An Economic Analysis In The Context Of Environmental Impact Assessment Of An Irrigation Project In Gutu District, Zimbabwe

A Mini Dissertation

Submitted To The University Of The Free State In Partial Fulfillment Of The Requirements For The Masters Degree In Disaster Management

Presented By

Lynnette Tshabangu

Supervised By

Mr Andries Jordaan

November 2009

Abstract

Previous economic analysis of agriculture projects has excluded the cost implications of environmental protection. Analyzing the gross margin budgets, a project can prove to be economically viable, but such viability does not factor in the cost of the natural resources (environment). Exploitation of the environment and local institutions have a strong bearing on the successful implementation of the project and its sustainability. This study was an effort to do an economic analysis of a proposed irrigation project scheme for Gutu south in Zimbabwe with a backdrop of environmental impact of the scheme. The study utilized the Environmental Impact Assessment (EIA) framework to analyze the socio economic and biophysical impacts of the proposed scheme. Under the socioeconomic impacts the study leant that the project will bring about food security (food availability and diversified diet), employment creation, business opportunities, infrastructure development and increased household income for engaging farmers. Undesired outcomes of the scheme-included disputes on water rights and participation in the scheme, increased risk to HIV/AIDS infection during scheme construction and increased exposure to water born diseases. Considering the biophysical impacts of the scheme, increased vegetation cover, increased crop yield, land conservation through good agronomic practices constitute the positive side. The negative side is predominantly soil erosion, slope instability, soil salinity and reduced biodiversity. The project design incorporated environmental management strategies to mitigate the negative impacts. The economic analysis of the project indicated a gross benefit of US$13.930 million, by comparing the economic values of the '*with*' and '*without*' project situation over a 30-year project life spun. Incorporating environmental protection costs of US$27,560 the proposed irrigation project showed a net present value of US$1.729 million. The proposed irrigation project can then be safely recommended for implementation with a higher degree of confidence. The result of integrating EIA in economic analysis of a project provides a comprehensive decision making approach in development programming.

Declaration

I, the undersigned, hereby declare that the work contained in this dissertation is my own original work, that all sources used or quoted, have been indicated and acknowledged by means of complete references, and that this dissertation was not previously submitted by me or any other person at any other university for a degree.

Signature: ________________________

Date: 25 November 2009

Acknowledgements

This study would not have been possible without the provision, protection and promotion from the Lord Almighty, whose grace is enough for me. I wish to express my sincere gratitude to the people and institutions that made this study a success. My special thanks goes to my husband, Mdabuli for all the spiritual and intellectual inspiration, which enabled me to go the distance. My heart-felt gratitude goes to our boys Thubalami and Thandolwenkosi for enduring with me through-out the study period. I am indebted to my sister Mrs Sharbert Munyoro for making it possible for me to give this task all my attention the final days before the due date of submission. I am grateful to the support and encouragement I received from my supervisor Mr Andries Jordaan through out the study period. I would like to acknowledge the support I received from my line manager Clement Mhlanga, a colleague Taungana Dzikati and Debra Maleni from AGRITEX. I also want to thank Oxfam GB for creating a conducive environment and availing relevant materials used during the study period.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

CHAPTER 1: INTRODUCTION

1.0 Introduction

Irrigation schemes are being strategically established in the rural areas of Zimbabwe as a drought mitigation measure for income and food security reasons. Since 1980, the use of water from river flow, reservoir storage and deep motorized boreholes has seen the development of 187 smallholder irrigation schemes, across the agriculture sector (FAO, 2000). The country has vast potential water resources in Trans-boundary Rivers and in-land dams. An assessment done in Zimbabwe on Irrigation Feasibility by FAO in 2000 revealed that the country has potential for irrigation development to cover at least 240,000 hectares of arable land in the agricultural farming sector. Gutu district in Masvingo province is one such area with potential water resources for irrigation development given that it is prone to recurrent droughts. At the boundary of the south-eastern part of the district is a perennial Ruti dam. This dam is a potential water resource for irrigation development as a drought mitigation measure for the Gutu community.

The Gutu rural district council drew a plan to develop the irrigation scheme sometime in the 1990s but due to a lack of funding from the government, the implementation of the plan has been delayed. Oxfam Great Britain (Oxfam GB), a non-governmental organization operating in the area was approached in 2007 for funding. In response, Oxfam GB conducted a feasibility study for irrigation development in the area towards the end of 2007. The study recommended development of an irrigation project as key priority for the community in view of climate change impact. The study also pointed out the need to promote sustainable livelihood options, which are economically viable given that the community has been food insecure since 2002. These indications prompted Oxfam GB to fund the establishment of an irrigation project with the aim of meeting food security for the Gutu community, in view of achieving sustainable livelihoods. This study is therefore a follow-up to conduct an economic analysis of the proposed irrigation project. The analysis is done in the context of Environmental Impact Assessment (EIA) framework. The EIA framework provides an opportunity to predict environmental damages and mitigation measures, as well as providing options for maximizing productive and non-productive benefits of the environment. The economic analysis focuses on establishing the benefits and costs for establishing the irrigation project incorporating the environmental protection measures.

The study takes into account the national and international policies on environmental damage prevention and mitigation. This includes the National Environmental Management Act and the International Protocols and Agreements on the environmental management. Therefore the EIA framework is used in view of Zimbabwe Environmental Management Act, to ensure that environmental protection measures are incorporated in the design of the irrigation project.

1.1 Working Definitions

In view of the proposed study, the following terms are defined as follows;

- **EIA** is a generic term that embraces both an administrative process and set of analytical techniques designed to predict and appraise environmental impacts of development proposals. In summary it is a process of ensuring that proper consideration has been given to environmental effects in development decisions.
- **Environment** is the physical, ecological, economic and social aspects, which are life support systems for local communities around the proposed site for the irrigation scheme.
- **Economic analysis** refers to assessing the efficiency with which resources are used to meet community preferences. This entails making use of valuation methods that allows the placing of economic values on many environmental impacts and incorporates them in benefit-cost appraisals.

These definitions have been adopted from the United Nations Environment Programme (UNEP, 2004) and David James (1994).

1.2 Preliminary Literature Review

The long-term fluctuation in the earth's weather conditions has been associated with global warning induced by greenhouse gases such as carbon dioxide, methane, nitrous oxides and hydro-fluorocarbons emitted from human activity (Chasi, 2009). Trend analysis on annual rainfall across Zimbabwe is decreasing by about 5 to 20% of the 1961-90 average and annual warming reaching about 0.15 to 0.55^0C per decade by 2080 (Chasi, 2009). The accelerating and deepening impacts of climate change is affecting all especially the poor who stand to suffer most due to the inherent vulnerability caused by poverty and an already degraded environment. The current climate variability experienced in Zimbabwe, particularly drought cycles, means that rain-fed agriculture which is the major source of livelihood for the rural majority will be greatly affected. Climate change has been observed to show increased drought frequency, water scarcity, land degradation and reduced or loss of ecosystem functions.

Coping strategies to the impacts of climate change for agricultural based livelihoods especially in Zimbabwe have often been characterized by disposing of productive assets, reduce food consumption, dependency on food aid, as well as reduced expenditure on health and education (Chasi, 2009). Most if not all of these mechanisms will push more people into extreme poverty with long term repercussions to increased vulnerability to climate change related hazards. In light of this, most assessments have concluded that there is need to improve food security, water and environmental management. This implies better management of disaster risks including early warning systems and protection from vector borne diseases. Recommendations have been made to build the capacity of the rural poor to adapt to changing climate through technology transfer and strengthening positive coping mechanisms. One way of building community capacity to adapt to the effects of climate change is through irrigation development.

According to a study done by Stockle (2001) on a Review of An Environmental Impact of Irrigation, irrigated lands contribute significantly to the world agriculture output and food supply. The study estimates that in 1986 about half of the increase in agricultural production in the previous 35 years had come from irrigated land. It also highlights that about one-third of the world's crops were grown on one-sixth of the cropped area, which was irrigated. Irrigated land was found on average to be more than twice as productive as rain-fed land.

A study done in Ethiopia by Mahmoud (2007) on an Irrigation Project suggests that irrigation projects have an imperative importance to realize development policies like poverty reduction and food self-sufficiency, especially in developing world. Therefore much attention should be given to the environmental conservation in view of maximizing production and productivity. This emanates from analyzing the water conservation measures and uses by considering issues such as the utilization of agro-chemicals in irrigated fields, which may find their way back to the water source. The study recommends that it is indispensable to carry out the EIA of an irrigation project in a given area.

The Environmental Management Act (Act 13 of 2002, Chapter 20:27) of Zimbabwe has a provision that protects environmental degradation in all economic sectors such as manufacturing, mining, construction, tourism and agriculture. To promote environmental management practices the Department of Natural Resources and Environmental Management has drawn guidelines to conduct EIA as a statutory requirement. The guidelines stipulate that for all irrigation projects, there is need to conduct EIA in view of environmental protection. Therefore environmental related projects at all levels are expected to demonstrate environmental protection measures before they are implemented.

An irrigation evaluation study done by FAO (2000) in Zimbabwe on irrigation schemes across the country revealed some of the problems faced by communities operating the schemes. These problems include market access, water management, social conflicts, operation and maintenance expertise. The study recommends that specialized technical experts especially in irrigation development, social, environmental and agricultural management should work closely with the farmers to develop viable and sustainable irrigation projects.

According to James (1994), economic analysis is becoming increasingly important as a planning and evaluation method in environmental assessments. The economic approach offers a logical means of integrating applied science and public decision making. It provides a basis of reaching balanced decisions on development and environmental protection. Economics in EIA have been found to provide a framework for the collection, analysis and interpretation of information. This allows efficient assessment of resource utilization in view of meeting community preferences.

1.3 Background To The Problem Area

Gutu district has a population of over 198 000 people with more than 90% of the population depending on subsistence rain-fed agriculture for livelihood. It covers natural regions III, IV and V, which are characterized by erratic and unreliable rainfall patterns (Rukuni and Eicher, 1994 pp 42). This makes rain-fed agriculture a risky venture and statistics indicate that success rate of rain-fed agriculture in these regions especially IV and V are in the order of one good harvest in every 4 to 5 years (FAO, 2000). Lately due to climate change, the district has experienced repeated droughts and faces chronic food insecurity. It has been a seasoned recipient of food aid from various institutions including World Food Programme, Churches and the government since the 2002.

Water resource management is a major concern in rural areas as most irrigation schemes that were operational are no longer functional (Dzvurumi, 2006). Poor management of irrigation systems poses a threat to the environment as this contributes to the severity of the impact of drought to the environment. Other agriculture activities such as overgrazing, over-cultivation, stream bank cultivation and deforestation can further compound the impact of a drought on the environment. Therefore there is need to effectively manage the environment and water resources for irrigation. This will provide leverage to the local population from the current droughts and improve their food security and livelihood. This includes managing factors that can make the environment vulnerable to drought such as the supply and demand of water sources, water use patterns and drought preparedness measures. According to James (1994), the environment is viewed as a natural resource that constitutes part of the national capital stock. Therefore it yields goods and services that have recognizable economic value to a community, despite the fact that not all such goods and services can be valued explicitly in terms of market price.

Despite being in region IV, the south-eastern part of Gutu has the potential to reduce dependence on unsustainable rain fed agriculture through effective utilization of Ruti Dam. The dam was commissioned in 1979 and is along Nyazvidzi River in the Save Catchment Area and covers an area of over 1500ha. A report done early 2000 by the Gutu Irrigation Department on the irrigation assessment utilizing the Ruti dam indicates that there are 3 sites suitable for irrigation that can cover a total area of 250 hectares. The initial assessment report revealed that the area nearest to the weir has a potential for 80 hectares, and up to 20 hectares can be irrigated by gravity. The drawn irrigation proposal is intended to irrigate a maximum of 20 hectares of arable land. This targets to engage 80 farmers directly to produce crops in the irrigation. In the subsequent years and depending on funding available, the scheme will be developed to its full capacity, initially by expanding it to irrigate up to 80 hectares and later up to 250 hectares. The figure below shows the south eastern part of Gutu district and the proposed site for the irrigation scheme.

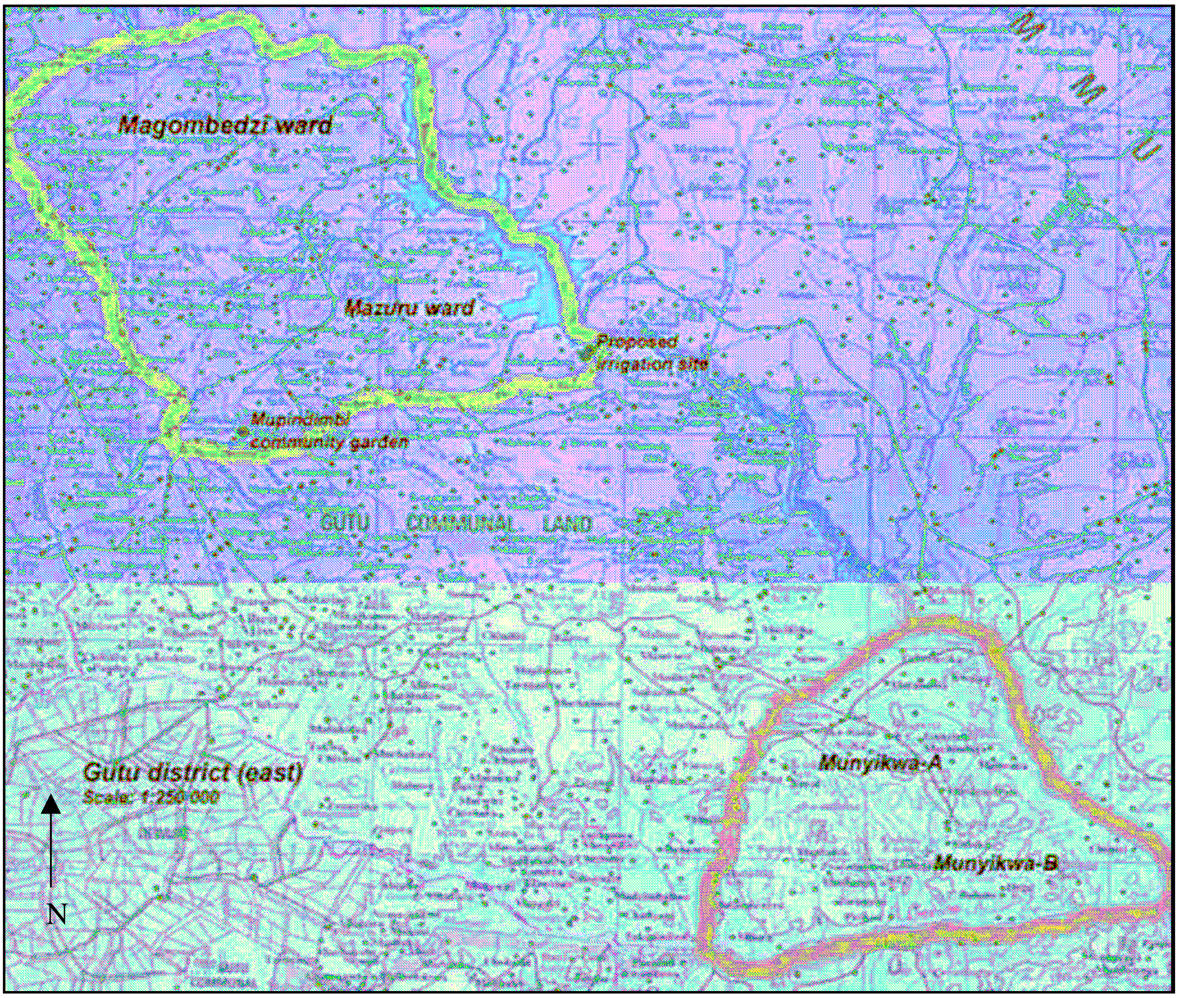

Figure 1: A map of the proposed site for the Ruti irrigation scheme

1.4 Problem Statement And Research Questions

As a drought mitigation option, an irrigation project proposal has been drawn to utilize the Ruti dam in the south eastern part of Gutu district. This study therefore seeks to answer the broad research question; Is it economically viable to develop the proposed irrigation project in Gutu district, incorporating environmental protection measures?

In view of answering this question, the following specific research questions were pursued:

- What are the probable environmental damages and benefits arising as a result of the proposed irrigation project?
- What are the environmental protection measures to be considered in view of the probable environmental damages?
- What are the costs and benefits of '*with*' and '*without*' the irrigation project?

1.5 Research Design

This study considered economic analysis and EIA as a means of internalizing environmental effects by placing values on damage to or improvements in the environment as part of development planning. The application of economics in EIA allows for the evaluation and provision of recommendations on the ranking of alternatives and design options. Economic analysis will be applied to help design and select project options that contribute to the welfare of the people in a community.

Benefit-cost analysis will be used to assess the potential benefits and costs of the irrigation project to the community, in view of calculating the net benefits. In order to do this, the '*with*' and '*without*' irrigation project situations will be compared. The *without*-project is captured as the present baseline conditions of the irrigation site. The *with*-project situation focuses on future conditions if the irrigation project was to be undertaken. The benefit-cost analysis focuses on the net changes that are predicted to occur; that is the differences between the '*with*' and the '*without*' project situations. This method permits the local authorities to determine in the broad sense whether the proposal would use available resources efficiently from a community standpoint. However, other considerations especially social factors are considered in drawing recommendations as the benefit-cost analysis only offers economic efficiency.

The study will collect information on:

- The physical and temporal boundaries of the irrigation project
- The physical, ecological, social and economic environment of the proposed irrigation project
- Possible adverse and beneficial environmental impacts that may influence the design of the irrigation project.

- The environmental safeguards and mitigation measures in view of the predictions of environmental impacts of the irrigation project
- The cost and benefit implication of the project considering the '*with'* and '*without'* irrigation project situations.
- The indication of recommended course of action for implementation of the proposed irrigation project, including environmental management aspects.

1.5.1 Data Sources

Oxfam GB and the Gutu Rural District Council will provide the proposed irrigation project documents for reference. Institutions focusing on environmental and irrigation issues such as the Department of Agriculture and Extension Services (AGRITEX), Department of Irrigation, District Development Fund, Zimbabwe Electricity Supply Authority (ZESA), FAO and statutory authorities will be consulted to collect secondary data for literature review and indicators for economic analysis. The local community and key informants such as community leaders, local based AGRITEX and Irrigation officials will be consulted to provide information on the physical, ecological, social and economic environment of the irrigation project.

1.5.2 Data Collection Methods

Data collection from environmental and irrigation institutions will be done through reviewing of documents, reports and publications. Informal interviews will be conducted with key informants, while focus groups discussions will be conducted with the community surrounding the proposed irrigation site. For both the key informant and local community interviews, semi-structured questionnaires will be used to guide the discussions. Site visits will complement this to verify the identified baseline environmental issues.

1.5.3 Sampling

Participants for the focus groups discussions will be drawn from the community surrounding the proposed site. Both men and women are expected to attend and efforts will be made to invite people who are currently utilizing the site such as farmers, fisher-men and others. The study proposes 4 focus group discussions each with at most 12 people, which is more that 10% of the targeted 80 farmer households expected to be operating and benefit directly from the proposed irrigation project. Triangulation of information will be done with the key informants who are stakeholders in the design and development of the irrigation project. This includes people such as the community leaders, local based specialists in agriculture, irrigation, environment, land use planning and ZESA officials.

1.5.4 Data Analysis

Information collected will be analyzed and presented in varying degrees of detail, such as summary tables and narrative descriptions. Collected quantitative information will be analyzed by simple statistical aids and use Microsoft Excel to construct graphs as applicable. Qualitative information collected through informal interviews and focus group discussions will be analyzed by inductive reasoning and presented in words and narratives.

1.6. Delimitations Of The Study

The study was limited to the south-eastern part of Gutu district, which is serviced by the Ruti dam. Due to resource limitations, the proposed irrigation site and community targeted by the proposed irrigation project were the primary sources of information for this study.

1.7 Outline Of Chapters

The study has the following layout of chapters;

Chapter 1: This section provides the background of the study, justification and the focus of the study. It describes the research objectives, research questions and methodology, which guides the conduction of the study.

Chapter 2: With the purpose of giving an insight into the theoretical background and related studies, this chapter provides the reviewed literature. It also gives insights on key emerging findings and gaps existing from previous studies and related assessments.

Chapter 3: This chapter documents the design and methodology followed during the research fieldwork. It discusses the instruments used in the measurement of the key variables of the study and explains the sample design, techniques used in data collection and analysis.

Chapter 4: This chapter presents the findings and results of the information collected for an economic analysis of an irrigation project in the context of EIA framework.

Chapter 5: This chapter discusses the main findings of the study and draws conclusion and recommendations. It provides a summary of the research project in view of the broad research focus.

Annexes of tools used to conduct the study and other relevant detailed analysis for the study.

CHAPTER 2: Theoretical Framework

2.0 Introduction

This chapter provides the theoretical framework and literature reviewed that relates to this study. It discusses the theoretical framework of economic analysis in the context of EIA. The first section discusses the EIA framework for irrigation development. Reference is made to the Zimbabwean EIA framework as a statutory requirement for environmental management. The next section of the chapter provides literature on the relevance of economic analysis in EIA as a tool for project planning and designing. Key concepts used in economic analysis that are specific in this study are also defined. A detailed review of the methodologies used in economic analysis of environmental impacts is also discussed. The last section provides information on reviewed evaluations done on existing smallholder irrigation schemes in view of economic viability and mitigating the negative impacts of drought in communities.

2.1 The Environmental Impact Assessment Framework

Irrigation agriculture has proved to enormously contribute towards increased food production and improved quality of life for millions in developing countries. However, irrigated agricultural development also has had negative environmental impacts, which according to Amerasinghe and Boelee (2004) are largely through:

- ***The physical construction of irrigation systems.*** This involves issues such as human resettlement; watershed degradation, encroachment into unique ecosystems, historical and cultural sites; biodiversity loss and change (including wildlife and fishery resources); proliferation of invertebrate and vertebrate pests and disease carriers, soil erosion and sedimentation.
- ***The management of irrigation systems***. This depends on the nature of water sources (surface or ground water or both), quality of water, and its delivery to the irrigated land. The withdrawal of groundwater can lead to land subsidence, salination and increased pollution by other chemical contaminants. Withdrawal of surface water leads to changes in river hydrology. Examples include water quantity, flow regime and quality that can affect these and other associated aquatic ecosystems. Water delivery to the irrigated land and agricultural run-off can lead to soil erosion, impact on aquifers, water-logging and salination of soil and water.

- ***Agriculture management practices***. These may contribute to the pollution of ground water and down stream surface water through inputs of salts, agrochemicals and toxic leachates.

There is therefore an increasing trend to make irrigated agricultural development accountable for its impact on the environment. This includes the need to improve its environmental performance so as to ensure long term sustainability (Stockle, 2001). In order to achieve this, United Nations Environmental Protection (UNEP, 2003) promotes EIA to identify environmental and social impacts of a project prior to implementation, during and after implementation. As a prospective tool, EIA can be used to predict environmental impacts at an early stage in project planning and design. This allows one to find ways to reduce adverse impacts, mould projects to suit local conditions, and present options to decision-makers. EIA also can be used as a retrospective tool, to identify and sometimes quantify impacts after implementation. Ideally, EIA should examine environmental implications in all project phases under both normal conditions and defined worst-case scenarios. It should also assess the overall environmental risks associated with the project.

The EIA as a component of environmental management is part of the broader responsibility of nations to preserve the environment and pursue sustainable development. This was agreed at the United Nations Conference on Environment and Development (UNCED) 1992 conference in Rio de Janeiro. In view of protecting the integrity of the global environmental and developmental systems, 27 principles were documented in the Rio Declaration on Environment and Development. These principles are part of the International agreements, which respect the interests of all and protect the integrity of the global environmental and developmental system. As a guide to implementing the principles, the Agenda 21 document was drawn detailing progamme management information. It gives a comprehensive detail of action to be taken globally, nationally and locally by organizations of the UN, governments, and major groups (Wikipedia, 2009).

The implementation of Agenda 21 was reviewed in 1997 (Rio +5) by the general Assembly of the United Nations. It was recognized that progress was uneven and noted key trends including increasing globalization, widening inequalities in income and a continued deterioration of the global environment. The Rio+10 conference conducted in Johannesburg in 2002, focused on the World Summit on Sustainable Development (Earth Summit 2002). It affirmed the United Nation's commitment to the implementation of Agenda 21, alongside achievement of other international agreements such as the Millennium Development Goals (Wikipedia, 2009). The call on countries is to adopt the National Sustainable Development Strategies in view of the human impact on the environment. Implementation by member states is voluntary and they should work within the context of Agenda 21. The conference assessed progress on implementation of the results of the Rio Summit and pointed out the need for countries to develop approaches that would tackle social and ecological problems jointly, in dealing with environmental problems effectively. One of the recommended approaches was for countries to ensure that EIA is incorporated as a national instrument. This way, EIA will be undertaken for proposed activities that are likely to have a significant adverse impact on the environment and are subject to a decision of a competent national authority (UNCEP, 1992).

The Asian Development Bank (ADB) publication on EIA (2000) refers to sustainable development as the result of carefully integrating environmental, economic and social needs. This should achieve an increased standard of living and a net gain or equilibrium among human, natural and economic resources to support future generations. This was borne out of the realization of the need to overcome environmental challenges in order to achieve sustainable development. These environmental challenges include land degradation and depletion of natural resources; human settlements unfit for habitation due to inadequate shelter, sanitation and water supplies; soil water and air pollution; and global issues like global warming, ozone depletion, and loss of biodiversity (ADB, 2000). In view of these challenges, EIA processes come in handy for examining the social and environmental consequences of projects prior to their execution. In this regard, the purpose of EIA is to provide information to decision makers and the public about the environmental implications of proposed actions before decisions are made. The information provided is broadly on the environmental impacts and the means for preventing or reducing those impacts.

The ADB (2000) publication highlights 3 essential phases in conducting an EIA:

i. ***The identification phase.*** This involves characterizing the existing physical, social, economic and ecological environment and identifying components of a development project which are likely to impact that environment.

ii. ***The prediction phase.*** The project impacts are quantified using standards and by comparison with the findings of the other projects. This phase forecasts on the nature and extent of the identified environmental impacts, and estimates the likelihood of the occurring impacts.

iii. ***The assessment phase.*** This phase judges the importance or significance of the predicted impacts. It determines the costs and benefits to user groups and the population affected by the project. It also specifies and compares trade-offs between various alternatives.

These processes should lead to the development of a report that clearly gives an identification and analysis of the environmental effects of proposed activities, including their probability of occurrence. An environmental management plan should be drawn in the report, which outlines the mitigation measures to be undertaken. The report should also document an environmental monitoring programme, which outlines the data that must be collected in conjunction with the project. The results of these processes should allow decision makers to clearly identify beneficial and adverse impacts of the proposed project and its development alternatives (ADB, 2000).

Most countries in the southern Africa region have demonstrated commitment to the International agreements on environment and development systems by ensuring that environmental management issues are incorporated in statutory instruments. In Zimbabwe, this has been done through the enactment of the Environmental Management Act 13 of 2002, Chapter 20:27. The Act has a section on Environmental Impact Assessment, Audit and Monitoring of Projects. Though EIA has been recognized as an integral part of environmental management for most developing countries, ADB (2000) recommends that there is need to overcome the following limitations in its implementation:

- Insufficient procedural guidance;
- Inadequate baseline data upon which to base analyses;
- The cost of EIA study preparation; potential delays in project implementation;
- The lack of expertise for assessing impacts;
- Inefficient communication of EIA results to decision makers;

- Lack of niter-agency coordination;
- Limited capacity for review of EIA reports; and
- Insufficient commitment to follow up on the implementation of environmental protection and monitoring requirements.

2.1.1 EIA as a Statutory Requirement in Zimbabwe

The Zimbabwe Agricultural Policy Framework (ZAPF) 1995-2020 documents the national policies and objectives for the agriculture sector. Pertaining to water resources and irrigation, ZAPF clearly states the policy objectives as follows:

- Growth in the irrigated area particularly in the smallholder sector with minimal negative impacts on the environment and human health;
- Equitable allocation and efficient use of scarce water resources;
- Establishment of a water pricing structure which is consistent with cost and social efficiency;
- Establishment of an effective institutional structure; and
- Implementation of drought mitigation strategies

Milestones towards achieving these objectives include the Zimbabwe Environmental Impact Assessment Policy of 1997, which stipulates that irrigation is a prescribed activity, which require EIA to be conducted before authorization to proceed is granted. The Zimbabwe National Water Authority Act of 1998 (Chapter 20:25) reformed the water sector to ensure a more equitable distribution of water resources and stakeholder involvement in water resource management. In this policy, water is now treated as an economic good and the "*user pays principle*" applies. This follows that water is no longer privately owned, therefore water users require water permit of limited duration, which will be allocated by Catchment Councils. Such measures are aimed at ensuring that water resources are utilized and managed efficiently in view of achieving development and sustainable objectives. The recent Environmental Management Act (2002) enforces the EIA policy of 1997. It further requires public and private development institutions to adhere to mitigating activities that protect the environment. The Environmental Management Act 2002 (Act 13 of 2002) was developed to provide for the following;

- The sustainable management of natural resources and protection of the environment;

- The prevention of pollution and environmental degradation;
- The preparation of a national Environmental Plan and other plans for the management and protection of the environment;
- The establishment of an Environmental Management Agency (EMA) and an Environment Fund;
- To amend references to intensive conservation areas and committees and associated matter in various Acts;
- To repeal the Natural Resources Act (Chapter 20:13), the Atmospheric Pollution Prevention Act (Chapter 20:03), the Hazardous Substances and Articles Act (Chapter 15:05) and The Noxious Weeds Act (Chapter 19:07); and
- To provide for matter connected with or incidental to the foregoing.

The Environmental Management Act (Act 13 of 2002) defines the environment and environmental impact assessment as follows:

Environment means

a) *the natural and man-made resources, physical resources, both biotic and abiotic, occurring in the lithosphere and atmosphere, water, soil, minerals and living organisms, whether indigenous or exotic, and the interaction between them;*
b) *ecosystems, habitats, spatial surroundings and their constituent parts, whether natural or modified or constructed by people and communities, including urbanized areas, agricultural areas, rural landscapes and places of cultural significance;*
c) *the economic, social, cultural or aesthetic conditions and qualities that contribute to the value of matters set out in paragraphs (a) and (b).*

Environmental Impact Assessment means *an evaluation of a project to determine its impact on the environment and human health and to set out the required environmental monitoring and management procedures and plans*.

The mandate to regulate, monitor, review and approve environmental impact assessments for specific listed projects, such as irrigation schemes, lies with EMA. To effectively execute its functions, EMA has developed general terms of reference for all the listed projects for which EIA should be conducted. These terms of reference are for use by consultants who are specialists listed by EMA.

The Environmental Management Act (Act 13 of 2002) requires the project developer to submit a prospectus containing information regarding the assessment and the proposed project to EMA, prior to conducting an EIA. Once the prospectus has been approved, the developer can conduct the EIA in reference to the terms of reference provided by EMA. In some instances, EMA may require an independent person or consultant who is an expert in environmental planning and management services to conduct the EIA.

According to the Environmental Management Act (Act 13 of 2002), the EIA report on a project is expected to contain the following information:

a) Give a detailed description of the project and the activities to be undertaken in implementing it; and
b) State the reasons for selecting the proposed site of the project; and
c) Give a detailed description of the proposed site of the project; and
d) Specify the measures proposed for eliminating, reducing or mitigating any anticipated adverse effects the project may have on the environment, identifying ways of monitoring and managing the environmental effects of the project; and
e) Indicate whether the environment of any other country is likely to be affected by the project and any measures to be taken to minimize any damage to that environment; and
f) Where applicable, indicate how the developer proposes to integrate biological diversity in the project; and
g) Describe concisely the methodology used by the developer to compile the environmental impact assessment report.

2.2 An Overview Of Economic Analysis Of Projects

As defined in chapter 1, economic analysis implies assessing and tracing the real resources flow induced by investment rather than the investment's monetary effects. In projects, economic analysis entails evaluation of projects that will last several years and that have differently shaped future cost and benefits streams; and evaluating projects of varying sizes (Gittinger, 1982). The analysis allows one to judge among alternative projects or alternative forms of a particular project, as to which will make a significant contribution to project objectives. This allows decision-makers to make objective informed decisions regarding proposed projects, as well as enhancing the quality of the project. Therefore the basic purpose of project-based economic analysis is to help design and select projects that contribute to the welfare of a country and its people (Belli *et al*, 1998).

Economic analysis allows determination of whether, and by how much, the benefits exceed the costs in terms of achieving the objective of the project. According to Gittinger (1982) the economic analysis of a project entails identifying and valuing the costs and benefits that will arise '*with*' the proposed project and compares them with the situation as it would be '*without*' the project. In this regard, anything that reduces or subtracts from the project objective is a cost and anything that increases or adds to the project objective is a benefit. Financial values are a starting point for estimation of economic values, and these can be adopted if they reflect the market price of a commodity or service. Adjustments should be made, if necessary, for transfer payments, distortions of the exchange rate and wage rate, and capital constraints by using shadow prices (James, 1994).

A benefit-cost analysis of a development proposal permits the relevant government agency to determine whether, in the broad sense, the proposal would use available resources efficiently from a community standpoint (James, 1994). The results of a benefit-cost analysis do indicate the preferences of the community in relation to the use of resources and the pattern of development. The analysis process entails identifying costs and benefits, pricing, and valuing them, in order to determine the incremental net benefit arising from the project investment. That is benefit-cost analysis focuses on the net changes that are predicted to occur; the difference between the '*with*' project and the '*without*' project situations. This can be done through a process called discounting. This is a process of finding the present worth of a future amount or the time value of money, using a discount rate (Gittinger, 1982).

The process will give the Net Present Value (NPV), which is one of the 3 discounted cash flow measures of project worth. NPV refers to the expected present value of the net benefits of the project. For a project to be accepted, the NPV must not be negative when discounted at an appropriate rate, and the project's expected NPV must be at least as high as the NPV of mutually exclusive alternatives (Gittinger, 1982). The other 2 discounted cash flow measures of project worth are the Internal Rate of Return (IRR) and the Net Benefit-Investment Ratio (NBIR). IRR is the discount rate that results in zero

NPV for the project. A project whose NPV is greater than or equal to zero at some discount rate, say *d*, also has IRR that is greater than or equal to *d*, leads to the same results, accept project (Gittinger, 1982). IRR will not be the basis for decision making given that a project can have multiple IRR and there is need to choose if the IRR is acceptable. NBIR is often abbreviated N/K ratio and refers to the present worth of the net benefits divided by the present worth of the investment. When using the NBIR, the selection criterion is to accept all projects with a net benefit-investment ration of 1 or greater when discounted at a suitable discount rate, in order of ration value until all available investment funds are exhausted. The NBIR can be used to rank independent projects and cannot be used directly to choose among mutually exclusive alternatives (Gittinger, 1982).

Belli *et al* (1998), recommends that for projects whose benefits are measurable in monetary terms, the appropriate yardstick for judging whether the project is acceptable in the project's NPV. For EIA, this implies quantifying and assigning monetary values to the impact of the project on the environment. It therefore requires that the EIA report provide all the possible environmental impacts of the project. It should also provide sufficient quantitative and qualitative descriptions of identified environmental impacts. This information becomes the basis for the economic valuation carried out.

Below are the key concepts for economic analysis that will be referred to in this study:

- **Present value** refers to the value at present of an amount to be received or paid at some time in the future, determined by multiplying the future value by a discount factor. It is therefore the value of future flows discounted to the present. It is also referred to as the present worth.
- **Discount rate** refers to the interest rate used to determine the present worth of a future value by discounting.
- **Net benefit** refers to the amount remaining after all outflows are subtracted from all inflows. This can be referred to as the net cash flow.
- **Incremental net benefit** is the increase in net benefit with the project as opposed to the case without the project. It is the incremental cash flow, and is the basis for calculating measures of project worth.

- **Shadow price** refers to the value used in economic analysis for a cost or a benefit in a project when the market price is felt to be a poor estimate of economic value.
- **Conversion factor** refers to a number usually less than 1, that can be multiplied by the domestic market price, opportunity cost, or value in use of a non-traded item to convert it to an equivalent border price that reflects the effect of trade distortions on domestic prices of that good or service. A standard conversion factor is the reciprocal of 1 plus the foreign exchange premium stated in decimal form.
- **Economic value** refers to the amount by which production of a project output or use of a project input changes national income. This can be a market price or may be an estimate of value in use or opportunity cost that differs from the market price.

2.3 The Role Of Economic Analysis In EIA

Sustainable development recognizes a relationship between economic development and environmental protection that takes into account the productive role of natural resources and the environment. Economic analysis and EIA have proved to be effective tools in integrating effects on the environment in project planning. With economic analysis, damage to and improvements in the environment can be weighed by placing economic values. This allows the value of the environment as a natural asset to be recognized more readily, and it is less likely to be damaged unaccountably. Thus the application of economics in EIA offers a practical mechanism for protection of the environment, including the design of mitigating measures (James, 1994).

James (1994) further highlights that under the traditional EIA, judgments about the significance of effect tend to be derived in an ad hoc manner. However, under the economic approach an attempt is made to measure rigorously social costs and benefits and express them in a familiar unit of measurement, that is the monetary value. An acknowledgment is however noted that although economic techniques are capable of valuing a wide range of environmental impacts, in cases where there is insufficient scientific information on environmental effects, ethical judgment should be used.

According to the Asian Development Bank (2000), the methodology of valuing costs and benefits of environmental goods and services is still evolving; the role of economics in EIA can be summarized as follows:

a. The use of economics for “benefit-cost analysis” as an integral part of the project selection. Benefit-cost analysis can be used in the prescreening stage of the project, and the environmental components can be brought into the process of presenting various options and selecting among them. This leads to a project selection process, which takes the environment into consideration.
b. The use of economics in the assessment of activities suggested by the EIA. The economic assessment is focused on the cost assessment of environmental mitigation measures and management plans suggested in the EIA. The Economic analysis in the EIA may include a summary of the project costs and how such cost estimates would change due to the activities proposed under the EIA. This can be considered as an accounting of the environmental investment of a project.
c. The economic assessment of the environmental impacts of the project. This is geared towards seeking the economic values (of both costs and benefits) of the environmental impacts. These impacts are neither mitigated, nor taken into account in traditional economic analysis of projects. They should be identified by the EIA and sufficient quantitative and qualitative explanations should be given in EIA documents.

James (1994) indicates that economic analysis of environmental impacts is important in project preparation to determine whether the net benefits of undertaking the project are greater than the alternatives, including the non-project scenario. He argues that economic assessment of different alternatives in the early stages of project planning should provide important inputs to improve the quality of decision-making. He further indicates that economic analysis of the environmental impacts of the selected projects also allows for a more complete assessment of project’s costs and benefits.

Beder, (1997) highlights that because environmental '*assets*' are free or under-priced they tend to be overused or abused, resulting in environmental damage. She notes that by estimating a monetary value for environmental '*assets*' more weight will be given to environmental protection in the decision-making process. Therefore analyzing the costs and benefits in conjunction with environmental impact assessment is promoted as a primary method for integrating economic and environmental considerations in decision-making. (Noorbakhsh and Ranjan, 1998) Suggests that for an environmental assessment process to be meaningful and to be able to serve the purpose of promoting sustainability, integration of environmental considerations in economic appraisal and development plans is required.

2.4 Methodologies Used In Economic Analysis Of Environmental Impacts

There is increasing interest in measures to promote sustainable development, leading to interest in integration of environmental considerations in project and development planning. Sustainable development can be defined as the level of welfare that is to be sustained and promoted through economic, social, institutional and technological change (Noorbakhsh and Ranjan, 1998). This implies integration of economic, social and environmental considerations when planning and selecting new projects and guiding future development. Noorbakhsh and Ranjan note that although the significance of environmental impact may be expressed in economic terms it is not a requirement of an EIA. They indicate that in the majority of the cases, this is not considered to be practical, because of problems regarding the quality of data available and the reliability of economic valuation methods available. The following challenges are said to have an effect on the process of expressing environmental impacts in economic terms:

- Environmental costs do not reflect their true social costs and benefits as markets for them are often distorted or absent;
- There are associated uncertainties and ignorance with respect to the reality and relevance of their effects;
- They can occur in complicated systems hence not always easily detectable and attributable;
- They are usually unequally distributed; and
- Being public goods with no well-defined property rights they often result in a conflict between individual and collective interests.

The authors (Noorbakhsh and Ranjan) however acknowledge that when the environmental impacts are not expressed in economic terms it becomes difficult to integrate the EIA findings in the decision making process and much is left to the value judgement of the decision maker. According to Little and Mirrlees (1991) a number of investment projects implemented in many developing countries by aid agencies, international donors and public sectors have yielded little or nothing. These failures can be partly attributed to the disproportionate emphasis on the financial and economic viability of projects at the expense of other important planning aspects.

Beder presents an interesting discussion on the issue of incorporating economic analysis in EIA. She highlights that advocates of increased quantification in cost-benefit analysis argue that by placing explicit values on proposed actions, the process is more open to scrutiny by others. She however points out that once economic terms are integrated, the analysis becomes highly technical, and neither available nor accessible to the public. She argues that the value judgements are hidden beneath a mass of figures that give the impression that the analysis is rational, neutral and objective. She concludes that this hinders public debate of the policy issues and lessens the accountability of bureaucratic officials; as numbers carry an unwarranted authority when used to legitimate decisions that are basically political in character. In view of these issues, Lee and Kirkpatrick (1997) have concluded that given the wide variety of legal and institutional context within which decision making takes place there is no '*best*' way of integrating environmental assessment with economic or other forms of appraisal. They acknowledge that the economic analysis approach is more demanding in its data requirements while the other forms of appraisal can have serious shortcomings.

According to the Asian Development Bank (2000), the methodology of valuing costs and benefits of environmental changes is still evolving. Three conceptual issues are recommended for the process of valuing environmental impacts and these are; ***the need to choose valuation techniques; the definition of analysis boundaries and the selection of an appropriate time horizon***. Some general guidelines for conducting useful economic analysis of the environmental impacts of development projects adopted from the Asian Development Bank's Guidelines for Economic Analysis of Projects (Asian Development Bank, 1987) are noted below.

i. Start with the most obvious and easily valued environmental impacts. First select the effects that have directly measurable productivity changes that can be valued by market prices, for example, changes in fish or crop production due to a diversion of water for a hydroelectric power project.

ii. Always look at both the benefit and cost sides. A clear distinction should be made between benefits and costs, as these will be the reference from which changes are measured.

iii. Economic analysis should be done in a "*with and without project"* framework. Project alternatives should also be considered.

iv. All assumptions in the economic analysis should be stated clearly.

v. When market prices cannot be used directly, surrogate market prices should be used.

Belli *et al* (1998), recommends that the first step in assessing costs or benefits of environmental impacts is to determine the functional relationship between the project and the environmental impact, as measured by some physical characteristics. The second step is to assign a monetary value to the environmental impact by means of objective and /or subjective valuation techniques. Belli *et al* (1998), defines objective valuation techniques as techniques, which are based on technical and/or physical relationships that can be measured. They rely on observable environmental changes and on market prices of goods or services (or expenditures). The authors further define subjective valuation techniques as techniques, which are based on behavioral or revealed relationships. Frequently, they use surrogate measures to estimate values; that is, the analyst uses a value for a marketed good to infer a value for an unpriced environmental good or service. The subjective measures are said to rely on surrogate markets, hypothetical markets (based on surveys), or implicit values as expressed by various "hedonic" techniques. Subjective techniques offer the only practical way to measure certain categories of environment-related benefits and costs, and they are increasingly accepted for decision-making (Belli *et al*, 1998).

Belli *et al* (1998) discusses a number of important methods available for valuating environmental impacts. One of the methods discussed is the changes in productivity technique. This technique is useful for valuing environmental impacts that affect the productivity of fisheries, forests and agriculture, amongst others. It values physical changes in production due to environmental impacts. Market prices for inputs and outputs can be used or, when distortions exist, appropriately modified market prices should be considered. The first step is to identify the changes in productivity caused by the environmental impacts both on-site and off-site. Effects on productivity "*with the* *project*" and "*without the project*" should be assessed as the second step. The latter option is used to specify the change the project will cause and to clarify the degree of damage or the damage avoided by the project. Assumptions should be made about the time over which the changes in productivity must be measured, and any future changes expected in relative prices.

Aravosis and Karydis (*n.d*) categorize the environmental impact evaluation techniques of non-tradable goods into 3 general evaluation approaches as follows:

Revealed preference techniques (direct valuation), which derives from preferences from actual, observed, market-based information. The techniques include the hedonic pricing, travel cost method and replacement cost. These techniques infer environmental values from markets in which environmental factors have an immediate influence.

Stated preference techniques (indirect valuation), which attempt to elicit preferences in direct way by use of questionnaire. The same techniques enable economic values to be estimated for a wide range of commodities, which are not traded in real markets, such as environmental resources. The common approaches used are the contingent valuation and conjoint analysis.

Production function approaches, which link environmental quality changes to changes in production relationships. These approaches are indirect means of non-market good evaluation, related either to firm's productions goods or services, or to household producing services that generate positive utility. The averting behavior and dose-response functions are 2 such approaches.

In their inquiry of the most suitable combination of environmental assessment techniques of non-tradable goods for project evaluation, Aravosis and Karydis conclude that each monetary valuation technique is applicable in specific cases and under certain circumstances. They emphasize that the final choice of the most desirable combination is based on the critical judgment of the involved evaluators. It should also be according to its applicability and result credibility.

Belli *et al* (1998), indicates that the choice of valuation technique depends on the impact to be valued; data, time, and financial resources available for the analysis, and the socio-cultural setting within which the valuation exercise is carried out. They recommend that the simplest techniques are usually the most useful. They further indicate that in most bank projects, the most useful valuation techniques are those that rely on actual changes in production, on replacement costs or preventive expenditures, or on information about impacts on human health (cost of illness). All of these deal with physical changes that can be valued using market prices and are all included in the objective set of techniques.

There are however a number of challenges noted by the Asian Development bank (2000) with regards to economic analysis of projects when incorporating environmental values into benefit cost analysis. The table below presents some of the challenges and recommended course of actions, which will be considered in this study.

Table 1: Challenges And Recommendations For Economic Analysis Of Environmental Impacts

Challenge	**Recommended Action**
Economic analysis does not address the effects of the project on income distribution. Some projects may show high benefit cost ratios yet they benefit wealthy individuals at the expense of poor individuals.	There is need to incorporate distributional impacts into the economic analysis by assigning different weights to different income groups.
Intergenerational equity is difficult to address for projects with environmental issues having an impact over a long period. Future generations might have fewer resources available than they would have had without the project, resulting in a high benefit-cost ratio.	One way of addressing this issue is directly related to the choice of discount rate. A high discount rate will favor projects with immediate net benefits, while a low one will have fewer restrictive effects on projects with long-term negative benefits and will give more weight to negative future impact.
Economic analysis also has to deal with risk and uncertainty. Natural events such as drought, floods, earthquakes, and plant and animal diseases may seriously affect projects.	Expected values are used as alternative values for variables (that is, prices, quantities whose precise value cannot be known in advance). By using a single number, this "expected value" method of accounting for risk and uncertainty does not indicate the degree of uncertainty or the range of values, which might actually be expected. Sensitivity analysis can also be used to handle risk and uncertainty in projects. Here, the use of optimistic and pessimistic values for different variables can indicate which variables will have the most pronounced effects on benefits and costs.

Accounting of the irreversible damage projects have on available natural resources. Irreversible impacts may have significant consequences in the future.	Irreversibility can be accounted for by the opportunity-cost approach since it indirectly provides information on the cost of preservation. Caution should be made in the choice of projects, by wisely using nonrenewable resources and implementing projects, which promote sustainable use of renewable resources.
Ethical and moral considerations in the valuation of human lives, especially in determining how much compensation an individual will accept for the loss of his life.	Methods have been devised to evaluate project activities, which will affect human health. The most useful valuation techniques rely on information about impacts on human health (cost of illness). However, ethically no project proponent could shamelessly show willingness to buy/pay for human lives that might be affected by the project.
Economic valuation will also have limits if the resources in question are imbedded in the people's cultural traditions and value systems. This is specifically true for cultural, historical, and aesthetic resources where the people's perception of losses of these resources depends a great deal on their cultural and historical attachment to them.	The preventive expenditures valuation technique may be used in this case. However, although people may be willing to pay to preserve or retain a resource, they might be constrained by income.

Source: Adopted from the Asian Development Bank, 2000.

2.5 Case Studies From Other Countries

An economic assessment of an irrigation project in Greece by Psychoudakis et al, (1995) revealed that the internationally significant wetlands surrounding Lake Mikri Prespa were adversely affected in the 1960s by an irrigation project to increase agricultural production and income. The irrigation project was delayed by 2 years resulting in an increase in public costs by 4.4 times the initial estimate and the irrigation area reduced to 41.3% of the initially planned area. A reduction in wetland area and the effects of intensive farming are highlighted as key adverse environmental impacts. An ex-post cost-benefit analysis shows that the social value of the project is negative, such that the economic losses would have been avoided by conserving the area in its natural state, besides its intrinsic environmental value. However, the benefits to farmers were substantial, although less than that expected, thus explaining the local support for further expansion of irrigation.

A technical paper on Irrigation development in New Zealand documented by the Ministry of Agriculture and Forestry (MAF, 2001) indicates that irrigation development is a huge business investment requiring detailed analysis for decision makers. Provision of a decision-making framework to assist individual on-farm decisions is an important part of the information flow, which is highly recommended. Even though the document does not directly highlight the need to conduct an environmental impact assessment, it recommends the need to maximize non-productive benefits of water resource enhancement such as environmental, recreational and cultural.

In a review study on the Environmental Impact of Irrigation, Stockle (2002) mentions that the potential to increase substantially the irrigated area of the world is limited. The study argues that gains from new capacity are expected to be offset by losses such as water logging and salinization, as well as retirement of areas being irrigated by pumping water in excess of rates of recharge. It points out that managing existing irrigation projects so as to minimize their environmental impact is a requirement for long-term sustainability of irrigated agriculture. However, a note is made that developing countries are already struggling to provide safe drinking water and proper sanitation to their exploding populations, let alone enough irrigation water to maintain sufficient food production levels. As a result, their ability to restore and maintain the environment is questionable, especially considering the negative effect of global warming on water resources and the environment (Stockle).

Amerasinghe and Boelee (2004), in their documentation on assessing the impact of irrigation projects on health and the environment, noted that water resources development has major impact on human health. Positive impact arise from higher incomes, better diet and nutrition, and improved access to health care systems, all of which translate to better overall health status. Negative impacts are illnesses resulting from water-related diseases, obtainable from 4 groups of water-associated diseases that are distinguished by their method of transmission:

- Water-borne or faecal-orally transmitted diseases, such as cholera, typhoid and diarrhea;
- Water-washed diseases, such as louse-borne infections and eye infections and skin diseases;
- Water-based diseases with an intermediate host living in water, such as guinea worm and schistosomiasis; and
- Water-related insect-borne parasitic diseases such as malaria, river blindness and filariasis.

The authors however indicated that water-washed diseases might be reduced with irrigation, while water related diseases transmitted through vectors might increase with irrigation development. In order to minimize these negative impacts and identify mitigation measures, impact assessments, which take health issues into consideration, are recommended before implementation of water-related projects.

A study by Assefa (2008) on small-scale irrigation in The Central Rift Valley (CRV) in Ethiopia revealed that the increased use of water for irrigation puts a great pressure on the local hydrology and ecosystem. The sustainability of irrigated agriculture is questioned as the study points out that competition for irrigation water, land and biomass increases resource management complexity. In view of providing information to guide resource management, the study recommends the need to ensure economic viability of irrigations schemes. Other specific issues recommended by the author include the need to improve the economic and environmental performance of small scale-irrigation schemes, institutional support, training of farmers on improved crop and water management issues, regular supervision and monitoring of scheme activities.

2.6 Case Studies From Zimbabwe

A study done by ECHO on Food Aid in Zimbabwe (2007) revealed that food insecurity in communal lands is caused by population pressure. The resultant increased environmental degradation leads to reduced production in dry land farming. The study by ECHO (2007) argued that soil fertility is deteriorating tremendously over the years, resulting in farmers failing to achieve reasonable or optimum harvests. It is also highlighted that decline in food production is a result of extensive soil erosion in the arable areas, thereby rendering the soil less productive. These factors, coupled with the effect of drought, have been used as the basis for land reform and resettlement. Land reform has seen "*new*" farmers with no prior experience of irrigation being allocated plots on former commercial irrigated farms. The main problem noted amongst these farmers with surface drainage system is lack of proper maintenance resulting in below optimum functioning of the systems (FAO, 2007). It was also noted that some farmers in these irrigation schemes had planted trees in the surface drainage systems, rendering them malfunction.

A report by the Department of Agricultural Engineering and Technical Services, (AETS, 2002) on the status of irrigation development in Zimbabwe highlighted that poor drainage and salinity are not a major problem in irrigated areas in Zimbabwe. The preceding are normally associated with poor land levelling and poor water management or the use of poor quality irrigation water. The report however highlighted that there is a general increase in the use of agrochemicals in the country due to the intensification of crop production. It is thought that regular use of commercial levels of agrochemicals is an occupational risk for irrigation farmers which also risks contamination of both surface water and groundwater resources (FAO, 2007). However, data on water analysis showing agrochemicals levels in natural water sources in Zimbabwe has not been documented to establish the extent of pollution due to irrigated agriculture. Clinical reports have records indicating that communities from especially surface irrigation schemes are more vulnerable to agrochemical poisoning and enteric diseases like diarrhoea, skin and eye diseases, as well as a high risk of malaria and schistosomiasis (FAO, 2007).

Smallholder irrigation in Zimbabwe has been viewed as a contributor to rural development and for improving the standards of living among the rural communities. This is borne from the fact that most evaluations done on irrigations schemes have revealed that yields achieved on smallholder schemes are higher than rain-fed dry-land yields in communal areas (FAO, 1999). However, Makhado (1984) questioned the economic viability of these smallholder irrigation and points out that certain smallholder schemes have failed and are under-utilized. The failure has been attributed to poor management, lack of inputs and irrigation experience by smallholder farmers. Poor catchment management, which results in siltation of some water bodies, has been highlighted as one of the factors contributing to irrigation failure.

A study was done on smallholder irrigation in Zimbabwe (1995), focusing on the Hama Mavhaire Irrigation scheme in Chirumhanzu district, to share innovative experiences. The study describes the scheme as an oasis of life and a hive of commercial activities. The scheme proved to be both financial and economically viable, having farmers averaging US$2,500 to US$2,700 gross margins per hectare per year (Chitsiko, 1995). The scheme operations demonstrated a good integration of environmental and conservation management aspects. Soils that were once exposed to erosion prior to the establishment of the irrigation scheme were relieved of grazing pressure giving vegetation a chance to recover. Additionally, the year-round crop production in the scheme increased vegetation cover. Resultantly, water storage capacity in rivers and tributary streams increased as sedimentation loads were significantly reduced. Additionally, the pipe system used for irrigation proved to be environmentally friendly and healthy with no run-off to cause water logging that can be a source of malaria and bilhazia (Chitsiko, 1995).

2.7 Conclusion

The foregoing sections discussed the EIA and economic analysis framework, and related studies. The literature accessed especially for Zimbabwe chronicled mostly the socio-economic aspects of smallholder irrigation schemes in terms of agriculture, financial and economic viability. The studies reviewed on EIA related to irrigation schemes in Zimbabwe focused more on issues of employment, business opportunities, increase in farmer incomes, rural infrastructure development and the enjoyment of human dignity by farmers in producing their own food instead of depending on food aid.

However, none of the literature reviewed presented economic analysis of the environmental impacts of the irrigation schemes. This study therefore attempts to do an economic analysis of the environmental impacts of the Ruti irrigation scheme in Gutu district in Zimbabwe.

CHAPTER 3: METHODOLOGY AND PROCEDURES

3.0 Introduction

This chapter documents the design and methodology followed during the research fieldwork. It discusses instruments that were used in the measurement of key variables of the study and explains the sample design and techniques used in data collection. It also describes the procedures used in capturing and editing data and the rationale behind the selection of data analysis procedures employed. It concludes by giving a discussion on the quality of data collected by highlighting shortcomings, limitations and gaps in the data.

3.1 Selection of study area

The selection of the study area was mostly influenced by the fact that Oxfam GB has been operating in Gutu district implementing livelihoods project for a period of about 8 years. The proposed irrigation project in the district is currently being funded by Oxfam GB, which enabled the researcher (currently employed by Oxfam GB) to have easy access in the area as well as information. Selection of the irrigation site was done in conjunction with the local authorities and the local leadership. It was also influenced by the fact that the proposed irrigation site is located around the Ruti Dam in Gutu district, which forms the eastern boundary of Mazuru and Magombedze wards. Ruti dam is about 65 kilometers east of Gutu Mpandawana Growth Point. Consideration was also made in view of the proposal that the project will be implemented in three phases. The first phase which has secured funding is aimed at developing 20 hectares, estimated to benefit 80 farmer households. The proposed site for this initial phase lies in the Mazuru ward. This study therefore focused more on the Mazuru ward which has approximately 277 households.

Selection of the study area was also influenced by the EIA study which was conducted in the Mazuru ward focusing on the proposed site for the initial 20 hectares. The assessment was conducted to ensure that the positive impacts of the proposed project on the environment are enhanced, while the negative impacts are mitigated. This study is therefore enhancing the EIA study, by conducting an economic analysis of the proposed irrigation projects taking into consideration the environmental impacts and mitigation measures identified.

3.2 Methods Employed in Data Collection

Focus group discussions were organized in four villages out of six in the study area. An effort was made to have at least 10 participants taking part in each of the focus group discussions. The objective of these focus group discussions was to collect in-depth qualitative information about the irrigation scheme with regards to the community's expectations, planned activities, contributions towards setting up the scheme, as well as perceptions on environmental management. A checklist with key questions was drawn up to guide the discussions. Male and female participants were combined during the discussions as the proposed irrigation scheme is expected to benefit both men and women equally with no special bias to gender. Efforts were made to have both the youth and adults to accommodate diversity in terms of views and perceptions.

A total of 43 community members participated in the four focus group discussions conducted in the ward. Of these, 23 were male and 20 were female. This maybe due to the fact that culturally the community expects men to be the decision makers. Therefore more men will be encouraged to attend community meetings and discussions, which are likely to influence change in the community. Three of the group discussion had 10 members each and only one had 13 members. Their ages varied from 18 to late 60s, with the majority in their early to mid-40s.

Various interviews were conducted with key informants from the Environmental Management Authority, Ruti Irrigation Committee Members, Irrigation Department, Food and Agriculture Organization, local chief and village head, ward councilor, AGRITEX, Oxfam GB Programme Manager, Zimbabwe National Water Authority (ZINWA), and Rural Electrification Agency (REA). Information collected through key informant interviews was broadly centered on:

- The temporal or spatial boundaries of the irrigation project;
- The social dimensions in relation to the irrigation project;
- The economic factors relating to the irrigation project;
- The possible adverse and beneficial environmental impacts that may influence the design of irrigation project; and
- The environmental safeguards and mitigation measures in view of the predictions of environmental impacts of the irrigation project.

A total of 13 key informants were interviewed over a period of 5 days. Information obtained was both qualitative and quantitative in nature. The roles and responsibilities of interviewed key informants are as follows:

- ***Oxfam GB:*** Financing the implementation of the irrigation project. It is responsible for coordination of activities during the irrigation scheme establishment. It is also responsible for building capacity of the targeted community, through community mobilization, organization and awareness raising on gender, HIV/AIDS and policy issues related to natural resource and environmental management.
- ***Ruti Irrigation Project Committee (RIPC)*** is responsible for the direct management of the irrigation scheme set up and implementation on behalf of the community, which includes mobilizing community members to provide labour and local available resources during construction. The committee represents the community members in stakeholder meetings and decision-making.
- ***The Irrigation Services Department*** is responsible for topographical surveys, design of the irrigation scheme and hiring out heavy machinery (graders, front loaders and dousers) at subsidized rates. The department will be responsible for providing irrigation management and training in relation to equipment utilization and maintenance.
- ***Zimbabwe National Water Authority*** is responsible for technical design of water movement from the dam to overnight storage systems and pipelines to the field. It also provides trainings on community based water management and maintenance. The department currently issues and manages water rights permits and receipts water users' fee.
- ***District Development Authority*** is responsible for providing expertise for construction of access roads, surveying of boreholes and fencing of the irrigation fields. The department will facilitate trainings on water point and fence maintenance.
- ***District Administrator and Local government*** are responsible for land administration and related policy implementation. They are responsible for gazetting the proposed area from being a communal area to an irrigation scheme area. This implies enforcement and administering of by-laws related to land designated for irrigation purposes.
- ***Local leadership (traditional chief, councilor and village heads)*** is responsible for mobilizing community members, providing basic information on the community

such as social, cultural and traditional values. They also participate in decision making as they represent the views and interests of the community from a political, social and cultural points of view.

- ***Agricultural Training and Extension Services*** are responsible for agronomic issues and agriculture conservation practices. They provide agriculture information and extension services to the community and shall be giving similar support to the targeted farmers in the project.
- ***Ministry of Health and Child Welfare*** is responsible for implementation of health programmes with special focus on sanitation, HIV/AIDS, malaria control and bilharzias in relation to the irrigation project.
- **Zimbabwe Electricity and Supply Authority** is responsible for providing electricity connections and maintenance of the electrical systems.
- ***Environmental Management Agency*** is responsible for environmental management, which includes overseeing the conduction of the EIA, monitoring and evaluation of the environmental mitigation measures proposed by the EIA study.

3.3 Methods Used In Data Analysis

Information collected through focus group discussions was largely qualitative and thus deductive reasoning was used to analyze the data, given that the research questions were both exploratory and interpretive. Data analysis was guided by use of the constant comparative method where emerging themes were categorized and reevaluated. Comparison of new data sets with old data sets on related or similar themes to check for variations was conducted to generate appropriate discussion sections. Throughout the process, analyzed information was reexamined and interpreted in view of the research questions established earlier. An in-depth description and interpretation of findings is presented in words and narratives.

Quantitative data was compiled through document review and key informant interviews. This was information on gross margin budgets, crop production trends and the proposed irrigation project budget. The data was analyzed using Microsoft Excel, a simple statistical aid to construct graphs and pie charts.

Economic analysis of environmental impacts was done by initially identifying the spatial and conceptual boundaries of the proposed project site. This was achieved through consultations with the lead consultant who undertook the EIA exercise for the proposed irrigation project. Through the EIA study, as well as literature review on climate change impacts and coping strategies, the environmental impacts of the irrigation project were identified. The identified environmental impacts were quantified where possible and organized according to importance in relation to the irrigation project. This was a mammoth task in study as it required a good basis for deciding which environmental impacts to include and how to quantify and monetarise the same. In determining the significance of the relationship of identified impacts to the irrigation project, the environmental impacts were screened using the steps illustrated on the diagramme below.

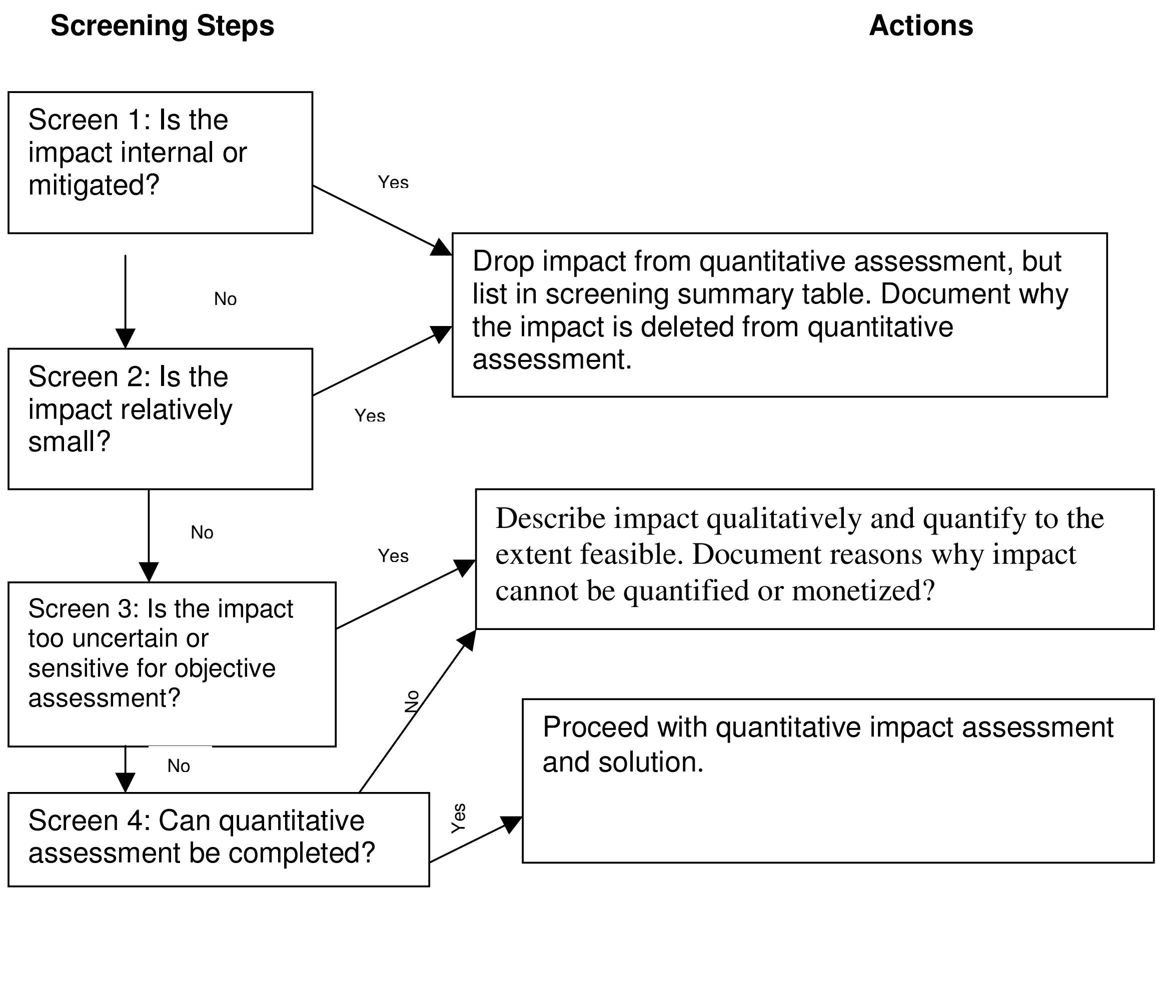

Figure 2: The Impact Screening Process

Source: *Asian Development Bank, 1996*

Following the quantification of impacts, economic valuation techniques were selected based on the nature of the identified environmental impacts. In reference to the valuation flowchart presented below, adopted from Dixon *et al* (1994), the quantified environmental impacts were presented in monetary values using the appropriate valuation techniques. As illustrated on the flowchart below, the environmental impacts were divided into 3 categories. The first two categories are those that cause measurable changes in the production of a specific good or service, and thereby affect: 1) human welfare, and 2) human health. The third category comprise of impacts that cause changes in the quality of the environment. However, in reference to the screening of impacts done using the process illustrated earlier, the impacts affecting human welfare and health were quantifiable, while the impacts on changes in environmental quality were qualified.

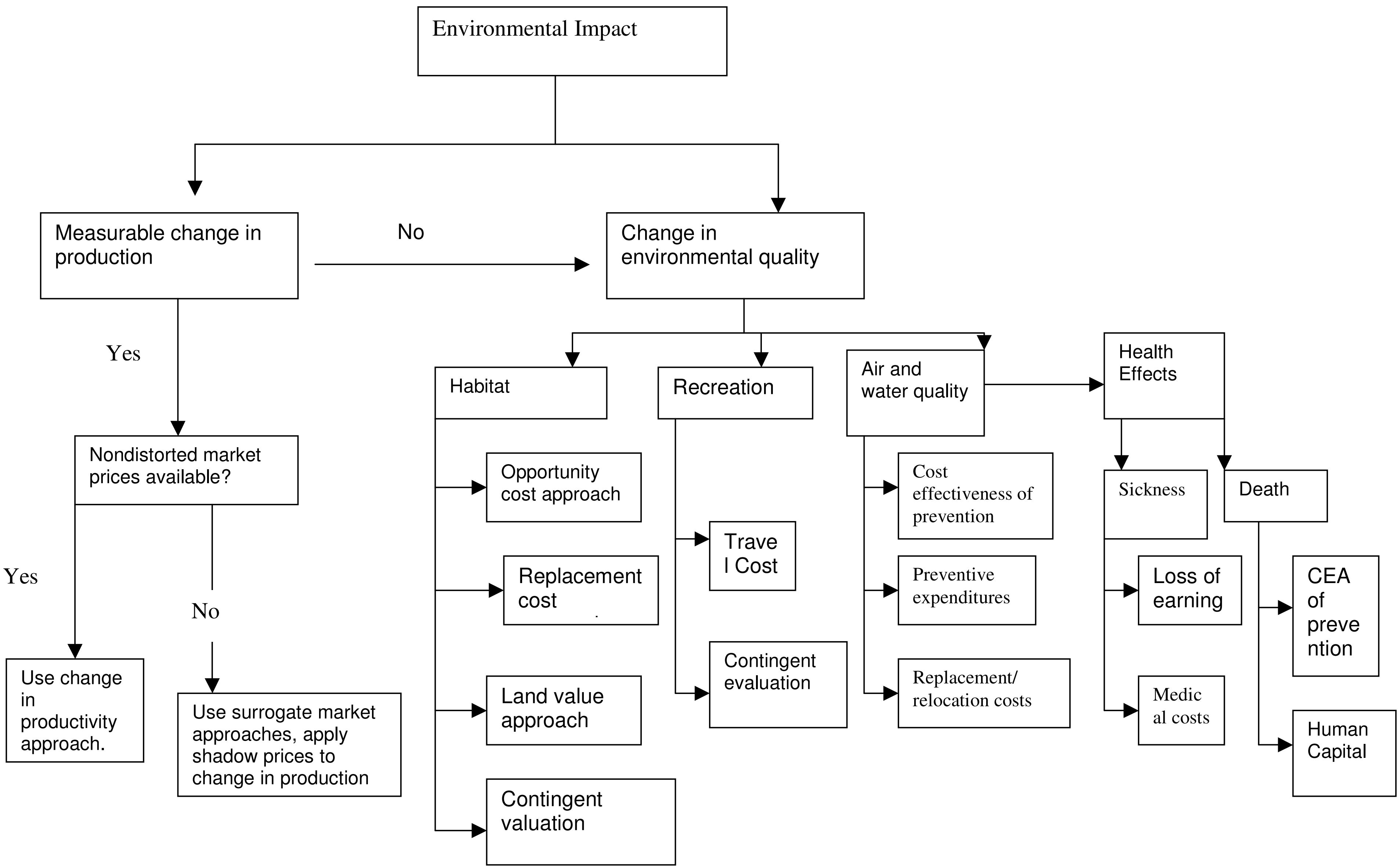

Figure 3: A Simple Valuation Flowchart

Source: Asian Development Bank 1996. Adopted from Dixon *et al* 1994.

Following the economic valuation of environmental impacts, a period of a month was set to collect relevant data for the extended benefit cost analysis. The process entailed collection of gross margin budgets for the proposed irrigation scheme's cropping calendar and for the current rain-fed crops grown in the study area. In partnership with the farmers in the proposed site and key stakeholders involved in the setting up of the irrigation scheme, Oxfam GB consolidated a bill of quantities for the scheme on behalf of the farmers. The consolidated bill of quantities was incorporated in this study as the capital investment of the irrigation project. Cash flows for both the '*with*' project and '*without'* project scenarios were calculated from the collected financial information.

The computed financial cash flows were the starting point for economic analysis. The prices were then adjusted to reflect the economic value to Zimbabwean society for the two scenarios. The economic values of both inputs and outputs differ from financial values because of market distortions created either by the government or by the private sector. The main causes of distortion in the Zimbabwean economy are tariffs and export taxes. This has resulted in distortions of prices for traded items, non-traded items and wage rates. The distortions on market prices were corrected using a conversion factor obtained from the Planning Commission of Zimbabwe to arrive at shadow prices. The following relationship, which exists between financial prices and shadow prices, was used;

Shadow Price = (Financial Price) X (Conversion Factor)

In March 2009 the Zimbabwe dollar was abandoned and the government announced the undertaking of total economic reform liberalizing most sectors of the economy through the Short Term Economic Recovery Programme (STERP). However, since the government of Zimbabwe adopted the new policy in March 2009 of using stable foreign currencies, a pay-as-you-go budget and the cessation of quasi-fiscal activities, this has resolved the problem of inflation. Measures implemented to guarantee profitability and viability of farming centre around deregulation of the marketing and pricing of commodities and allowing farmers to sell freely their commodities in the open market and market determined prices. Against this background, the following assumptions were made underlying the economic analysis of this study:

- The macro-economic context in the country is expected to be stable with less or no distortions in marketing systems.
- Policies that promote local production and protect producers especially farmers will be implemented.
- Both farmers and consumers will have access to market information for decision-making.
- The local based institutions will have capacity to effectively play their role and support the irrigation project as expected.
- There is no uncertainty about either the costs or returns of the project.
- The proposed irrigation scheme has a 30-year life span.
- There will be no civil unrest in the planned 2013 presidential elections, which can result in relocation of farmer households.

Examining the difference between the availability of inputs and outputs for the '*with'* and '*without'* project situations, was used as the basic method of identifying project costs and benefits. This method measures the incremental benefits arising from the project over time. Measures of change in costs and benefits over time were compared by expressing the corrected market prices in present values or as an annualized figure. This involves use of social discount rate, which is similar to the rate of interest, but which reflects society's time preference for the consumption of goods and services, or the productivity of capital. The time horizon of the analysis was set at 25 years, informed by the expected life-span of the irrigation infrastructure before major improvements are required.

The technique for economic evaluation used in this study is the net present value (NPV) also known as the net present worth. The NPV determines the present value of net benefits by discounting the streams of benefits and costs back to the beginning of the base year. In view of economic analysis of environmental impacts, the present value of the net benefits can be expressed as presented in the formula below:

$$\mathbf{NVP = (B_d - C_d) - C_p + (B_e - C_e) + (B_o - C_o)}$$

Where NPV is the net present value of the development alternative,

- Bd and Cd are the present values of direct benefits and costs of outputs and resources used in the proposal
- C_p is the present value of environmental protection costs, which are an additional cost item incurred within the proposed activity
- B_e is the value of the environmental benefits, which are external to the proposal
- C_e is the present value of remaining environmental damage, which are external to the proposal.
- B_o and C_o are the present values of other indirect or secondary benefits and costs.

For Bd, Cd and Cp, financial values are a starting point for estimation of economic values. Adjustments of the financial values were considered given the distortions on prices in Zimbabwe as explained earlier. For Be and Ce, the idea was to consider using market-based techniques first, surrogate market methods next and contingent valuation last. The general rule is to maximize and have the NPV positive and it is calculated by means of a formula;

$$\mathbf{NPV} = \sum_{t=1}^{n} \frac{(B_t - C_t)}{(I + r)^t}$$

Where B_t are economic benefits at time *t,* C_t are economic costs at time *t*, *r* is the social discount rate and *n* is the number of years or project life span.

3.4 Limitations

Due to the political and economic instability experienced in the last decade, the country has continued to suffer from brain drain. This affected effective and timely collection of information for this study. During key informant interviews, information was provided as estimates as opposed to actual due to institutional memory loss. Some of the respondents interviewed were new in their positions due to high staff turn over especially in local based institutions. Therefore more time was required to follow up with respondents to get information. Also, the adoption of foreign currency in March 2009 coupled with reduced activities in communal irrigation scheme presented challenges in getting gross margin budgets for communal irrigation crops. Given that 2009/10 agricultural season is the first under the use of foreign currency, producer prices for some crops were not readily available as these are determined at the end of the production period. This was noted especially with prices for wheat and maize. This delay was also due to the government's delay to remove price controls and GMB as the sole buyer of maize and wheat.

3.5 Conclusion

Research indicates that conducting an economic analysis of a development project can be done more effectively in environments with low socio-economic and political distortions. This study was conducted in a context characterized by uncertainty in terms of political and economic stability. The context was best described as a transiting context from socio-economic and political instability to a seemingly stable context. However, given that a lot of work towards achieving stability has to be done, this study faced challenges in getting updated figures such as the current discount rate. To overcome the challenges, assumptions were made under which the proposed project would be successful.

The question on whether the agricultural sector and macro preconditions are satisfactory for the project could not be answered during the course of this research study. This was due to the uncertainty of economic stability as the government faced challenges in operating as Government of National Unity. There are however hopes pinned on the government to implement favourable policies and strategies in view of creating a stable environment. During the course of the study the agriculture sector was faced with 4 critical issues which needed to be addressed, for all farmers to realize meaningful benefits from farming. These areas were Market intermediation and evolving market support systems; financing mechanisms; agriculture related policy formulation and implementation; and land tenure and administration for different farmer groups.

CHAPTER 4: FINDINGS AND RESULTS

4.0 Introduction

This section presents the findings and results of the information collected for an economic analysis of an irrigation project in the context of EIA framework. The results are presented in 3 major sections of the EIA findings; analysis of the environmental impacts; and the economic analysis of the proposed irrigation project.

4.1 The EIA Of The Proposed Ruti Irrigation Scheme

This section presents findings from the focus group discussions and key informant interviews. It also presents an analysis of findings obtained from the EIA study, which provided the basis for the economic analysis. The EIA findings were categorized into 2 broad sections of socio-economic and biophysical aspects. The socio-economic aspects focus on the social and economic issues, while the bio-physical aspects look at the ecological and physical dimensions of the study area.

4.1.1 The Socio-Economic Aspects

The proposed irrigation scheme would make use of the dam and weirs constructed previously. The physical boundary of the proposed irrigation scheme covers an area of at least 20 hectares. The proposed site would attract communities from the 2 adjacent wards (ward 13 and 14), with the majority coming from ward 13 where the scheme will be. Consultations with local authorities and extension officers revealed that the current 20 hectares proposal if well managed, would provide sufficient food to feed the 2 wards through-out the year, and be able to produce surplus for selling. Therefore part of the boundary for the proposed irrigation scheme was established to be the 2 wards.

In terms of social dimensions, the community surrounding the proposed irrigation site was fully aware of possible development of the site into an irrigation project. As a result, the site had no cultural or heritage sites. Previous occupants of the proposed sites had been relocated long back and fully compensated. However, given that the area has been lying fallow for more than a decade before funding could be secured for further development, surrounding communities have encroached back into the site. The area was being utilized for mainly dry-land farming. The major crops grown were maize, sorghum, rapoko and groundnuts. Other crops such as pumpkins, watermelons, round nuts, sweet potatoes sugar beans, cowpeas and sweet reeds are also grown in the area though at a very low quantities. These crops are popularly referred to as *'women's crops'* given that they are grown on field portions allocated to women for household consumption. Gardening, hunting and gathering of wild fruits and fishing is also done but on a very small scale compared to farming.

Due to economic instability, the majority of youth in the area had migrated to urban areas and neighbouring countries in search of "*greener pastures*". Thus the current community set up is characterized by dependant people above the ages of 40 and school going children. Irrigation development in the area is expected to reunite the families, as the youth will be attracted back to the community to earn a living from the scheme. The irrigation would result in continuous cropping, 3 seasons instead of 1, thus eliminating droughts and increasing food security. According to the District Administrator, the incomes from the scheme is currently projected to triple the current salaries (US$90) of those who are working in urban areas as general hands. Employment creation is also expected for skilled people such as builders during construction as well as general hands during land clearing and supply of locally available raw materials during construction. The infrastructure development is projected to require at least 150 locals during the peak period of construction.

The major source of livelihood is agriculture, which is dry-land farming though the effects of climate change coupled with the current unfavorable market systems were making this venture not viable. The current marketing policy of Grain Marketing Board (GMB) controlling maize and wheat producer prices makes producers fail to realize value for their produce. GMB has no resources to pay market prices, further influencing alternative buyers who then offer less money to producers who are desperate to sell their produce. However, opportunity exists for farmers to form strong unions or associations to influence policy formulation and market systems. This has been witnessed in the soyabean production sector in Zimbabwe where the farmers formed an association, influenced by government in policy issues relating to marketing of soyabeans, and are enjoying favorable marketing terms.

Fishing is also another livelihoods venture for the community. However, the absence of electricity in the area leaves fisher-men with one option of selling dried fish only. Also, most of the community members do not possess fishing licenses making the venture illegal. Additionally, the presence of hippopotamus in the dam imposes risk on fishing and threatens crop production in the absence of fencing and other security measures.

Improved road networks is expected as the District Development Fund (DDF) has already drawn a plan to further develop the main road which passes near the scheme with a web of access roads sprouting from it. There are numerous business centers close and linking to the proposed irrigation site. This makes marketing and information sharing relatively easy for irrigation operations. Boarding schools and hospitals in the district also provide a potential market once the irrigation project is established and running. These market opportunities will ensure that farmers are not restricted to limited marketing options thereby maximizing their returns.

Electricity installation as part of the irrigation scheme infrastructure development would enable nearby shopping centres and homesteads to access electricity at a lower cost as the community will not be installing on their own. The expected development in the area due to electrification include improvement in provision of services such as grinding mills, use of computers in schools and use of fridges in both households and shopping centers especially in relation to freezing fish for commercial purposes.

4.1.2 The Bio-Physical Aspects

The adverse and beneficial environmental impacts that may influence the design of the irrigation project were identified through the EIA conducted by a team of specialists. The EIA study reported that in terms of water quality, the chemical component analysis of dam water (96mg/l), downstream water (168mg/l) and underground water (498mg/l) indicted that the total dissolved solids results fall within the acceptable irrigation water limits. The general salinity levels for irrigation are 435mg/l, while salt tolerant crops can withstand up to 3485mg/l. Soil salinity from irrigation can occur over time wherever irrigation occurs; since almost all water contains dissolved salts due to the leaching of bases. The proposed project area was found to have relatively low salt concentrations of less than 390mg/l. Greater part of the area has levels below 15, there is however a saltpan near the riverbed, which requires constant monitoring, given that the water table in this area is high, making the soils more susceptible to salt accumulation. The area is however very small and can be managed with minimum costs and good cropping practices. Maize, wheat, sugar beans, groundnuts and vegetables can be grown on this site provided the salinity levels are kept in check.

In terms of soil quality, soils from the proposed site have been reported to have a pH level ranging between 5.44 and 8.53 (UZ, 2009). The middle section of the site has acidic to neutral soils, while the north-east and south-east sections have neutral to alkaline soils. This has a bearing on the crops to be grown. Acid soils negatively impact on the production of food crops such as maize, wheat and sorghum. The pH levels for dam water, downstream water and underground water are 7.64, 8.12 and 7.49 respectively; making the water neutral to slightly alkaline in general. These conditions make the water suitable for irrigation.

66 tree species were identified in the proposed project area despite that greater portion of the area has been cleared of vegetation for cultivation and during the construction of the dam in 1976. The tree species are along the contours, while most grass species were observed in the cultivated fields. Cultivated fields occupy a greater portion of the area. The proposed project will disturb few trees as much clearance has already been done for dry land cropping currently underway.

Some few portions of the proposed site have deep gullies, which are evidence of vulnerability of certain areas to erosion. Generally the proposed site for irrigation has relatively low erosive hazard although it has some very steep areas that are susceptible to erosion. These are areas close to the river and around kopjes, and would require conservation measures to be implemented to avoid land degradation.

The Ruti dam capacity during serious droughts, which occur once or twice a decade, is reported to be around or below 0.48 mega-litres. However during normal periods the dam can have as much as 154,227 mega-litres. The dam yield is $77.7 \times 10^6 m^3$, while the average irrigation requirements are $15,000m^3$/ ha/year. According to ZINWA, the irrigation community members need to apply for abstraction of water from ZINWA given that approximately $2,878,400m^3$ of water is reported to be uncommitted and can be used for the development of the proposed irrigation scheme. An excess of $2,578,400m^3$ of water is expected to remain uncommitted after part of the dam water is committed to irrigating the proposed 20 hectares.

4.2 Analysis of the Environmental Impact Identified

The EIA study identified both negative and positive environmental impacts of the proposed irrigation project. The table below presents a summary of the negative environmental impacts and mitigation measures identified;

Table 2: Identified Negative Environmental Impact Identified And Mitigation Measures

Environmental impact	Mitigation Measure
A. SOCIO-ECONOMIC ENVIRONMENT	
Disputes on who should be prioritised for the scheme, i.e the previous occupants who were moved and compensated; the current 'temporary' users of the proposed site; outstanding farmers; poor household farmers; or youth who do not own land.	Community engagement in irrigation project design, implementation, monitoring and management.
Disputes on water access, management and water rights issues among up-stream and down-stream communities and individuals with water permits.	Introduce water and power pricing that better represent the market value of water. Introduce transferable water entitlements.
Increase in water borne diseases such as malaria and bilharzia as people get more exposed to water when the irrigation scheme is operational.	Health education and hygiene promotion would be vital to address these challenges.
Increase in Sexual Transmitted Infections and HIV & AIDS during the construction phase, as campsite for constructors will be set up.	HIV/AIDS awareness, prevention and mitigation measures.
B. BIOPHYSICAL ENVIRONMENT	

Environmental impact	Mitigation Measure
Increased slope instability due to leveling and cliff creation that occurs during construction.	Provide incentives for land reclamation. This includes reinforcing boundary slopes with artificial cliff stabilization and channeling water away from unstable areas.
Changed tree density on the sites that are used for the irrigation scheme	Provide incentives for monitoring and reduction of the tree species on the site. Community should be encouraged to leave some wild fruit species during land clearing to minimize loss of tree species.
Soil erosion may increase in relatively steep areas due to land clearing during construction	Enhance farmers' involvement in management and maintenance of irrigation and drainage facilities.
Potential contamination of groundwater due to use of chemical fertilizers and pesticides in areas that have shallow water tables.	Manage fertilizer programs so as to minimize nutrients available for detachment and transport.
Soil salinity that may arise from irrigating the land	Apply soil amendments and reclamation practices.

Source: Environmental Impact Assessment, University of Zimbabwe 2009

Apart from these negative impacts, the following positive impacts were also noted:

- Increased crop production on the site due to water availability under the irrigation scheme, facilitating all year round crop production. The increase is in quantity and varieties;

- Infrastructure development, especially road and electricity, improving communication network and technology advancement opportunities from electricity;
- Increase in employment opportunities during construction of the irrigation infrastructure and related supporting infrastructure; and
- Increase in food diversity and income generated from the irrigation scheme proceeds.

The identified positive impacts are based on the assumptions that the Zimbabwean economy will continue on the path to recovery and attain stability. This will ensure that there is effective information sharing on market issues. Also policies promoting an enabling environment for these positive aspects to occur are assumed.

The identified negative and positive environmental impacts were screened in reference to the Impact Screening Process illustrated in chapter 3. This was done to determine the significance of the relationship of identified impact to the proposed irrigation project. The results below present a summary of the screening process to identify the significant impacts which could be quantified for further analysis.

Table 3: Impact Screening Process Results

Environmental Impact	Significance Of The Impact	Quantification Or Qualification Of The Impact
A. BIOPHYSICAL ENVIRONMENT		
Increased slope instability due to leveling and cliff creation that occurs during construction.	The general rugged terrain of the proposed site for irrigation makes the impact significant and the need to be mitigated as part of the construction and operational costs.	A topographic survey conducted as part of the irrigation establishment determined the correctional factors of slope instability, which were factored into the irrigation structure as part of the capital requirements. Periodic surveys (once every 5 years) have to be undertaken during operational stage to check evidence of slope failure so as to mitigate it.
Changed tree density on the sites that are used for the irrigation scheme	Reduction of tree density during land clearing to open space for irrigation will be mitigated by farming of various crop all year round to ensure vegetation cover. Leaving specific tree species will ensure limited loss of indigenous trees. The impact is therefore internal and mitigated in the process.	The impact of change in tree density was therefore not assessed further for quantifying given that it can be mitigated internally.
Soil erosion may increase in relatively steep areas due to land clearing during construction	Topographic surveys established that the area has relatively low erosive hazard, except a few steep areas noted.	The impact was dropped as insignificant given that the steep areas vulnerable to erosion were less than a 10^{th} of the proposed site for irrigation. Additionally,

Environmental Impact	Significance Of The Impact	Quantification Or Qualification Of The Impact
		increasing vegetation cover during crop production as well as leaving some trees to enhance soil stability can internally mitigate the impact.
Soil salinity that may arise from irrigating the land	The EIA established that the area has relatively low salt concentrations and overall, the soils can be classified as non-saline. There is potential for salt accumulation, which can occur from irrigation over time, and this can be checked and corrected periodically. The checks can be done once every 5 years.	The costs for soil salinity tests done once every 5 years were estimated and factored in as part of the environmental management costs. The costs for correcting possible soil salinity could however not be established as this stage.
Potential contamination of groundwater due to use of artificial fertilizers and pesticides in areas that have shallow water tables.	The impact is too uncertain for objective assessment and the impact was dropped as significant.	The estimated area of contamination was very small given that there are few sections where the water table is close to the surface. Therefore the impact could not be quantified further.
Increase in crop production	The proposed irrigation will allow for all-year production under the 20-hectares. This significantly contributes to increase in food production and type of crops produced, compared to rain-fed agriculture.	Under irrigation, expected crop type and average yield (tonnes) per hectare are maize (4.8), wheat (3), sugar beans (1.6), carrots (20), Onions (24), tomatoes (25), green maize (8) and potatoes (18),

Environmental Impact	Significance Of The Impact	Quantification Or Qualification Of The Impact
		compared to current average crop yield per hectare of rain-fed crops maize (0.1), sorghum (0.3), groundnuts (0.2) and rapoko (0.15).
B. SOCIO-ECONOMIC ENVIRONMENT		
Disputes with regard to operating in the scheme.	Community disputes with regards to selection of participants to operate in the irrigation scheme can have significant repercussions if not well managed. Indications of such disputes have been noted during various engagements with the community.	The impact of community disputes will be evident in irrigation scheme management as well as community support or engagement.
Disputes on water access, management and water rights issues.	Water rights are significant in implementing irrigation schemes. By-laws regarding transferable water entitlements and market value water charges needs to be enforced for effective management of related disputes.	Water disputes are social in nature, therefore difficult to quantify.
Increase in water borne diseases such as malaria and bilharzia	Generally the area is less prone to malaria and bilharzias. Establishment of an irrigation scheme will increase exposure of community to these water related diseases. However, these impacts were not regarded as significant considering experience from related communities in the district with irrigation facilities.	The impact was not considered for quantitative analysis. However, community awareness and periodic assessment of the impact is vital.

Environmental Impact	Significance Of The Impact	Quantification Or Qualification Of The Impact
Increase in Sexual Transmitted Infections and HIV & AIDS	Previous trends of construction projects have revealed that there are high incidents of sexual affairs established between the constructors and surrounding community. Given the high prevalence of HIV (13,7%) in the country, there are high chances of infections.	The impact could not be quantified due to its sensitivity nature for objective assessment.
Infrastructure development	An improved road network for effective linkages and access to markets will support the irrigation scheme. Installation of electricity for pumping implies that surrounding community will have access to connection points for electrifying the community.	The impact could not be quantified due to the subjective nature of the development. It depends on the willingness and ability of the community to make use of the opportunity presented by the irrigation scheme facilities.
Increase in employment opportunities	Construction phase of the irrigation infrastructure presents opportunities for employment for skilled and casual labour. During operation of the irrigation scheme, security labour as well as maintenance and repair of equipment presents employment opportunities to the community.	The estimated cost of construction will be factored in as part of capital costs required to set up the irrigation infrastructure. Maintenance and repair costs were estimated from related operations and factored in as part of operational costs incurred during implementation.
Increased food diversity and income	Food diversity contributes to quality health, through improved nutritional status. Income can be generated through selling of surplus produce. This will	Both consumed produce and income generated from operations in the irrigation scheme is valued considering the gross

Environmental Impact	Significance Of The Impact	Quantification Or Qualification Of The Impact
	significantly improve the welfare of the participating farmers.	margin budgets for communal irrigation schemes. However, improved quality of health is an intangible benefit, which could not be quantified in this study.

Source: Research Study Data Analysis, 2009

4.3 Economic Analysis Of the Proposed Irrigation Project

The framework for economic evaluation of the proposed irrigation project is an environmental benefit-cost analysis. The approach incorporates the findings from the EIA and includes the economic valuations of the relevant effects. For a proper benefit-cost analysis, the study takes into account both the location of goods and services and their valuation. It incorporates the identified changes in productivity caused by environmental impact both on-site and off-site. In this study, changes on-site are the outputs such as increased crop production, for which the proposed irrigation project is designed to achieve. Changes off-site include all the environmental or economic externalities, which are included in this analysis to give a true picture of the project impact. In order to conduct the economic analysis for the proposed irrigation project, the quantified environmental impacts were valued and incorporated in a benefit-cost analysis. In determining whether the proposed irrigation project would use the available resources efficiently from a community standpoint, analysis of the '*with*' project and '*without*' project was made. The focus was on the net changes that are predicted to occur, that is, the differences between the without-project and with-project situations.

4.3.1 The '*Without*' Project Situation

The baseline conditions of the current crop production patterns of the community were established, noting the crop yield and production levels. For the '*without*' project situation, the average production levels have been deteriorating over the years mostly due to the changing climate resulting in recurrent droughts. This has been further compounded by the unavailability of inputs, poor soil fertility and unfavourable policies for agricultural production. Maize has been affected the most as the producers of green maize are currently operating at a loss due to increased costs of production compared to the set producer prices. Consultations with the community for the targeted irrigation site revealed that maize yield levels under rain-fed range between one and half to two 50kgs bags per hectare. However, production of small grains such as sorghum and rapoko was reported to be constant and in some instances increasing. This was mainly because the grown small grains are drought tolerant and require fewer inputs. Therefore current yield levels per hectare of sorghum were presented as ranging from 4 to 8 50kgs bags, rapoko at 2 to 3 50kgs bags and ground nuts ranging from 2 to 6 50kgs bags. The table below shows the average annual cropping pattern in the study area.

Table 4: Current Annual Cropping Pattern In The Study Area

Crop	**% Estimated of Area Planted**	**Area planted (ha)**	**Average Yield per Hectare (t/ha)**	**2008/09 Production levels (t)**
Maize	70	14	0.1	1.4
Groundnuts	10	2	0.2	0.4
Rapoko	10	2	0.15	0.3
Sorghum	10	2	0.3	0.6
Total	**100**	**20**		

Source: Gutu AGRITEX Ward 13 and 14 crop production records 2008/09

The area planted was calculated assuming that the proposed site of 20 hectares was being fully utilized under rain-fed farming. The communities and the extension workers provided the percentage estimates of area allocated to various crops under rain-fed farming. Given that season 2008/09 was a better season compared to previous seasons, this study has assumed 2009 to be the base year for evaluation. Realistically, this situation would change over time, even without implementation of the proposed project. Generally, the change would be due to economic, social, climatic and institutional forces, which can alter the life-style and land-use practices of the community. Indications from consultations with various key informants were that the current crop yield levels can increase if factors of availability and accessibility to inputs are addressed which affected production in the community during the season. However, the recurrent droughts and deterioration of soil quality and fertility, were highlighted as key threats to achieving maximum crop yield levels in the study area. As a result, the maximum yield levels in tones per hectare (t/ha) expected for the dry land crops in the study area are maize 1t/ha, groundnuts 2t/ha, rapoko 3t/ha and sorghum 3t/ha.

4.3.2 The *'With'* Project Situation

For the 'with project' situation, analysis was made on the type of crops, which could be planted, expected yield levels and production area. The community indicated maize, wheat, sugar beans, potatoes, tomatoes, cabbage, rape, onions, covo, spinach, carrots and butternuts, as the crops preferred under irrigation. Consultation with local based agronomist and agriculture economists revealed the recommended crops as maize, wheat, sugar beans, carrots, onions, cabbages, tomatoes and potatoes. These crops were recommended in view of the soil type, recurrent droughts resulting in food insecurity and current economic challenges associated with pricing and marketing crop produce in Zimbabwe. Given the unfavourable marketing terms and policies prevailing in the country, farmers are better off producing non-perishable crops, which can be stored for future use.

Also, the changing climate implies that communities have to find measures of ensuring food security, such as production of staple cereal crops and small grains, which are drought tolerant. The expected crop production pattern was to begin by planting maize and sugar beans during summer period, October to January. This is to be followed by sugar beans and potatoes planted from late January to April. This will be followed by wheat from May to August, while carrots, cabbages, tomatoes, green maize and onions will be produced from August to October. Traditionally the targeted community has not been producing potatoes, wheat and carrots. This study therefore assumes that yield levels for these new crops would generally be low in the first 2 years and start to pick up from the third year onwards and reach the maximum expected yield levels by year 5, *ceteris paribus*. The table below provides the summary of expected crop production trend under irrigation.

Table 5: Expected Crop Production Pattern 'With' Irrigation

Crop Type	**Cropping Period**	**% Area To Be Planted**	**Area To Be Planted (ha)**	**Expected Average Yield per hectare (t/ha)**				
				Year 1	**Year 2**	**Year 3**	**Year 4**	**Year 5**
Maize	Oct - Jan	90	18	4.2	4.8	5.4	6	6
Sugar beans	Oct - Jan	10	2	1.4	1.6	1.8	2	2
	Jan - April	50	10					
Potatoes	Jan - April	50	10	16	18	20	22	23
Wheat	May - Aug	100	20	2.5	3	3.5	4.5	4.5
Carrots	Aug - Oct	30	6	18	20	23	25	25
[1]Cabbages	Aug - Oct	30	6	28000	32000	36000	40000	40000
Onions	Aug - Oct	15	3	21	24	27	30	30

[1] The yield per hectare for cabbages is expressed in terms of heads per hectare

Tomatoes	Aug - Oct	15	3	20	25	30	35	35
[2]Green Maize	Aug - Oct	10	2	31500	36000	40500	45000	45000

Source: AGRITEX Estimates, 2009

The crop production estimates were given on assumptions that inputs will be readily available, accessible and there will be a favourable macro and sectoral policy environment to enable increasing agricultural production. However, to achieve maximum production levels reflected in year 5, the study assumes that good agronomic and environmental management practices will be employed by the farmers targeted to participate in the irrigation scheme.

4.3.3 Valuation Of the On-Site Effects

The on-site effects of the project are measured as the increase in the net value of production for the farmers targeted to participate in the irrigation scheme. In order to place monetary values to the environmental impact of change in crop production, this study used the changes in productivity technique. This technique allows for the assessment of effects on productivity for the '*with*' and '*without*' project situations. Gross margin budgets for crop production under irrigation and rain-fed agriculture were used to determine the financial situation for the '*with*' and '*without*' project situations. 2009 was considered as the base year for this analysis. The financial situation given the current prices in Zimbabwe is presented in the gross margin budgets attached in the annex. The table below provides a summary of the cash flow situations.

Table 6: Financial Gross Margins For Rain-Fed And Irrigated Crops

Crop Type	**Yield Levels (t/ha)**	**Selling Price (US$/t)**	**Gross Income ($/ha)**	**Total Variable Costs ($/ha)**	**Gross Margin ($/ha)**
Without Irrigation					
Maize	0.1	265	26.5	467	- 440
Sorghum	0.2	400	80	239	- 159
Rapoko	0.15	400	60	239	- 179
Groundnuts	0.3	1000	300	489	- 189

[2] The yield per hectare for green maize is expressed in terms of cobs and not tonnes

Total			**466.5**	**1434**	**- 967**
With Irrigation					
Maize	4.2	265	1113	1715	- 602
Sugar beans	1.4	1200	1680	2005	- 325
Potatoes	16	1000	7875	3641	4234
Wheat	2.5	650	1625	1359	266
Carrots	18	500	8750	1044.9	7705.1
[3]Cabbages	28000	0.33	9240	1739	7501
Onions	21	500	10500	1856	8644
Tomatoes	20	1000	10,000	7802	2198
[4]Green Maize	31500	0.08	2615	1509	1106
Total			**53398**	**22670.9**	**30727.1**

Source: AGRITEX gross margin budgets for communal dry land and irrigation, October 2009

The financial analysis indicates that dry-land farming is currently generating negative profit for the communal farmers given the yield levels, which are way below normal. Sugar beans and grain maize under irrigation is also generating negative gross margin. This is largely due to price distortions in the country as imported inputs such as fertilizer and chemicals are more expensive compared to importing crop produce from neighboring countries like South Africa. This is partly because production of crops in other countries is subsidized, while in Zimbabwe the government is not providing any subsidies. Also, the current policies of charging duty on inputs imported and no duty charges on crop produce and processed commodities in Zimbabwe, has resulted in high production costs compared to purchasing of finished products. For grain produce such as maize, government prostates like the Grain Marketing Board determine the floor price at the beginning of the selling season. This further distorts the market forces as the set price for the season is fixed and does not respond to market forces.

In order to perform an economic analysis, shadow prices, which reflect the real value of the produce, were used. The shadow prices were calculated using conversion factors to adjust the financial prices. The conversion factors used are 0.78 for fertilizers, 0.9 for irrigation, 0.76 for chemicals, 0.4 for labour and 0.78 for energy. The conversion factors

[3] The unit for the selling price for cabbages is given as dollars per head
[4] The unit for the selling price for green maize is given as dollars per cob

were derived from Planning Commission of Zimbabwe. The calculation of shadows prices was done and not presented in this document but the results of the computation were used in the economic analysis.

Following the calculations of the shadow prices, the value of incremental production was calculated. In doing this, additional costs of capital, operations and maintenance and environmental management for the '*with*' irrigation project situation were included in the analysis in addition to variable costs. The projected capital cost was calculated to be US$300,656. The proposed irrigation method is surface irrigation using canals. The capital cost therefore took into consideration an additional engineering intervention of preventing canal seepage through lining. This will aid in reducing the effect of soil salinity over time.

The operations and maintenance costs were estimated to be at least 10% of the capital costs. The operational and maintenance costs will be incurred from year 6 onwards. Identified environmental costs of conducting soil salinity tests and slope stability surveys were estimated to be the same as the cost of initial topographic survey conducted prior to the construction of the irrigation systems, which is US$5,300 every 5 years. This translates to US$1,060 per year for environmental management costs, starting from year 5 onwards. All these costs would be included in the economic analysis. The period of analysis was considered to be 30 years, which was derived from related benefit-cost analysis parameters, used on irrigation projects in Zimbabwe. The graph below shows how the value of incremental production (gross benefit) was derived for the '*with*' and '*without*' project situations.

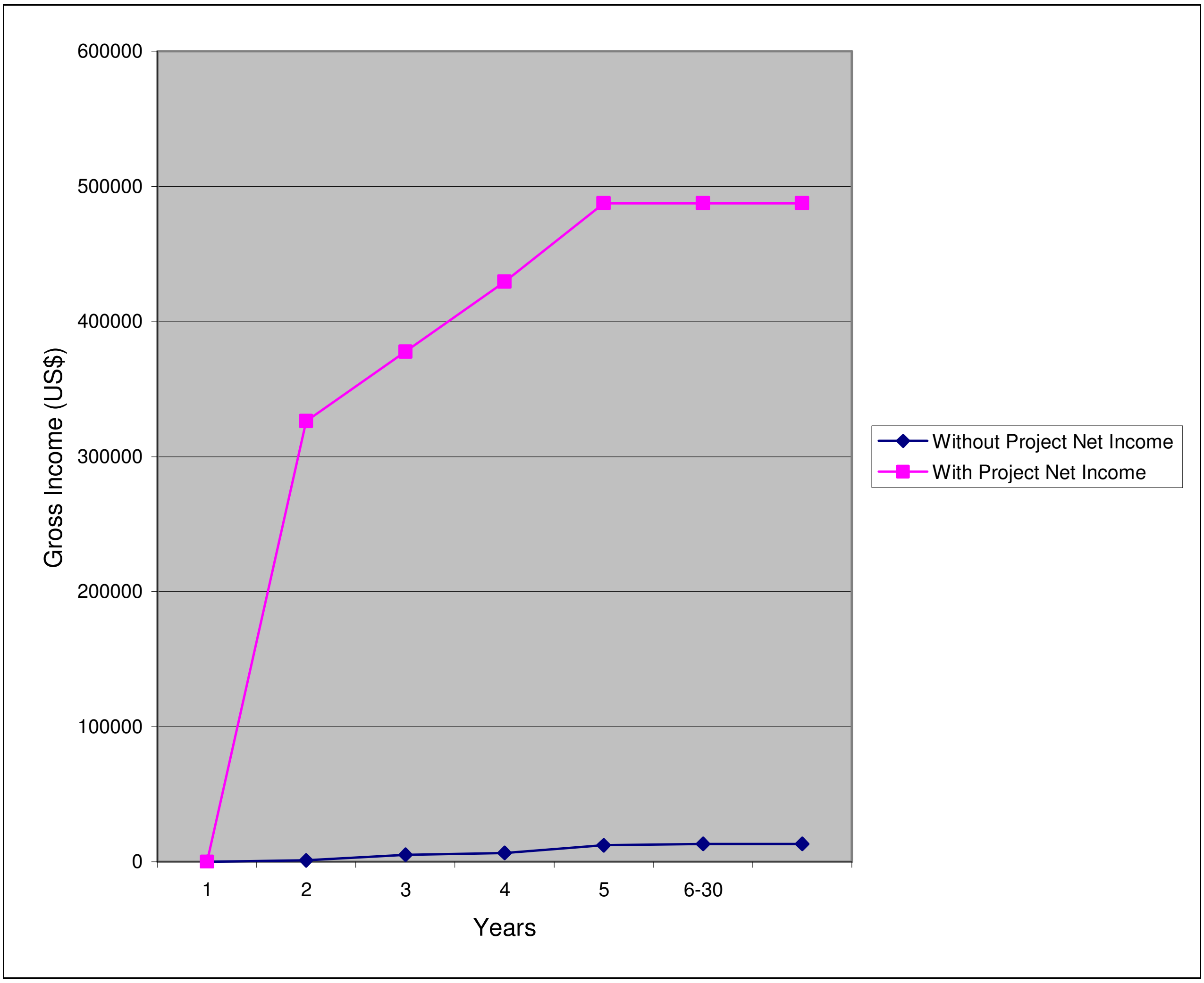

Figure 4: The Incremental Production of Irrigation Project

The graph was plotted on the assumption that under the '*without*' project situation, farmers would continue producing. The production levels will be expected to increase as farmers adapt to the effects of climate change and inputs would be accessible and available through various mechanisms such as distributions from Non-Governmental Organizations, Government input supply scheme as well as other channels. For the '*with*' project situation it has been assumed that farmers will be able to achieve maximum yield levels by year 5 to allow them time to master production of crops that were not traditionally grown in the area. The annual amount for years 6 through to 30 inclusive is expected to be constant. To reach the total amount of the incremental net benefit, the amount in year 6 was included 25 times. The calculated total gross income '*without*' project is US$368,710 and the total gross income '*with*' project is US$14,298,248. Therefore the value of incremental production of the irrigation project is US$13,929,538. As indicated on the figure above, the area between the '*with*' and '*without*' project is the incremental production.

4.3.4 Valuation of Off-Site Effects

Besides the increased crop production as a result of the proposed irrigation scheme, there are environmental management and conservation issues to be integrated. As discussed earlier, the significant environmental management issues related to the proposed irrigation project includes the issue of slope instability expected to occur during construction and soil salinity. The mitigation measures will be partly incorporated in the design of the irrigation system. As indicated earlier, soil salinity and slope stability checks will be conducted after every 5 years, beginning from year 5. The costs will be included as part of gross costs required for operating the irrigation project in view of sustainable development.

Conservation measures identified as significant environmental impact is the change in tree density and removal of up to 66 tree species during construction. Mitigation measures to this impact include the need to purposively leave some fruit species during land clearing to minimize loss of indigenous tree species in the area. Agronomic practices, which enhance conservation measures, will be encouraged during farming in the scheme. This includes the following measures as indicated by the irrigation and agronomy specialists in the area;

- Minimizing water losses in the irrigation scheme distribution system;
- Improving irrigation systems performance to minimize deep percolation and surface runoff;
- Irrigation watercourse improvement and precision land leveling;
- Implement more efficient irrigation methods to minimize evaporation and sediment concentration in run-off water;
- Grow different crops or introduce different crop rotations ;
- Irrigating according to reliable crop water requirement estimates and leaching requirement calculations;
- Managing fertilizer programs so as to minimize nutrients available for detachment and transport; and

- Applying soil amendments and reclamation practices.

Most of these mitigation measures were noted to be part of crop production measures, which are internal and can be mitigated and included in production costs. In consultation with local based agronomists, farmers participating in the irrigation scheme should be able to adjust the fertilizer application rates as well as soil amendments and reclamation measures according to the soil type and various crops to be grown. Farmers participating in the irrigation project will be expected to regularly monitor soil quality to minimize negative impacts on the environment due to irrigation operations. Resultantly, no off-site effects were valued separately from the on-site effects in this study.

4.3.5 Measurement of Economic Viability of The Proposed Irrigation Project

Computation of economic benefits and costs will take into account the cash flow discussed earlier under on-site and off-site valuations. A discount factor of 12% was used to compute the net present value of the benefits of the proposed project. The selected discount rate is recommended for agriculture related studies for most developing countries. The discount factors were obtained from Compounding and Discounting Table in Gittinger (1982, pp310). From economic analysis studies done by FAO in Zimbabwe on irrigation projects, the discount rates were selected basing on the social opportunity cost of capital and or the social rate of time preference ranges from 9% to 15%.

The net present value used in this study was computed by discounting the incremental net benefit stream or incremental cash flow to obtain the present worth, which were then summed up. The gross incremental cost in each year was subtracted from the value of incremental production to obtain the incremental net benefit. The net present value was obtained from summing the present worth of the incremental net benefit stream. Given that the calculated incremental net benefit yields the same amount from year 6 onwards, a decision was made to use discount factor up to year 9 and find the present worth of this future income stream from year 10 through 30 inclusive. To find the present worth of from year 1 to year 9, discounting tables were used adopted from Gittinger (1982 pp310). To find the present worth of future income stream of one currency unit a year, an annuity factor was used. An annuity is an amount payable yearly or at other regular intervals. Thus the present worth of an annuity factor for years 10 through 30 inclusive was calculated using the formula below.

Present worth of an annuity factor for 30 years at 12%

Less Present worth of an annuity factor for 9 years at 12%

Equals Present worth of an annuity factor for 10^{th} through 30^{th} year at 12%.

Table 7: Computation of Net Present Value For The Irrigation Project (In Millions of US$)

Year	Incremental Cost					Value of incremental production (gross benefit)	Incremental net benefit	Discount factor 12%	Present Worth 12%
	Capital costs	Operational and maintenance cost	Production costs	Environmental Management Costs	Gross (Total)				
1	0.301	0	0	0	0.301	0	-0.301	0.893	-0.268
2	0	0	0.136	0	0.136	0.325	0.189	0.797	0.151
3	0	0	0.140	0	0.140	0.372	0.233	0.712	0.166
4	0	0	0.143	0	0.143	0.423	0.280	0.638	0.178
5	0	0	0.148	0.001	0.149	0.475	0.326	0.567	0.185
6	0	0.030	0.148	0.001	0.179	0.475	0.296	0.507	0.150
7	0	0.030	0.148	0.001	0.179	0.475	0.296	0.452	0.134
8	0	0.030	0.148	0.001	0.179	0.475	0.296	0.404	0.120
9	0	0.030	0.148	0.001	0.179	0.475	0.296	0.361	0.107
10-30	0	0.030[5]	0.148[5]	0.001[5]	0.179[5]	0.475[5]	0.296[5]	2.727[6]	0.807
Total	**0.301**	**0.752**	**4.273**	**0.028**	**5.353**	**13.480**	**8.127**	**8.056**	**1.729**

Source: Research Analysis of Ruti Irrigation Budget and AGRITEX Crop Gross Margin Budgets, 2009

[5] Annual amount for years 10 through 30 inclusive. To reach column total, this amount was included 21 times.
[6] Present worth of an annuity factor for years 10 through 30 inclusive. The calculations were done using tables showing Present worth of an annuity factor at 12%.

As shown on the table above, the present worth for the proposed irrigation project in US$1.729 million. In this case the present worth refers to the net present value (NPV) of the project. Therefore the NPV of the proposed irrigation project is US$1.729 million.

4.4 Conclusion

The EIA study provided the general information that was analyzed for the physical, ecological, social and economic environment of the study area. This was complemented by interviews with key informants to establish the physical and temporal boundaries. The possible adverse and beneficial environment impacts, as well as mitigation measures that may influence the design of the irrigation project were derived from the EIA study report. The benefit-cost analysis was based on the assumptions noted during the discussions with both communities and key informants. This analysis was largely informed by on-site analysis of benefits and costs, given that off-site analysis of the proposed irrigation project presented impacts that were mostly incorporated internally in the project design.

CHAPTER 5: CONCLUSION AND RECOMMENDATIONS

5.0 Introduction

This chapter discusses the main findings of the study and draws conclusion and recommendations. The chapter discusses the findings in view of the specific research questions as highlighted in chapter one. The conclusion drawn is based on the analysis done in this study in pursuit of answering the broad research question also highlighted in chapter one. Way forward following conduction of this study and areas of further research are discussed in the recommendations section.

5.1 Discussion Of Findings And Results

This study was conducted to answer the specific questions on, what are the probable environmental damages and benefits arising as a result of the proposed irrigation project; what are the environmental protection measures to be considered in view of the probable environmental damages; and what are the monetary implications of such costs and benefits.

5.1.1 Discussion of Bio-physical and Socio-economic Findings

As illustrated in chapter 4, the probable environmental damage and benefits were drawn mostly from the EIA study, which are in fulfillment of the Environmental Management Act's requirement for irrigation projects. Key issues highlighted in the findings were centered on the bio-physical and socio-economic aspects. Generally the impact of the proposed irrigation on the bio-physical is expected to be less compared to socio-economic aspects. This is mainly because the physical and ecological aspects of the study area were already under a transformation from the time the dam was constructed in 1976 to the present land use of dry-land farming. Thus by the time the EIA was conducted the proposed site had been cleared during dam construction and land preparation for farming.

As already indicated in chapter 4, the identified negative bio-physical environmental impacts can be mitigated internally in the design of the irrigation establishment. This is because some of the aspects such as slope instability and removal of vegetation cover and decrease in tree density are partly a result of work done during construction of irrigation infrastructure. Adoption of conservation measure to avoid land degradation will be encouraged. These can be effectively adopted if incentives are provided such as promotion of field days to encourage cross learning and awarding best performers amongst the farmers.

The tests and analysis done established that generally, the proposed irrigation site is suitable for irrigation operations in terms of soil quality, water quality and quantities. However, periodic monitoring of these aspects will enable prompt response to mitigate any negative effects.

The general negative impacts expected in terms of social and economic aspects are largely due to the economic instability experienced in the country over the past decade. This has been further compounded by the global economic down-turn experienced in 2008 and 2009. This has left communities, especially rural communities more vulnerable to shocks such as hazards due to climate change. For the community in the study area, they have experienced food insecurity, loss of livelihood sources and a decrease in household income due to recurrent droughts. This has exposed the poor vulnerable community members to harmful livelihoods coping strategies like prostitution, stealing, disposing productive assets as well as poaching and fishing in hippopotamus infested river. As a result HIV/AIDS was noted as a possible negative impact, which has a long term bearing on the community if not prevented and mitigated.

Water borne diseases such as malaria, agro-chemical poisoning and bilharzia were noted as potential threats to health as a result of Ruti irrigation development. Even thought the area is generally less prone to these diseases, health education will be essential to equip communities with essential information to prevent and mitigate the impacts of water borne diseases.

Disputes in terms of scheme participants and water rights issues are inevitable in a community, which is desperate for sustainable livelihoods options. Community engagement by local authorities will be vital in managing these potential disputes. This will be complemented by community involvement as well as transparent and accountable processes from project design, development and implementation.

Despite these negative impacts, the net effect of the proposed irrigation project on human health and quality of life was noted to out-weigh the negative impacts. An increase in crop production is expected in terms of crop varieties and yield levels under irrigation as compared to dry-land farming. The increase in crop varieties has a positive impact on the nutritional status of the people both on the scheme and in the surrounding communities. Directly the scheme is expected to achieve food security and generate income for participating farmer households. Indirectly this implies that participating households will afford better health services and other household requirements. The prospects of upgrading infrastructure in terms of roads and electricity also implies that the targeted community will have effective access to other surrounding areas as well as improved access to technology for further community development. This will generally improve the livelihoods of the community. Capacity of the community will be increased to meet its basic requirements and be prepared for any shocks or climatic hazards that are likely to affect the community.

5.1.2 Discussion of Benefit-Cost Analysis Findings

The study identified the '*with*' and '*without*' project situations as well as the on-site and off-site effects of the proposed irrigation project in order to undertake a benefit-cost analysis. The '*without*' project situation revealed that crop production under dry-land or rain-fed conditions favours the production of small grains such as sorghum, rapoko and groundnuts compared to maize which is the staple food grown. Trends analysis done by the Ministry of Agriculture of production levels of these crops revealed that maize yield levels are decreasing compared to small grains. This is partly due to the drought tolerant nature of small grains compared to maize. Also, input availability and accessibility has also contributed to decreased production of maize. In view of all these factors, the '*without*' project situation was projected to have generally low yield levels of maize compared to other small grains.

The *'with'* project situation assumed all things constant in terms of input availability and accessibility as well as adoption of good agronomy and conservation practices. This enable progressive production to achieve maximum crop yield levels expected. The selected crops to be produced under irrigation (green maize, grain maize, sugar beans, wheat, potatoes, cabbages, carrots, onions and tomatoes) were selected based on the need to ensure food security and produce crops that can be stored for later use.

Shadow prices were used in the analysis to obtain economic values using conversion factors. This was done to correct the distortions currently prevailing in the Zimbabwe economy. Analysis of the on-site effects in terms of increased crop production for the '*with*' and '*without*' situations revealed the value of the incremental production to be US$13.930 million. This implies that producing crops under irrigation compared to dry-land farming yields better positive gross benefits. Therefore the project is expected to create more net benefits to the economy compared to the option of not having the project. Further economic analysis using the net present value over a period of 30 years revealed that the project yields a positive NPV, of US$1.729 million. This implies that the project can be accepted for implementation on the basis that it is economically viable.

5.2 Conclusion

From the discussions highlighted above, the use of economic analysis in EIA aids in assessing the proposed project more objectively. In this study, EIA is used as a planning tool to manage the negative environmental impacts and promote positive environmental effects. The result of integrating economic analysis in projects assessed using the EIA provides a comprehensive decision making.

The economic analysis showed that the project is economically viable incorporating the environmental protection measures identified. The findings demonstrate that with an irrigation project, the community will be able to realize more benefits, and can be able to achieve food security requirements. Despite the identified negative environmental impacts of the irrigation proposal on people, the benefits out-weigh the negative impacts. Additionally, the proposal presents prevention and mitigation measures of the possible negative impacts, which can be adopted at the inception of the project.

The study was however limited in terms of the analysis around the nature and type of irrigation systems that can be considered. Additionally, the EIA study did not consider a particular irrigation method in its analysis presenting a challenge for applying economic analysis. Limited time available to do this study further limited the analysis in terms of gathering more data to quantify identified environmental impacts regardless of their significance to the proposed project. This could have presented a more holistic picture in terms of benefits and costs from a community welfare point of view.

5.3 Recommendations

Implementing the proposed irrigation project implies savings from both government and NGOs as efforts will be directed towards sustainable development. The project is a viable disaster risk reduction measure as opposed to planning for food aid subsequent to drought periods.

As highlighted earlier in terms of limitations, areas of further research can be pursued to determine the economic analysis of various alternatives in terms of irrigation systems which can range from surface irrigation, drip irrigation or over-head sprinklers. The economic analysis if done considering the various impact of each system on the environment, it will enable the establishment of the most beneficial alternative to the community, from an environmental conservation perspective. This approach incorporates environmental impact considerations in the design, construction, and operation of new irrigation projects.

There is also need for the government to revise the policy in terms of charging water and electricity in communal areas. During the study, it was not clear how the local institutions responsible for water and electricity provision in rural areas were pricing these services. As a result, AGRITEX could not effectively factor in these costs in the gross margin budgets given that the policy on pricing these services in rural communities was still not clear. Services were then assumed to be subsidized by the government. However, in real terms communities indicated that these services were not 'free' as implied by charges ranging from US$0.5 per farmer per year. Still the costs were difficult to factor in the study effectively as these were not linked to any amount of power or water required for the various operations.

LIST OF REFERENCES

1. Abebe W.B., McCartney M., Douven W.J.A.M. and Leentvaar J., nd. *Environmental Impact Assessment Follow-Up In The Koga Irrigation Project, Ethiopia*. Burea of Agriculture, Bahir Dar Ethiopia. Retrieved from: ifwf2.org/addons/download_presentation.php?fid=1038 [Accessed 2 September 2009].
2. Agriculture New Zealand (ANZ). 2001. *Irrigation Development. Issues to consider when promoting a water resource scheme. Lessons from the last 125 years.* MAF Technical Paper No: 2001/8. Retrieved from: http://www.maf.govt.nz/mafnet/rural-nz/sustainable-resource-use/irrigation/irrigation-scheme-development/irrigation-scheme-development.pdf [Accessed 17 April 2008].
3. Amerasinghe, F., and Boelee, E., 2004. *Assessing The Impact Of Irrigation Development On The Environment And Human Health.* Retrieved from: http://www.iwmi.cgiar.org/Assessment/files/word/ImpactsIrrigation/IrrigationEnvironment.pdf [Accessed 9 June 2008].
4. Aravossis K.G., and Karydis V, n.d. *An Integrated Approach Towards Environmental Impact Assessment of Projects and Policies.* University of Thessaly, Greece. Retrieved from: http://simor.mech.ntua.gr/prosopiko/WebPageAravosis/PAPERS/AN%20INTEGRATED%20APPROACH%20TOWARDS%20ENVIRONMENTAL%20IMPACT.pdf [Accessed 17 August 2009].
5. Arnadottir K.L., 2002. *Participation In The Environmental Impact Assessment Process. Analysis Of Two Case Studies From The Energy Sector In Iceland.* University of Lund, Sweden. Retrieved from: http://www.lumes.lu.se/database/Alumni/01.02/theses/arnadottir_kristin.pdf [Accessed 13 June 2009].
6. Asian Development Bank. 1996. *Economic Evaluation of Environmental Impacts: A Workbook.* Part II and I. Environment Division, Office of Environment and Social Development, Asian Development Bank, Manila, Philippines. 303 pp.
7. Asian Development Bank. 2000. *Environmental Impact Assessment for Developing Countries in Asia.* Volume 1: Overview. Retrieved from: http://www.adb.org/Documents/Books/Environment_Impact/ [Accessed 24 May 2009].

8. Assefa, M. 2008. *Socio-economic Assessment of Two Small-scale Irrigation Schemes in Adami Tullu Jido Kombolcha Woreda, Central Rift Valley of Ethiopia.* Environmental Economics and Natural Resource Group. Ethiopia.
9. Beder, S. 1997. *Environmental Impact Assessment*. Ecodate, pp 3-8. Retrieved from: http://homepage.mac.com/herinst/sbeder/eis2.html [Accessed 17 August 2009].
10. Belli, P., Anderson, J., Barnum, H., Dixon, J. and Tan, JP. 1998. *Handbook on Economic Analysis of Investment Operations.* Washington, DC: World Bank, Operational Core Services Network, Learning and Leadership Center.
11. Benson, C. and Twigg, J., 2007. *Measuring Mitigation: Methodologies for Assessing natural Hazard Risks and The Net Benefits of Mitigation*. Retrieved from http://www.proventionconsortium.org/mainstreaming_tools [Accessed 20 March 2008].
12. Cabot Venton, C. and Venton, P. *Disaster Preparedness Programmes in India: A Cost Benefit Analysis.* Humanitarian Practice Network Paper 49. London: Overseas Development Institute, 2004. Commissioned and Published by the Humanitarian Practice Network at the Overseas Development Institute (ODI).
13. Chasi, M., 2009. *Climate Change and Coping Strategies of the Rural Poor.* Environmental Management Authority Resource Paper. Environmental Management Authority of Zimbabwe.
14. Chitsiko, R.,J., 1995. *Hama Mavhaire Irrigation Development. Smallholder Irrigation in Zimbabwe*. Harare, Zimbabwe. Innovative Experience Paper.
15. Department of Agricultural Engineering and Technical Services. 2002. *Report On The Status Of Irrigation Development In Zimbabwe.* Harare.
16. Dixon, J.A, Carpenter, R.A., Fallon, L.A., Sherman, P.B., and Manipomoke, S., 1988. *Economic Analysis of the Environmental Impacts of Development Project.* Earthscan Publication Ltd., London. 134 pp.
17. Dixon, J.A, Carpenter, R.A., Fallon, L.S., and Sherman, P.B., 1994. *Economic Analysis of the Environmental Impacts.* Published in Association with The Asian Development Bank and The World Bank. Retrieved from: http://faculty.unlv.edu/wjsmith/smithtest/DIXONecolECONrestOFtext.pdf [Accessed 1 October 2009].
18. Douglas S.M, 2007. Drought, *It's After Effects And Management Strategies Woody Ornamentals.* The Connecticut Agricultural Experiment Station.

Retrieved from: http://www.ct.gov/caes/cwp/view.asp?A=2815&Q=376788 [Accessed 17 April 2008].

19. Dougherty T.C and Hall A.W., 1995. *Environmental Impact Assessment Of Irrigation And Drainage Projects.* 53 FAO Irrigation And Drainage Paper. HR Wallingford. United Kingdom. Retrieved from: http://www.fao.org/docrep/V8350E/v8350e00.HTM [Accessed 2 September 2009].
20. Dzvurumi, F. 2006. *Evaluation of Emergence Small Scale Irrigation Projects in Southern Africa.* FAO Emergency Operations and Rehabilitation Division (TCE).
21. Earth Summit, 2002. *The World Summit on Sustainable Development in Johannesburg 2002.* Retrieved from: http://www.earthsummit2002.org/ [Accessed 2 September 2009].
22. Environmental Impact Assessment Approach and Methods. Retrieved from: http://www.transportscotland.gov.uk/files/documents/projects/ArisaigLochNanUamh/Arisaig_Envi_Impact_Apprch_Methods.pdf [Accessed 5 April 2008].
23. European Commission Delegation 2007. *Report on Food Aid Review in Zimbabwe.*
24. Food And Agriculture Organization, 1999. *Smallholder Irrigation Development Project.* Preparation Report, Volume 1-3. Report No 99/030 ADB – Zimbabwe. Rome.
25. Food And Agriculture Organization, 2000. *Socio-Economic Impact Of Smallholder Irrigation Development in Zimbabwe.* Retrieved from: http://www.fao.org/docrep/X5594E/X5594e11.htm [Accessed 15 August 2008]
26. Food and Agriculture Organization, 2007. *Water profile of Zimbabwe.* In: Encyclopedia of Earth. Environmental Information Coalition, National Council for Science and the Environment. Retrieved from http://www.eoearth.org/article/Water_profile_of_Zimbabwe [Accessed June 15, 2009].
27. Federal Emergency Management Agency (FEMA), 2006. *Mitigation Benefit Cost Analysis Toolkit.* Version 3. CD-Rom. Washington, DC: Retrieved from http://www.femw.gov.government/grant/bca.shtm [Accessed March 3, 2009].
28. Gallagher K., Ackerman F. and Ney L., 2002. *Economic Analysis in Environmental Reviews Of Trade Agreements: Assessing The North America*

Experience. Global Development And Environmental Institute Working Paper No. 02-01. Tufts University , USA.

29. Gittinger, J.P., 1982. *Economic Analysis of Agricultural Projects*. 2nd ed. John Hopkins University Press for Economic Development Institute World Bank, Baltimore.
30. James D., 1994. *The Application of Economic Techniques in Environmental Impact Assessment.* Kluwer Academic Publishers, Netherlands.
31. Kruopiene J., Zidoniene S., Dvarioniene J. and Mikalauskas A., 2008. *Evaluation Of Environmental Impact Assessment Effectiveness in Lituania.* Environmental Research, Engineering and Management. Number 2(44), P. 28-33. Retrieved from: www.fess-global.org/WorkingPapers/EIA.pdf [Accessed 28 August 2009].
32. Lohani B., Evans J.W, Ludwig H., Everitt R.R., Carpenter R. A. and Tu S.L., 1997. Environmental Impact Assessment for Developing Countries. Asian Development Bank. http://www.adb.org/documents/books/environment_impact/env_impact.pdf
33. Mahmoud A. A, 2007. *GIS and Remote Sensing Integrated Environmental Impact Assessment of Irrigation Project in Finchaa Valley Area.* Addis Ababa University. Retrieved from: http://www.uni-siegen.de/fb10/fwu/ww/publikationen/volume0607/amdihun.pdf [Accessed 15 September 2008].
34. Makhado, J., 1984. *A Review of Some Factors Affecting Viability of Smallholder Irrigation Schemes in Africa. African Smallholder Irrigation Symposium.* Wallingford, UK, Overseas development Unit of Hydralics Research Limited.
35. Manoliadis O.G. and Vatalis K.I., 2003. *An Environmental Impact Assessment Decision Analysis System Fro Irrigation Systems.* Technological Educational Institute of Western Macedonia, Greece. Retrieved from: [Accessed 2 September 2009].
36. Mechler, R., 2005. *Cost-benefit Analysis Of Natural Disaster Risk Management in Developing Countries:* Manual. Bonn: Deutsche Gesellschaft fur Zusammernarbeit (GTZ) GmbH. Retrieved from: http://gtz.de/disaster-reduction/english [Accessed 5 March 2008]
37. Ministry of Lands, Agriculture and Rural Resettlement. 1995. *Zimbabwe Agricultural Policy Framework: 1995-2020*. Government Printer, Harare.

38. National Drought Mitigation Centre (NDMC). *Understanding Your Risks And Impacts: Environmental Impacts of Drought.* Retrieved from: http://www.drought.unl.edu/risk/environment.htm [Accessed 2 April 2008].
39. Ntsonto E. N., 2004. *Economic Performance Of Smallholder Irrigation Schemes: A Case Study In Zanyokwe, Eastern Cape, South Africa.* University of Pretoria. South Africa. Retrieved from: http://upetd.up.ac.za/thesis/available/etd-02062006-130808/unrestricted/00dissertation.pdf [Accessed 7 September 2009].
40. Oxfam Great Britain, 2007. *Irrigation Feasibility Study*. Harare, Zimbabwe.
41. Oxfam Great Britain, 2008. **Ruti Irrigation Project Proposal**. Harare Zimbabwe.
42. Psychoudakis, A., Papoutsi-Psychoudaki, S., and McFarquhar A. M. M., 1995. *An Economic Assessment Of An Irrigation Project Affecting A Greek Wetland* . Retrieved from: http://www.springerlink.com/content/vl825p3825237165/ [Accessed 15 August 2009].
43. Rukuni, M and Eicher, C.K. 1994. *Zimbabwe's Agricultural Revolution.* University of Zimbabwe Publication. Harare, Zimbabwe.
44. Simon E., 1997. *Environmental Impact Assessment, Kano River Irrigation Project (Phase I) Extension, Nigeria.* Department of Hydrology, TAHAL, Israel. Retrieved from: http://iahs.info/redbooks/a240/iahs_240_0185.pdf [Accessed 2 September 2009].
45. Stockle C.O., 2001. *Environmental Impact Of Irrigation: A Review*. State of Washington Water Research Center. Washington State University. Retrieved from: http://www.swwrc.wsu.edu/newsletter/fall2001/IrrImpact2.pdf [Accessed 15 September 2008].
46. Tieternberg, T. 2003. *Environmental and Natural Resource Economics.* Adison-Wesley 6th Edition
47. United Nations Development Programme (UNDP) 2008. *Human Development Report 2007/2008: Fighting Climate Change.* 2007 Human Solidarity In A Divided World Publication. Palgrave MacMillan ISBN 978-0-230-54704-9.
48. United Nations Environmental Protection (UNEP) 2003. *Environment Impact Assessment.* Retrieved from: http://www.uneptie.org/pc/pc/tools/eia.htm [Accessed 20 August 2008].
49. United Nations Publication, 1992. *Rio Declaration on Environment and Development.* The United Nations Conference on Environment and Development

(UNCED). Retrieved from: http://www.worldsummit2002.org/guide/sds.htm [Accessed 14 September 2008].

50. Wikipedia, 2009. *AGENDA 21.* Retrieved from: http://www.en.wikipedia.org/wiki/Agenda_21 [Accessed 17 July 2009].

51. Zimbabwe, 1997. *Zimbabwe Environmental Impact Assessment Policy Framework*. Government Printer, Harare, Zimbabwe.

52. Zimbabwe, 1998. *Zimbabwe National Water Authority Act of 1998. Chapter 20:25* Government Printer, Harare Zimbabwe

ANNEXURE

A. Discussion Guide

This discussion guide complements the EIA study undertaken by an independent consultant to enable economic analysis of the irrigation scheme in the context of environmental protection measures.

Discussion Guide for Community Groups

Question	**Probes**
What is the name of the proposed irrigation scheme?	
What are the major livelihood activities on the site proposed for irrigation development?	Identify the types and number of households involved?
What is the current annual cropping pattern and production?	List crops produced annually and average production levels.
Who proposed the irrigation development in the community?	Check for community involvement in decision making
What is the cost on the community of setting out the irrigation project? i.e. the contribution of the community to the establishment of the scheme.	Consider direct, indirect and secondary costs.
What will be the benefits to the community of having the proposed irrigation project?	Consider direct, indirect and secondary costs.
What business opportunities are likely to be created by the project?	Check on the multiplier effect of the scheme
Who will be responsible for the maintenance of the scheme?	Probe to check who will be paying the costs associated
What is the preferred annual cropping pattern for the irrigation?	List the inputs associated with the production of the named crops
Who will be responsible for financing the inputs associated with the expected crop production?	
Who will be responsible for managing the operations of	Decision making on crops

Question	Probes
the irrigation project?	grown and marketing.
How is the community going to decide who will be farming in the scheme and how many households are expected to operate the 20ha scheme?	Capture the targeting criteria and number of farmers expected.
Any relocation expected due to the proposed site? If yes what are the associated benefits and costs associated.	

Discussion Guide for Key Informants

Question	Source
1. The temporal or spatial boundaries of the irrigation project	
What is the life span of the irrigation scheme or time-frame for the project before major changes are anticipated?	- Land, Environment and Irrigation specialist
What is the spatial boundary of analysis, within which environmental effects may occur?	The Environmental Specialist in the EIA team.
2.The social dimensions in relation to the irrigation project	
What is the demographic and social capital of the proposed community?	- Gutu RDC, chief, village head,
What is the history of the proposed site in terms of social dimensions considering cultural and heritage sites, as well as community settlement and livelihoods operations?	
Who are the current water users at the proposed site?	
How will their operations be affected by setting up the scheme?	
3. The economic factors relating to the irrigation project	
What infrastructure is in place to support the establishment of the irrigation project?	- Oxfam GB Irrigation scheme budget
What is the agri-business environment in terms of credit, inputs and output markets?	- Irrigation Department (irrigation plan)
What is the capital required to construct the irrigation scheme?	- Gross margin budgets from AGRITEX for

Of the 20ha how much land will be committed to crop production?	summer maize, groundnuts, beans and sorghum; and winter green mealies, onions, cabbage, tomatoes, rape carrots, butternuts and peas. - FAO documents for NPV and IRR calculations. - Discount rate from Agribank - Inflation rate in Zimbabwe on the US$
How much land will be allocated to each farmer fro cropping?	
What is the most appropriate cropping pattern for the irrigation scheme?	
What is the expected area allocation for various crops?	
What is the average annual crop production in the area, considering the major food crops such as maize, sorghum, wheat and groundnuts?	
What are the expected production levels from the irrigation scheme?	
What are the inputs required?	
What is the frequency of implementing the environmental mitigation measures and the associated costs?	
From the technical side, what are the estimated maintenance costs (of pumps)?	
What can be the estimated life-span of the major components of the irrigation pumps before major replacements?	
How much would the council charge as monthly rates from the plot holders?	
4. Possible adverse and beneficial environmental impacts that may influence the design of the irrigation project	
Is there a defined area for each environmental effect identified?	- EMA, Irrigation specialist, EIA specialist
What is the time horizon over which each identified environmental impact may be taking place?	
5. The environmental safeguards and mitigation measures in view of the predictions of environmental impacts of the irrigation project	
What is the time horizon over which each identified environmental measure may need to be implemented?	- EMA, Irrigation specialist, AGRITEX

	officer, community groups

B. Gross Margin Budget for Irrigated Crops

GROSS MARGIN BUDGET FOR IRRIGATED CABBAGE

			Year 1		**Year 2**		**Year 3**		**Year 4**
Saleable Yield (heads/ha)			28000		32000		36000		40000
Price ($/head)		$	0	$	0	$	0	$	0
GROSS INCOME		$	9,240	$	10,560	$	11,880	$	13,200
TOTAL VARIABLE COSTS		$	1,739	$	1,771	$	1,803	$	1,835
GROSS MARGIN		$	7,501	$	8,789	$	10,077	$	11,365
<u>VARIABLE COSTS</u>			**$/ha**				**$/ha**		**$/ha**
Land Preparation		$	35	$	35	$	35	$	35
Seed	0.45kg	$	45	$	45	$	45	$	45
Fertilizer:									
Compound S	1000kg	$	600	$	600	$	600	$	600
Ammonium Nitrate	400kg	$	240	$	240	$	240	$	240
Transport to farm	1400kg	$	6	$	6	$	6	$	6
Insecticide									
Endosulfan 35MO	2kg	$	8	$	8	$	8	$	8
Dichlorvos	1litre	$	7	$	7	$	7	$	7
Dimethoate	0.75litres	$	5	$	5	$	5	$	5
Seasonal loan interest		$	426	$	426	$	426	$	426
Hired labour	90days	$	144	$	144	$	144	$	144
Transport		$	224	$	256	$	288	$	320
TOTAL VARIABLE COSTS		$	1,739	$	1,771	$	1,803	$	1,835

GROSS MARGIN BUDGET FOR IRRIGATED CARROTS

Yield levels	kg/ha	17500	20000	22500	25000
Selling price	$/kg	0.5	0.5	0.5	0.5
Gross Income	$/ha	8750	10000	11250	12500
Total Variable Costs	$/ha	1044.9	1074.9	1104.9	1134.9
Gross Margin	$/ha	7705.1	8925.1	10145.1	11365.1
VARIABLE COSTS ITEMS		$/HA		$/HA	$/HA
a. Land preparation		35	35	35	35
b. Seed,	5kg/ha	250	250	250	250
c. Fertilizer (ex-factory, Harare)					
Compound D,	600kg/ha	420	420	420	420
Transport to farm ,	600kg/ha	2.4	2.4	2.4	2.4
d. Insecticides					
Dimethoate	1.5litres	10.5	10.5	10.5	10.5

e. Fungicide					
Copper oxychloride	9kg	117	117	117	117
d. Transport to market		70	80	90	100
e. Packing		140	160	180	200
TOTAL VARIABLE COSTS		1045	1075	1105	1135

GROSS MARGIN BUDGET FOR IRRIGATED GREEN MAIZE

Yield (cobs/ha)		31500	36000	40500	45000
Price ($/cob)		0.08	0.08	0.08	0.08
GROSS INCOME		$ 2,615	$ 2,988	$ 3,362	$ 3,735
TOTAL VARIABLE COSTS		$ 1,509	$ 1,509	$ 1,509	$ 1,509
GROSS MARGIN		$ 1,106	$ 1,479	$ 1,853	$ 2,226
VARIABLE COSTS		**$/ha**	**$/ha**	**$/ha**	**$/ha**
Land preparation		$ 35	$ 35	$ 35	$ 35
Seed	25kg	$ 2	$ 2	$ 2	$ 2
Fertilizer:					
Compound D	350kg	$ 245	$ 245	$ 245	$ 245
Ammonium Nitrate	350kg	$ 315	$ 315	$ 315	$ 315
Transport to farm	700kg	$ 3	$ 3	$ 3	$ 3
Insecticide					
Dipterex	4kg	$ 408	$ 408	$ 408	$ 408
Seasonal loan interest		$ 453	$ 453	$ 453	$ 453
Hired labour	30days	$ 48	$ 48	$ 48	$ 48
TOTAL VARIABLE COSTS		$ 1,509	$ 1,509	$ 1,509	$ 1,509

GROSS MARGIN BUDGET FOR IRRIGATED GRAIN MAIZE

Yield (t/ha)		4.2	4.8	5.4	6
Price ($/t)		$ 265	$ 265	$ 265	$ 265
GROSS INCOME		$ 1,113	$ 1,272	$ 1,431	$ 1,590
VARIABLE COSTS		**$/ha**	**$/ha**	**$/ha**	**$/ha**
Land preparation		$ 35	$ 35	$ 35	$ 35
Seed	25kg/ha	$ 40	$ 40	$ 2	$ 2
Fertilizer:					
Compound D	350kg/ha	$ 245	$ 245	$ 245	$ 245
Ammonium Nitrate	250kg/ha	$ 225	$ 225	$ 225	$ 225
Transport to farm	600kg	$ 2	$ 2	$ 2	$ 2
Insecticide					
Dipterex	4kg/ha	$ 408	$ 408	$ 408	$ 408

Seasonal Interest		$ 430	$ 430	$ 413	$ 413
Hired labour	42 labour days	$ 67	$ 67	$ 67	$ 67
Bags		$ 168	$ 192	$ 216	$ 240
Twine		$ 3	$ 3	$ 3	$ 4
Transport out		$ 17	$ 19	$ 22	$ 24
TOTAL VARIABLE COSTS		$ 1,640	$ 1,667	$ 1,638	$ 1,664
GROSS MARGIN		-$ 527	-$ 395	-$ 207	-$ 74

GROSS MARGIN BUDGET FOR IRRIGATED ONION

	Year 1	Year 2	Year 3	Year 4
Yield (t/ha)	21	24	27	30
Price($/t)	500	500	500	500
GROSS INCOME	10,500	12,000	13,500	15,000
TOTAL VARIABLE COSTS	1,856	1,892	1,928	1,964
GROSS MARGIN	8,644	10,108	11,572	13,036

VARIABLE COSTS		**$/ha**		**$/ha**	**$/ha**
Land Preparation		$ 35	$ 35	$ 35	$ 35
Seed	3kg	$ 10	$ 10	$ 10	$ 10
Fertilizer:					
Compound S	1200kg	$ 720	$ 720	$ 720	$ 720
Ammonium Nitrate	200kg	$ 120	$ 120	$ 120	$ 120
Tansport to farm	1400kg	$ 6	$ 6	$ 6	$ 6
Insecticide					
Carbaryl	2kg	$ 8	$ 8	$ 8	$ 8
Dithane M45	6kg	$ 42	$ 42	$ 42	$ 42
Seasonal loan		$ 423	$ 423	$ 423	$ 423
Hired labour	150	$ 240	$ 240	$ 240	$ 240
Marketing Costs					
Pockets		$ 168	$ 192	$ 216	$ 240
Transport out		$ 84	$ 96	$ 108	$ 120
TOTAL VARIABLE COSTS		$ 1,856	$ 1,892	$ 1,928	$ 1,964

GROSS MARGIN BUDGET FOR IRRIGATED SUGAR BEAN

Yield (t/ha)	1.4	1.6	1.8	2
Price ($/t)	$ 1,200	$ 1,200	$ 1,200	$ 1,200
GROSS INCOME	$ 1,680	$ 1,920	$ 2,160	$ 2,400
TOTAL VARIABLE COSTS	$ 2,005	$ 2,014	$ 2,023	$ 2,031
GROSS MARGIN	-$ 325	-$ 94	$ 137	$ 369

VARIABLE COSTS		$/ha	$/ha	$/ha	$/ha
Land preparation		$ 35	$ 35	$ 35	$ 35
Seed	90kg	$ 270	$ 270	$ 270	$ 270
Fertilizer:					
Compound D	500kg	$ 350	$ 350	$ 350	$ 350
Ammonium Nitrate	100kg	$ 60	$ 60	$ 60	$ 60
Tansport to farm	690kg	$ 3	$ 3	$ 3	$ 3
Chemicals					
Carbaryl	1kg	$ 4	$ 4	$ 4	$ 4
Dicofol	1kg	$ 564	$ 564	$ 564	$ 564
Copper Oxychloride	0.6kg	$ 8	$ 8	$ 8	$ 8
Seasonal loan interest		$ 582	$ 582	$ 582	$ 582
Hired labour (30% of total)	42labour days	$ 67	$ 67	$ 67	$ 67
Bags		$ 56	$ 64	$ 72	$ 80
Twine		$ 0	$ 0	$ 0	$ 1
Transport out		$ 6	$ 6	$ 7	$ 8
TOTAL VARIABLE COSTS		$ 2,005	$ 2,014	$ 2,023	$ 2,031

GROSS MARGIN BUDGET FOR IRRIGATED TABLE TOMATOES

Yield (kg/ha)	20000	25000	30000	35000
Price ($/kg)	$ 1	0.5	0.5	0.5
GROSS INCOME ($/ha)	10,000	12,500	15,000	17,500
VARIABLE COSTS	7,802	9,156	10,509	11,862
GROSS MARGIN	2,198	3,344	4,491	5,638

VARIABLE COSTS		$/ha	$/ha	$/ha	$/ha
Seed	0.25kg	$ 6	$ 6	$ 6	$ 6
Land preparation		$ 35	$ 35	$ 35	$ 35
Fertilizer:					
Compound S	1500kg	$ 1,350	$ 1,350	$ 1,350	$ 1,350
Ammonium Nitrate	200kg	$ 120	$ 120	$ 120	$ 120
Transport to farm	1700kg	$ 7	$ 7	$ 7	$ 7
Chemicals					
Carbaryl 85WP	2.7kg	$ 11	$ 11	$ 11	$ 11
Dithane M45	1kg	$ 7	$ 7	$ 7	$ 7
Dimethoate	0.5litres	$ 4	$ 4	$ 4	$ 4
Seasonal interest		$ 690	$ 690	$ 690	$ 690
Hired labour (30%of total)	100days	$ 160	$ 160	$ 160	$ 160
Marketing Costs					
Packaging		$ 5,333	$ 6,667	$ 8,000	$ 9,333
Transport out		$ 80	$ 100	$ 120	$ 140
TOTAL VARIABLE COSTS		$ 7,802	$ 9,156	$ 10,509	$ 11,862

GROSS MARGIN BUDGET FOR COMMNUNAL IRRIGATED WHEAT 25-Nov-09

Target Yield (t/ha)		2.5	3	3.5	4.5
Selling price ($/t)		$ 650	$ 650	$ 650	$ 650
GROSS INCOME		$ 1,625	$ 1,950	$ 2,275	$ 2,925
TOTAL VARIABLE COSTS		$ 1,359	$ 1,361	$ 1,403	$ 1,447
GROSS MARGIN		$ 266	$ 589	$ 872	$ 1,478
Variable costs		**$/ha**	**$/ha**	**$/ha**	**$/ha**
Land preparation		$ 35	$ 35	$ 35	$ 35
Seed,	120kg/ha	$ 330	$ 330	$ 330	$ 330
Compound D	450kg/ha	$ 315	$ 315	$ 315	$ 315
Ammonium Nitrate	300kg/ha	$ 180	$ 180	$ 180	$ 180
Transport to farm	900kg	$ 4	$ 4	$ 4	$ 4
Demeton-S-Methyl	0.4litres/ha	$ 4	$ 4	$ 4	$ 4
Irrigation	6000cub m	$ 60	$ 60	$ 60	$ 60
Labour	200days	$ 320	$ 320	$ 320	$ 320
Bags		$ 100	$ 100	$ 140	$ 180
Twine		$ 1	$ 1	$ 1	$ 1
Transport off farm		$ 10	$ 12	$ 14	$ 18
TOTAL VARIABLE COSTS		$ 1,359	$ 1,361	$ 1,403	$ 1,447

C. Gross Margin Budgets for Dry-Land Crops

A GROSS MARGIN BUDGET FOR GROUNDNUT PRODUCTION 25-Nov-09

YIELD LEVEL (UNSHELLED)(T/HA)	0.5	1	1.5	2
	US$20/bucket			
BLEND SELLING PRICE (UNSHELLED)($/T)	$ 1,000	$ 1,000	$ 1,000	$ 1,000
GROSS INCOME($/HA)	$ 500	$ 1,000	$ 1,500	$ 2,000
TOTAL VARIABLE COSTS ($/HA)	$ 424	$ 506	$ 552	$ 635
GROSS MARGIN ($/HA)	$ 76	$ 494	$ 948	$ 1,365
GROSS MARGIN ($/$100 VC)	$ 18	$ 98	$ 171	$ 215
GROSS MARGIN PER LABOUR HOUR	$ 0	$ 1	$ 2	$ 2
GROSS MARGIN PER LABOUR DAY (6hrs)	$ 1	$ 6	$ 11	$ 14

No. of labour hours		455	498	541	584
VARIABLE COSTS		$/ha	$/ha	$/ha	$/ha
A. PRIOR TO HARVESTING					
1. Seed, purchased	25 kg/ha	$ 50	$ 50	$ 50	$ 50
homegrown	75 kg/ha	$ 131	$ 131	$ 131	$ 131
2. Fertilizer (ex-factory)					
a. Compound L		$ 140	$ 211	$ 211	$ 246
b. Gypsum		$ 70	$ 70	$ 105	$ 140
d. Transport		$ 0	$ 0	$ 0	$ 0
3. Insecticide					
Dimethoate	1 litres/ha	$ 5	$ 5	$ 5	$ 5
4. Seed Treatment					
a. Innoculant	2 units	$ 8	$ 8	$ 8	$ 8
b. Thiram 80WP	0.1 kg/ha	$ 0	$ 0	$ 0	$ 0
5. Miscellaneous,	2%	$ 8	$ 10	$ 10	$ 12
SUBTOTAL		$ 413	$ 485	$ 521	$ 592
B. HARVESTING & MARKETING					
1. Packing materials					
a. Bags		$ 10	$ 20	$ 30	$ 40
b.Twine	0.2 kg/tonne	$ 0	$ 1	$ 1	$ 1
2. Transport off farm		$ 0	$ 0	$ 0	$ 0
3. Miscellaneous,	2%	$ 0	$ 0	$ 1	$ 1
SUBTOTAL		$ 11	$ 21	$ 32	$ 42

A GROSS MARGIN RESULT BUDGET FOR DRYLAND MAIZE, 25/11/2009

YIELD LEVEL (T/HA)	2	3	4	5
	Gazzetted US$ 265 minimum parity price/tonne or US$ 6.20/bucket			
BLEND SELLING PRICE ($/T)	265	265	265	265
GROSS INCOME($/HA)	530	795	1,060	1,325
TOTAL VARIABLE COSTS ($/HA)	**408**	**516**	**617**	**780**

GROSS MARGIN ($/HA)			122	279	443	545
GROSS MARGIN ($/$100 VC)			30	54	72	70
GROSS MARGIN PER LABOUR HOUR			0	1	1	1
GROSS MARGIN PER LABOUR DAY (6hrs)			3	5	7	9
No of labour hours/ha			269	353	368	378
VARIABLE COSTS			$/ha	$/ha	$/ha	$/ha
A. PRIOR TO HARVESTING						
1. Seed,	25 kg	kg/ha	35	35	35	35
2. Land Prep			40	40	40	40
3. Fertilizer (ex-factory)						
a. Maize fert (D)			90	120	150	210
b. Ammonium nitrate			31	62	94	156
d. Transport			$6.30	$7.70	$9.10	$11.90
4. Insecticide						
Dipterex 2.5%	4 kg	kg/ha	21	21	21	21
5. Miscellaneous,	2%		4	6	7	9
SUBTOTAL			228	292	356	484
B. HARVESTING & MARKETING						
1. Packing materials						
a. Bags			40	60	80	100
b.Twine	0.09 kg/tonne	kg/ton	1	1	1	1
Combine			80	80	80	80
2. Transport off farm			28.00	42.00	56.00	70.00
3. Miscellaneous,	2%		3	4	4	5
SUBTOTAL			152	186	221	256
Labour			29	38	39	40
TVC			408	516	617	780
TVC/tonne			204	172	154	156

A GROSS MARGIN BUDGET FOR RAPOKO PRODUCTION,

YIELD LEVEL (T/HA)	t/ha	1	2	3
BLEND SELLING PRICE ($/T)	$/t	$ 400	$ 400	$ 400.00
GROSS INCOME($/HA)	$/ha	$ 400	$ 800	$ 1,200.00

TOTAL VARIABLE COSTS ($/HA)		$/ha	$	202	$	122	$	143.14
GROSS MARGIN ($/HA)		$/ha	$	198	$	678	$	1,056.86
GROSS MARGIN ($/$100 VC)		$/$100VC	$	98	$	556	$	738.34
GROSS MARGIN PER LABOUR HOUR			$	0	$	1	$	1.67
GROSS MARGIN PER LABOUR DAY (6hrs)			$	2	$	6	$	10.02
No. of hours/ha		Hrs/ha	$	633	$	633		633
VARIABLE COSTS			$/ha		$/ha		$/ha	
A. PRIOR TO HARVESTING								
1. Seed,	15	kg/ha	$	11	$	11	$	11.25
2. Land preparation			$	40	$	40	$	40
3. Fertilizer (ex-factory)								
a. Compound D			$	68	$	0	$	0
b. Amm Nitrate			$	31	$	0	$	0
c. Transport			$	0	$	0	$	0.06
4. Insecticide								
Dimethoate	1	Lits/ha	$	5	$	5	$	5.32
Dipterex	4	kg/ha	$	21	$	21	$	21.28
5. Miscellaneous,	2%		$	4	$	2	$	1.56
SUBTOTAL			$	180	$	80	$	79.67
B. HARVESTING & MARKETING								
1. Packing materials								
a. Bag hire	20	per tonne	$	20	$	40	$	60.00
b.Twine	0.2	kg/tonne	$	1	$	1	$	1.80
2. Transport off farm			$	0	$	0	$	0.42
3. Miscellaneous,	2%		$	0	$	1	$	1.24
SUBTOTAL			$	21	$	42	$	63.46
TVC			$	202	$	122	$	143.14
Fertilizer and lime Table in kgs								
Compound D			$	150	$	200		250
Ammonium Nitrate			$	50	$	100		150
Total			$	200	$	300		400

A GROSS MARGIN BUDGET FOR COMMUNAL WHITE SORGHUM
PRODUCTION,

YIELD LEVEL (T/HA)			1		2		3
BLEND SELLING PRICE		$/tonne	$	450.00	$	450.00	$ 450.00
GROSS INCOME		$/ha	$	450.00	$	900.00	$ 1,350.00
TOTAL VARIABLE COSTS		$/ha	$	160.29	$	236.35	$ 312.42
GROSS MARGIN		$/ha	$	289.71	$	663.65	$ 1,037.58
GROSS MARGIN		$/$100VC	$	180.74	$	280.78	$ 332.11
VARIABLE COSTS			$/ha		$/ha		$/ha
A. PRIOR TO HARVESTING							
1. Seed,	15	kg/ha	$	11.25	$	11.25	$ 11.25
2. Fertilizer (ex-factory)							
a. Compound D			$	67.86	$	90.48	$ 113.10
b. Amm Nitrate			$	31.20	$	62.40	$ 93.60
c. Lime			0		0		0
d. Transport			$	0.03	$	0.04	$ 0.06
3. Insecticide							
Dimethoate	0.9	lits/ha	$	4.79	$	4.79	$ 4.79
Dipterex	4	kg/ha	$	21.28	$	21.28	$ 21.28
4. Miscellaneous,	2%		$	2.73	$	3.80	$ 4.88
SUBTOTAL			$	139.13	$	194.04	$ 248.96
B. HARVESTING & MARKETING							
1. Packing materials							
a. Bags			$	20.00	$	40.00	$ 60.00
b.Twine	0.2	kg/tonne	$	0.60	$	1.20	$ 1.80
2. Transport off farm			$	0.14	$	0.28	$ 0.42
3. Miscellaneous,	2%		$	0.41	$	0.83	$ 1.24
SUBTOTAL			$	21.15	$	42.31	$ 63.46
TVC			$	160.29	$	236.35	$ 312.42

Fertilizer and lime Table in kgs

Compound D	150	200	250
Ammonium Nitrate	50	100	150
Total	200	300	400

D. Ruti Irrigation Scheme Project Budget

Oxfam GB compiled this budget in collaboration with Gutu communities and key stakeholders supporting the establishment of the Ruti Irrigation Scheme. The budget is presented in British pounds and an exchange rate of 1.6 was used to convert the pounds to US dollars.

Ruti Irrigation Scheme Project Budget for 2009 **Project Title: Smallholder Farmer Sustainable Livelihoods**		
ACTIVITIES (Provide detailed breakdown on detailed sheet - formula means costs will automatically flow through using the ref number)	**Reference**	**BUDGET IN GBP**
Land Survey study Constultancy fees	1.1	3,310
connection of electricity	1.2	10,000
Electric motor 3 phase 30hp	1.3	5,935
Star-delta starter 30hp, 3 phase	1.4	3450
Stock pump 50-250	1.6	5,500
F70 Coupling complete	1.7	2,110
Suction pipe works	1.8	1,860
Delivery pipe works	1.9	1,450
Check valve	1.10	1,490
Gate valve 6" C.I.	1.11	2,025
Pump House	1.12	2,500
Accessories @ 5% of total above	1.13	2,000
Land clearing - Grader hire	1.14	15,000
Canal construction and lining	1.15	9,490
Construction of pump house	1.16	150
Storage Tank - 50,000litres	1.17	12,000
Delivery line 150mm class 24 AC (80m)	1.18	18,500
Cement procurement - 135MT	2.1	21,600
Concerate stone procurement- 300M	2.2	9,000
Fencing Material procurement	2.3	15,000
(2x) well upgrading	2.4	1,000
(2x) Latrine construction	2.5	180
Irrigation Tools	2.6	6,000

Purchase of inputs	2.7	10,000
Market Analysis	2.8	800
Truck hire	2.9	5,000
training in irrigation scheme management	3.10	200
Training in agronomy	3.2	200
Training in market linkage and business management skills	3.30	1,000
Training in SASE	3.4	400
Training in Gender based violence	3.5	400
Training in Post harvest technologies	3.6	200
Procurement of IEC materials	4.1	400
Holding exchange visits	4.2	1,000
Field day	4.3	500
Training in gender and HIV/AIDS awareness	4.4	750
Grant to partner (DDF & Irrigation Management Committee)	5.1	18,000
Direct Project Staff (Programme Coordinator, Project Officer and Driver salaries for 11months)	5.2	30,800
Total		187,910