table 14 shows that the present worth of US$1 000 paid yearly over the next 5 years is not US$5 000, but US$3 791.

It is time-consuming and unnecessary to do these calculations for equal income streams. Instead, the sum of the discount factors can be used:

PV = Amount received x annuity factor
= 1 000 x (0.9091 + 0.8264 + 0.7513 + 0.6830 + 0.6209)
= 1 000 x (3.7907)
= 3 790

The sum of the discount factors equals the present worth of the annuity factor. Present worth of annuity factor values over a period of 40 years for different interest rates are given in Table A4-3 (Appendix 4). The formula to calculate them is:

Equation 4

$$AF_n = \left[\frac{AF_{n-1} - AF_{n-2}}{(1 + i)}\right] + AF_{n-1}$$

Where:

AF = Present worth of annuity factor
n = Number of years
i = Interest rate

2.6. Measuring the project worthiness

Having introduced methods to deal with the time dimension, the viability or worthiness of the project that takes the timing of costs and benefits into account can now be measured, using the following indicators:

- Net Present Value (NPV)
- Benefit/Cost (B/C) ratio
- Internal Rate of Return (IRR)

2.6.1. Net Present Value (NPV)

The NPV is defined as the present worth of the net benefits (= benefits - costs) of the project. In the financial analysis, it is the present value of the net income stream accruing to the entity from whose point of view the analysis is being undertaken. Net benefits for the Mutange irrigation scheme were shown in the last column of Table 11.

To calculate the NPV, one must determine a discount rate. This should be the rate below which it will be unacceptable for the return to capital to fall. For the purposes here, this will be the cost of borrowing money. If the project cannot generate an income stream sufficient to pay back the loan plus the interest, then it is not worth undertaking.

In Table 15 the NPV of the Mutange irrigation scheme is calculated. For the purposes of the exercise, the discount rate is set at 12% and the discount factors are listed in Table A4-2 (Appendix 4). Benefits accruing every year are multiplied by the appropriate discount factor to give the present value (PV) of the benefits. The NPV then is the sum of all the present values for the project life.

The NPV in Table 15 is positive, which means that, at the chosen discount rate, the investment will be more than recovered and it will be profitable to go ahead with the project. If the NPV had been negative, it would mean that the return of the investment would not be acceptable and one would have to look elsewhere to invest money. The selection criteria is thus NPV > 0. The NPV being an absolute measure, it does not give us any idea of the relative return of capital. It only tells us that all the projects with a positive NPV are profitable to initiate. If this leads to lack of funds, then the discount rate is set too low.

2.6.2. The Benefit/Cost (B/C) ratio

The B/C ratio is the ratio between the PV of the benefit stream and the PV of the cost stream. It thus is an indication of how much the benefits exceed the costs. Table 16 presents the calculations leading to the B/C ratio. Appendix 3 shows more details on the types of costs included in the calculation.

Dividing the sum of the PV of the benefits (US$4 372 760) by the sum of the PV of the costs (US$1 764 335) gives the B/C ratio of 2.48. This ratio being greater than 1 shows that, at the current discount rate, the benefits exceed the costs. This means that it would be profitable to go ahead with this project. If the ratio had been below 1, the project would not be viable. The selection criteria is thus B/C ratio > 1.

Table 15

Calculation of the Net Present Value of Mutange irrigation scheme at 12% discount rate (US$)

Year	Net benefits	Discount factor (at 12%)	Present value (PV)
1	-1 127 787	0.8929	-1 007 001
2	345 387	0.7972	275 343
3	442 077	0.7118	314 670
4	521 171	0.6355	331 204
5	606 193	0.5674	343 954
6	581 257	0.5066	294 465
7	606 193	0.4523	274 181
8	606 193	0.4039	244 841
9	606 193	0.3606	218 593
10	606 193	0.3220	195 194
11	529 096	0.2875	152 115
12	606 193	0.2567	155 610
13	606 193	0.2292	138 939
14	606 193	0.2046	124 027
15	606 193	0.1827	110 751
16	521 737	0.1631	85 095
17	606 193	0.1456	88 262
18	606 193	0.1300	78 805
19	606 193	0.1161	70 379
20	606 193	0.1037	62 862
21	606 193	0.0926	56 133
Total	**10 299 643**		**2 608 425**
		Net Present Value (NPV) at 12%	**2 608 425**

Table 16

Calculation of the Benefit/Cost ratio for Mutange irrigation scheme at 12% discount rate (US$)

Year	Total project costs	With-project benefits	Discount factor (at 12%)	Present value of costs	Present value of benefits
1	1 127 787	0	0.8929	1 007 001	0
2	106 276	451 663	0.7972	84 723	360 066
3	106 276	548 352	0.7118	75 647	390 317
4	106 276	627 446	0.6355	67 538	398 742
5	106 276	712 469	0.5674	60 301	404 255
6	131 212	712 469	0.5066	66 472	360 937
7	106 276	712 469	0.4523	48 068	322 250
8	106 276	712 469	0.4039	42 925	287 766
9	106 276	712 469	0.3606	38 323	256 916
10	106 276	712 469	0.3220	34 221	229 415
11	183 373	712 469	0.2875	52 720	204 835
12	106 276	712 469	0.2567	27 281	182 891
13	106 276	712 469	0.2292	24 358	163 298
14	106 276	712 469	0.2046	21 744	145 771
15	106 276	712 469	0.1827	19 417	130 168
16	190 732	712 469	0.1631	31 108	116 204
17	106 276	712 469	0.1456	15 474	103 735
18	106 276	712 469	0.1300	13 816	92 621
19	106 276	712 469	0.1161	12 339	82 718
20	106 276	712 469	0.1037	11 021	73 883
21	106 276	712 469	0.0926	9 841	65 975
Total	**3 439 786**	**13 739 429**		**1 764 335**	**4 372 760**
				Benefit/Cost (B/C) ratio	**2.48**

2.6.3. Internal Rate of Return (IRR)

The IRR is the rate of discount at which the total discounted cash benefits expected from the project equal the total discounted cash costs required by the investments. It is the rate that makes the NPV of the project equal to zero. The IRR can also be described as the rate of growth of an investment. This rate can be interpreted as the highest rate of interest an investor could pay, without losing money, if all the funds to finance the investment are borrowed and if the debt service (loan and accrued interest) was repaid by use of cash proceeds from the investment. The investment criterion is that the IRR should be greater than the discount rate.

The IRR can be computer generated. Excel, for example, provides the facility to calculate the IRR, using the accounting function. If no computers are available, then the calculation of IRR is done by trial and error. Two discount rates within ten percentage points need to identified. One discount rate should give a positive NPV and the other a negative NPV. The following formula is used:

Equation 5

$$IRR = ldr + \frac{(hdr - ldr) \times NPV\ at\ ldr}{(NPV\ at\ ldr - NPV\ at\ hdr)}$$

Where:

IRR = Internal Rate of Return
hdr = Higher discount rate
ldr = Lower discount rate
NPV = Net Present Value

Using the example of Mutange irrigation scheme, at 12% discount rate there is a high positive NPV of US$2 608 425. Increasing the discount rate to 35% gives a positive NPV of US$201 319. Using 45% gives a negative NPV of -US$50 613. Using these two points one can interpolate:

$$IRR = 35 + \frac{(45 - 35) \times 201\ 319}{(201\ 319 - - 50\ 613)} = 35 + 8 = 43\%$$

The difference between the IRR calculated through trial and error and the computer-generated IRR is small (1%). From the financial analysis, the proposed irrigation scheme is viable since the IRR of 42% exceeds 12%, which is the cost of borrowing.

2.6.4. Payback period

This is the period it takes for annual net benefits to equal initial investment. It shows how long it takes for the project to generate benefits to cover costs incurred in the investment. The example of Mutange irrigation scheme gives a payback period of 4 years using discounted costs and benefits. This figure has been calculated using Table A3-1 (Appendix 3). Looking at column 14, it can be seen that after 3 years the discounted net benefit is equal to US$921 217. This is still less than the investment of US$1 090 909 (column 2). After 4 years the discounted net benefit is US$1 265 171, which is more than the initial investment. This means that the costs are paid back in about 4 years. The payback period can also be calculated on undiscounted benefits and cost streams. Generally, lower payback periods are preferred although notice should be taken of the fact that payback period criterion ignores potential benefits in later years.

2.6.5. Establishing the project worthiness

Having established how to deal with costs and benefits spread over time and the theory behind the project worthiness measures, one can now return to the evaluation of the investment budget given in Table 11. The calculated project worthiness indicators (NPV, B/C ratio, IRR) show that the irrigation project as an investment is viable, which means that the investors are likely to get their money back and earn a fair return on top.

It should be realized that the B/C ratio and IRR values are rather high. They would have been much lower if a dam had needed to be constructed, which was not necessary in this case, since the dam had already been constructed and was thus considered as sunk cost (see Section 2.2.4). The cost of a dam constructed for irrigation purposes could constitute up to 70-80% of the total investment cost (FAO, 2000). However, in the case of smallholder farmers, it is rare that a dam is built only for irrigation purposes. Normally, a dam would be constructed for many purposes, of which irrigation is but one, and thus only part of its total cost should be included in the investment cost of the irrigation scheme.

2.7. Cash flow analysis

Section 2.6 looked at the investment period as a whole and determining whether the investment would accumulate enough benefits to justify the cost. This is the correct viewpoint for an investor looking for the best way to invest capital. For the participating farmers, however, the viewpoint would normally be different. Farmers would focus on the actual income that participating in the project is likely to earn them, meaning how much cash they would get. Accordingly, the cash flow of the project will have to be determined to find out what will be left when all costs have been deducted (Appendix 3). In order to establish the cash flow one first has to find out how much the farmers will have to pay for the loans taken to finance the project.

2.7.1. Project investment financing

Assuming that the financial needs and the terms of financing (interest rate and period of payment) are known, the debt service then has to be scheduled in order to determine the net benefit after financing, which is the increased income available to the farmers.

Assuming that the payments are to be distributed equally over the period of the loan, one needs to calculate how much to pay in each period in order to cover both interest and outstanding balance, so that the balance will be zero at the end of the loan period. In other words, the capital recovery factor amount is the annual payment that will recover the initial investment plus the interest on the unrecovered amount over the period fixed. This can be estimated through the following equation:

Equation 6

$$CRF_n = \frac{i}{1 - (1 + i)^{-n}}$$

Where:

CRF = Cost recovery factor

n = Number of years

i = Interest rate

Capital recovery factor values over a period of 40 years for different interest rates are given in Table A4-4 (Appendix 4).

As an example, take the loan that the farmers in Mutange irrigation scheme would have to obtain to finance the irrigation scheme. The interest rate offered is assumed to be 12% and the loan period 20 years with equal payments. The size of the loan would be equal to the investment cost, which is US$1 090 909 (Table 11). The capital recovery factor for 20 years is 0.1339 (Table A4-4). This means the farmers will have to pay about US$1 090 909 x 0.1339 = US$146 073 every year in order to meet the repayment schedule. The scheduling of the payment is outlined in Table 17.

The principal (column 1) is the main part of the investment, as distinct from the interest it generates by it (column 2). The annual repayment (column 4) is rounded off in such a way that the principal at the end of the 20 year (column 6, figure at 20 years) is as close to 0 as possible. Paying US$146 073 would give a figure of -US$1 688, meaning that the farmers would have paid a surplus of US$1 688 at the end of the 20 years. Paying US$146 050 gives an end balance of -US$31 at the end of the 20 year, which is almost equal to 0. The difference between the annual payment (column 4) and the interest amount (column 3) is the repayment of the principal (column 5).

Table 17

Repayment schedule for a loan of US$1 090 909 for Mutange irrigation scheme with a loan period of 20 years and an interest rate of 12%

Year	Principal year start	Interest 12%	Fixed annual repayment	Payment on principal	Principal year end
(1)	(2)	(3) = 0.12 x (2)	(4)	(5) = (4) - (3)	(6) = (2) + (3) - (4)
1	1 0909 909	130 909	146 050	15 141	1 075 768
2	1 075 768	129 092	146 050	16 958	1 058 810
3	1 058 810	127 057	146 050	18 993	1 039 817
4	1 039 817	124 778	146 050	21 272	1 018 546
5	1 018 546	122 225	146 050	23 825	994 721
6	994 721	119 367	146 050	26 683	968 038
7	968 038	116 165	146 050	29 885	938 152
8	938 152	112 578	146 050	33 472	904 680
9	904 680	108 562	146 050	37 488	867 192
10	867 192	104 063	146 050	41 987	825 205
11	825 205	99 025	146 050	47 025	778 180
12	778 180	93 382	146 050	52 668	725 511
13	725 511	87 061	146 050	58 989	666 522
14	666 522	79 983	146 050	66 067	600 455
15	600 455	72 055	146 050	73 995	526 460
16	526 460	63 175	146 050	82 875	443 585
17	443 585	53 230	146 050	92 820	350 765
18	350 765	42 092	146 050	103 958	246 807
19	246 807	29 617	146 050	116 433	130 374
20	130 374	15 645	146 050	130 405	- 31
Total		**1 830 060**	**2 921 000**	**1 090 940**	

Table 18

Cash flow budget for Mutange irrigation scheme without considering inflation (US$)

Year	With-project benefit	Without-project benefit	Replacement cost	Energy cost	Repairs and maintenance	Debt service	Total cost	Net benefit
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9) = (2) - (8)
1		36 878					36 878	-36 878
2	451 663	36 878		22 126	32 727	146 050	237 781	213 882
3	548 352	36 878		22 126	32 727	146 050	237 781	310 572
4	627 446	36 878		22 126	32 727	146 050	237 781	389 666
5	712 469	36 878		22 126	32 727	146 050	237 781	474 688
6	712 469	36 878	24 936	22 126	32 727	146 050	262 717	449 752
7	712 469	36 878		22 126	32 727	146 050	237 781	474 688
8	712 469	36 878		22 126	32 727	146 050	237 781	474 688
9	712 469	36 878		22 126	32 727	146 050	237 781	474 688
10	712 469	36 878		22 126	32 727	146 050	237 781	474 688
11	712 469	36 878	77 097	22 126	32 727	146 050	314 878	397 591
12	712 469	36 878		22 126	32 727	146 050	237 781	474 688
13	712 469	36 878		22 126	32 727	146 050	237 781	474 688
14	712 469	36 878		22 126	32 727	146 050	237 781	474 688
15	712 469	36 878		22 126	32 727	146 050	237 781	474 688
16	712 469	36 878	84 456	22 126	32 727	146 050	322 237	390 232
17	712 469	36 878		22 126	32 727	146 050	237 781	474 688
18	712 469	36 878		22 126	32 727	146 050	237 781	474 688
19	712 469	36 878		22 126	32 727	146 050	237 781	474 688
20	712 469	36 878		22 126	32 727	146 050	237 781	474 688
21	712 469	36 878		22 126	32 727	146 050	237 781	474 688
Total	**13 739 429**	**774 428**	**186 489**	**442 527**	**654 545**	**2 921 000**	**4 978 977**	**8 760 452**

(8) = (3) + (4) + (5) + (6) + (7)

Table 19

Annual cash flow per farmer in Mutange irrigation scheme without considering inflation (US$)

Year	Total net benefit	Annual cash flow per farmer
2	213 882	1 018
3	310 572	1 478
4	389 666	1 856
5	474 688	2 260
6	449 752	2 142
7-10	474 688	2 260
11	397 591	1 893
12-15	474 688	2 260
16	390 232	1 858
17-21	474 688	2 260
Peak	**474 688**	**2 260**
Average	**439 867**	**2 095**

2.7.2. Cash flow budget

One now has all information to be able to establish the cash flow budget, which is summarized in Table 18 for Mutange irrigation scheme.

From the cash flow budget for the project period, shown in Table 18, it transpires that the farmers of Mutange irrigation scheme will reap a positive net benefit from participating in the scheme right from the first year of operation (Year 2). The net benefit for the first year of operation (Year 2) is US$213 882, which is US$1 018 per farmer. It increases, as the productivity grows and the relative burden of the debt service decreases, to a maximum of US$474 688, which is US$2 260 per farmer. In years with replacement costs, however, the cash flow decreases as farmers are expected to cover these costs. The results from the cash flow from the irrigated area are summarized in Table 19.

Table 20 summarizes the gross margin per farmer on the rainfed land, before the project (3.0 ha) and after the project (2.5 ha). For details, see Table A2-1 in Appendix 2.

Table 20

Rainfed land gross margin per farmer participating in Mutange irrigation scheme

Rainfed area per farmer	Gross margin per farmer
Before the project: 3.0 ha	US$625
With the project: 2.5 ha	US$449

Analysis of cash flows is concerned with the incremental income generated by the project, which is the difference in income between the 'without-project' and the 'with-project' situation. Tables 19 and 20 show that even when the full cost of irrigation development and operation (excluding technical support) is passed on to the farmers, the farmers' income is much higher with irrigation than without irrigation. The minimum (year 2) with irrigation is equal to US$1 467 (= 1 018 + 449), while without the project the income would have been US 625.

One can also calculate the return to labour needed to go into irrigation and compare it to the return to labour that farmers have on their rainfed land as well as return to labour in any feasible alternative employment. This will show whether there is an incentive for the farmers to participate. The labour requirements ware calculated to be 390.6 days per year for the rainfed area of 3 ha (Table 4) and 495.2 days per year for the irrigated area of 0.5 ha (Table 5). The total return with irrigation is the net benefit from the project (0.5 ha) plus the income from the remainder of the rainfed land (2.5 ha).

Total return with irrigation is US$2 095 + US$449 = US$2 544

The return on labour with irrigation is US$2 544/495.2 = US$5.14 per labour day

The return to labour for the 'without-project' situation is US$ is US$625/390.6 = US$1.60 per day

It may be further assumed that the farmer's next best alternative to earn a living is to find employment on commercial farms. The return to labour in this alternative employment is estimated to be $3.72 per labour day, which is the current farm wage.

It can be seen from the above that the return to labour with irrigation is much higher than with rainfed production alone. This is an incentive to farmers to go into irrigation, which is over and above the gainful employment all year and a secured water supply and higher food security compared to the rainfed cropping alone. Return to labour with irrigation is also much higher than return to labour in commercial farm employment.

2.7.3. Inflation

The above calculations did not take into consideration changes in prices because of inflation, which will affect the repayment of loans (Section 2.7.1). Inflation means that prices are rising, which means that one pays more for the same goods next year. Inflation can be a general rise affecting all goods in the economy and/or changes in relative prices. In this analysis it is assumed that inflation is general, meaning that all prices rise at the same rate. If this is true, there is no need to include inflation in the calculations because it would mean compounding all the costs and benefits with the same factor. This does not affect the measures of project worthiness. This one is operating in constant prices. Accordingly, the price level is taken at the beginning of the investment and it is assumed that the price will be constant throughout the lifetime of the project. This means, however, that the figures given for the costs and benefits will be at the price level for the beginning of the project (say the year 2001). So income in the year 2004 is expressed in terms of 2001 prices. It is not the actual sum one expects to receive. The actual sum will be the year 2001 income inflated by the inflation rate. This operation will lead to the current prices of the year 2004. So, operating in constant prices avoids the calculations for inflation.

There is one exception, however, namely the debt service. The debt service is fixed at the time of the disbursement of the loan and does not change with inflation. Therefore, the relative value of the debt service is going to fall over the years due to inflation. To account for this, one will have to deflate the debt service by the use of the discounting techniques. In the debt service column of Table 21 this principle has been applied. It is, however, difficult to know the inflation at the long term. For calculation purposes an annual inflation of 5.5% is assured. The yearly debt payment of US$146 050 (See Section 2.7.1) is thus deflated, allowing for the 5.5% inflation. The discount factor of Table A4-2 (Appendix 4) is used for this purpose. For example at year 2, the first year of operation, the debt service is US$146 050 x 0.9479 = US$138 441 (0.9479 being equal to the discount factor of the first year at an interest rate of 5.5%).

Perfoming the same calculation as in Section 2.7.2 gives the following results:

The net benefit for the first year of operation (Year 2) is US$221 491, which is US$1 055 per farmer. It increases, as the productivity grows and the relative burden of the debt service decreases, to a maximum of US$570 687, which is US$2 718 per farmer. The average annual cash flow is US$2 374 per farmer.

When the full cost of irrigation development and operation (excluding technical support) is passed on to the farmers, the minimum income with irrigation (Year 2) is equal to US$1 504 (= 1 055 + 449), while without the project the income would have been US$625. Total return with irrigation is US$2 374 + US$449 = US$2 823.

The return on labour with irrigation is US$2 823/495.2 = US$5.70 per labour day.

The return to labour for the 'without-project' situation is US$is US$625/390.6 = US$1.60 per day.

The return to labour if employed on a commercial farm is US$3.72 per labour day.

Table 21

Cash flow budget for Mutange irrigation scheme, taking into consideration an annual inflation of 5.5% (US$)

Year	With-project benefit	Without-project benefit	Replacement cost	Energy cost	Repairs and maintenance	Debt service	Total cost	Net benefit
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9) = (2) - (8)
1		36 878					36 878	-36 878
2	451 663	36 878		22 126	32 727	138 441	230 171	221 491
3	548 352	36 878		22 126	32 727	131 226	222 956	325 396
4	627 446	36 878		22 126	32 727	124 376	216 107	411 339
5	712 469	36 878		22 126	32 727	117 892	209 622	502 847
6	712 469	36 878	24 936	22 126	32 727	111 743	228 409	484 059
7	712 469	36 878		22 126	32 727	105 915	197 646	514 823
8	712 469	36 878		22 126	32 727	100 395	192 125	520 343
9	712 469	36 878		22 126	32 727	95 166	186 897	525 572
10	712 469	36 878		22 126	32 727	90 200	181 931	530 538
11	712 469	36 878	77 097	22 126	32 727	85 498	254 325	458 143
12	712 469	36 878		22 126	32 727	81 043	172 774	539 695
13	712 469	36 878		22 126	32 727	76 822	168 553	543 916
14	712 469	36 878		22 126	32 727	72 821	164 551	547 918
15	712 469	36 878		22 126	32 727	69 023	160 754	551 715
16	712 469	36 878	84 456	22 126	32 727	65 416	241 602	470 866
17	712 469	36 878		22 126	32 727	62 013	153 743	558 725
18	712 469	36 878		22 126	32 727	61 925	153 656	558 813
19	712 469	36 878		22 126	32 727	55 718	147 449	565 020
20	712 469	36 878		22 126	32 727	52 812	144 542	567 926
21	712 469	36 878		22 126	32 727	50 051	141 782	570 687
Total	**13 739 429**	**774 428**	**186 489**	**442 527**	**654 545**	**1 748 496**	**3 806 473**	**9 932 956**

(8) = (3) + (4) + (5) + (6) + (7)

Chapter 3
Economic analysis

A financial analysis takes the point of view of the primary stakeholders in the project, which are the investors (for example government, farmers, local authorities, NGOs, etc.) and other stakeholders. It looks at a change in income as a result of the project in domestic market prices and in general is expressed in domestic currency. In a financial analysis, the prices used are the actual prices that stakeholders experience, whether they are free market prices or controlled prices, non-taxed or taxed. For ease of comprehension, the prices in the previous chapter have been converted to US$. In reality they should be expressed in the currency of the country.

An economic analysis takes the point of view of the society and seeks to clarify whether projects will benefit the economy as a whole. Thus the objective of the economic analysis is not income maximization of the primary stakeholders, as is the case with the financial analysis, but maximization of benefits at the national level.

3.1. Determining economic values

To determine the economic values from a project's performance, the financial prices are used and adjusted for various factors that distort the real value to the society. The main elements that are included in these adjustments are:

- ❖ The premium on foreign exchange
- ❖ Transfer payments
- ❖ Price distortions in traded items
- ❖ Price distortions in non-traded items
- ❖ Evaluation of land and labour

The economic prices (actual values) that are arrived at after these adjustments are called shadow prices.

All the corrections made to the financial price add up to an economic conversion factor. The relationship between the financial price and the shadow price is then:

Equation 7

Shadow price = financial price x conversion factor

3.1.1. Shadow exchange rate

If people could buy foreign currency at the official exchange rate (OER), there would not be enough foreign currency to go around, because demand would outstrip supply. The price could be raised until demand met supply and this would be then the shadow price. In most countries, the central planning agency calculates this premium. Where this is not available, the analyst will be forced to make their own estimate of the shadow exchange rate[1] .

3.1.2. Transfer payments

Transfer payments include payments between the people and the government. All types of duties and taxes such as customs duties, excise duties, tariffs, land taxes, corporation taxes, sales taxes, contribution to various social security funds, are transfer payments from the individual consumer to the government. Subsidies and grants paid by the government to the people are transfer payments from the government to the people. In the financial analysis, these payments are shown as costs and benefits. In the economic analysis, however, they should be excluded.

As for transfer payments, loans and debt services should be excluded in economic analysis, because these are transfer payments between the borrowers and the lenders. Such payments do not reflect additional use of real resources.

3.1.3. Price distortions in traded items

Traded items in this context are defined as goods that are traded across national borders, thus involving exchange of foreign currency. This could be wheat, maize and other crops, or inputs like machinery.

When a crop is traded and one of the outcomes of the project is increased production of the crop, then the real value to society is the foreign currency earned by being

[1] *In Zimbabwe, for example, the official exchange rate (OER) is US$1: ZW$55 (May 2002). Economic analysts claim that on the parallel market the exchange rate is US$1 to ZW$370 (The Daily News of 22 May 2002). They are urging government to devalue the Zimbabwe dollar to US$1 to ZW$250. Taking ZW$250 as the shadow exchange rate (SER), means that all foreign currency components, be it imports or exports, should be valued at that price in the economic analysis. The Zimbabwe example is the one used in the discussion on economic analysis.*

able to increase exports or the foreign currency saved by being able to reduce imports. The economic value of a traded good, in this case the crops produced, is its export or import parity price (parity is the equivalence in value as expressed in the currency of another country). These values are derived by adjusting the c.i.f. (cost, insurance and freight) price or the f.o.b. (free on board) price, converted to economic values, for all relevant charges between the project and the point where the c.i.f. or f.o.b. price is quoted. The steps in calculating export and import parity prices are shown in Table 22, 23 and 24. These tables show how economic prices for tradable commodities are arrived at. These economic prices are valid as long as:

- The country remains a net exporter of groundnuts and a net importer of wheat and maize
- Assumptions made on the SER and transfer payments remain valid

Table 22
Economic value of grain maize: import parity

Steps in the calculation	Value per ton	
	Unit	Cost
f.o.b. at point of export (e.g. Gulf)	US$	100
+ freight to point of import + insurance	US$	45
+ unloading at point of import	US$	10
= c.i.f. at point of import (Beira)	US$	155
Convert foreign currency to domestic currency at shadow exchange rate (155 x 250)	ZW$	38 750
+ local transport	ZW$	2 475
+ handling charges (15% of 38 750)	ZW$	5 813
Wholesale value (Grain Marketing Board (GMB)	**ZW$**	**47 038**

Table 23
Economic value of wheat: import parity

Steps in the calculation	Value per ton	
	Unit	Cost
f.o.b. at point of export (e.g. Gulf)	US$	120
+ freight to point of import + insurance	US$	45
+ unloading at point of import	US$	10
= c.i.f. at point of import (Beira)	US$	175
Convert foreign currency to domestic currency at shadow exchange rate (175 x 250)	ZW$	43 750
+ local transport	ZW$	2 475
+ handling charges (15% of 43 750)	ZW$	6 563
Wholesale value (Grain Marketing Board (GMB)	**ZW$**	**52 788**

Table 24
Economic value of groundnuts: export parity

Steps in the calculation	Value per ton	
	Unit	Cost
c.i.f. at point of import	US$	964
- freight at point of import, unloading and insurance	US$	42
= f.o.b. at point of export (Beira)	US$	922
Convert foreign currency to domestic currency at shadow exchange rate (922 x 250)	ZW$	230 500
- tariffs	ZW$	0
+ subsidies	ZW$	0
- local port charges	ZW$	606
- local transport	ZW$	2 475
- handling charges (15% of 230 500)	ZW$	34 575
Wholesale value (Grain Marketing Board (GMB)	**ZW$**	**192 844**

Table 25 shows a comparison of financial and economic prices for grain maize, wheat and groundnuts. Because of the high shadow price of foreign currency compared to the official exchange rate (SER/OER = 250/55 = 4.55), the value to society of the above crops is much higher than what the farmer is paid.

Table 25

Comparison of financial and economic prices for grain maize, wheat and groundnuts

Crop	Financial price ZW$	Economic price ZW$	Economic conversion factor
Grain maize	15 000	47 038	3.14
Wheat	30 000	52 788	1.76
Groundnuts	40 000	192 844	4.82

The economic conversion factor is the ratio of the economic price to the financial price (Equation 7). In some countries, central planning agencies produce economic conversion factors for various commodities. Where they do not exist, the planner will calculate them. Tables 26 and 27 show the calculation of conversion factors for some agricultural commodities.

In the two tables commodities have been given a weighted financial score of 100. Each commodity's financial score has been split into its various components that include local materials, imported materials, labour and taxes and surcharges.

The financial price of fertilizer, for example, comprises 44% local material, 38% imported material, 16% labour and 2% taxes and surcharges. The weight of local materials in the financial price has been taken as a good estimate of their weight in the economic price. The weight of imported materials is adjusted to take into account the shadow exchange rate and is thus multiplied by 4.55, which is SER/OER. Labour used in fertilizer production is assumed to be 30% skilled and 70% unskilled. For skilled labour it is assumed that the market wage rate reflects its true opportunity cost, as the employment rate is quite high. Unskilled labour is estimated to have less value than the market wage, 0.4 in the example, because of high periods of unemployment and sometimes existence of minimum wages. The weight of labour in the financial price of fertilizer is adjusted to take into account its components: (0.30 x 16 x 1) + (0.7 x 16 x 0.4) = 9.28. Taxes and surcharges included in the financial price of fertilizer represent transfer payments and are therefore reduced to zero. Whereas the weight of fertilizer in the financial analysis was 100, in the economic analysis the weight is 226.18, which translates to an economic conversion factor of 2.26.

Table 26

Economic conversion factors for fertilizer, chemicals and seed

	Commodity		
	Fertilizer	Chemicals[a]	Seed[b]
Financial cost component:			
Materials (local)	44	3	26
Materials (imported)	38	76	33
Labour	16	1	36
Taxes and surcharges	2	20	5
Total	**100**	**100**	**100**
Economic cost component:			
Materials (local)	44	3	26
Materials (imported)[c]	173	346	150
Labour[d]	9	1	21
Taxes and surcharges[e]	0	0	0
Total	**226**	**350**	**197**
Economic conversion factor	**2.26**	**3.50**	**1.97**

a. Pesticides, insecticides and other chemicals

b. Imported components include bags, dressing, fumigants, etc.

c. The cost components of imported materials are converted by 4.55 which is SER/OER

d. Labour is 30% skilled and 70% unskilled; the shadow wage rate is 1 and 0.4 respectively

e. Taxes and surcharges represent transfer payments and are therefore reduced to zero

Table 27

Economic conversion factors for irrigation equipment, replacement cost and energy cost

	Commodity		
	Irrigation equipment	Replacement	Energy
Financial cost component:			
Materials (local)	40	65	70
Materials (imported)	10	5	5
Labour	30	10	5
Taxes and surcharges	20	20	20
Total	**100**	**100**	**100**
Economic cost component:			
Materials (local)	40	65	70
Materials (imported)	46	23	23
Labour	17	6	3
Taxes and surcharges	0	0	0
Total	**103**	**94**	**96**
Economic conversion factor	**1.03**	**0.94**	**0.96**

Table 28

Some economic conversion factors used in Zimbabwe (Year 2001)

Item	Conversion factor	Comment
Foreign exchange	4.55	
Transfer payments	0.00	By definition
Chemicals	3.50	76% Forex content assumed
Electricity	0.96	
Irrigation equipment	1.03	
Repair and maintenance	0.94	
Road transport	1.00	
Skilled labour	1.00	Free market price
Unskilled labour	0.40	
Seed	0.97	33% Forex content assumed
Fertilizer	2.26	38% Forex content assumed
Grain maize	3.14	Based on 2002 GMB prices
Groundnuts	4.82	
Wheat	1.76	Based on 2002 GMB prices
Perishable horticultural crops[a]	1.00	Free market price
Non-perishable locally-marketed crops[b]	1.00	Free market price

a. Includes cabbages, green beans, okra, onions, potatoes, etc.

b. Includes dry beans, pearl millet, sunflowers, sorghum, etc.

A comprehensive list of conversion factors that would be used in an economic appraisal of smallholder irrigation schemes in Zimbabwe is given in Table 28. These factors are based on estimates by the Department of Agricultural Technical and Extension Services (AGRITEX) in the Ministry of Agriculture, Lands and Rural Resettlement.

3.1.4. Price distortions in non-traded items

Non-traded items include bulky goods, such as straw or bricks, which by their very nature tend to be cheaper to produce domestically than to import but for which the export price is lower than the domestic cost of production. In other instances, non-traded items are highly perishable goods like fresh vegetables. In general these are produced under relatively competitive conditions. They are produced either by many small farmers or by a few industrial producers for whom entry into the market is relatively easy; thus prices cannot rise too far out of line before new competition appears.

Where a reasonably competitive market exists for these items, the financial price would be a good estimate of the opportunity cost and can be used for the economic analysis. This covers crops like tomatoes, onions, potatoes, rape, cabbages, etc. This, however, is done under the assumption that the output of the project is marginal, which means that it does not in itself significantly alter the relationship between demand and supply and thereby the prices. This will be the case for most smallholder irrigation schemes that would sell a large proportion of their output in the major city centres.

If there is not a competitive market and the sale and/or the prices are regulated, the prices will have to be adjusted by the method outlined in Section 3.1.3 in order to eliminate the distortions.

3.1.5. Land

In a financial analysis, the value of land depends on tenure. If a tenant farmer pays annual rent, this is included in the cash outflow. If land was purchased in order to construct an irrigation scheme, the cost of the land will be reflected in the cash outflow during the year the expense is incurred for the same amount paid.

In an economic analysis, however, the value of land is its opportunity cost, which is the income foregone by using the land for irrigation. If the land in the 'without-project' situation would be used for dryland cropping, either now or in the future, then the value of the land would be equal to the estimated net income from dryland based on an average cropping pattern typical for the area. The economic net income from dryland is derived from the financial crop budgets adjusted for economic prices as indicated above. If there is no other use for the land than irrigation then the opportunity cost and the economic value is zero.

If the project takes up more land than is being irrigated, for example an area flooded by a dam, then this land should be valued also. Incidentally, evaluating the economic value of a dam could also include other benefits not directly associated with the irrigation project, like primary water supply. Where possible, the dam cost should be allocated to the different users, based on the amount of water required for each use.

3.1.6. Labour

In a financial analysis, hired labour is valued in terms of the market wage rates. The market wage rate does not always reflect the true opportunity cost of shifting labour from its 'without-project' occupation to its 'with-project' use. Rural wages may be higher than the opportunity cost of labour, because of social pressure on the more prosperous farmers in the community to share their wealth with their less fortunate neighbours. Or there may exist government-set minimum wages.

In an economic analysis, the opportunity cost of labour or the shadow wage is used. This cost reflects the contribution that the labour employed in the project could make elsewhere in the economy. Often the 'without-project' occupation would be unemployment and in that case the opportunity cost will be close to zero. In Zimbabwe, where currently there is a large pool of unemployed unskilled labour, this is the reason behind the conversion factor of 0.4 for unskilled labour estimated by AGRITEX. This means that the economic value of $1 spent on unskilled labour is 40 cents. If, however, the labour is employed during the peak harvesting periods in the rural areas, it is likely that there are plenty employment opportunities and then the market wage rate is a good estimate of the opportunity cost. For skilled labour it is likely that the market wage rate reflects the true opportunity cost, as the employment rate is quite high.

3.2. Economic analysis

When the economic values for the project input and output have been determined, the same methods that were used in the financial investment analysis can be applied.

For the economic analysis, where the point of view of the whole economy rather than that of the farmer is taken, the interest charged by the lender is not relevant. Instead, one would focus on the opportunity cost of capital. Theoretically this is the rate that would be set in an ideal capital market. The government and the Central Bank, however, regulate the capital market. As an approximation, the interest rate for long-term government bonds could be used. Another estimate for the real economic discount rate is based on the cost of borrowing money on the international capital market where it is assumed that marginal borrowing in the economy will take place. Rates set by international financing institutions, such as the World Bank (WB), International Monetary Fund (IMF) and African Development Bank (AfDB) approximate to the economic discount rate.

The financial analysis in the working example was worked out in US$, for reasons explained at the beginning of this Chapter, thus it was not possible to produce an economic analysis using the above calculated figures.

3.3. Secondary costs and benefits

Secondary costs and benefits are the effects that the project has on people and /or things outside the project that are not included in the project accounts. These effects are also called externalities or spillover effects and the main ones are discussed below.

3.3.1. Multiplier effects

These are the effects that the increased spending of the project beneficiaries will have on the rest of the economy. The increased spending will mean higher demand for goods and, if there is excess capacity in the economy, more production and growth. These effects are very difficult to measure unless one has a very detailed picture of how the economy is functioning.

3.3.2. Technological externalities

These cover the real effects on people outside the project caused by the physical design and the use of resources. For example, if one pumps water from a well to irrigate an area, it might have adverse effects on the flow of other wells. Or if one uses water from a dam it might affect the amounts of fish available for other people. Other externalities of an irrigation project may include pollution of reservoirs due to chemicals used in intensive crop production. If these technological externalities are significant, they should be identified, quantified, valued and included in the project costs. An environmental impact assessment should be carried out at project preparation (see Section 1.2.7) and monitored throughout the project implementation and afterwards in order to minimize negative effects.

3.3.3. Pecuniary externalities

Pecuniary externalities arise when a change in price is caused by the project. This could happen if the project caused a significant increase in the production of one good, thus affecting the supply and demand relations and thereby the fixing of prices and accordingly the incomes of other people.

In this analysis, however, it is assumed that one is dealing with small projects, that in themselves do not influence the system in which they are operating, or the market place. Prices of centrally-marketed crops are not likely to be affected by the increased production from the relatively small sized projects being dealt with. The same goes for freely marketed crops.

3.3.4. Income distribution

The financial and economic analysis, as presented here, do not explicitly take the distributional effects into account. This is because of the relatively small size of the projects and the well-defined target group. An integration of income distribution into the financial and economic analysis would complicate matters a great deal and clarify little. This is not to say that the distributional matters are not considered in the projects. The main beneficiaries of irrigation income distribution will be smallholder farmers, as set out in the project objectives.

3.3.5. Employment creation

The employment created by an irrigation project is an important factor in evaluation as employment is a powerful instrument in raising incomes. Smallholder irrigation projects, however, are primarily concerned with employing the family labour of the participating households more efficiently. Employment creation is not a factor specifically considered in the analysis. Irrigation could, however, constitute a possibility of gainful employment for young people in the rural areas, thus helping to reduce the incentive for those people to migrate to urban centres and add to the already serious housing and unemployment problems there. Indirectly, irrigation can also provide employment in marketing of produce and in agricultural inputs distribution.

3.3.6. Effects on savings and investment

When analyzing the economic effects of a project, the question arises as to what will happen with the proceeds that the beneficiaries reap from the project. That is, what will the owners of capital do with their remuneration? Will they reinvest for further economic growth or will they spend on consumption? For the project size being considered here, however, these effects are not considered to be significant.

3.3.7. Diversification of activities

It is the goal in the economic development of social groups that they should not be dependent on one activity alone. The project's contribution to a diversification of activities will have to be considered along with the other aspects. Irrigating farmers may diversify into processing of irrigation produce, for example.

Besides the above-mentioned economic considerations there can be other aspects, such as ecological and aesthetic considerations (conserving ecosystems, scenic beauty, etc.), that might have to be taken into account.

Furthermore, one has to assess whether the project will have any effect on the social and health situation of the community involved. Will the project change the existing social patterns, division of work, etc.? Likelihood of increased cases of malaria or water-borne diseases, such as bilharzia, must also be considered.

3.4. Summary of financial and economic analysis

It is expected that financial and economic analysis may give conflicting results for decision-making. The following are possible combinations:

Type of project	Financial test	Economic test
I	Accept	Accept
II	Accept	Reject
III	Reject	Accept
IV	Reject	Reject

Explanation:

I: These projects are ideal

II: Economic analysis weeds out these projects, possibly due to heavy use of foreign exchange and dependence on government subsidies.

III: Farmers are financially disadvantaged, possibly due to government intervention in pricing. Private investors have no incentives. The project could have positive externalities (environmental, public goods etc.).

IV: The project is rejected on economic grounds but the social benefits may be high, for example opening up remote areas to create employment and for political reasons etc. These types may be approved as long as the objectives are clear and least cost means are used.

Chapter 4
Planning under uncertainty

Planning irrigation schemes involves projections of inputs and outputs over a period of time. There is thus a need to consider the element of uncertainty. What happens if the future developments are not as envisaged? How can the uncertainty element be taken into consideration in the financial and economic analysis?

4.1. Sensitivity analysis

Sensitivity analysis is done to allow planners and investors to take into consideration eventualities that cannot be pre-determined or are beyond the direct control of those involved in project implementation. It is done in order to protect investment decisions from risk. For most agricultural projects four major risk areas affect the viability of projects:

- Unstable prices
- Delay in implementation
- Cost overrun
- Unstable yields

4.1.1. Unstable prices

Changes in prices are naturally of the utmost importance when one is considering the viability of an agricultural project. There is need to test the project viability's dependence on price changes, especially the prices of the major components of the project.

4.1.2. Delay in implementation

A delay in implementation means that the benefits from the project are delayed too. This can be important for the viability of the project as the developments in the implementation period carry a relatively heavy weight in the analysis due to the time value of money (see Section 2.5).

However, when evaluating small irrigation schemes with no major construction activities, delays are unlikely to incur any great costs. Farming operations will continue until the contractors move in and no substantial amount of money will be disbursed before the scheme has been commissioned.

If, however, major capital outlays are involved, delays are more likely to cause additional expenses as loan repayments become due and dryland production is forfeited as long as irrigation construction is taking place.

4.1.3. Cost overrun

There can be considerable uncertainty involved in the estimation of the prices of spare parts and in the estimations of the construction costs. There is therefore a need to test the viability of the project in the event of cost overrun.

4.1.4. Unstable yields

Yields may vary because of adverse weather conditions, lack of inputs, etc. Therefore, it is important to use conservative yield estimates in the analysis, except for grain maize. Grain maize is generally a well-known crop in the region for which it seems reasonable to expect normal yields.

Dryland income foregone (that is treated as cost in the analysis) is estimated to be stable, which means that it is assumed that drought will not affect the dryland yields. This adds leeway to the estimates of the viability of the project.

4.2. Process of sensitivity analysis

Sensitivity analysis involves recalculating the measures of project worthiness (Section 2.6) under new assumptions and including the results in the analysis. In the example of Mutange irrigation scheme, the viability of the project will be tested in the event of 30% cost overrun on investment, replacement, repair and maintenance costs. The results are given in Table 29, which is the same as Table 11, but with an increase of 30% in investment, replacement and repair and maintenance costs. The effect of the cost increase is to reduce the viability statistics presented earlier.

Table 29

Investment budget for Mutange irrigation scheme (US$): sensitivity analysis with 30% increase in investment, replacement and repair and maintenance costs

Year	Investment cost	Replacement cost	Energy cost	Repairs and maintenance	Technical support	Without-project benefit	With-project benefit	Net benefit
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
1	1 418 182		0	0	0	36 878	0	-1 455 059
2			22 126	42 545	14 545	36 878	451 663	335 569
3			22 126	42 545	14 545	36 878	548 352	432 259
4			22 126	42 545	14 545	36 878	627 446	511 352
5			22 126	42 545	14 545	36 878	712 469	596 375
6		32 417	22 126	42 545	14 545	36 878	712 469	563 958
7			22 126	42 545	14 545	36 878	712 469	596 375
8			22 126	42 545	14 545	36 878	712 469	596 375
9			22 126	42 545	14 545	36 878	712 469	596 375
10			22 126	42 545	14 545	36 878	712 469	596 375
11		100 226	22 126	42 545	14 545	36 878	712 469	496 149
12			22 126	42 545	14 545	36 878	712 469	596 375
13			22 126	42 545	14 545	36 878	712 469	596 375
14			22 126	42 545	14 545	36 878	712 469	596 375
15			22 126	42 545	14 545	36 878	712 469	596 375
16		109 793	22 126	42 545	14 545	36 878	712 469	486 582
17			22 126	42 545	14 545	36 878	712 469	596 375
18			22 126	42 545	14 545	36 878	712 469	596 375
19			22 126	42 545	14 545	36 878	712 469	596 375
20			22 126	42 545	14 545	36 878	712 469	596 375
21			22 126	42 545	14 545	36 878	712 469	596 375
Total	**1 418 182**	**242 436**	**442 520**	**850 902**	**290 909**	**774 428**	**13 739 429**	**9 720 061**

Table 30 above shows a comparison of the viability statistics under the two scenarios.

Table 30

Viability statistics under current conditions compared to with 30% cost overrun

Viability statistics	Current conditions	30% Cost overrun
Net Present Value (NPV) at 12%	US$2 608 425	US$2 236 154
Benefit/Cost (B/C) ratio	2.48	2.05
Internal Rate of Return (IRR)	42%	33%
Payback Period	4 years	5 years

4.3. Other considerations with sensitivity analysis

Sensitivity analysis requires a lot of information that may be costly to obtain in terms of time and resources. Some may not be available. The simple assumption on varying one variable may not hold in practice. In life, variables may change jointly. Higher input costs may be accompanied by lower demand for products. It is, however, necessary that a judgement be made in analyzing these likely effects. It is not adequate to just highlight problems. Some ways to reduce risk and uncertainty include:

- Physical contingency allowances for major items
- Introducing flexibility in design and implementation
- Further market surveys or technical studies
- Improved marketing arrangements (possibly contracts, etc.)
- Pilot schemes for unproven technologies and development interventions
- Using best estimates, not just conservative estimates
- Manageable monitoring systems (efficient and effective flow of information)

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Appendix 1
Labour requirements

Table A1-1

Monthly labour requirements for Mutange irrigation scheme 'without project' situation, 3 ha rainfed

Crop	Area (ha)	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Grain maize	1.10	9.3	15.1	6.1	24.2	12.2	13.4	14.6				18.2	18.4	131.5
Sorghum	0.15	0.9	0.0	0.0	0.0	5.2	8.9					0.4	0.9	16.4
Pearl millet	0.05	0.3	0.0	0.0	0.0	1.7	3.0					0.1	0.3	5.5
Groundnuts, dryland	0.70	0.8	8.6	24.2	8.5	2.7						0.2	10.2	55.3
Cotton, dryland	1.00	10.1	5.3	27.6	96.7	7.7						12.4	22.1	181.9
Total requirement		21.4	29.0	57.8	129.4	29.6	25.3	14.6	0.0	0.0	0.0	31.4	52.0	390.6
Available labour		90.0	60.0	60.0	90.0	90.0	60.0	60.0	90.0	90.0	60.0	60.0	90.0	900.0
Hired labour		0.0	0.0	0.0	39.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	39.4

Table A1-2

Monthly labour requirements for Mutange irrigation scheme 'with project' situation, 0.5 ha irrigated + 2.5 ha rainfed

Crop	Area (ha)	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Grain maize, irrigated	0.20	2.1	3.2	0.7	6.8	0.9	0.9	0.9				5.8	5.9	27.3
Sugar bean, irrigated	0.20	6.4	6.6	4.1	5.3	4.2	1.6							28.1
Groundnut, irrigated	0.10	2.9	5.0	3.8	0.8						3.6	3.1	1.6	20.7
Wheat, irrigated	0.20					4.5	6.1	2.8	3.7	2.8	20.2			40.0
Green maize, irrigated	0.20								5.8	5.9	2.1	2.8	5.3	21.9
Cabbage, irrigated	0.10			0.2	4.0	3.3	2.3	2.0	4.4					16.2
Grain maize, rainfed	1.00	8.5	13.8	5.5	22.0	11.1	12.2	13.3				16.5	16.7	119.6
Groundnut, rainfed	0.50	0.6	6.2	17.3	6.1	1.9						0.2	7.3	39.5
Cotton, rainfed	1.00	10.1	5.3	27.6	96.7	7.7						12.4	22.1	181.9
Total requirement		30.5	40.0	59.1	141.7	33.6	23.1	19.0	13.9	8.6	25.9	40.8	58.9	495.2
Available labour		90.0	60.0	60.0	90.0	90.0	60.0	60.0	90.0	90.0	60.0	60.0	90.0	900.0
Hired labour		0.0	0.0	0.0	51.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	51.7

Table A1-3

Labour requirements for irrigated beans/peas for a 1 ha plot

Task	Month				Total days
	1	2	3	4	
Manuring	0.6				0.6
Land preparation	2.0				2.0
Basal application	3.3				3.3
Planting by hand	10.0				10.0
Disease and pest control		1.0	1.0	1.0	3.0
Topdressing			2.0		2.0
Weeding	5.0	5.0	5.0	5.0	20.0
Irrigation	3.6	3.6	3.6	3.6	14.4
Harvesting			50.0	50.0	100.0
Sub-total	24.5	9.6	61.6	59.6	155.3
Contingency (10%)	2.5	1.0	6.2	6.0	15.5
Total	**27.0**	**10.6**	**67.8**	**65.6**	**170.8**

Table A1-4

Labour requirements for irrigated sugar beans for a 1 ha plot

Task		Month						Total days
		1	2	3	4	5	6	
Manuring		0.6						0.6
Land preparation		2.0						2.0
Basal application		3.3						3.3
Planting by hand		10.2						10.2
Covering seed		0.3						0.3
Irrigation		12.5	12.5	5.0	5.0			35.0
Weeding			13.3	11.2				24.5
Disease and pest control			2.4	2.4				4.8
Topdressing			2.0					2.0
Harvesting:	Reaping off plant and transport				8.3	8.3		16.6
	Shelling by hand				10.7	10.7		21.4
	Grading, weighing and bagging						4.7	4.7
Marketing:	Free market crops						2.5	2.5
Sub-total		28.9	30.2	18.6	24.0	19.0	7.2	127.9
Contingency (10%)		2.9	3.0	1.9	2.4	1.9	0.7	12.8
Total		**31.8**	**33.2**	**20.5**	**26.4**	**20.9**	**7.9**	**140.7**

Table A1-5

Labour requirements for irrigated cabbage for a 1 ha plot

Task	Month						Total days
	1	2	3	4	5	6	
Seedbed operations	1.7						1.7
Manuring		0.6					0.6
Land preparation		2.0					2.0
Basal fertilization		3.3					3.3
Transplanting		16.0					16.0
Weeding			13.3	13.3	13.3		39.9
Disease and pest control		2.4	2.4	2.4			7.2
Topdressing			2.0				2.0
Irrigation		12.5	12.5	5.0	5.0	5.0	40.0
Harvesting: Lifting and transporting						15.0	15.0
Marketing: 1 day per ton (used 5-ton truck)						20.0	20.0
Sub-total	1.7	36.8	30.2	20.7	18.3	40.0	147.7
Contingency (10%)	0.2	3.7	3.0	2.1	1.8	4.0	14.8
Total	**1.9**	**40.5**	**33.2**	**22.8**	**20.1**	**44.0**	**162.5**

Table A1-6

Labour requirements for irrigated carrots for a 1 ha plot

Task	Month					Total days
	1	2	3	4	5	
Manuring	0.6					0.6
Land preparation	2.0					2.0
Basal application	3.3					3.3
Planting by hand	7.8					7.8
Covering seed	0.3					0.3
Disease and pest control	2.4	2.4	2.4	2.4		9.6
Thinning			18.0			18.0
Topdressing				2.0		2.0
Weeding		13.3		13.3		26.6
Irrigation	12.5	12.5	12.5	12.5	12.5	62.5
Harvesting: Lifting and transporting					100.0	100.0
Grading, weighing and bagging					28.0	28.0
Marketing: 1 day per ton					20.0	20.0
Sub-total	28.9	28.2	32.9	30.2	160.5	280.7
Contingency (10%)	2.9	2.8	3.3	3.0	16.1	28.1
Total	**31.8**	**31.0**	**36.2**	**33.2**	**176.6**	**308.8**

Table A1-7

Labour requirements for irrigated groundnuts for a 1 ha plot

Task		Month 1	2	3	4	5	6	7	Total days
Manuring		0.6							0.6
Land preparation		2.0							2.0
Basal application		4.0							4.0
Planting by hand		10.2							10.2
Basal fertilization		3.3							3.3
Covering seed		0.3							0.3
Weeding			13.3		11.2				24.5
Topdressing				2.0					2.0
Disease and pest control			2.4		2.4				4.8
Irrigation		12.5	12.5	12.5	12.5	12.5			62.5
Harvesting:	Lifting and transporting					20.3	15.0		35.3
	Picking groundnut pods					10.8	10.8		21.6
	Grading, weighing and bagging					1.5	1.5		3.0
Marketing:	Free market crops						7.0	7.0	14.0
Sub-total		32.9	28.2	14.5	26.1	45.1	34.3	7.0	188.1
Contingency (10%)		3.3	2.8	1.5	2.6	4.5	3.4	0.7	18.8
Total		**36.2**	**31.0**	**16.0**	**28.7**	**49.6**	**37.7**	**7.7**	**206.9**

Table A1-8

Labour requirements for irrigated grain maize for a 1 ha plot

Task		Month 1	2	3	4	5	6	7	8	9	Total days
Manuring		0.6									0.6
Land preparation		2.0									2.0
Basal application		3.3									3.3
Planting by hand		7.8									7.8
Covering seed		0.3									0.3
Disease and pest control			4.7	4.7							9.4
Topdressing			2.0		2.0						4.0
Weeding			7.5		7.5						15.0
Irrigation		12.5	12.5	5.0	5.0	3.1	3.1				41.2
Harvesting:	Cutting and starking						7.0				7.0
	Dehusking and transporting						21.0				21.0
	Shelling by hand							2.0	2.0	2.0	6.0
	Grading, weighing and bagging							0.7	0.7	0.7	2.1
Marketing:	Controlled crops							1.4	1.4	1.4	4.2
Sub-total		26.5	26.7	9.7	14.5	3.1	31.1	4.1	4.1	4.1	123.9
Contingency (10%)		2.7	2.7	1.0	1.5	0.3	3.1	0.4	0.4	0.4	12.4
Total		**29.2**	**29.4**	**10.7**	**16.0**	**3.4**	**34.2**	**4.5**	**4.5**	**4.5**	**136.3**

Table A1-9

Labour requirements for irrigated green maize for a 1 ha plot

Task	Month 1	2	3	4	5	Total days
Manuring	0.6					0.6
Land preparation	2.0					2.0
Basal fertilization	3.3					3.3
Planting by hand	7.8					7.8
Covering seed	0.3					0.3
Disease and pest control		4.7	4.7			9.4
Topdressing		2.0		2.0		4.0
Weeding		7.5		7.5		15.0
Irrigation	12.5	12.5	5.0	3.1	3.1	36.2
Harvesting				7.0	7.0	
Marketing: Free market crops					14.0	14.0
Sub-total	26.5	26.7	9.7	12.6	24.1	99.6
Contingency (10%)	2.7	2.7	1.0	1.3	2.4	10.0
Total	**29.2**	**29.4**	**10.7**	**13.9**	**26.5**	**109.6**

Table A1-10

Labour requirements for irrigated okra for a 1 ha plot

Task	Month 1	2	3	4	5	Total days
Basal application	1.0					1.0
Ploughing	1.0					1.0
Row marking	4.0					4.0
Planting by hand	1.0					1.0
Top dressing		1.0	1.0	1.0		3.0
Disease and pest control	10.0	10.0	10.0	10.0	10.0	50.0
Weeding	2.0	2.0	2.0	2.0	2.0	10.0
Irrigation	1.5	1.5	1.5	1.5	1.5	7.5
Harvesting: Lifting and transporting			10.0	10.0	10.0	30.0
Sub-total	20.5	14.5	24.5	24.5	23.5	107.5
Contingency 10%	2.1	1.5	2.5	2.5	2.4	10.8
Total	**22.6**	**16.0**	**27.0**	**27.0**	**25.9**	**118.3**

Table A1-11

Labour requirements for irrigated green onions for a 1 ha plot

Task		Month								Total days
		1	2	3	4	5	6	7	8	
Manuring				0.6						0.6
Seedbed		5.0								5.0
Land preparation				2.0						2.0
Basal application				3.3						3.3
Transplanting				80.0						80.0
Disease and pest control			2.4	2.4	2.4	2.4				9.6
Topdressing					2.0		2.0			4.0
Weeding					11.2		11.2			22.4
Irrigation				12.5	12.5	12.5	12.5			50.0
Harvesting:	Lifting and transporting							11.0	11.0	22.0
	Grading, weighing and bagging							33.0	33.0	66.0
Marketing:	Free market crops							4.0	4.0	8.0
Sub-total		5.0	2.4	100.8	28.1	14.9	25.7	48.0	48.0	272.9
Contingency (10%)		0.5	0.2	10.1	2.8	1.5	2.6	4.8	4.8	27.3
Total		**5.5**	**2.6**	**110.9**	**30.9**	**16.4**	**28.3**	**52.8**	**52.8**	**300.2**

Table A1-12

Labour requirements for irrigated paprika for a 1 ha plot

Task	Month							Total days
	1	2	3	4	5	6	7	
Seedbed preparation	6.0							6.0
Land preparation		2.0						2.0
Basal application		4.0						4.0
Planting by hand		20.0						20.0
Disease and pest control		7.0	7.0	7.0	7.0			28.0
Topdressing		3.3	3.3	3.3				9.9
Weeding		10.0	10.0					20.0
Irrigation		12.5	12.5	12.5	5.0			42.5
Harvesting						100.0	50.0	150.0
Sub-total	6.0	58.8	32.8	22.8	12.0	100.0	50.0	282.4
Contingency (10%)	0.6	5.9	3.3	2.3	1.2	10.0	5.0	28.2
Total	**6.6**	**64.7**	**36.1**	**25.1**	**13.2**	**110.0**	**55.0**	**310.6**

Table A1-13

Labour requirements for irrigated potatoes for a 1 ha plot

Task		Month 1	2	3	4	5	6	Total days
Manuring		0.6						0.6
Land preparation		2.0						2.0
Basal application		3.3						3.3
Planting by hand		7.8						7.8
Disease and pest control		2.4	2.4	2.4	2.4			9.6
Topdressing					2.0			2.0
Weeding			13.3		13.3			26.6
Ridging				7.5				7.5
Irrigation		12.5	12.5	12.5	12.5	12.5		62.5
Harvesting:	Lifting and transporting					45.0	45.0	90.0
	Grading, weighing and bagging					13.5	13.5	27.0
Marketing:	Free market crops					15.0	15.0	30.0
Sub-total		28.6	28.2	22.4	30.2	86.0	73.5	268.9
Contingency (10%)		2.9	2.8	2.2	3.0	8.6	7.4	26.9
Total		**31.5**	**31.0**	**24.6**	**33.2**	**94.6**	**80.9**	**295.8**

Table A1-14

Labour requirements for irrigated rape for a 1 ha plot

Task		Month 1	2	3	4	Total days
Manuring			0.6			0.6
Seedbed operations		1.7				1.7
Land preparation			2.0			2.0
Basal application			3.3			3.3
Transplanting			16.0			16.0
Disease and pest control			2.4	2.4	2.4	7.2
Topdressing				2.0		2.0
Weeding			13.3	13.3	13.3	39.9
Irrigation			12.5	12.5	5.0	30.0
Harvesting:	Lifting and transporting			72.0	72.0	144.0
Marketing:	Free market crops			22.9	22.9	45.8
Sub-total		1.7	50.1	125.1	115.6	292.5
Contingency (10%)		0.2	5.0	12.5	11.6	29.3
Total		**1.9**	**55.1**	**137.6**	**127.2**	**321.8**

Table A1-15

Labour requirements for irrigated tomatoes for fresh sale for a 1 ha plot

Task	Month						Total days
	1	2	3	4	5	6	
Manuring		0.6					0.6
Seedbed	2.0						2.0
Land preparation		2.0					2.0
Basal application		3.3					3.3
Planting by hand		20.0					20.0
Staking		120.0					120.0
Disease and pest control	10.0	10.0	10.0	10.0	10.0	10.0	60.0
Topdressing		1.0	1.0	1.0			3.0
Pruning and trellising			10.0	10.0	10.0	10.0	40.0
Weeding		2.0	2.0	2.0	2.0	2.0	10.0
Irrigation		1.5	1.5	1.5	1.5	1.5	7.5
Harvesting						57.6	57.6
Marketing: Free market crops						30.0	30.0
Sub-total	12.0	160.4	24.5	24.5	23.5	111.1	356.0
Contingency (10%)	1.2	16.0	2.5	2.5	2.4	11.1	35.6
Total	**13.2**	**176.4**	**27.0**	**27.0**	**25.9**	**122.2**	**391.6**

Table A1-16

Labour requirements for irrigated tomatoes for canning for a 1 ha plot

Task	Month						Total days
	1	2	3	4	5	6	
Manuring		0.6					0.6
Seedbed	2.0						2.0
Land preparation		2.0					2.0
Basal application		3.3					3.3
Planting by hand		20.0					20.0
Disease and pest control	10.0	10.0	10.0	10.0	10.0	10.0	60.0
Topdressing		1.0	1.0	1.0			3.0
Pruning and trellising			10.0	10.0	10.0	10.0	40.0
Weeding		2.0	2.0	2.0	2.0	2.0	10.0
Irrigation		1.5	1.5	1.5	1.5	1.5	7.5
Harvesting					28.8	28.8	57.6
Marketing: Free market crops					10.0	10.0	20.0
Sub-total	12.0	40.4	24.5	24.5	62.3	62.3	226.0
Contingency (10%)	1.2	4.0	2.5	2.5	6.2	6.2	22.6
Total	**13.2**	**44.4**	**27.0**	**27.0**	**68.5**	**68.5**	**248.6**

Table A1-17
Labour requirements for irrigated wheat for a 1 ha plot

Task		Month						Total days
		1	2	3	4	5	6	
Manuring		0.6						0.6
Land preparation		2.0						2.0
Basal fertilization		3.3						3.3
Planting by hand		1.7						1.7
Covering seed		0.3						0.3
Weeding			13.3					13.3
Topdressing			2.0		2.0			4.0
Irrigation		12.5	12.5	12.5	12.5	12.5		62.5
Disease and pest control					2.4			2.4
Harvesting:	Reaping of plants and transport						63.3	63.3
	Threshing by hand						20.8	20.8
	Grading, weighing, bagging						5.0	5.0
Marketing:	(controlled crops)						2.5	2.5
Sub-total		20.4	27.8	12.5	16.9	12.5	91.6	181.7
Contingency (10%)		2.0	2.8	1.3	1.7	1.3	9.2	18.2
Total		**22.4**	**30.6**	**13.8**	**18.6**	**13.8**	**100.8**	**199.9**

Table A1-18
Labour requirements for rainfed cotton for a 1 ha plot

Task	Month							Total days
	1	2	3	4	5	6	7	
Manuring	0.6							0.6
Land preparation	2.0							2.0
Row marking	2.0							2.0
Basal application	1.7							1.7
Planting by hand	4.7							4.7
Covering seed	0.3							0.3
Disease and pest control		2.4	2.4	4.8	4.8	4.8		19.2
Thinning		9.0						9.0
Topdressing			1.0		20.3			21.3
Weeding		8.7	5.8					14.5
Picking and grading						79.7		79.7
Grading, weighing and baling						3.4		3.4
Marketing							3.0	3.0
Destruction							4.0	4.0
Sub-total	11.3	20.1	9.2	4.8	25.1	87.9	7.0	165.4
Contingency (10%)	1.1	2.0	0.9	0.5	2.5	8.8	0.7	16.5
Total	**12.4**	**22.1**	**10.1**	**5.3**	**27.6**	**96.7**	**7.7**	**181.9**

Table A1-19

Labour requirements for rainfed groundnuts for a 1 ha plot

Task		Month							Total days
		1	2	3	4	5	6	7	
Manuring		0.6							0.6
Land preparation		2.0							2.0
Basal application		1.7							1.7
Planting by hand		10.2							10.2
Covering seed		0.3							0.3
Weeding			13.3		11.2				24.5
Topdressing				1.0					1.0
Harvesting:	Lifting and transporting					20.3			20.3
	Picking groundnut pods					9.7	9.7		19.4
	Grading, weighing and bagging					1.4	1.4		2.8
Marketing:	Free market crops							3.5	3.5
Sub-total		0.3	13.3	1.0	11.2	31.4	11.1	3.5	71.8
Contingency (10%)		0.0	1.3	0.1	1.1	3.1	1.1	0.4	7.2
Total		**0.3**	**14.6**	**1.1**	**12.3**	**34.5**	**12.2**	**3.9**	**79.0**

Table A1-20

Labour requirements for rainfed grain maize for a 1 ha plot

Task		Month									Total days
		1	2	3	4	5	6	7	8	9	
Manuring		0.6									0.6
Land preparation		2.0									2.0
Basal application		3.3									3.3
Planting by hand		7.8									7.8
Covering seed		0.3									0.3
Disease and pest control			4.7	4.7							9.4
Topdressing			1.0		1.0						2.0
Weeding			7.5		7.5						15.0
Harvesting:	Cutting and starking						3.5				3.5
	Dehusking and transporting						10.5				10.5
	Shelling by hand							1.0	1.0	1.0	3.0
	Grading, weighing and bagging							0.7	0.7	0.7	2.1
Marketing:	Controlled crops							1.4	1.4	1.4	4.2
Sub-total		15.0	15.2	7.7	12.5	5.0	20.0	10.1	11.1	12.1	108.7
Contingency (10%)		1.5	1.5	0.8	1.3	0.5	2.0	1.0	1.1	1.2	10.9
Total		**16.5**	**16.7**	**8.5**	**13.8**	**5.5**	**22.0**	**11.1**	**12.2**	**13.3**	**119.6**

Table A1-21
Labour requirements for rainfed pearl millet for a 1 ha plot

Task	Month								Total days
	1	2	3	4	5	6	7	8	
Land preparation	1.5								1.5
Basal application	0.6								0.6
Planting by hand	0.1								0.1
Harrowing	0.5								0.5
Cultivation		5.6	5.6						11.2
Harvesting							31.7	31.7	63.4
Threshing and winnowing								20.1	20.1
Other								2.0	2.0
Sub-total	2.7	5.6	5.6	0.0	0.0	0.0	31.7	53.8	99.4
Contingency (10%)	0.3	0.6	0.6	0.0	0.0	0.0	3.2	5.4	9.9
Total	**3.0**	**6.2**	**6.2**	**0.0**	**0.0**	**0.0**	**34.9**	**59.2**	**109.3**

Table A1-22
Labour requirements for rainfed sorghum for a 1 ha plot

Task	Month								Total days
	1	2	3	4	5	6	7	8	
Land preparation	1.5								1.5
Basal application	0.6								0.6
Planting by hand	0.1								0.1
Harrowing	0.5								0.5
Cultivation		5.6	5.6						11.2
Harvesting							31.7	31.7	63.4
Threshing and winnowing								20.1	20.1
Other								2.0	2.0
Sub-total	2.7	5.6	5.6	0.0	0.0	0.0	31.7	53.8	99.4
Contingency (10%)	0.3	0.6	0.6	0.0	0.0	0.0	3.2	5.4	9.9
Total	**3.0**	**6.2**	**6.2**	**0.0**	**0.0**	**0.0**	**34.9**	**59.2**	**109.3**

Table A1-23
Labour requirements for rainfed sunflowers for a 1 ha plot

Task		Month							Total days
		1	2	3	4	5	6	7	
Manuring		0.6							0.6
Land preparation		2.0							2.0
Basal application		1.7							1.7
Planting by hand		10.2							10.2
Covering seed		0.3							0.3
Weeding			7.5						7.5
Topdressing				1.0					1.0
Harvesting:	Reaping and transporting					12.5			12.5
	Shelling by hand					15.3	15.3		30.6
	Grading, weighing and bagging					2.5	2.5		5.0
Marketing:	Free market crops							3.5	3.5
Sub-total		14.8	7.5	1.0	0.0	30.3	17.8	3.5	74.9
Contingency (10%)		1.5	0.8	0.1	0.0	3.0	1.8	0.4	7.5
Total		**16.3**	**8.3**	**1.1**	**0.0**	**33.3**	**19.6**	**3.9**	**82.4**

Appendix 2
Gross margin crop budgets

Table A2-1
Gross margin of rainfed area of farmers participating in Mutange irrigation scheme (US$)

Gross margin for 3.0 ha rainfed area

	Area		Gross margin (US$)	
	(%)	(ha)	per ha	per area
Grain maize	36.7	1.10	252	278
Sorghum	5.0	0.15	203	30
Pearl millet	1.7	0.05	230	12
Groundnuts	23.3	0.70	542	379
Cotton	33.3	1.00	-74	-74
Total	**100.0**	**3.00**		**625**

Gross margin for 2.5 ha rainfed area

	Area		Gross margin (US$)	
	(%)	(ha)	per ha	per area
Grain maize	40	1.00	252	252
Sorghum	0	0.00	203	0
Pearl millet	0	0.00	230	0
Groundnuts	20	0.50	542	271
Cotton	40	1.00	-74	-74
Total		**2.50**		**449**

Table A2-2
Gross margin foregone of rainfed area due to transformation into irrigated area in Mutange irrigation scheme (US$)

Gross margin foregone per plot of 0.5 ha

	Area		Gross margin (US$)	
	(%)	(ha)	per ha	per area
Grain maize	20	0.10	252	25
Groundnuts	40	0.20	542	108
Sorghum	30	0.15	203	30
Pearl millet	10	0.05	230	12
Total		**0.50**		**176**

Gross margin foregone for a total of 105 ha

	Area		Gross margin (US$)	
	(%)	(ha)	per ha	per area
Grain maize	20	21.00	252	5 294
Groundnuts	40	42.00	542	22 770
Sorghum	30	31.50	203	6 396
Pearl millet	10	10.50	230	2 418
Total		**105.00**		**36 878**

Table A2-3

Gross margin of the irrigated area in Mutange irrigation scheme (US$)

Gross margin per plot of 0.5 ha irrigated (200% cropping intensity)

	Area		Year 1		Year 2		Year 3		Year 4	
	(%)	(ha)	per ha	per area	per ha	per area	per ha	per area	per ha	per area
Grain maize	40	0.2	510	102	964	193	964	193	964	193
Sugar beans	40	0.2	854	171	1 064	213	1 275	255	1 486	297
Groundnuts	20	0.1	994	99	1 206	121	1 488	149	2 053	205
Wheat	40	0.2	1 148	230	1 402	280	1 656	331	1 910	382
Green maize	40	0.2	5 157	1 031	5 967	1 193	6 777	1 355	7 587	1 517
Cabbage	20	0.1	5 176	518	6 111	611	7 045	705	7 980	798
Total	**200**	**1.0**		**2 151**		**2 611**		**2 988**		**3 393**
Less:										
Energy costs (drag-hose sprinkler):				105		105		105		105
Repair and maintenance costs (= 3% of investment):				156		156		156		156
(Investment cost: US$1 090 909)										
Net income				**1 890**		**2 350**		**2 727**		**3 132**

Gross margin for the whole scheme of 105.00 ha irrigated (200% cropping intensity)

	Area		Year 1		Year 2		Year 3		Year 4	
	(%)	(ha)	per ha	per area	per ha	per area	per ha	per area	per ha	per area
Grain maize	40	42	510	21 410	964	40 487	964	40 487	964	40 487
Sugar beans	40	42	854	35 852	1 064	44 702	1 275	53 552	1 486	62 402
Groundnuts	20	21	994	20 879	1 206	25 325	1 488	31 254	2 053	43 111
Wheat	40	42	1 148	48 227	1 402	58 897	1 656	69 567	1 910	80 237
Green maize	40	42	5 157	216 593	5 967	250 613	6 777	284 633	7 587	318 653
Cabbage	20	21	5 176	108 701	6 111	128 327	7 045	147 953	7 980	167 579
Total	**200**	**210**		**451 663**		**548 352**		**627 446**		**712 469**
Less:										
Energy costs (drag-hose sprinkler):				22 126		22 126		22 126		22,126
Repair and maintenance costs (= 3% of investment):				32 727		32 727		32 727		32 727
(Investment cost: US$1 090 909)										
Net income				**396 809**		**493 498**		**572 592**		**657 615**

Table A2-4
Gross margin budget for irrigated baby corn for a 1 ha plot

	Quantity	Unit	Unit cost	Year 1	Year 2	Year 3	Year 4
Area (1)		ha		1.00	1.00	1.00	1.00
Saleable yield (2)		tons/ha		0.63	0.72	0.81	0.90
Saleable harvest (3) = (1) x (2)		tons/ha		0.63	0.72	0.81	0.90
Price (4)		US$/ton		1 636.36	1 636.36	1 636.36	1 636.36
Gross income (5) = (3) x (4)		**US$**		**1 030.91**	**1 178.18**	**1 325.45**	**1 472.72**
Variable costs:			**US$**	**US$**	**US$**	**US$**	**US$**
Land preparation	1.00	ha	38.18	38.18	38.18	38.18	38.18
Seed	60	kg	2.73	163.80	163.80	163.80	163.80
Fertilizer							
- Compound D	600	kg	0.38	228.00	228.00	228.00	228.00
- Ammonium nitrate	300	kg	0.37	111.00	111.00	111.00	111.00
Transport of inputs to farm	0.96	ton	18.18	17.45	17.45	17.45	17.45
Chemicals							
- Dipterex	4	kg	1.73	6.92	6.92	6.92	6.92
Seasonal loan interest (6%)		US$		33.92	33.92	33.92	33.92
Transport of output to market		ton	18.18	11.45	13.09	14.73	16.36
Total variable cost (6)		**US$**		**610.73**	**612.36**	**614.00**	**615.64**
Gross margin (7) = (5) - (6)		**US$**		**420.18**	**565.82**	**711.45**	**857.09**

Table A2-5
Gross margin budget for irrigated baby marrows for a 1 ha plot

	Quantity	Unit	Unit cost	Year 1	Year 2	Year 3	Year 4
Area (1)		ha		1.00	1.00	1.00	1.00
Saleable yield (2)		tons/ha		2.8	3.2	3.6	4.0
Saleable harvest (3) = (1) x (2)		tons		2.8	3.2	3.6	4.0
Price (4)		US$/ton		727.27	727.27	727.27	727.27
Gross income (5) = (3) x (4)		**US$**		**2 036.36**	**2 327.26**	**2 618.17**	**2 909.08**
Variable costs:			**US$**	**US$**	**US$**	**US$**	**US$**
Land preparation	1.00	ha	38.18	38.18	38.18	38.18	38.18
Seed	6	kg	27.27	163.62	163.62	163.62	163.62
Fertilizer							
- Compound D	600	kg	0.38	228.00	228.00	228.00	228.00
- Ammonium nitrate	100	kg	0.37	37.00	37.00	37.00	37.00
Transport of inputs to farm	0.706	ton	18.18	12.84	12.84	12.84	12.84
Chemicals							
- Mancozeb	2	kg	25.91	51.82	51.82	51.82	51.82
- Malathion	2.8	kg	12.55	35.14	35.14	35.14	35.14
- Bravo	1.5	litre	36.37	54.56	54.56	54.56	54.56
- Dimethoate 40EC	1	kg	15.45	15.45	15.45	15.45	15.45
Seasonal loan interest (6%)		US$		38.20	38.20	38.20	38.20
Hired labour	100	days	3.09	309.00	309.00	309.00	309.00
Packing material		10 kg pocket	0.27	75.60	86.40	97.20	108.00
Transport of output to market		ton	18.18	50.90	58.18	65.45	72.72
Total variable cost (6)		**US$**		**1 110.30**	**1 128.37**	**1 146.44**	**1 164.52**
Gross margin (7) = (5) - (6)		**US$**		**926.06**	**1 198.89**	**1 471.73**	**1 744.56**

Table A2-6

Gross margin budget for irrigated fine beans for a 1 ha plot

	Quantity	Unit	Unit cost	Year 1	Year 2	Year 3	Year 4
Area (1)		ha		1.00	1.00	1.00	1.00
Saleable yield (2)		tons/ha		3.15	3.60	4.05	4.50
Saleable harvest (3) = (1) x (2)		tons/ha		3.15	3.60	4.05	4.50
Price (4)		US$/ton		818.18	818.18	818.18	818.18
Gross income (5) = (3) x (4)		**US$**		**2 577.27**	**2 945.45**	**3 313.63**	**3 681.81**
Variable costs:			**US$**	**US$**	**US$**	**US$**	**US$**
Land preparation	1.00	ha	38.18	38.18	38.18	38.18	38.18
Seed	75	kg	1.40	105.00	105.00	105.00	105.00
Fertilizer							
- Compound D	300	kg	0.38	114.00	114.00	114.00	114.00
- Ammonium nitrate	50	kg	0.37	18.50	18.50	18.50	18.50
Transport of inputs to farm	0.425	ton	18.18	7.73	7.73	7.73	7.73
Chemicals							
- Karate (Fenvelerate)	0.4	litre	12.28	4.91	4.91	4.91	4.91
- Solvirex (Disulfoton 5% GR)	12	kg	2.91	34.92	34.92	34.92	34.92
- Funginex	0.15	litre	109.07	16.36	16.36	16.36	16.36
- Endosulfan 35MO	2.8	litre	24.12	67.54	67.54	67.54	67.54
- Copper oxychloride	4.4	kg	14.55	64.02	64.02	64.02	64.02
Seasonal loan interest (6%)		US$		28.27	28.27	28.27	28.27
Hired labour	100	days	3.09	309.00	309.00	309.00	309.00
Transport of output to market		ton	18.18	57.27	65.45	73.63	81.81
Total variable cost (6)		**US$**		**865.69**	**873.87**	**882.05**	**890.23**
Gross margin (7) = (5) - (6)		**US$**		**1 711.58**	**2 071.58**	**2 431.58**	**2 791.58**

Table A2-7

Gross margin budget for irrigated green beans for a 1 ha plot

	Quantity	Unit	Unit cost	Year 1	Year 2	Year 3	Year 4
Area (1)		ha		1.00	1.00	1.00	1.00
Saleable yield (2)		tons/ha		5.6	6.4	7.2	8.0
Saleable harvest (3) = (1) x (2)		tons/ha		5.6	6.4	7.2	8.0
Price (4)		US$/ton		636.36	636.36	636.36	636.36
Gross income (5) = (3) x (4)		**US$**		**3 563.62**	**4 072.70**	**4 581.79**	**5 090.88**
Variable costs:			**US$**	**US$**	**US$**	**US$**	**US$**
Land preparation	1.00	ha	38.18	38.18	38.18	38.18	38.18
Seed	75	kg	1.40	105.00	105.00	105.00	105.00
Fertilizer							
- Compound D	600	kg	0.38	228.00	228.00	228.00	228.00
- Ammonium nitrate	100	kg	0.37	37.00	37.00	37.00	37.00
Transport of inputs to farm	0.775	ton	18.18	14.09	14.09	14.09	14.09
Chemicals							
- Karate (Fenvelerate)	0.4	litre	12.28	4.91	4.91	4.91	4.91
- Solvirex (Disulfoton 5% GR)	12	kg	2.91	34.92	34.92	34.92	34.92
- Funginex	0.15	litre	109.07	16.36	16.36	16.36	16.36
- Endosulfan 35MO	2.8	litre	24.12	67.54	67.54	67.54	67.54
- Copper oxychloride	4.4	kg	14.55	64.02	64.02	64.02	64.02
Seasonal loan interest (6%)		US$		36.60	36.60	36.60	36.60
Hired labour	100	days	3.09	309.00	309.00	309.00	309.00
Transport of output to market		ton	18.18	101.81	116.35	130.90	145.44
Total variable cost (6)		**US$**		**1 057.43**	**1 071.97**	**1 086.52**	**1 101.06**
Gross margin (7) = (5) - (6)		**US$**		**2 506.19**	**3 000.73**	**3 495.28**	**3 989.82**

Table A2-8
Gross margin budget for irrigated sugar beans for a 1 ha plot

	Quantity	Unit	Unit cost	Year 1	Year 2	Year 3	Year 4
Area (1)		ha		1.00	1.00	1.00	1.00
Saleable yield (2)		tons/ha		1.4	1.6	1.8	2.0
Saleable harvest (3) = (1) x (2)		tons/ha		1.4	1.6	1.8	2.0
Price (4)		US$/ton		1 090.91	1 090.91	1 090.91	1 090.91
Gross income (5) = (3) x (4)		**US$**		**1 527.27**	**1 745.46**	**1 963.64**	**2 181.82**
Variable costs:			**US$**	**US$**	**US$**	**US$**	**US$**
Land preparation	1.00	ha	38.18	38.18	38.18	38.18	38.18
Seed	90	kg	1.27	114.30	114.30	114.30	114.30
Fertilizer							
- Compound D	500	kg	0.38	190.00	190.00	190.00	190.00
- Ammonium nitrate	100	kg	0.37	37.00	37.00	37.00	37.00
Transport of inputs to farm	0.69	ton	18.18	12.54	12.54	12.54	12.54
Chemicals							
- Carbaryl 85WP	1	kg	52.73	52.73	52.73	52.73	52.73
- Dicofol	1	kg	10.25	10.25	10.25	10.25	10.25
- Copper oxychloride	0.6	kg	14.55	8.73	8.73	8.73	8.73
Seasonal loan interest (6%)		US$		27.82	27.82	27.82	27.82
Hired labour	42	days	3.09	129.78	129.78	129.78	129.78
Bags		50 kg bag	0.91	25.48	29.12	32.76	36.40
Twine (0.09 kg/ton)		kg	10.91	1.37	1.57	1.77	1.96
Transport of output to market		ton	18.18	25.45	29.09	32.72	36.36
Total variable cost (6)		**US$**		**673.64**	**681.12**	**688.59**	**696.06**
Gross margin (7) = (5) - (6)		**US$**		**853.63**	**1 064.34**	**1 275.05**	**1 485.76**

Table A2-9
Gross margin budget for irrigated butternut for a 1 ha plot

	Quantity	Unit	Unit cost	Year 1	Year 2	Year 3	Year 4
Area (1)		ha		1.00	1.00	1.00	1.00
Saleable yield (2)		tons/ha		10.5	12.0	13.0	15.0
Saleable harvest (3) = (1) x (2)		tons		10.5	12.0	13.0	15.0
Price (4)		US$/ton		363.63	363.63	363.63	363.63
Gross income (5) = (3) x (4)		**US$**		**3 818.12**	**4 363.56**	**4 727.19**	**5 454.45**
Variable costs:			**US$**	**US$**	**US$**	**US$**	**US$**
Land preparation	1.00	ha	38.18	38.18	38.18	38.18	38.18
Seed	3	kg	54.55	163.65	163.65	163.65	163.65
Fertilizer							
- Compound D	600	kg	0.38	228.00	228.00	228.00	228.00
- Ammonium nitrate	100	kg	0.37	37.00	37.00	37.00	37.00
Transport of inputs to farm	0.703	ton	18.18	12.78	12.78	12.78	12.78
Chemicals							
- Mancozeb	2	kg	25.91	51.82	51.82	51.82	51.82
- Malathion	3	kg	12.55	37.65	37.65	37.65	37.65
- Bravo	2	litre	36.37	72.74	72.74	72.74	72.74
- Dimethoate 40EC	1	kg	15.45	15.45	15.45	15.45	15.45
Seasonal loan interest (6%)		US$		39.44	39.44	39.44	39.44
Hired labour	40	days	3.09	123.60	123.60	123.60	123.60
Packing material		12.5 kg pock	0.27	226.80	259.20	280.80	324.00
Transport of output to market		ton	18.18	190.89	218.16	236.34	272.70
Total variable cost (6)		**US$**		**1 238.00**	**1 297.67**	**1 337.45**	**1 417.01**
Gross margin (7) = (5) - (6)		**US$**		**2 580.12**	**3 065.89**	**3 389.74**	**4 037.44**

Table A2-10

Gross margin budget for irrigated cabbage for a 1 ha plot

	Quantity	Unit	Unit cost	Year 1	Year 2	Year 3	Year 4
Area (1)		ha		1.00	1.00	1.00	1.00
Saleable yield (2)		heads/ha		28 000	32 000	36 000	40 000
Saleable harvest (3) = (1) x (2)		heads		28 000	32 000	36 000	40 000
Price (4)		US$/head		0.27	0.27	0.27	0.27
Gross income (5) = (3) x (4)		**US$**		**7 560.00**	**8 640.00**	**9 720.00**	**10 800.00**
Variable costs:			**US$**	**US$**	**US$**	**US$**	**US$**
Land preparation	1.00	ha	38.18	38.18	38.18	38.18	38.18
Seed	0.45	kg	18.18	8.18	8.18	8.18	8.18
Fertilizer							
- Compound S	1000	kg	0.67	670.00	670.00	670.00	670.00
- Ammonium nitrate	400	kg	0.37	148.00	148.00	148.00	148.00
Transport of inputs to farm	1.4	ton	18.18	25.45	25.45	25.45	25.45
Chemicals							
- Endosulfan 35MO	2	litre	24.12	48.24	48.24	48.24	48.24
- Dichlorvos	1	litre	76.36	76.36	76.36	76.36	76.36
- Dimethoate 40EC	0.75	kg	15.45	11.59	11.59	11.59	11.59
Seasonal loan interest (6%)		US$		61.56	61.56	61.56	61.56
Hired labour	90	days	3.09	278.10	278.10	278.10	278.10
Transport of output to market		1000 head	36.36	1 018.08	1 163.52	1 308.96	1 454.40
Total variable cost (6)		**US$**		**2 383.74**	**2 529.18**	**2 674.62**	**2 820.06**
Gross margin (7) = (5) - (6)		**US$**		**5 176.26**	**6 110.82**	**7 045.38**	**7 979.94**

Table A2-11

Gross margin budget for irrigated carrots for a 1 ha plot

	Quantity	Unit	Unit cost	Year 1	Year 2	Year 3	Year 4
Area (1)		ha		1.00	1.00	1.00	1.00
Saleable yield (2)		tons/ha		17.5	20.0	22.5	25.0
Saleable harvest (3) = (1) x (2)		tons/ha		17.5	20.0	22.5	25.0
Price (4)		US$/ton		272.73	272.73	272.73	272.73
Gross income (5) = (3) x (4)		**US$**		**4 772.78**	**5 454.60**	**6 136.43**	**6 818.25**
Variable costs:			**US$**	**US$**	**US$**	**US$**	**US$**
Land preparation	1.00	ha	38.18	38.18	38.18	38.18	38.18
Seed	5	kg	14.91	74.55	74.55	74.55	74.55
Fertilizer							
- Compound D	600	kg	0.38	228.00	228.00	228.00	228.00
Transport of inputs to farm	0.605	ton	18.18	11.00	11.00	11.00	11.00
Chemicals							
- Dimethoate 40EC	1.5	kg	15.45	23.18	23.18	23.18	23.18
- Copper oxychloride	9	kg	14.55	130.95	130.95	130.95	130.95
Seasonal loan interest (6%)		US$		30.35	30.35	30.35	30.35
Hired labour	0	days	3.09	0.00	0.00	0.00	0.00
Packing material		12.5 kg pock	0.27	378.00	432.00	486.00	540.00
Transport of output to market		ton	18.18	318.15	363.60	409.05	454.50
Total variable cost (6)		**US$**		**1 232.36**	**1 331.81**	**1 431.26**	**1 530.71**
Gross margin (7) = (5) - (6)		**US$**		**3 540.42**	**4 122.79**	**4 705.17**	**5 287.54**

Table A2-12
Gross margin budget for irrigated cotton for a 1 ha plot

	Quantity	Unit	Unit cost	Year 1	Year 2	Year 3	Year 4
Area (1)		ha		1.00	1.00	1.00	1.00
Saleable yield, unginned (2)		tons/ha		2.1	2.4	2.7	3.0
Saleable harvest (3) = (1) x (2)		tons/ha		2.1	2.4	2.7	3.0
Blend selling price (4)		US$/ton		581.81	581.81	581.81	581.81
Gross income (5) = (3) x (4)		**US$**		**1 221.80**	**1 396.34**	**1 570.89**	**1 745.43**
Variable costs:			**US$**	**US$**	**US$**	**US$**	**US$**
Land preparation	1.00	ha	38.18	38.18	38.18	38.18	38.18
Seed	25	kg	1.11	27.75	27.75	27.75	27.75
Fertilizer							
- Compound L	250	kg	0.43	107.50	107.50	107.50	107.50
- Ammonium nitrate	200	kg	0.37	74.00	74.00	74.00	74.00
Transport of inputs to farm	0.475	ton	18.18	8.64	8.64	8.64	8.64
Chemicals							
- Carbaryl 85WP	2.5	kg	52.73	131.83	131.83	131.83	131.83
- Endosulfan 35MO	2.5	litre	24.12	60.30	60.30	60.30	60.30
- Synthetic pyrethroid	1	litre	12.27	12.27	12.27	12.27	12.27
- Dimethoate 40EC	0.5	kg	15.45	7.73	7.73	7.73	7.73
- Triazophos 40EC	0.7	litre	176.36	123.45	123.45	123.45	123.45
- Molasses	30	litre	1.45	43.50	43.50	43.50	43.50
Seasonal loan interest (6%)		US$		38.11	38.11	38.11	38.11
Hired labour	60	days	3.09	185.40	185.40	185.40	185.40
Bale hire		120 kg bale	5.45	95.38	109.00	122.63	136.25
Twine (0.13 kg/ton)		kg	10.91	2.98	3.40	3.83	4.25
Transport of output to market		ton	18.18	38.18	43.63	49.09	54.54
Total variable cost (6)		**US$**		**995.18**	**1 014.68**	**1 034.19**	**1 053.69**
Gross margin (7) = (5) - (6)		**US$**		**226.62**	**381.66**	**536.70**	**691.74**

Table A2-13

Gross margin budget for irrigated cucumbers for a 1 ha plot

	Quantity	Unit	Unit cost	Year 1	Year 2	Year 3	Year 4
Area (1)		ha		1.00	1.00	1.00	1.00
Saleable yield (2)		tons/ha		8.4	9.6	10.8	12.0
Saleable harvest (3) = (1) x (2)		tons		8.4	9.6	10.8	12.0
Price (4)		US$/ton		145.45	145.45	145.45	145.45
Gross income (5) = (3) x (4)		**US$**		**1 221.78**	**1 396.32**	**1 570.86**	**1 745.40**
Variable costs:			US$	US$	US$	US$	US$
Land preparation	1.00	ha	38.18	38.18	38.18	38.18	38.18
Seed	3	kg	54.55	163.65	163.65	163.65	163.65
Fertilizer							
- Compound D	600	kg	0.38	228.00	228.00	228.00	228.00
- Ammonium nitrate	100	kg	0.37	37.00	37.00	37.00	37.00
Transport of inputs to farm	0.703	ton	18.18	12.78	12.78	12.78	12.78
Chemicals							
- Karate	1.5	litre	12.28	18.42	18.42	18.42	18.42
- Copper oxychloride	4	kg	25.91	103.64	103.64	103.64	103.64
- Bravo	2	litre	36.37	72.74	72.74	72.74	72.74
- Dimethoate 40EC	2	kg	15.45	30.90	30.90	30.90	30.90
Seasonal loan interest (6%)		US$		42.32	42.32	42.32	42.32
Hired labour	30	days	3.09	92.70	92.70	92.70	92.70
Packing material		12.5 kg pock	0.27	181.44	207.36	233.28	259.20
Transport of output to market		ton	18.18	152.71	174.53	196.34	218.16
Total variable cost (6)		**US$**		**1 174.48**	**1 222.22**	**1 269.95**	**1 317.69**
Gross margin (7) = (5) - (6)		**US$**		**47.30**	**174.10**	**300.91**	**427.71**

Table A2-14
Gross margin budget for irrigated groundnuts for a 1 ha plot

	Quantity	Unit	Unit cost	Year 1	Year 2	Year 3	Year 4
Area (1)		ha		1.00	1.00	1.00	1.00
Saleable yield, unshelled (2)		tons/ha		2.5	2.8	3.2	4.0
Saleable harvest (3) = (1) x (2)		tons/ha		2.5	2.8	3.2	4.0
Price (4)		US$/ton		727.27	727.27	727.27	727.27
Gross income (5) = (3) x (4)		**US$**		**1 818.18**	**2 036.36**	**2 327.26**	**2 909.08**
Variable costs:			**US$**	**US$**	**US$**	**US$**	**US$**
Land preparation	1.00	ha	38.18	38.18	38.18	38.18	38.18
Seed	100	kg	0.73	73.00	73.00	73.00	73.00
Fertilizer							
- Compound L	400	kg	0.43	172.00	172.00	172.00	172.00
- Gypsum	400	kg	0.09	36.00	36.00	36.00	36.00
Transport of inputs to farm	0.9	ton	18.18	16.36	16.36	16.36	16.36
Chemicals							
- Carbaryl 85WP	2	kg	52.73	105.46	105.46	105.46	105.46
- Dimethoate 40EC	0.9	kg	15.45	13.91	13.91	13.91	13.91
- Endosulfan 35MO	2	litre	24.12	48.24	48.24	48.24	48.24
- Dithane M45	3	kg	25.91	77.73	77.73	77.73	77.73
Seasonal loan interest (6%)		US$		34.85	34.85	34.85	34.85
Hired labour	50	days	3.09	154.50	154.50	154.50	154.50
Bags hire		80 kg bag	0.09	2.81	3.15	3.60	4.50
Twine (0.2 kg/ton)		kg	10.91	5.46	6.11	6.98	8.73
Transport of output to market		ton	18.18	45.45	50.90	58.18	72.72
Total variable cost (6)		**US$**		**823.95**	**830.39**	**838.99**	**856.18**
Gross margin (7) = (5) - (6)		**US$**		**994.23**	**1 205.96**	**1 488.28**	**2 052.90**

Table A2-15
Gross margin budget for irrigated grain maize for a 1 ha plot

	Quantity	Unit	Unit cost	Year 1	Year 2	Year 3	Year 4
Area (1)		ha		1.00	1.00	1.00	1.00
Saleable yield (2)		tons/ha		4.2	6.0	6.0	6.0
Saleable harvest (3) = (1) x (2)		tons		4.2	6.0	6.0	6.0
Local sale price (4)		US$/ton		272.73	272.73	272.73	272.73
Gross income (5) = (3) x (4)		**US$**		**1 145.47**	**1 636.38**	**1 636.38**	**1 636.38**
Variable costs:			**US$**	**US$**	**US$**	**US$**	**US$**
Land preparation	1.00	ha	38.18	38.18	38.18	38.18	38.18
Seed (long)	25	kg	3.03	75.75	75.75	75.75	75.75
Fertilizer							
- Compound D	350	kg	0.38	133.00	133.00	133.00	133.00
- Ammonium nitrate	350	kg	0.37	129.50	129.50	129.50	129.50
Transport of inputs to farm	0.725	ton	18.18	13.18	13.18	13.18	13.18
Chemicals							
- Dipterex	4	kg	1.73	6.92	6.92	6.92	6.92
Seasonal loan interest (6%)		US$		23.79	23.79	23.79	23.79
Hired labour	42	days	3.09	129.78	129.78	129.78	129.78
Bags		50 kg bag	0.91	76.44	109.20	109.20	109.20
Twine (0.2 kg/ton)		kg	10.91	9.16	13.09	13.09	13.09
Transport of output (local sale)		1000 kg	18.18	0.00	0.00	0.00	0.00
Total variable cost (6)		**US$**		**635.71**	**672.39**	**672.39**	**672.39**
Gross margin (7) = (5) - (6)		**US$**		**509.76**	**963.99**	**963.99**	**963.99**

Table A2-16
Gross margin budget for irrigated green maize for a 1 ha plot

	Quantity	Unit	Unit cost	Year 1	Year 2	Year 3	Year 4
Area (1)		ha		1.00	1.00	1.00	1.00
Saleable yield (2)		cobs/ha		31 500	36 000	40 500	45 000
Saleable harvest (3) = (1) x (2)		cobs/ha		31 500	36 000	40 500	45 000
Price (4)		US$/cob		0.18	0.18	0.18	0.18
Gross income (5) = (3) x (4)		**US$**		**5 670.00**	**6 480.00**	**7 290.00**	**8 100.00**
Variable costs:			**US$**	**US$**	**US$**	**US$**	**US$**
Land preparation	1.00	ha	38.18	38.18	38.18	38.18	38.18
Seed (long)	25	kg	3.03	75.75	75.75	75.75	75.75
Fertilizer							
- Compound D	350	kg	0.38	133.00	133.00	133.00	133.00
- Ammonium nitrate	350	kg	0.37	129.50	129.50	129.50	129.50
Transport of inputs to farm	0.725	ton	18.18	13.18	13.18	13.18	13.18
Chemicals							
- Dipterex	4	kg	1.73	6.92	6.92	6.92	6.92
Seasonal loan interest (6%)		US$		23.79	23.79	23.79	23.79
Hired labour	30	days	3.09	92.70	92.70	92.70	92.70
Transport of output (local sale)		1000 kg	18.18	0.00	0.00	0.00	0.00
Total variable cost (6)		**US$**		**513.02**	**513.02**	**513.02**	**513.02**
Gross margin (7) = (5) - (6)		**US$**		**5 156.98**	**5 966.98**	**6 776.98**	**7 586.98**

Table A2-17
Gross margin budget for irrigated mange tout (pea) for a 1 ha plot

	Quantity	Unit	Unit cost	Year 1	Year 2	Year 3	Year 4
Area (1)		ha		1.00	1.00	1.00	1.00
Saleable yield (2)		tons/ha		2.1	2.4	2.7	3.0
Saleable harvest (3) = (1) x (2)		tons/ha		2.1	2.4	2.7	3.0
Price (4)		US$/ton		1 000.00	1 000.00	1 000.00	1 000.00
Gross income (5) = (3) x (4)		**US$**		**2 100.00**	**2 400.00**	**2 700.00**	**3 000.00**
Variable costs:			**US$**	**US$**	**US$**	**US$**	**US$**
Land preparation	1.00	ha	38.18	38.18	38.18	38.18	38.18
Seed	40	kg	18.11	724.40	724.40	724.40	724.40
Fertilizer							
- Compound D	500	kg	0.38	190.00	190.00	190.00	190.00
- Ammonium nitrate	300	kg	0.37	111.00	111.00	111.00	111.00
- Muriate of Potash	75	kg	0.65	48.75	48.75	48.75	48.75
Transport of inputs to farm	0.915	ton	18.18	16.63	16.63	16.63	16.63
Chemicals							
- Copper oxychloride	2.4	kg	14.55	34.92	34.92	34.92	34.92
- Folicur	1	litre	50.91	50.91	50.91	50.91	50.91
- Karate (Fenvelerate)	0.14	litre	12.28	1.72	1.72	1.72	1.72
- Sulphur 80	7.8	kg	5.42	42.28	42.28	42.28	42.28
- Benlate	2	kg	27.28	54.56	54.56	54.56	54.56
- DDVP	1	litre	76.36	76.36	76.36	76.36	76.36
Seasonal loan interest (6%)		US$		83.38	83.38	83.38	83.38
Hired labour	120	days	3.09	370.80	370.80	370.80	370.80
Transport of output to market		ton	18.18	38.18	43.63	49.09	54.54
Total variable cost (6)		**US$**		**1 882.07**	**1 887.52**	**1 892.98**	**1 898.43**
Gross margin (7) = (5) - (6)		**US$**		**217.93**	**512.48**	**807.02**	**1 101.57**

Table A2-18
Gross margin budget for irrigated okra for a 1 ha plot

	Quantity	Unit	Unit cost	Year 1	Year 2	Year 3	Year 4
Area (1)		ha		1.00	1.00	1.00	1.00
Saleable yield (2)		tons/ha		11.2	12.8	14.4	16.0
Saleable harvest (3) = (1) x (2)		tons		11.2	12.8	14.4	16.0
Price (4)		US$/ton		363.63	363.63	363.63	363.63
Gross income (5) = (3) x (4)		**US$**		**4 072.66**	**4 654.46**	**5 236.27**	**5 818.08**
Variable costs:			**US$**	**US$**	**US$**	**US$**	**US$**
Land preparation	1.00	ha	38.18	38.18	38.18	38.18	38.18
Seed	3	kg	9.09	27.27	27.27	27.27	27.27
Fertilizer							
- Compound D	600	kg	0.38	228.00	228.00	228.00	228.00
- Ammonium nitrate	100	kg	0.37	37.00	37.00	37.00	37.00
Transport of inputs to farm	0.703	ton	18.18	12.78	12.78	12.78	12.78
Chemicals							
- Mancozeb	2	kg	25.91	51.82	51.82	51.82	51.82
- Malathion	2.8	kg	12.55	35.14	35.14	35.14	35.14
- Dimethoate 40EC	1	kg	15.45	15.45	15.45	15.45	15.45
Seasonal loan interest (6%)		US$		26.74	26.74	26.74	26.74
Hired labour	40	days	3.09	123.60	123.60	123.60	123.60
Packing material		10 kg box	0.02	22.40	25.60	28.80	32.00
Transport of output to market		ton	18.18	203.62	232.70	261.79	290.88
Total variable cost (6)		**US$**		**821.99**	**854.28**	**886.57**	**918.86**
Gross margin (7) = (5) - (6)		**US$**		**3 250.66**	**3 800.18**	**4 349.70**	**4 899.22**

Table A2-19
Gross margin budget for irrigated onions for a 1 ha plot

	Quantity	Unit	Unit cost	Year 1	Year 2	Year 3	Year 4
Area (1)		ha		1.00	1.00	1.00	1.00
Saleable yield (2)		tons/ha		21	24	27	30
Saleable harvest (3) = (1) x (2)		tons/ha		21	24	27	30
Price (4)		US$/ton		272.73	272.73	272.73	272.73
Gross income (5) = (3) x (4)		**US$**		**5 727.33**	**6 545.52**	**7 363.71**	**8 181.90**
Variable costs:			**US$**	**US$**	**US$**	**US$**	**US$**
Land preparation	1.00	ha	38.18	38.18	38.18	38.18	38.18
Seed	3	kg	29.45	88.35	88.35	88.35	88.35
Fertilizer							
- Compound S	1200	kg	0.67	804.00	804.00	804.00	804.00
- Ammonium nitrate	200	kg	0.37	74.00	74.00	74.00	74.00
Transport of inputs to farm	1.403	ton	18.18	25.51	25.51	25.51	25.51
Chemicals							
- Carbaryl 85WP	2	kg	52.73	105.46	105.46	105.46	105.46
- Dithane M45	6	kg	25.91	155.46	155.46	155.46	155.46
Seasonal loan interest (6%)		US$		77.46	77.46	77.46	77.46
Hired labour	150	days	3.09	463.50	463.50	463.50	463.50
Packing material		12.5 kg pock	0.27	453.60	518.40	583.20	648.00
Transport of output to market		1000 kg	18.18	381.78	436.32	490.86	545.40
Total variable cost (6)		**US$**		**2 667.29**	**2 786.63**	**2 905.97**	**3 025.31**
Gross margin (7) = (5) - (6)		**US$**		**3 060.04**	**3 758.89**	**4 457.74**	**5 156.59**

Table A2-20
Gross margin budget for irrigated paprika for a 1 ha plot

	Quantity	Unit	Unit cost	Year 1	Year 2	Year 3	Year 4
Area (1)		ha		1.00	1.00	1.00	1.00
Saleable yield (2)		tons/ha		2.1	2.4	2.7	3.0
Saleable harvest (3) = (1) x (2)		tons/ha		2.1	2.4	2.7	3.0
Price (4)		US$/ton		1 636.36	1 636.36	1 636.36	1 636.36
Gross income (5) = (3) x (4)		**US$**		**3 436.36**	**3 927.26**	**4 418.17**	**4 909.08**
Variable costs:			**US$**	**US$**	**US$**	**US$**	**US$**
Land preparation	1.00	ha	38.18	38.18	38.18	38.18	38.18
Seed	0.8	kg	26.18	20.94	20.94	20.94	20.94
Fertilizer							
- Compound S	50	kg	0.67	33.50	33.50	33.50	33.50
- Compound L	700	kg	0.43	301.00	301.00	301.00	301.00
- Ammonium nitrate	200	kg	0.37	74.00	74.00	74.00	74.00
- Gypsum	200	kg	0.09	18.00	18.00	18.00	18.00
Transport of inputs to farm	1.1508	ton	18.18	20.92	20.92	20.92	20.92
Chemicals							
- Methyl bromide	7	kg	18.18	127.26	127.26	127.26	127.26
- Trichomerda	10	kg	28.04	280.40	280.40	280.40	280.40
- Copper oxychloride	4.8	kg	14.55	69.84	69.84	69.84	69.84
- Dithane M45	5	kg	25.91	129.55	129.55	129.55	129.55
- Captan	1.12	kg	27.28	30.55	30.55	30.55	30.55
- Orthene	0.64	kg	50.73	32.47	32.47	32.47	32.47
- Bayfidan 1%	1	kg	7.27	7.27	7.27	7.27	7.27
- Karate	0.3	litre	12.28	3.68	3.68	3.68	3.68
- Metasystox	0.8	kg	34.29	27.43	27.43	27.43	27.43
Seasonal loan interest (6%)		US$		72.90	72.90	72.90	72.90
Hired labour	60	days	3.09	185.40	185.40	185.40	185.40
Transport of output to market		ton	18.18	38.18	43.63	49.09	54.54
Total variable cost (6)		**US$**		**1 511.48**	**1 516.93**	**1 522.39**	**1 527.84**
Gross margin (7) = (5) - (6)		**US$**		**1 924.88**	**2 410.33**	**2 895.78**	**3 381.24**

Table A2-21

Gross margin budget for irrigated sweet peppers for a 1 ha plot

	Quantity	Unit	Unit cost	Year 1	Year 2	Year 3	Year 4
Area (1)		ha		1.00	1.00	1.00	1.00
Saleable yield (2)		tons/ha		14	16	18	20
Saleable harvest (3) = (1) x (2)		tons/ha		14	16	18	20
Price (4)		US$/ton		909.09	909.09	909.09	909.09
Gross income (5) = (3) x (4)		**US$**		**12 727.26**	**14 545.44**	**16 363.62**	**18 181.80**
Variable costs:			**US$**	**US$**	**US$**	**US$**	**US$**
Land preparation	1.00	ha	38.18	38.18	38.18	38.18	38.18
Seed	0.4	kg	26.18	10.47	10.47	10.47	10.47
Fertilizer							
- Compound S	1000	kg	0.67	670.00	670.00	670.00	670.00
- Ammonium nitrate	400	kg	0.37	148.00	148.00	148.00	148.00
Transport of inputs to farm	1.4004	ton	18.18	25.46	25.46	25.46	25.46
Chemicals							
- Karate (Fenvelerate)	0.14	litre	12.28	1.72	1.72	1.72	1.72
- Sulphur	4.8	litre	5.42	26.02	26.02	26.02	26.02
- Bayfidan 1%	1.5	kg	7.27	10.91	10.91	10.91	10.91
- Copper oxychloride	4.2	kg	14.55	61.11	61.11	61.11	61.11
Seasonal loan interest (6%)		US$		59.51	59.51	59.51	59.51
Hired labour	50	days	3.09	154.50	154.50	154.50	154.50
Transport of output to market		ton	18.18	254.52	290.88	327.24	363.60
Total variable cost (6)		**US$**		**1 460.39**	**1 496.75**	**1 533.11**	**1 569.47**
Gross margin (7) = (5) - (6)		**US$**		**11 266.87**	**13 048.69**	**14 830.51**	**16 612.33**

Table A2-22

Gross margin budget for irrigated potatoes for a 1 ha plot

	Quantity	Unit	Unit cost	Year 1	Year 2	Year 3	Year 4
Area (1)		ha		1.00	1.00	1.00	1.00
Saleable yield (2)		pockets/ha		1 260	1 440	1 620	1 800
Saleable yield (3) = 0.0125 x (2)		tons/ha		15.75	18.00	20.25	22.50
Saleable harvest (4) = (1) x (3)		tons		15.75	18.00	20.25	22.50
Price (5)		US$/pocket		3.64	3.64	3.64	3.64
Price (6) = (5)/0.0125		US$/ton		291.20	291.20	291.20	291.20
Gross income (5) = (3) x (4)		**US$**		**4 586.40**	**5 241.60**	**5 896.80**	**6 552.00**
Variable costs:			**US$**	**US$**	**US$**	**US$**	**US$**
Land preparation	1.00	ha	38.18	38.18	38.18	38.18	38.18
Seed	1200	kg	0.55	660.00	660.00	660.00	660.00
Fertilizer							
- Compound S	1500	kg	0.67	1 005.00	1 005.00	1 005.00	1 005.00
Transport of inputs to farm	2.7	ton	18.18	49.09	49.09	49.09	49.09
Chemicals							
- Mancozeb	10	kg	25.91	259.10	259.10	259.10	259.10
- Endosulfan 35MO	10	litre	24.12	241.20	241.20	241.20	241.20
- Monocrotophos	6.5	litre	7.27	47.26	47.26	47.26	47.26
Seasonal loan interest (6%)		US$		137.99	137.99	137.99	137.99
Hired labour	80	days	3.09	247.20	247.20	247.20	247.20
Packing material		per pocket	0.27	340.20	388.80	437.40	486.00
Transport of output to market		ton	18.18	286.34	327.24	368.15	409.05
Total variable cost (6)		**US$**		**3 311.55**	**3 401.05**	**3 490.56**	**3 580.06**
Gross margin (7) = (5) - (6)		**US$**		**1 274.85**	**1 840.55**	**2 406.24**	**2 971.94**

Table A2-23

Gross margin budget for irrigated rape for a 1 ha plot

	Quantity	Unit	Unit cost	Year 1	Year 2	Year 3	Year 4
Area (1)		ha		1.00	1.00	1.00	1.00
Saleable yield (2)		bundles/ha		9 100	10 400	11 700	13 000
Saleable harvest (3) = (1) x (2)		bundles		9 100	10 400	11 700	13 000
Price (4)		US$/bundle		0.55	0.55	0.55	0.55
Gross income (5) = (3) x (4)		**US$**		**5 005.00**	**5 720.00**	**6 435.00**	**7 150.00**
Variable costs:			**US$**	**US$**	**US$**	**US$**	**US$**
Land preparation	1.00	ha	38.18	38.18	38.18	38.18	38.18
Seed	1	kg	18.18	18.18	18.18	18.18	18.18
Fertilizer							
- Compound S	1000	kg	0.67	670.00	670.00	670.00	670.00
- Ammonium nitrate	400	kg	0.37	148.00	148.00	148.00	148.00
Transport of inputs to farm	1.4	ton	18.18	25.45	25.45	25.45	25.45
Chemicals							
- Endosulfan 35MO	2	litre	24.12	48.24	48.24	48.24	48.24
- Dichlorvos	1	litre	76.36	76.36	76.36	76.36	76.36
- Dimethoate 40EC	0.75	kg	15.45	11.59	11.59	11.59	11.59
Seasonal loan interest (6%)		US$		62.16	62.16	62.16	62.16
Hired labour	97	days	3.09	299.73	299.73	299.73	299.73
Transport of output to market		1000 bundles	18.18	165.44	189.07	212.71	236.34
Total variable cost (6)		**US$**		**1 563.33**	**1 586.96**	**1 610.60**	**1 634.23**
Gross margin (7) = (5) - (6)		**US$**		**3 441.67**	**4 133.04**	**4 824.40**	**5 515.77**

Table A2-24

Gross margin budget for irrigated tomatoes for a 1 ha plot

	Quantity	Unit	Unit cost	Year 1	Year 2	Year 3	Year 4
Area (1)		ha		1.00	1.00	1.00	1.00
Saleable yield (2)		tons/ha		20	25	30	35
Saleable harvest (3) = (1) x (2)		tons/ha		20	25	30	35
Price (4)		US$/ton		363.63	363.63	363.63	363.63
Gross income (5) = (3) x (4)		**US$**		**7 272.60**	**9 090.75**	**10 908.90**	**12 727.05**
Variable costs:			**US$**	**US$**	**US$**	**US$**	**US$**
Land preparation	1.00	ha	38.18	38.18	38.18	38.18	38.18
Seed	0.25	kg	84.36	21.09	21.09	21.09	21.09
Fertilizer							
- Compound S	1000	kg	0.67	670.00	670.00	670.00	670.00
- Ammonium nitrate	200	kg	0.37	74.00	74.00	74.00	74.00
Transport of inputs to farm	1.20025	ton	18.18	21.82	21.82	21.82	21.82
Chemicals							
- Carbaryl 85WP	2.7	kg	52.73	142.37	142.37	142.37	142.37
- Dimethoate 40EC	0.5	kg	15.45	7.73	7.73	7.73	7.73
- Dithane M45	1	kg	25.91	25.91	25.91	25.91	25.91
Seasonal loan interest (6%)		US$		60.07	60.07	60.07	60.07
Hired labour	100	days	3.09	309.00	309.00	309.00	309.00
Packing material		15 kg box	0.02	26.67	33.33	40.00	46.67
Transport of output to market		1000 kg	18.18	363.60	454.50	545.40	636.30
Total variable cost (6)		**US$**		**1 760.43**	**1 858.00**	**1 955.56**	**2 053.13**
Gross margin (7) = (5) - (6)		**US$**		**5 512.17**	**7 232.75**	**8 953.34**	**10 673.92**

Table A2-25
Gross margin budget for irrigated wheat for a 1 ha plot

	Quantity	Unit	Unit cost	Year 1	Year 2	Year 3	Year 4
Area (1)		ha		1.00	1.00	1.00	1.00
Saleable yield (2)		tons/ha		3.5	4.0	4.5	5.0
Saleable harvest (3) = (1) x (2)		tons/ha		3.5	4.0	4.5	5.0
Price (4)		US$/ton		545.45	545.45	545.45	545.45
Gross income (5) = (3) x (4)		**US$**		**1 909.08**	**2 181.80**	**2 454.53**	**2 727.25**
Variable costs:			**US$**	**US$**	**US$**	**US$**	**US$**
Land preparation	1.00	ha	38.18	38.18	38.18	38.18	38.18
Seed	100	kg	0.51	51.00	51.00	51.00	51.00
Fertilizer							
- Compound D	500	kg	0.38	190.00	190.00	190.00	190.00
- Ammonium nitrate	300	kg	0.37	111.00	111.00	111.00	111.00
Transport of inputs to farm	0.9	ton	18.18	16.36	16.36	16.36	16.36
Chemicals							
- Demeton-S-Methyl	0.4	litre	32.33	12.93	12.93	12.93	12.93
Seasonal loan interest (6%)		US$		25.17	25.17	25.17	25.17
Hired labour	60	days	3.09	185.40	185.40	185.40	185.40
Bags		50 kg bag	0.91	63.70	72.80	81.90	91.00
Twine (0.09 kg/ton)		kg	10.91	3.44	3.93	4.42	4.91
Transport of output to market		1000 kg	18.18	63.63	72.72	81.81	90.90
Total variable cost (6)		**US$**		**760.81**	**779.49**	**798.17**	**816.85**
Gross margin (7) = (5) - (6)		**US$**		**1 148.27**	**1 402.31**	**1 656.35**	**1 910.40**

Table A2-26
Gross margin budget for rainfed cotton for a 1 ha plot

	Quantity	Unit	Unit cost	Year
Area (1)		ha		1.00
Saleable yield, unginned (2)		tons/ha		1.0
Saleable harvest (3) = (1) x (2)		tons/ha		1.0
Price (4)		US$/ton		581.81
Gross income (5) = (3) x (4)		**US$**		**581.81**
Variable costs:			**US$**	**US$**
Land preparation	1.00	ha	38.18	38.18
Seed	25	kg	1.11	27.75
Fertilizer				
- Compound L	200	kg	0.43	86.00
- Ammonium nitrate	150	kg	0.37	55.50
Transport of inputs to farm	0.375	ton	18.18	6.82
Chemicals				
- Carbaryl 85WP	2.5	kg	52.73	131.83
- Endosulfan 35MO	2.5	litre	24.12	60.30
- Synthetic pyrethroid	1	litre	12.27	12.27
- Dimethoate 40EC	0.5	kg	15.45	7.73
- Molasses	30	litre	1.45	43.50
Seasonal loan interest (6%)		US$		28.19
Hired labour	30	days	3.09	92.70
Bale hire		120 kg bale	5.45	45.42
Twine (0.13 kg/ton)		kg	10.91	1.42
Transport of output to market		1000 kg	18.18	18.18
Total variable cost (6)		**US$**		**655.77**
Gross margin (7) = (5) - (6)		**US$**		**- 73.96**

Table A2-27

Gross margin budget for rainfed groundnuts for a 1 ha plot

	Quantity	Unit	Unit cost	Year
Area (1)		ha		1.00
Saleable yield, unshelled (2)		tons/ha		1.4
Saleable harvest (3) = (1) x (2)		tons/ha		1.4
Price (4)		US$/ton		727.27
Gross income (5) = (3) x (4)		**US$**		**1 018.18**
Variable costs:			**US$**	**US$**
Land preparation	1.00	ha	38.18	38.18
Seed	100	kg	0.73	73.00
Fertilizer				
- Compound L	50	kg	0.43	21.50
- Gypsum	100	kg	0.09	9.00
Transport of inputs to farm	0.25	ton	18.18	4.55
Chemicals				
- Carbaryl 85WP	2	kg	52.73	105.46
- Endosulfan 35MO	2	litre	24.12	48.24
- Dithane M45	3	kg	25.91	77.73
- Dimethoate 40EC	0.9	kg	15.45	13.91
Seasonal loan interest (6%)		US$		23.49
Hired labour	10	days	3.09	30.90
Bags hire		80 kg bags	0.09	1.58
Twine (0.2 kg/ton)		kg	10.91	3.05
Transport of output to market		1000 kg	18.18	25.45
Total variable cost (6)		**US$**		**476.04**
Gross margin (7) = (5) - (6)		**US$**		**542.14**

Table A2-28

Gross margin budget for rainfed grain maize for a 1 ha plot

	Quantity	Unit	Unit cost	Year
Area (1)		ha		1.00
Saleable yield (2)		tons/ha		1.1
Saleable harvest (3) = (1) x (2)		tons		1.1
Local sale price (4)		US$/ton		272.73
Gross income (5) = (3) x (4)		**US$**		**300.00**
Variable costs:			**US$**	**US$**
Land preparation	0.00	ha	38.18	0.00
Seed (short)	25	kg	1.64	41.00
Fertilizer				
- Compound D	0	kg	0.38	0.00
- Ammonium nitrate	0	kg	0.37	0.00
- Lime	0	kg		0.00
Transport of inputs to farm	0	ton	18.18	0.00
Chemicals				
- Dipterex	4	kg	1.73	6.92
Hired labour	0	days	3.09	0.00
Bags	0	50 kg bag	0.91	0.00
Twine (0.2 kg/ton)	0	kg	10.91	0.00
Transport of output (local sale)	0	ton	18.18	0.00
Total variable cost (6)		**US$**		**47.92**
Gross margin (7) = (5) - (6)		**US$**		**252.08**

Table A2-29

Gross margin budget for rainfed pearl millet for a 1 ha plot

	Quantity	Unit	Unit cost	Year
Area (1)		ha		1.00
Saleable yield (2)		tons/ha		0.9
Saleable harvest (3) = (1) x (2)		tons		0.9
Local sale price (4)		US$/ton		272.73
Gross income (5) = (3) x (4)		**US$**		**245.46**
Variable costs:			**US$**	**US$**
Land preparation	0.00	ha	38.18	0.00
Seed	15	kg	1.01	15.15
Fertilizer				
- Compound D	0	kg	0.38	0.00
- Ammonium nitrate	0	kg	0.37	0.00
- Lime	0	kg		0.00
Transport of inputs to farm	0	ton	18.18	0.00
Chemicals				
- Dipterex	0	kg	1.73	0.00
Hired labour	0	days	3.09	0.00
Bags	0	50 kg bag	0.91	0.00
Twine (0.2 kg/ton)	0	kg	10.91	0.00
Transport of output (local sale)	0	ton	18.18	0.00
Total variable cost (6)		**US$**		**15.15**
Gross margin (7) = (5) - (6)		**US$**		**230.31**

Table A2-30

Gross margin budget for rainfed sorghum for a 1 ha plot

	Quantity	Unit	Unit cost	Year
Area (1)		ha		1.00
Saleable yield (2)		tons/ha		0.8
Saleable harvest (3) = (1) x (2)		tons		0.8
Local sale price (4)		US$/ton		272.73
Gross income (5) = (3) x (4)		**US$**		**218.18**
Variable costs:			**US$**	**US$**
Land preparation	0.00	ha	38.18	0.00
Seed	15	kg	1.01	15.15
Fertilizer				
- Compound D	0	kg	0.38	0.00
- Ammonium nitrate	0	kg	0.37	0.00
- Lime	0	kg		0.00
Transport of inputs to farm	0	ton	18.18	0.00
Chemicals				
- Dipterex	0	kg	1.73	0.00
Hired labour	0	days	3.09	0.00
Bags	0	50 kg bag	0.91	0.00
Twine (0.2 kg/ton)	0	kg	10.91	0.00
Transport of output (local sale)	0	ton	18.18	0.00
Total variable cost (6)		**US$**		**15.15**
Gross margin (7) = (5) - (6)		**US$**		**203.03**

Table A2-31

Gross margin budget for rainfed sunflowers for a 1 ha plot

	Quantity	Unit	Unit cost	Year
Area (1)		ha		1.00
Saleable yield (2)		tons/ha		1.0
Saleable harvest (3) = (1) x (2)		tons/ha		1.0
Price (4)		US$/ton		290.91
Gross income (5) = (3) x (4)		**US$**		**290.91**
Variable costs:			**US$**	**US$**
Land preparation	0.00	ha	38.18	0.00
Seed	10	kg	4.70	47.00
Fertilizer				
- Compound L	100	kg	0.43	43.00
- Ammonium nitrate	100	kg	0.37	37.00
Transport of inputs to farm	0.21	ton	18.18	3.82
Chemicals				
- Endosulfan 50WP	2	kg	49.28	98.56
- Molasses	2	litre	1.45	2.90
Bags		50 kg bag	0.91	18.20
Twine (0.2 kg/ton)		kg	10.91	2.18
Transport of output to market		1000 kg	18.18	18.18
Total variable cost (6)		**US$**		**270.84**
Gross margin (7) = (5) - (6)		**US$**		**20.07**

Appendix 3

Net Present Value (NPV)

Benefit/Cost (B/C) ratio

Internal Rate of Return (IRR)

Payback period

Loan repayment

Cash flow

Table A3-1

Calculation of the Net Present Value (NPV), the Benefit/Cost (B/C) ratio and the Internal Rate of Return (IRR) for Mutange irrigation scheme (105 ha) at 12% discount rate (US$)

Year	Investment	Replacement costs[a]	Energy costs	Repairs and maintenance[b]	Technical support	Without-project benefits	Total project cost[c]	With-project benefits	Net benefits[d]	Discount factor (12%)	Present value of costs[e]	Present value of benefits[f]	Present value of net benefits[g]
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)
1	1,090,909					36 878	1 127 787	0	-1 127 787	0.8929	1 007 001	0	-1 007 001
2			22 126	32 727	14 545	36 878	106 276	451 663	345 387	0.7972	84 723	360 066	275 343
3			22 126	32 727	14 545	36 878	106 276	548 352	442 077	0.7118	75 647	390 317	314 670
4			22 126	32 727	14 545	36 878	106 276	627 446	521 171	0.6355	67 538	398 742	331 204
5			22 126	32 727	14 545	36 878	106 276	712 469	606 193	0.5674	60 301	404 255	343 954
6		24 936	22 126	32 727	14 545	36 878	131 212	712 469	581 257	0.5066	66 472	360 937	294 465
7			22 126	32 727	14 545	36 878	106 276	712 469	606 193	0.4523	48 068	322 250	274 181
8			22 126	32 727	14 545	36 878	106 276	712 469	606 193	0.4039	42 925	287 766	244 841
9			22 126	32 727	14 545	36 878	106 276	712 469	606 193	0.3606	38 323	256 916	218 593
10			22 126	32 727	14 545	36 878	106 276	712 469	606 193	0.3220	34 221	229 415	195 194
11		77 097	22 126	32 727	14 545	36 878	183 373	712 469	529 096	0.2875	52 720	204 835	152 115
12			22 126	32 727	14 545	36 878	106 276	712 469	606 193	0.2567	27 281	182 891	155 610
13			22 126	32 727	14 545	36 878	106 276	712 469	606 193	0.2292	24 358	163 298	138 939
14			22 126	32 727	14 545	36 878	106 276	712 469	606 193	0.2046	21 744	145 771	124 027
15			22 126	32 727	14 545	36 878	106 276	712 469	606 193	0.1827	19 417	130 168	110 751
16		84 456	22 126	32 727	14 545	36 878	190 732	712 469	521 737	0.1631	31 108	116 204	85 095
17			22 126	32 727	14 545	36 878	106 276	712 469	606 193	0.1456	15 474	103 735	88 262
18			22 126	32 727	14 545	36 878	106 276	712 469	606 193	0.1300	13 816	92 621	78 805
19			22 126	32 727	14 545	36 878	106 276	712 469	606 193	0.1161	12 339	82 718	70 379
20			22 126	32 727	14 545	36 878	106 276	712 469	606 193	0.1037	11 021	73 883	62 862
21			22 126	32 727	14 545	36 878	106 276	712 469	606 193	0.0926	9 841	65 975	56 133
	1 090 909	**186 489**	**442 520**	**654 540**	**290 900**	**774 428**	**3 439 786**	**13 739 429**	**10 299 643**		**1 764 335**	**4 372 760**	**2 608 425**
										Net Present Value (NPV) at 12%:			**2 608 425**
										Present value of benefits:			**4 372 760**
										Present value of costs:			**1 764 335**
										Benefit/Cost (B/C) ratio:			**2.48**
										Internal Rate of Return (IRR):			**42%**
										Payback period:			**4 years**

a Hoses and valves to be replaced every 5 years, cost: US$24 935; Sprinkler units to be rapleced every 10 years, cost: US$52 161; Pumping unit to be replaced every 15 years, cost: US$59 520

b Costs of repair and maintenance are estimated to be 3% of the total investment cost per year

c Total project costs (8) = (7) + (6) + (5) + (4) + (3) + (2)

d Net benefits (10) = (9) - (8)

e Present value of costs (12) = (8) x (11)

f Present value of benefits (13) = (9) x (11)

g Present value of net benefits (14) = (10) x (11)

Table A3-2

Calculation of the Net Present Value (NPV), the Benefit/Cost (B/C) ratio and the Internal Rate of Return (IRR) for Mutange irrigation scheme (105 ha) at 12% discount rate and taking into consideration a 30% increase in investment, replacement, repairs and maintenance costs (US$)

Year	Investment	Replacement costs[a]	Energy costs	Repairs and maintenance[b]	Technical support	Without-project benefits	Total project cost[c]	With-project benefits	Net benefits[d]	Discount factor (12%)	Present value of costs[e]	Present value of benefits[f]	Present value of net benefits[g]
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)
1	1 418 182		0	0	0	36 878	1 455 059	0	-1 455 059	0.8929	1 299 222	0	-1 299 222
2			22 126	42 545	14 545	36 878	116 094	451 663	335 569	0.7972	92 550	360 066	267 516
3			22 126	42 545	14 545	36 878	116 094	548 352	432 259	0.7118	82 635	390 317	307 682
4			22 126	42 545	14 545	36 878	116 094	627 446	511 352	0.6355	73 777	398 742	324 965
5			22 126	42 545	14 545	36 878	116 094	712 469	596 375	0.5674	65 872	404 255	338 383
6		32 417	22 126	42 545	14 545	36 878	148 510	712 469	563 958	0.5066	75 235	360 937	285 701
7			22 126	42 545	14 545	36 878	116 094	712 469	596 375	0.4523	52 509	322 250	269 740
8			22 126	42 545	14 545	36 878	116 094	712 469	596 375	0.4039	46 890	287 766	240 876
9			22 126	42 545	14 545	36 878	116 094	712 469	596 375	0.3606	41 863	256 916	215 053
10			22 126	42 545	14 545	36 878	116 094	712 469	596 375	0.3220	37 382	229 415	192 033
11		100 226	22 126	42 545	14 545	36 878	216 320	712 469	496 149	0.2875	62 192	204 835	142 643
12			22 126	42 545	14 545	36 878	116 094	712 469	596 375	0.2567	29 801	182 891	153 089
13			22 126	42 545	14 545	36 878	116 094	712 469	596 375	0.2292	26 609	163 298	136 689
14			22 126	42 545	14 545	36 878	116 094	712 469	596 375	0.2046	23 753	145 771	122 018
15			22 126	42 545	14 545	36 878	116 094	712 469	596 375	0.1827	21 210	130 168	108 958
16		109 793	22 126	42 545	14 545	36 878	225 886	712 469	486 582	0.1631	36 842	116 204	79 362
17			22 126	42 545	14 545	36 878	116 094	712 469	596 375	0.1456	16 903	103 735	86 832
18			22 126	42 545	14 545	36 878	116 094	712 469	596 375	0.1300	15 092	92 621	77 529
19			22 126	42 545	14 545	36 878	116 094	712 469	596 375	0.1161	13 478	82 718	69 239
20			22 126	42 545	14 545	36 878	116 094	712 469	596 375	0.1037	12 039	73 883	61 844
21			22 126	42 545	14 545	36 878	116 094	712 469	596 375	0.0926	10 750	65 975	55 224
Total	**1 418 182**	**242 436**	**442 520**	**850 902**	**290 900**	**774 428**	**4 019 367**	**13 739 429**	**9 720 061**		**2 136 607**	**4 372 760**	**2 236 154**
										Net Present Value (NPV) at 12%:			**2 236 154**
										Present value of benefits:			**4 372 760**
										Present value of costs:			**2 136 607**
										Benefit/Cost (B/C) ratio:			**2.05**
										Internal Rate of Return (IRR):			**33%**
										Payback period:			**5 years**

a *Hoses and valves to be replaced every 5 years, cost: US$ 24 935; Sprinkler units to be rapleced every 10 years, cost: US$ 52 161; Pumping unit to be replaced every 15 years, cost: US$ 59 520*
b *Costs of repair and maintenance are estimated to be 3% of the total investment cost per year*
c *Total project costs (8) = (7) + (6) + (5) + (4) + (3) + (2)*
d *Net benefits (10) = (9) - (8)*
e *Present value of costs (12) = (8) x (11)*
f *Present value of benefits (13) = (9) x (11)*
g *Present value of net benefits (14) = (10) x (11)*

Table A3-3

Repayment schedule for a loan of US$ 1 090 909 with a loan period of 20 years and an interest rate of 12%

Year	Principal year start	Interest 12%	Payment	Payment on principal	Principal year end
	(2)	(3)=0.12x(2)	(4)	(5)=(4)-(3)	(6)=(2)+(3)-(4)
1	1 090 909	130 909	146 050	15 141	1 075 768
2	1 075 768	129 092	146 050	16 958	1 058 810
3	1 058 810	127 057	146 050	18 993	1 039 817
4	1 039 817	124 778	146 050	21 272	1 018 546
5	1 018 546	122 225	146 050	23 825	994 721
6	994 721	119 367	146 050	26 683	968 038
7	968 038	116 165	146 050	29 885	938 152
8	938 152	112 578	146 050	33 472	904 680
9	904 680	108 562	146 050	37 488	867 192
10	867 192	104 063	146 050	41 987	825 205
11	825 205	99 025	146 050	47 025	778 180
12	778 180	93 382	146 050	52 668	725 511
13	725 511	87 061	146 050	58 989	666 522
14	666 522	79 983	146 050	66 067	600 455
15	600 455	72 055	146 050	73 995	526 460
16	526 460	63 175	146 050	82 875	443 585
17	443 585	53 230	146 050	92 820	350 765
18	350 765	42 092	146 050	103 958	246 807
19	246 807	29 617	146 050	116 433	130 374
20	130 374	15 645	146 050	130 405	-31
Total		**1 830 060**	**2 921 000**	**1 090 940**	

Table A3-4

Cash flow budget without considering inflation (US$)

Year	With-project benefit	Rainfed land income foregone	Replacement cost	Energy cost	Repairs and maintenance	Annual repayment	Total cost	Net benefit
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)=(2)-(8)
1	0	36 878		0	0	0	36 878	-36 878
2	451 663	36 878		22 126	32 727	146 050	237 781	213 882
3	548 352	36 878		22 126	32 727	146 050	237 781	310 572
4	627 446	36 878		22 126	32 727	146 050	237 781	389 666
5	712 469	36 878		22 126	32 727	146 050	237 781	474 688
6	712 469	36 878	24 936	22 126	32 727	146 050	262 717	449 752
7	712 469	36 878		22 126	32 727	146 050	237 781	474 688
8	712 469	36 878		22 126	32 727	146 050	237 781	474 688
9	712 469	36 878		22 126	32 727	146 050	237 781	474 688
10	712 469	36 878		22 126	32 727	146 050	237 781	474 688
11	712 469	36 878	77 097	22 126	32 727	146 050	314 878	397 591
12	712 469	36 878		22 126	32 727	146 050	237 781	474 688
13	712 469	36 878		22 126	32 727	146 050	237 781	474 688
14	712 469	36 878		22 126	32 727	146 050	237 781	474 688
15	712 469	36 878		22 126	32 727	146 050	237 781	474 688
16	712 469	36 878	84 456	22 126	32 727	146 050	322 237	390 232
17	712 469	36 878		22 126	32 727	146 050	237 781	474 688
18	712 469	36 878		22 126	32 727	146 050	237 781	474 688
19	712 469	36 878		22 126	32 727	146 050	237 781	474 688
20	712 469	36 878		22 126	32 727	146 050	237 781	474 688
21	712 469	36 878		22 126	32 727	146 050	237 781	474 688
Total	**13 739 429**	**774 428**	**186 489**	**442 520**	**654 540**	**2 921 000**	**4 978 977**	**8 760 452**

(8) = (3) + (4) + (5) + (6) + (7)

Table A3-5

Cash flow budget, taking into consideration an annual inflation of 5.5% (US$)

Year	With-project benefit	Rainfed land income foregone	Replacement cost	Energy cost	Repairs and maintenance	Discount factor (5.5%)[a]	Debt service[b]	Total cost[c]	Net benefit
(1)	(2)	(3)	(6)	(5)	(4)	(7)	(8)	(9)	(10)=(2)-(9)
1	0	36 878		0	0		0	36 878	-36 878
2	451 663	36 878		22 126	32 727	0.9479	138 441	230 171	221 491
3	548 352	36 878		22 126	32 727	0.8985	131 226	222 956	325 396
4	627 446	36 878		22 126	32 727	0.8516	124 376	216 107	411 339
5	712 469	36 878		22 126	32 727	0.8072	117 892	209 622	502 847
6	712 469	36 878	24 936	22 126	32 727	0.7651	111 743	228 409	484 059
7	712 469	36 878		22 126	32 727	0.7252	105 915	197 646	514 823
8	712 469	36 878		22 126	32 727	0.6874	100 395	192 125	520 343
9	712 469	36 878		22 126	32 727	0.6516	95 166	186 897	525 572
10	712 469	36 878		22 126	32 727	0.6176	90 200	181 931	530 538
11	712 469	36 878	77 097	22 126	32 727	0.5854	85 498	254 325	458 143
12	712 469	36 878		22 126	32 727	0.5549	81 043	172 774	539 695
13	712 469	36 878		22 126	32 727	0.5260	76 822	168 553	543 916
14	712 469	36 878		22 126	32 727	0.4986	72 821	164 551	547 918
15	712 469	36 878		22 126	32 727	0.4726	69 023	160 754	551 715
16	712 469	36 878	84 456	22 126	32 727	0.4479	65 416	241 602	470 866
17	712 469	36 878		22 126	32 727	0.4246	62 013	153 743	558 725
18	712 469	36 878		22 126	32 727	0.4240	61 925	153 656	558 813
19	712 469	36 878		22 126	32 727	0.3815	55 718	147 449	565 020
20	712 469	36 878		22 126	32 727	0.3616	52 812	144 542	567 926
21	712 469	36 878		22 126	32 727	0.3427	50 051	141 782	570 687
Total	**13 739 429**	**774 428**	**186 489**	**442 520**	**654 540**		**1 748 496**	**3 806 473**	**9 932 956**

a Year 2 is the first year of repayment

b (8) = US$ 146 050 x (7)

c (9) = (3) + (4) + (5) + (6) + (8)

Appendix 4
Compounding factors
Discount factors
Present worth of annuity factors
Capital recovery factors

Table A4-1
Compounding factors

$CF_n = (1 + i)^n$

Year	Interest (i)						
(n)	2.0%	3.0%	5.5%	8.5%	10.0%	12.0%	20.0%
1	1.0200	1.0300	1.0550	1.0850	1.1000	1.1200	1.2000
2	1.0404	1.0609	1.1130	1.1772	1.2100	1.2544	1.4400
3	1.0612	1.0927	1.1742	1.2773	1.3310	1.4049	1.7280
4	1.0824	1.1255	1.2388	1.3859	1.4641	1.5735	2.0736
5	1.1041	1.1593	1.3070	1.5037	1.6105	1.7623	2.4883
6	1.1262	1.1941	1.3788	1.6315	1.7716	1.9738	2.9860
7	1.1487	1.2299	1.4547	1.7701	1.9487	2.2107	3.5832
8	1.1717	1.2668	1.5347	1.9206	2.1436	2.4760	4.2998
9	1.1951	1.3048	1.6191	2.0839	2.3579	2.7731	5.1598
10	1.2190	1.3439	1.7081	2.2610	2.5937	3.1058	6.1917
11	1.2434	1.3842	1.8021	2.4532	2.8531	3.4785	7.4301
12	1.2682	1.4258	1.9012	2.6617	3.1384	3.8960	8.9161
13	1.2936	1.4685	2.0058	2.8879	3.4523	4.3635	10.6993
14	1.3195	1.5126	2.1161	3.1334	3.7975	4.8871	12.8392
15	1.3459	1.5580	2.2325	3.3997	4.1772	5.4736	15.4070
16	1.3728	1.6047	2.3553	3.6887	4.5950	6.1304	18.4884
17	1.4002	1.6528	2.4848	4.0023	5.0545	6.8660	22.1861
18	1.4282	1.7024	2.6215	4.3425	5.5599	7.6900	26.6233
19	1.4568	1.7535	2.7656	4.7116	6.1159	8.6128	31.9480
20	1.4859	1.8061	2.9178	5.1120	6.7275	9.6463	38.3376
21	1.5157	1.8603	3.0782	5.5466	7.4002	10.8038	46.0051
22	1.5460	1.9161	3.2475	6.0180	8.1403	12.1003	55.2061
23	1.5769	1.9736	3.4262	6.5296	8.9543	13.5523	66.2474
24	1.6084	2.0328	3.6146	7.0846	9.8497	15.1786	79.4968
25	1.6406	2.0938	3.8134	7.6868	10.8347	17.0001	95.3962
26	1.6734	2.1566	4.0231	8.3401	11.9182	19.0401	114.4755
27	1.7069	2.2213	4.2444	9.0490	13.1100	21.3249	137.3706
28	1.7410	2.2879	4.4778	9.8182	14.4210	23.8839	164.8447
29	1.7758	2.3566	4.7241	10.6528	15.8631	26.7499	197.8136
30	1.8114	2.4273	4.9840	11.5583	17.4494	29.9599	237.3763
31	1.8476	2.5001	5.2581	12.5407	19.1943	33.5551	284.8516
32	1.8845	2.5751	5.5473	13.6067	21.1138	37.5817	341.8219
33	1.9222	2.6523	5.8524	14.7632	23.2252	42.0915	410.1863
34	1.9607	2.7319	6.1742	16.0181	25.5477	47.1425	492.2235
35	1.9999	2.8139	6.5138	17.3796	28.1024	52.7996	590.6682
36	2.0399	2.8983	6.8721	18.8569	30.9127	59.1356	708.8019
37	2.0807	2.9852	7.2501	20.4597	34.0039	66.2318	850.5622
38	2.1223	3.0748	7.6488	22.1988	37.4043	74.1797	1020.6747
39	2.1647	3.1670	8.0695	24.0857	41.1448	83.0812	1224.8096
40	2.2080	3.2620	8.5133	26.1330	45.2593	93.0510	1469.7716

Table A4-2
Discount factors

$$DF_n = \frac{1}{(1 + i)^n}$$

Year	Interest (i)									
(n)	2.0%	3.0%	5.5%	8.5%	10.0%	12.0%	20.0%	30.0%	35.0%	45.0%
1	0.9804	0.9709	0.9479	0.9217	0.9091	0.8929	0.8333	0.7692	0.7407	0.6897
2	0.9612	0.9426	0.8985	0.8495	0.8264	0.7972	0.6944	0.5917	0.5487	0.4756
3	0.9423	0.9151	0.8516	0.7829	0.7513	0.7118	0.5787	0.4552	0.4064	0.3280
4	0.9238	0.8885	0.8072	0.7216	0.6830	0.6355	0.4823	0.3501	0.3011	0.2262
5	0.9057	0.8626	0.7651	0.6650	0.6209	0.5674	0.4019	0.2693	0.2230	0.1560
6	0.8880	0.8375	0.7252	0.6129	0.5645	0.5066	0.3349	0.2072	0.1652	0.1076
7	0.8706	0.8131	0.6874	0.5649	0.5132	0.4523	0.2791	0.1594	0.1224	0.0742
8	0.8535	0.7894	0.6516	0.5207	0.4665	0.4039	0.2326	0.1226	0.0906	0.0512
9	0.8368	0.7664	0.6176	0.4799	0.4241	0.3606	0.1938	0.0943	0.0671	0.0353
10	0.8203	0.7441	0.5854	0.4423	0.3855	0.3220	0.1615	0.0725	0.0497	0.0243
11	0.8043	0.7224	0.5549	0.4076	0.3505	0.2875	0.1346	0.0558	0.0368	0.0168
12	0.7885	0.7014	0.5260	0.3757	0.3186	0.2567	0.1122	0.0429	0.0273	0.0116
13	0.7730	0.6810	0.4986	0.3463	0.2897	0.2292	0.0935	0.0330	0.0202	0.0080
14	0.7579	0.6611	0.4726	0.3191	0.2633	0.2046	0.0779	0.0254	0.0150	0.0055
15	0.7430	0.6419	0.4479	0.2941	0.2394	0.1827	0.0649	0.0195	0.0111	0.0038
16	0.7284	0.6232	0.4246	0.2711	0.2176	0.1631	0.0541	0.0150	0.0082	0.0026
17	0.7142	0.6050	0.4024	0.2499	0.1978	0.1456	0.0451	0.0116	0.0061	0.0018
18	0.7002	0.5874	0.3815	0.2303	0.1799	0.1300	0.0376	0.0089	0.0045	0.0012
19	0.6864	0.5703	0.3616	0.2122	0.1635	0.1161	0.0313	0.0068	0.0033	0.0009
20	0.6730	0.5537	0.3427	0.1956	0.1486	0.1037	0.0261	0.0053	0.0025	0.0006
21	0.6598	0.5375	0.3249	0.1803	0.1351	0.0926	0.0217	0.0040	0.0018	0.0004
22	0.6468	0.5219	0.3079	0.1662	0.1228	0.0826	0.0181	0.0031	0.0014	0.0003
23	0.6342	0.5067	0.2919	0.1531	0.1117	0.0738	0.0151	0.0024	0.0010	0.0002
24	0.6217	0.4919	0.2767	0.1412	0.1015	0.0659	0.0126	0.0018	0.0007	0.0001
25	0.6095	0.4776	0.2622	0.1301	0.0923	0.0588	0.0105	0.0014	0.0006	0.0001
26	0.5976	0.4637	0.2486	0.1199	0.0839	0.0525	0.0087	0.0011	0.0004	0.0001
27	0.5859	0.4502	0.2356	0.1105	0.0763	0.0469	0.0073	0.0008	0.0003	0.0000
28	0.5744	0.4371	0.2233	0.1019	0.0693	0.0419	0.0061	0.0006	0.0002	0.0000
29	0.5631	0.4243	0.2117	0.0939	0.0630	0.0374	0.0051	0.0005	0.0002	0.0000
30	0.5521	0.4120	0.2006	0.0865	0.0573	0.0334	0.0042	0.0004	0.0001	0.0000
31	0.5412	0.4000	0.1902	0.0797	0.0521	0.0298	0.0035	0.0003	0.0001	0.0000
32	0.5306	0.3883	0.1803	0.0735	0.0474	0.0266	0.0029	0.0002	0.0001	0.0000
33	0.5202	0.3770	0.1709	0.0677	0.0431	0.0238	0.0024	0.0002	0.0001	0.0000
34	0.5100	0.3660	0.1620	0.0624	0.0391	0.0212	0.0020	0.0001	0.0000	0.0000
35	0.5000	0.3554	0.1535	0.0575	0.0356	0.0189	0.0017	0.0001	0.0000	0.0000
36	0.4902	0.3450	0.1455	0.0530	0.0323	0.0169	0.0014	0.0001	0.0000	0.0000
37	0.4806	0.3350	0.1379	0.0489	0.0294	0.0151	0.0012	0.0001	0.0000	0.0000
38	0.4712	0.3252	0.1307	0.0450	0.0267	0.0135	0.0010	0.0000	0.0000	0.0000
39	0.4619	0.3158	0.1239	0.0415	0.0243	0.0120	0.0008	0.0000	0.0000	0.0000
40	0.4529	0.3066	0.1175	0.0383	0.0221	0.0107	0.0007	0.0000	0.0000	0.0000

Table A4-3

Present worth of the annuity factors

$$AF_n = \left[\frac{AF_{n-1} - AF_{n-2}}{(1+i)}\right] + AF_{n-1}$$

Year (n)	Interest (i) 2.0%	3.0%	5.5%	8.5%	10.0%	12.0%	20.0%
1	0.9804	0.9709	0.9479	0.9217	0.9091	0.8929	0.8333
2	1.9416	1.9135	1.8463	1.7711	1.7355	1.6901	1.5278
3	2.8839	2.8286	2.6979	2.5540	2.4869	2.4018	2.1065
4	3.8077	3.7171	3.5052	3.2756	3.1699	3.0373	2.5887
5	4.7135	4.5797	4.2703	3.9406	3.7908	3.6048	2.9906
6	5.6014	5.4172	4.9955	4.5536	4.3553	4.1114	3.3255
7	6.4720	6.2303	5.6830	5.1185	4.8684	4.5638	3.6046
8	7.3255	7.0197	6.3346	5.6392	5.3349	4.9676	3.8372
9	8.1622	7.7861	6.9522	6.1191	5.7590	5.3282	4.0310
10	8.9826	8.5302	7.5376	6.5613	6.1446	5.6502	4.1925
11	9.7868	9.2526	8.0925	6.9690	6.4951	5.9377	4.3271
12	10.5753	9.9540	8.6185	7.3447	6.8137	6.1944	4.4392
13	11.3484	10.6350	9.1171	7.6910	7.1034	6.4235	4.5327
14	12.1062	11.2961	9.5896	8.0101	7.3667	6.6282	4.6106
15	12.8493	11.9379	10.0376	8.3042	7.6061	6.8109	4.6755
16	13.5777	12.5611	10.4622	8.5753	7.8237	6.9740	4.7296
17	14.2919	13.1661	10.8646	8.8252	8.0216	7.1196	4.7746
18	14.9920	13.7535	11.2461	9.0555	8.2014	7.2497	4.8122
19	15.6785	14.3238	11.6077	9.2677	8.3649	7.3658	4.8435
20	16.3514	14.8775	11.9504	9.4633	8.5136	7.4694	4.8696
21	17.0112	15.4150	12.2752	9.6436	8.6487	7.5620	4.8913
22	17.6580	15.9369	12.5832	9.8098	8.7715	7.6446	4.9094
23	18.2922	16.4436	12.8750	9.9629	8.8832	7.7184	4.9245
24	18.9139	16.9355	13.1517	10.1041	8.9847	7.7843	4.9371
25	19.5235	17.4131	13.4139	10.2342	9.0770	7.8431	4.9476
26	20.1210	17.8768	13.6625	10.3541	9.1609	7.8957	4.9563
27	20.7069	18.3270	13.8981	10.4646	9.2372	7.9426	4.9636
28	21.2813	18.7641	14.1214	10.5665	9.3066	7.9844	4.9697
29	21.8444	19.1885	14.3331	10.6603	9.3696	8.0218	4.9747
30	22.3965	19.6004	14.5337	10.7468	9.4269	8.0552	4.9789
31	22.9377	20.0004	14.7239	10.8266	9.4790	8.0850	4.9824
32	23.4683	20.3888	14.9042	10.9001	9.5264	8.1116	4.9854
33	23.9886	20.7658	15.0751	10.9678	9.5694	8.1354	4.9878
34	24.4986	21.1318	15.2370	11.0302	9.6086	8.1566	4.9898
35	24.9986	21.4872	15.3906	11.0878	9.6442	8.1755	4.9915
36	25.4888	21.8323	15.5361	11.1408	9.6765	8.1924	4.9929
37	25.9695	22.1672	15.6740	11.1897	9.7059	8.2075	4.9941
38	26.4406	22.4925	15.8047	11.2347	9.7327	8.2210	4.9951
39	26.9026	22.8082	15.9287	11.2763	9.7570	8.2330	4.9959
40	27.3555	23.1148	16.0461	11.3145	9.7791	8.2438	4.9966

Table A4-4
Capital recovery factors

$$CRF_n = \frac{i}{1 - (1 + i)^{-n}}$$

Year (n)	Interest (i) 2.0%	3.0%	5.5%	8.5%	10.0%	12.0%	20.0%
1	1.0200	1.0300	1.0550	1.0850	1.1000	1.1200	1.2000
2	0.5150	0.5226	0.5416	0.5646	0.5762	0.5917	0.6545
3	0.3468	0.3535	0.3707	0.3915	0.4021	0.4163	0.4747
4	0.2626	0.2690	0.2853	0.3053	0.3155	0.3292	0.3863
5	0.2122	0.2184	0.2342	0.2538	0.2638	0.2774	0.3344
6	0.1785	0.1846	0.2002	0.2196	0.2296	0.2432	0.3007
7	0.1545	0.1605	0.1760	0.1954	0.2054	0.2191	0.2774
8	0.1365	0.1425	0.1579	0.1773	0.1874	0.2013	0.2606
9	0.1225	0.1284	0.1438	0.1634	0.1736	0.1877	0.2481
10	0.1113	0.1172	0.1327	0.1524	0.1627	0.1770	0.2385
11	0.1022	0.1081	0.1236	0.1435	0.1540	0.1684	0.2311
12	0.0946	0.1005	0.1160	0.1362	0.1468	0.1614	0.2253
13	0.0881	0.0940	0.1097	0.1300	0.1408	0.1557	0.2206
14	0.0826	0.0885	0.1043	0.1248	0.1357	0.1509	0.2169
15	0.0778	0.0838	0.0996	0.1204	0.1315	0.1468	0.2139
16	0.0737	0.0796	0.0956	0.1166	0.1278	0.1434	0.2114
17	0.0700	0.0760	0.0920	0.1133	0.1247	0.1405	0.2094
18	0.0667	0.0727	0.0889	0.1104	0.1219	0.1379	0.2078
19	0.0638	0.0698	0.0862	0.1079	0.1195	0.1358	0.2065
20	0.0612	0.0672	0.0837	0.1057	0.1175	0.1339	0.2054
21	0.0588	0.0649	0.0815	0.1037	0.1156	0.1322	0.2044
22	0.0566	0.0627	0.0795	0.1019	0.1140	0.1308	0.2037
23	0.0547	0.0608	0.0777	0.1004	0.1126	0.1296	0.2031
24	0.0529	0.0590	0.0760	0.0990	0.1113	0.1285	0.2025
25	0.0512	0.0574	0.0745	0.0977	0.1102	0.1275	0.2021
26	0.0497	0.0559	0.0732	0.0966	0.1092	0.1267	0.2018
27	0.0483	0.0546	0.0720	0.0956	0.1083	0.1259	0.2015
28	0.0470	0.0533	0.0708	0.0946	0.1075	0.1252	0.2012
29	0.0458	0.0521	0.0698	0.0938	0.1067	0.1247	0.2010
30	0.0446	0.0510	0.0688	0.0931	0.1061	0.1241	0.2008
31	0.0436	0.0500	0.0679	0.0924	0.1055	0.1237	0.2007
32	0.0426	0.0490	0.0671	0.0917	0.1050	0.1233	0.2006
33	0.0417	0.0482	0.0663	0.0912	0.1045	0.1229	0.2005
34	0.0408	0.0473	0.0656	0.0907	0.1041	0.1226	0.2004
35	0.0400	0.0465	0.0650	0.0902	0.1037	0.1223	0.2003
36	0.0392	0.0458	0.0644	0.0898	0.1033	0.1221	0.2003
37	0.0385	0.0451	0.0638	0.0894	0.1030	0.1218	0.2002
38	0.0378	0.0445	0.0633	0.0890	0.1027	0.1216	0.2002
39	0.0372	0.0438	0.0628	0.0887	0.1025	0.1215	0.2002
40	0.0366	0.0433	0.0623	0.0884	0.1023	0.1213	0.2001