CCAP Sioma Irrigiation Scheme: Feasibility Report

Project Name: CCAP Sioma Irrigation

Version: Final

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Disclaimer

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List of Acronyms

Acronym	Long-Form
ADCC	Area Development Coordinating Committees
AfDB	African Development Bank
AIDS	Acquired Immuno Deficiency Syndrome
BRE	Barotse Royal Establishment
CAP	Chapter
CBA	Cost Benefit Analysis
CBR	California Bearing Ratio
CCAP	Adaptation to the Effects of Climate Variability and Change in Agro-ecological Regions I and II in Zambia
CFU	Conservation Faming Unit
CRIDF	Climate Resilient Infrastructure Development Facility
CSO	Central Statistical Office
CV	Curriculum Vitae
CWR	Crop Water Requirement
DACO	District Agriculture Coordinating Officer
DAO	District Administrative Officer
DDCC	District Development Coordinating Committee
DFID	Department of International Development
DSA	District Situation Analysis
EBCR	Economic Benefit Cost Ratio
EHS	Environmental, Health and Safety
EIA	Environmental Impact Assessment
EIS	Environmental Impact Statement
EMA	Environmental Management Act
ENPV	Economic Net Present Value
EOCC	Economic Opportunity Cost of Capital
ERR	Economic Rate of Return
ETc	Crop Evapotranspiration
ETo	Reference crop Evapotranspiration
FAO	Food and Agricultural Organisation
FBCR	Financial Benefit Cost Ratio
FIRR	Financial Internal Rate of Return

FNPV	Financial Net Present Value
FRA	Food Reserve Agency
FSP	Fertiliser Support Programme
GBP	Great British Pounds
GEF	Global Environment Facility
GESI	Gender, Equality and Social Inclusion
GMA	Game Management Area
GPS	Global Position System
GRZ	Government of the Republic of Zambia
HIV	Human Immuno Virus
IFC	International Finance Corporation
KAZA TFCA	Kavango-Zambezi Transfrontier Conservation Area
Km	Kilometre
LDCF	Least Developed Countries Fund
MACO	Ministry of Agriculture and Cooperatives
MA	Ministry of Agriculture
MFNP	Ministry of Finance and National Planning
mm	Millimetre
MEWD	Ministry of Energy and Water Development
MoU	Memorandum of Understanding
NAPA	National Adaptation Programme of Action
NGO	Non-Governmental Organisation
NHCC	National Heritage Conservation Commission
O&M	Operation and Maintenance
PACO	Provincial Agricultural Coordinator
PDCC	Provincial Development Coordinating Committee
PS	Permanent Secretary
RDA	Road Development Agency
SADC	Southern African Development Community
SCS	Soil Conservation Service
SDR	Social Discount Rate
SIS	Sioma Irrigation Scheme
SNDP	Sixth National Development Plan 2011-2015
STD	Sexually Transmitted Disease

STI	Sexually Transmitted Infection
TOR	Terms of Reference
UN	United Nations
UNDP	United Nations Development Programme
UNZA	University of Zambia
USD	United States Dollar
USDA	United States Department of Agriculture
WRMA	Water Resources Management Authority
ZAMCOM	Zambezi Watercourse Commission
ZANIS	Zambia News Information Services
ZAWA	Zambia Wildlife Association
ZEMA	Zambia Environmental Management Agency
ZESCO	Zambia Electricity Supply Corporation
ZMK	Zambian Kwacha
ZMW	Rebased Zambian Kwacha

Executive Summary

The “Adaptation to the Effects of Climate Variability and Change in Agro-ecological Regions I and II in Zambia” (or “Zambia Climate Change Adaptation Project” (CCAP)) was formulated with an objective to *“develop adaptive capacity of subsistence farmers and rural communities to withstand climate change in Zambia”*. The project is currently under implementation through the Ministry of Agriculture (MA), with support from the UNDP-GEF.

One such intervention identified through the CCAP initiative is the Sioma Irrigation Project – which aims to increase the climate resilience of the Malombe community in Sioma District. The community is located near the Zambezi River and comprises of 100 beneficiary households, who collectively own 57.8ha of land for agricultural purposes. Despite the vast water potential of the Zambezi River, the community has no means of accessing this water for irrigation due to a significant lack of resources for developing the required infrastructure. Instead, the community relies on rain-fed agriculture for food and small inflows of cash through the informal sale of excess crops. A changing climate that is characterised by more volatile rainfall patterns is expected to result in an increasing incidence of crop failure for the community, who already face significant vulnerability to climatic shocks.

Unfortunately, due to funding shortfalls the CCAP has been unable to take the Sioma Project through to implementation. However, when CRIDF carried out scoping and pre-feasibility assessments of several CCAP intervetnions in 2013 it was advised that World Bank funding for small-scale infrastructure projects (such as these irrigation schemes) is currently available through the Ministry of Energy and Water Development (MEWD), and it was advised that full feasibility studies should therefore be prepared and submitted as soon as possible.

Technical Study

CRIDF mobilised a feasibility study in late 2014. Due to the sheer remoteness of the Malombe community, the technical team was required to develop not only a sound engineering design with proven implementation success in Zambia, but also a scheme that employed appropriate technologies and practises that could be operated, managed and maintained by the local beneficiaries and institutions. A selection of infrastructure options were assessed against a range of criteria (including investment costs, O&M requirements, need for institutional and marketing support etc.), where the final design comprised of:

- Intake works, main canal and pumping station (including the supply and delivery of electricity to the pump house);
- Drag hose irrigation infrastructure for approximately 57.8 ha of land; and
- Elephant-proof fencing of approximately 15km (calculated on a perimeter of 70 ha of land).

Institutional Analysis, Stakeholder Endorsement & Environmental Assessment

Prior to finalising the feasibility study, each design option was first discussed at length with the Malombe community, and their written support and endorsement of the above design was received in November 2015. This engagement was the culmination of several missions to site, where institutional, social and environmental experts also engaged extensively with the beneficiaries and local institutions to better understand community structures, their roles and responsibilities, and the need for capacity building support to ensure the long term sustainability of the scheme.

The ESIA Expert also undertook a scoping assessment during the initial site mission, and confirmed that while no significant environmental impacts were foreseen as a result of the proposed intervention (primarily because the location of the scheme comprises of both plots already being utilised for farming activities, and vacant lots that are largely overgrown and unutilised), due to the size of the area (57.8ha) a full ESIA would need to be undertaken prior to implementation. A Terms of Reference has therefore been developed to guide this process in line with ZEMA specifications.

Economic and Financial Analysis

A cost-benefit analysis of the proposed design indicated that through the provision of capital investment of GBP 456,329, the Project is anticipated to result in significantly improved livelihoods for 100 households. Specifically, it will provide much needed capital investment for a large portion of households in the Malombe community, and it is anticipated to indirectly benefit the entire community, as well as the Sioma ward, through economic development and multiplier effects. Specifically, it is anticipated at the entire Malombe settlement will directly or indirectly benefit from this scheme – bringing the anticipated total number of indirect beneficiaries to a total of 1,150 households (that is, 5,708 beneficaires, consisting of 2,737 males and 2,971 females).

In addition to the financial benefits that stem from crop sales, further economic benefits from the Project are expected to include climate resilience, food security, lower levels of human-wildlife conflict, and health improvements through diversified diets.

Not only do the results of the financial appraisal indicate that the Project is financially viable[1], but the BCR is 1.48 and 2.15 at 3.5% and 10% respectively, demonstrating that there is social justification given the Project's cost to the community.

Potable Water Supply Component

During the technical team's mission to site in November 2014, it became apparent that there was no potable water supply system in place, and discussions with the Sioma District Council Secretary confirmed that there were no plans to provide this in the near future. At the time, the community

[1] The FIRR was calculated at 14% - which is higher than the discount rate of 11.5% indicating that it is financially viable

collected and used water from the river for domestic and livestock watering purposes. However, it was expected that out of convenience they would undoubtedly opt to use the irrigation scheme's untreated water supply to fulfil their domestic needs as well. To avoid any risk of the community drinking this untreated water, CRIDF decided to explore the option of providing a potable water supply scheme to the beneficiary families as well.

However, subsequent to the completion of a potable supply assessment, a recent site visit to Sioma in November 2015 found that a local NGO (Umbuntu) has drilled two boreholes and installed solar powered submersible pumps. Although these do not provide the quantities of water envisaged in CRIDF's study, they currently provide sufficient potable water to the community around Malombe.

It is therefore recommended that no further work be done to provide additional potable water at Malombe

Next Steps

This Report provides an overview of each element of the detailed feasibility study undertaken by CRIDF, and will now be presented to the Ministry of Agriculture, Ministry of Energy and Water Development, and the World Bank for consideration for funding.

1. Introduction

1.1 Introduction to the CCAP

In 2013 CRIDF commissioned an initial eligibility screening of the “Adaptation to the Effects of Climate Variability and Change in Agro-ecological Regions I and II in Zambia” or “Zambia Climate Change Adaptation Project” (CCAP). The intention of this work was to assess the potential for CRIDF support to the CCAP. These projects had formed part of the SADC Regional Infrastructure Development Master Plan (RIDMP), but funding shortfalls had meant that the CCAP had been unable to take all the of identified interventions through to implementation.

The overarching strategy for the CCAP suite of projects is rooted in a number of key CRIDF concepts. All of these have relevance across all of SADC’s transboundary rivers, so the individual projects (and the suite of projects under CCAP) are selected in order to prove (or disprove) CRIDF concepts, contributing to evidence that informs a wider set of CRIDF stakeholders. Outputs of CCAP relate to the benefits for communities in the face of increasing climate variability. Outcomes for CRIDF and their key stakeholders relate to what can be learned, with CRIDF’s help, from the processes that generate the outputs. CRIDF’s selection of CCAP interventions should be considered as a suite of projects, all of which examine different approaches to improving water use for small-scale agriculture shemes in areas of SADC exposed to variable, and at times extreme, climatic conditions.

The Sioma Project focusses specifically on r**educing vulnerability by developing irrigation production to replace (increasingly erratic) rain-fed crop production –** a core component of CRIDF’s wider stakeholder influencing plan for the Zambia CCAP suite. In the case of Sioma, the climate angle relates to the opportunity to develop ‘rules of use and curtailment’ in relation to schemes that draw directly from Transboundary Rivers that are essential for hydroelectric production. This applies especially in relation to curtailment or reduced use in dry climatic cycles and in years of particularly low flow. Though Sioma is a small irrigation scheme, CRIDF plans to use it as a strategic entry point to engage with a number of national stakeholders, including regulatory authorities, and to open the discussion with large-scale irrigation developers (some of which are trans-SADC or even international).

1.2 Strategic Aims of the Project

Poverty reduction

The Project directly contributes to poverty reduction in that it supports Government of the Republic of Zambia’s (GRZ) key development objective to expand agriculture through irrigation development. In this way, traditional subsistence farming is gradually upgraded to commercial agriculture, through adoption of new technologies and diversification of crops grown.

The area for the project is Sioma, located in the Zambezi river basin is prone to droughts that are attributed to climate change. Thus the development of the irrigation scheme will improve the resilience of the community to droughts. This scheme will be a pilot in the area, as no other scheme has been established in the area. The project is expected to make land use more efficient, reduce production risks, and spur agricultural industries, through increased availability of raw materials, as well as increased utilisation of agricultural products and support services. It is also proposed to develop a mixed cropping enterprise anchored on cereals, legumes, oilseeds and solanum (tomatoes and potatoes) crops.

The following are improvements expected:

- Expansion of area allocated to irrigation production area in the region;
- Reduction of risks in crop production;
- Intensification of land use through irrigation;
- Expansion of alternative cash crops in the area;
- Farmers' direct involvement in the market economy, through production of cash crops;
- Direct injection of capital into the area, through employment creation at implementation and during operation, through agricultural support services;
- Mushrooming of agro-based industries as a result of stable crop production, especially of horticultural crops. The proportion of land under horticultural crops could be increased as such embryonic industries to assimilate agricultural production start to appear in the area, reducing the quantity of crop marketed directly to consumer as fresh.

Trans-boundary relevance

The Project is located in the Zambezi River Basin which is an international water course shared by Zambia, Angola, Namibia, Zimbabwe, Botswana, Malawi, and Mozambique. Water abstraction for the irrigation scheme will not be significant enough to have Basin wide implications; however there remain other components of the Project that have trans-boundary relevance.

The first is the relevance of the Project to the Kavango-Zambezi Transfroniter Conservation Area (KAZA TFCA) that spans the five member states (Angola, Botswana, Namibia, Zambia and Zimbabwe). The Project is a prototype to address human-wildlife conflict affecting livelihoods activities, through a holistic strategy of defining wildlife corridors, and implementing wildlife-fencing and promoting sustainable livelihoods in alignment with these.

The Project will therefore provide lessons for other interventions in the TFCA, while also contributing to the strengthening of existing institutions in Zambia. Increased knowledge and experience will also be achieved in these areas - such as improving security of tenure, unlocking access to credit, and strengthening capacity in marketing of crops.

Food security

While malnutrition is not a major issue in the area, required improvements in food security are seen as diversification within diets and better knowledge around food variation. As such, the Sioma Mission Clinic stressed that their role in the Sioma Irrigation Scheme (SIS) would be to encourage a diversification of crops. In addition to maize, the cropping programme proposed in the agronomic model includes green maize, sugar/Michigan beans, wheat, soya beans, potatoes, onions and tomatoes. Horticultural crops (primarily vegetables) are limited in the cropping programme because of their perishable nature, fluctuating prices and marketing challenges; however are still included to a small degree primarily for local consumption. As such, the Sioma Irrigation Scheme will contribute significantly to variation in the local population's diet and improved nutrition.

Climate resilience

Past experience highlights the risks associated with dry-land agriculture, particularly in sub-Saharan Africa where extreme and variable weather patterns persist and are expected to intensify. The experience of the Malombe community specifically, and the inconsistency with which they are able to cultivate year on year as a result of water challenges, is testament to this.

Irrigation is a means to increase the resilience of farmers against such a climate, while also mainstreaming their participation in the economy and increasing their productivity and economic resilience. Indeed, the overarching objective of Zambia CCAP is to *"develop adaptive capacity of subsistence farmers and rural communities to withstand climate change in Zambia*". The cropping programme, increased scale of production, focus on commercial viability, and choice of the most appropriate irrigation infrastructure all answer the core objective of responding to climate change in Zambia and ensuring the resilience of rural communities to its impacts in a way that is appropriate to the communities' skillsets and location.

Drawing water directly from the river at a point where there is year round water will also provide a high degree of climate resilience. In other recent irrigation interventions drawing water from the Kariba Dam have been problematic as the level of the dam has declined and water has receded from the extraction points.

1.3 Background to Sioma

The Malombe Irrigation Scheme (also known as the Sioma Irrigation Scheme - SIS) is located in the Zambezi river basin, near Sioma town in Sioma District (formerly Shang'ombo District) in the Western Province of Zambia. It is 180 km South of Mongu, the provincial capital and some 6km upstream of the Ngonye Falls. Figure 1 shows the project location in relation to other sites in the area. Table 1 gives the general coordinates of the Sioma Irrigation Scheme. The area is accessed via the M10 road from Livingstone, some 300 km away.

The scheme, as originally designed under CCAP, involved pumping water from the Zambezi River at Sioma, to provide irrigation water for 68.5 hectares of established crop land. The total scheme was expected to benefit some 70 households, and provide the opportunity to ensure basic food security as well as some commercial agricultural enterprises.

The original design by CCAP was based on a range of solar pumps on barges on the Zambezi, pumping water to 4 holding reservoirs, and gravity feeding to the fields. The proposed CCAP design also supported capacity building and the establishment of community structures to manage the operation and finances of the scheme. The CCAP and MA floated a tender for the construction of the irrigation scheme, but the lowest tender price exceeded the available funds by a considerable margin.

Table 1 Sioma Irrigation Scheme project location

Key parameter	Value
Approximate Latitude of Site Northing	16^{o} 37’ 04” S
Approximate Longitude of Site ….Easting	23^{o} 30’ 16”E
Average mean altitude of site (m.a.s.l)	995
Air Temperature: Maximum °C	31
Air Temperature: Minimum °C	18
Maximum Flood Level (m.a.s.l)	994
River Bed Level (m.a.s.l)	985
Low Water Level	988

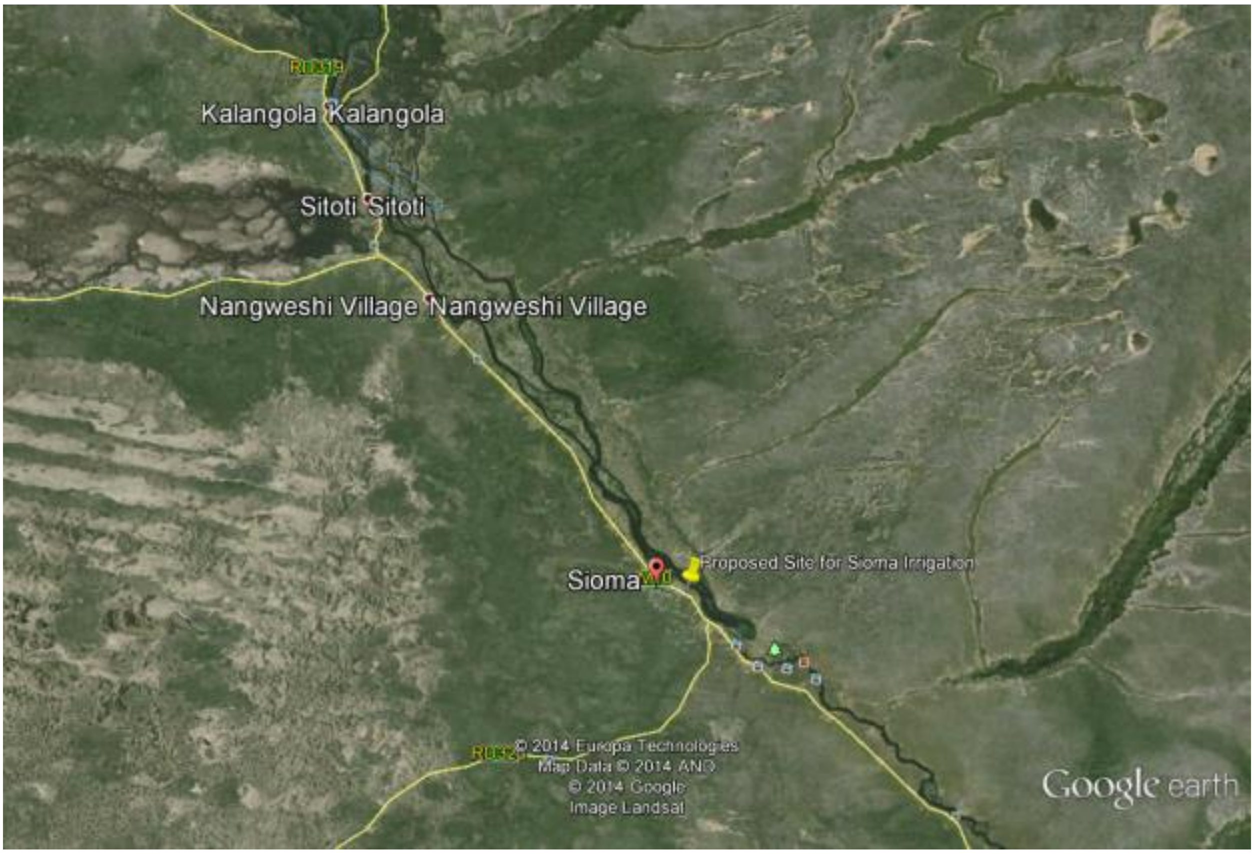


Figure 1 **Location of proposed Malombe (Sioma) Irrigation Scheme**

There have been several important changes since the completion of the CCAP initial design of the SIS near Sioma, and CRIDF's pre-feasibility study in 2013 indicated considerable potential for improvements. The key differences from the original design are that:

- a single pump – operating off the recently installed electricity grid – could be installed, enabling the construction of a single reservoir and gravity feeding the whole irrigation scheme.
- the irrigation demand, scheduling and irrigation type could then be optimized, reducing the total cost of pumping, and ultimately a farm-managed system would be most sustainable - provided sufficient capacity building was rolled-out alongside the infrastructure implementation
- the need to investigate potential markets for agricultural products and opportunities to add value by on-site processing should also be investigated
- potential human / wildlife conflict may also have to be addressed through the construction of elephant proof fencing for the irrigation scheme.

1.4 Aims and outputs of the Feasibility Study

It was initially envisaged that this Activity would be carried out as a two-phased approach (i.e. focussing on the first 25ha initially to avoid potentially significant EIA delays, and thereafter expanding to the full 58ha). However, after the first site mission, the team of experts concurred that EIA delays were unikley, and the most effective and economical way forward would be to develop a full feasibility study for the entire 58ha scheme and prepare an EIA ToR for the full area too.

The specific deliverables completed as part of this Feasibility Study are detailed below. The following Chapters in this report detail the key outputs of these deliverables.

Key Feasibility Outputs
Hydrological/water resources review
Preliminary technical assessment
Preliminary production, marketing, and cropping assessment
Preliminary Institutional and management arrangements assessment
Stakeholder analysis
Climate vulnerability assessment
Environmental scoping report
Stakeholder engagement report
Draft outline design and O&M plan
Cost benefit analysis
Assessment of potential funders and planned procurement options
Gender, Equality and Social Inclusion analysis
Potable water supply assessment
Finalised EIA ToR
Screen 2b – excel tool summarising all aspects of Feasibility
Project Development Monitoring Plan - excel tool tracking project progress
Risk register

2. Technical Analysis of Irrigation Scheme

2.1 Hydrological/water resource review

Climate

The climate of Zambia is tropical, modified by altitude. In the Koppen climate classification, the country is mostly humid subtropical with cool dry winters (May to October/November) and wet summers (November to April). The area is generally hot, with variable precipitation and high evaporation. The site is located in Zambian agro-ecological Region I, which receives average annual rainfall of less than 800mm.

The climatic summaries used for planning purposes were obtained from the SAPWAT database, which is derived from the Food and Agricultural Organisation's (FAO) CLIMWAT database. There are no long term weather data for Sioma, though a weather station has recently been constructed.

The nearest station is Senanga. Due to difficulties in extracting data from CLIMWAT, average monthly data for the three stations available in SAPWAT (Livingstone, Sesheke and Mongu) were used to derive reference crop evapotranspiration (ETo) figures, which were then extrapolated for Sioma

Water Resources

The scheme would draw water from Zambezi River. Detailed analyses of hydrological records and impact of abstractions were undertaken as part of the scheme design.

Zambia's total renewable water resources stand at 163.4 km^3 per year. Of this, internal renewable water resources are estimated at 114.8 km3 per year of run off and 49.6 km^3 per year from ground water. Water withdraws for agriculture is estimated at 1.7 km^3 per year. Zambia has an irrigation potential of 2.75Mha but only 256,000 ha is under irrigation. (MACO/FAO 2004)

The Zambezi River is the largest trans-boundary river in Southern Africa and flows 2,700 km through eight countries before entering the Indian Ocean in Mozambique.

The Zambezi River basin covers some 1.3 million square kilometres and spreads as: Zambia (40.7%), Angola (18.2%), Zimbabwe (18.0%), Mozambique (11.4%), Malawi (7.7%), Botswana (2.8%), Tanzania (2.0%) and Namibia (1.2%)

Zambezi River Authority carry out flow measurements at eight stations on the Zambezi River and Figure 3 shows flow hydrograph for the flow measurement taken at Ngonye Rapids (Sioma falls) station which is some few kilometres downstream of the project site. The following figure illustrates where the site lies in relation to Ngonye Rapids.

Figure 2 **Irrigation scheme location**

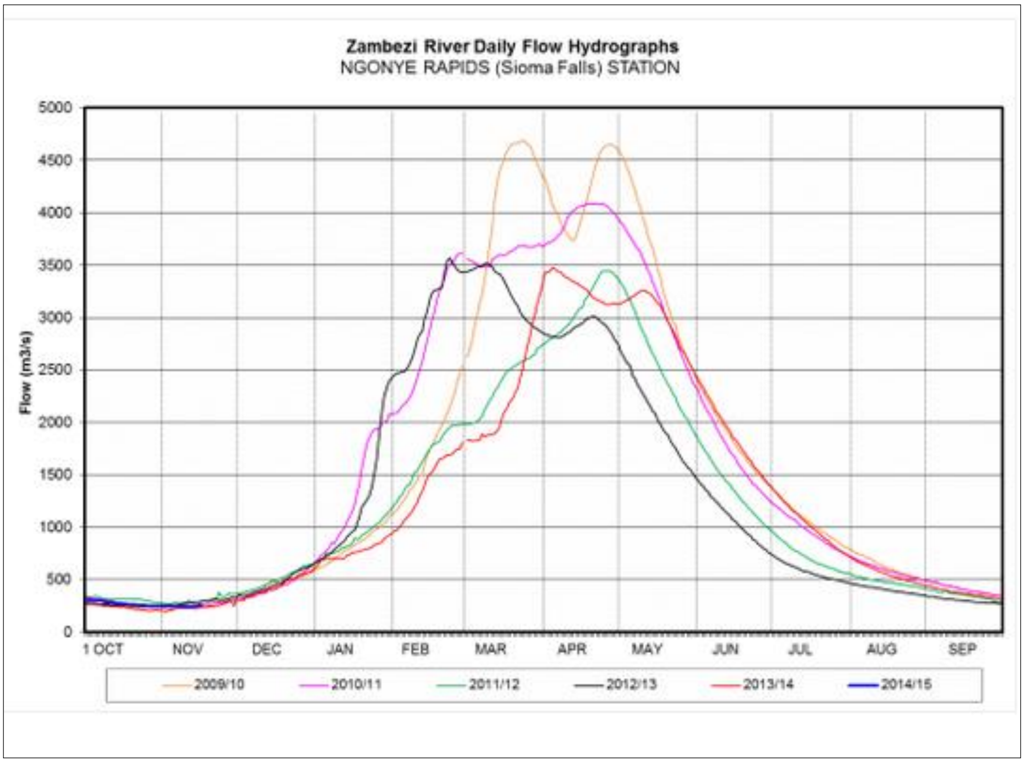


Figure 3 **Zambezi River Daily Flow Hydrograph (Source: Zambezi River Authority)**

The period for which the measurement data is displayed is from 2009/10 to 2014/15 and a cycle starting from the month of October to September. The figure shows the base flow of the Zambezi River is in the range of 250 - 300 m^3/s experienced in the months of September to November. The peak flow of the River is the months of March to May and was highest in the 2009/10 period at $4500m^3/s$ and lowest in 2011/12 at $3500m^3/s$.

From the available data and based on the analysis in the Zambian Irrigation Policy and Strategy (MACO/FAO 2004), it evident that the Zambezi River has sufficient water to meet the demand for this Project.

2.2 Engineering Assessment and Options Analysis

Introduction

Irrigated agriculture, especially in rural areas of Zambia, has become an essential means of mitigating the effects of climate change. Irrigation provides opportunities for improving land productivity, generating income, creating employment, and improving food security and poverty reduction.

The purpose of this section is to present the results of the consultative technical design process of the proposed Sioma Irrigation Scheme. The proposed irrigation lay-out, and bills of quantities for the design have also been prepared.

Location of the Proposed Scheme

The project is located around Latitude 16^{o} 37’ 04” S and Longitude 23^{o} 30’ 16” E at an altitude of 995m above mean sea level. It lies near the bank of the Zambezi River in Sioma District about 180km south of Senanga. The infrastructure development in Sioma will include construction of an intake from the Zambezi River, a conveyance canal, a pumping station, conveyance pipe lines, and installation of preferred option for irrigation (drag hose) of 57.8ha.

Existing Infrastructure

Currently there is limited infrastructure that could directly be utilised for the Project. Electricity connection, pump stations and conveyance pipelines will be required for the project. In addition, access roads to the pump station and in the scheme will also be required. Soil conservation works will also be required to reclaim eroded and un-rehabilitated borrow areas left from the road construction. This following scope works must be covered in the design and costing of the scheme:

- Land or bush clearing as well as land preparation
- River intake channel and sump
- River pump station
- Electricity transformers at head-works
- Mechanical and electrical equipment at the river pump station
- Irrigation mains, sub-mains, and infields
- Scheme access and haulage roads
- Soil Conservation works
- On farm facilities like sheds, operational office and sheds for storing equipment, implements and managing the farm.

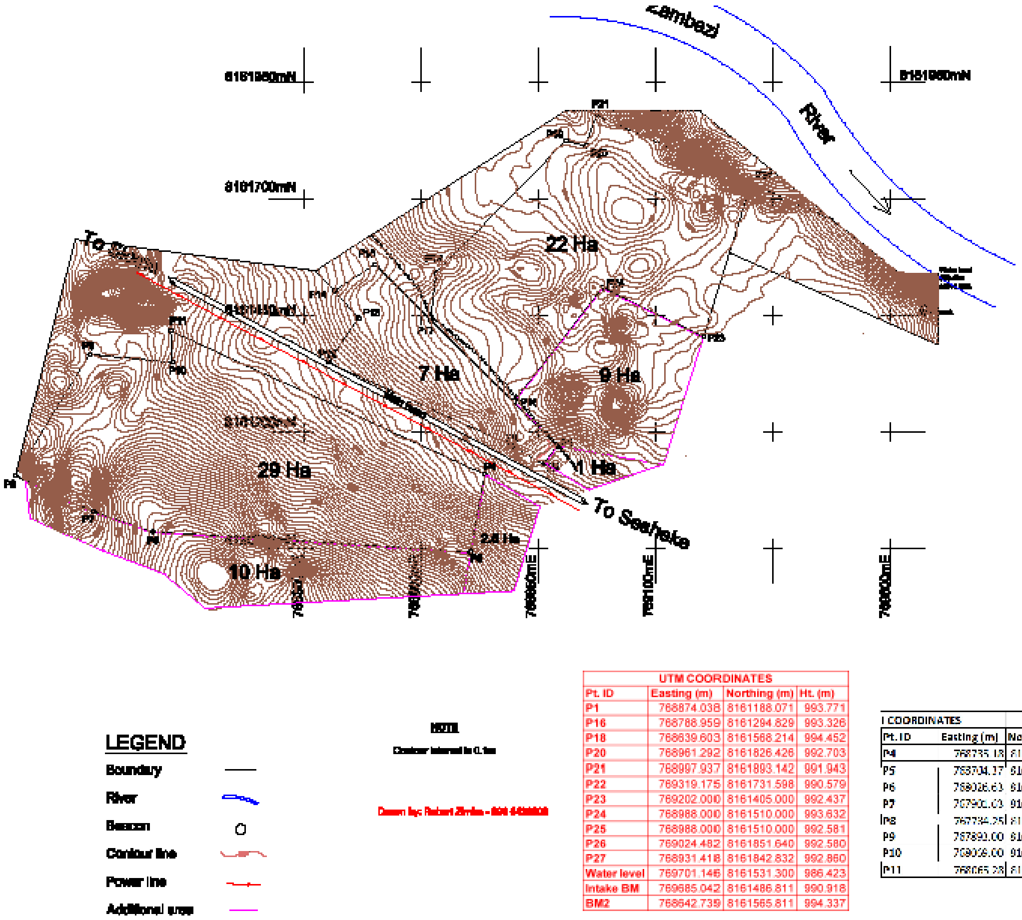
Communication facilities available to the area are the tarred road (M10), and cellular telephone base network.

Crop Water Requirements

The scheme's water requirement has been planned for 57.8 hectares under drag hose irrigation. A peak ET_c of 6.5 mm/day is proposed for SIS for design purposes, based on the Sesheke and Livingstone weather data and derivations. The net estimated demand is 10,133 m^3/ha/annum for the scheme. A gross of 13,511 m^3/ha/annum is required at 75 % efficiency of sprinkler irrigation, equivalent to a flow of 1.0 litre/s/ha occurring in September and total scheme demand of 925,504 m^3/annum; equivalent to 0.01% of the lowest base flow of the Zambezi. Thus the source, the Zambezi River, has sufficient water to meet the demand through direct pumping.

Topographical Survey

A Topographical survey for the scheme was carried out in November and December 2014. The resulting topographical map is shown in Figure 4. According to the survey, the total area of the *potential* irrigation made available by the community is **80.5-hectares** as of December 2014. The feasibility design has however been based on the original land available, as stated by the community, of 57.8 ha.



UTM COORDINATES			
Pt. ID	Easting (m)	Northing (m)	Ht. (m)
P1	768874.038	8161188.071	993.771
P16	768788.959	8161294.829	993.326
P18	768639.603	8161568.214	994.452
P20	768961.292	8161826.426	992.703
P21	768997.937	8161893.142	991.943
P22	769319.175	8161731.598	990.579
P23	769202.000	8161405.000	992.437
P24	768988.000	8161510.000	993.632
P25	768988.000	8161510.000	992.581
P26	769024.482	8161851.640	992.580
P27	768931.418	8161842.832	992.860
Water level	769701.146	8161531.300	986.423
Intake BM	769685.042	8161486.811	990.918
BM2	768642.739	8161565.811	994.337

I COORDINATES			
Pt. ID	Easting (m)	Northing (m)	Ht. (m)
P4	768735.18	8161100.63	995.735
P5	768704.17	8160941.61	997.670
P6	768026.63	8160986.49	994.452
P7	767900.03	8161029.49	992.703
P8	767734.25	8161106.13	1001.622
P9	767891.00	8161267.00	990.579
P10	768008.00	8161250.00	992.437
P11	768065.28	8161417.80	997.965

Figure 4 **Topographical Map of the Proposed Sioma Irrigation Site(Scale 1: 5,000)**

Irrigation Options

Three possible options of irrigation development were considered. These are as follows:

(a) Option-1: Rain fed system

(b) Option-2: Furrow irrigation system

(c) Option-3: Sprinkler system

- (i) Centre Pivot
- (ii) Combination of Centre Pivot and Drag Hose
- (iii) Drag Hose
- (iv) Quick Move

Bulk water Supply Infrastructure

Head Works

The head works will be located along the bank of the Zambezi River (intake). From the simple intake, water will flow by gravity along a 20-metre long conveyance canal to the pumping station.

Pump Station

The pumping station will consists of a pump house, fitted with two pump units, and control panels. Each of the two pump units will discharge 180-m^3/hour, at 70-m TDH, and 47-kW. One pump will be operating at a time while the other shall be on stand-by. The flow from each pump unit shall be regulated by a non-return valve and a gate valve. The motors will be driven by hydroelectric power supplied through an 11-kV power line from Zambia Electricity Supply Corporation (ZESCO) Limited. The transformer rating shall be 200-kVA. The pipes on the upstream side of the pump units shall be installed in the sump fully protected with a weed screen. The estimated cost of the pumping station is USD **366,005.00,** broken down as shown in **Annex A**. This pump station design shall apply to all design options.

Option 1 - Rain-fed

Description

The rain-fed system does not involve any infrastructure development for the purpose of artificial application of water for plant growth. The rain-fed system had been practiced in the area for some time. The farmers mainly grew sorghum and supplied Zambia Breweries Limited.

Option 2 – Furrow Irrigation

Description

The proposed scheme lay-out under furrow irrigation is shown below. The layout consists of a Pump station, reservoirs, and a network of irrigation and drainage canals, flow control structures, and scheme roads. The water is conveyed from the pumping station to reservoirs through 200-mm diameter uPVC pipe lines. The detailed Bill of Quantities (BoQ) for Option 2 appears in **Annex B**.

Cost Estimates

The total engineers' estimate for furrow irrigation infrastructure development covering the 57.8-hectares is USD **999,750.20** broken down as follows:

• Intake works and Pumping station	$ 366,005.00
• Conveyance pipelines, and night reservoirs	$ 417,928.80
• Irrigation and drainage canals	$ 215,816.40
▪ TOTAL	**$ 999,750.20**

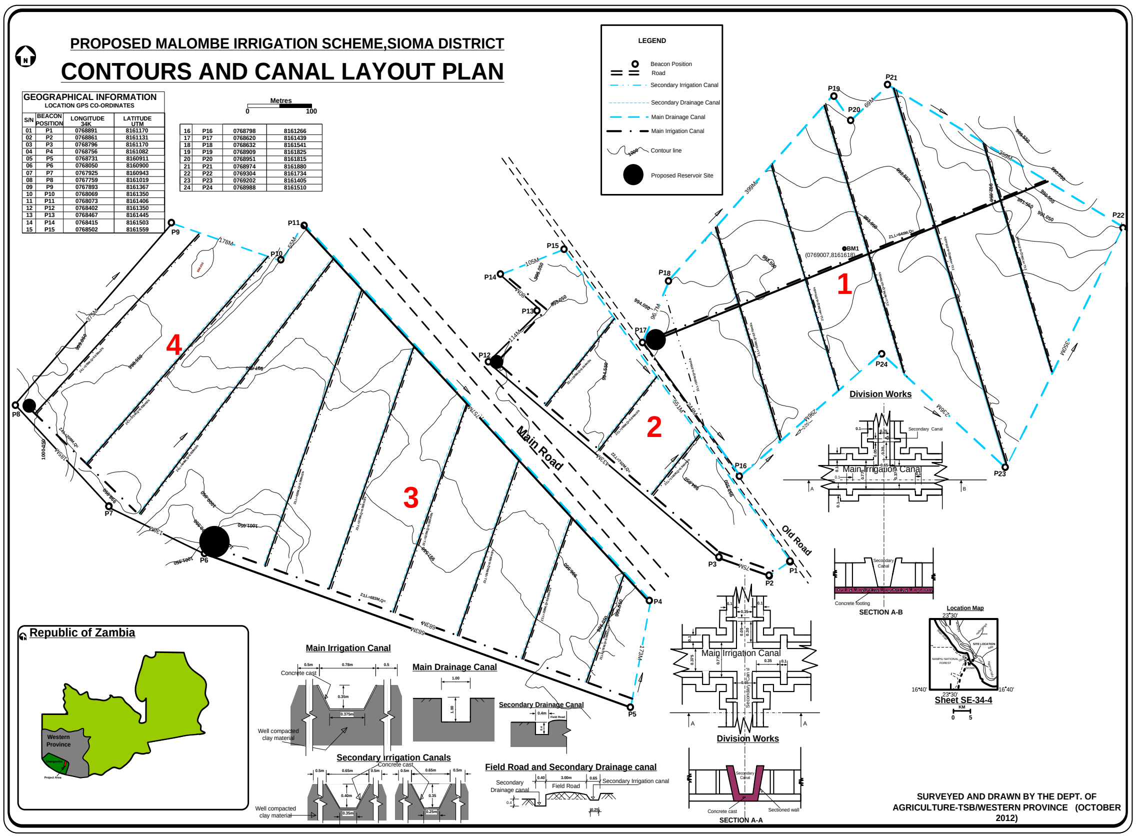


Figure 5 **Irrigation and Drainage Layout for Furrow Irrigation Scheme**

Option 3 – Sprinkler Irrigation

Sub-Option (i): Centre Pivot

Description of Layout

The intake and pumping station will be the same as that described under the above sections on bulk water supply infrastructure. From the pumping station, the water will be conveyed directly to five pivots of different sizes through a 200-mm uPVC pipe line. The five pivots will irrigate a total of 57.8-hectares out of the 80.5-hectares available land. To protect the pipelines from excessive operating pressure, pressure relief valves shall be installed in valve chambers located along the pipelines to centre pivots. The irrigation layout is shown below.

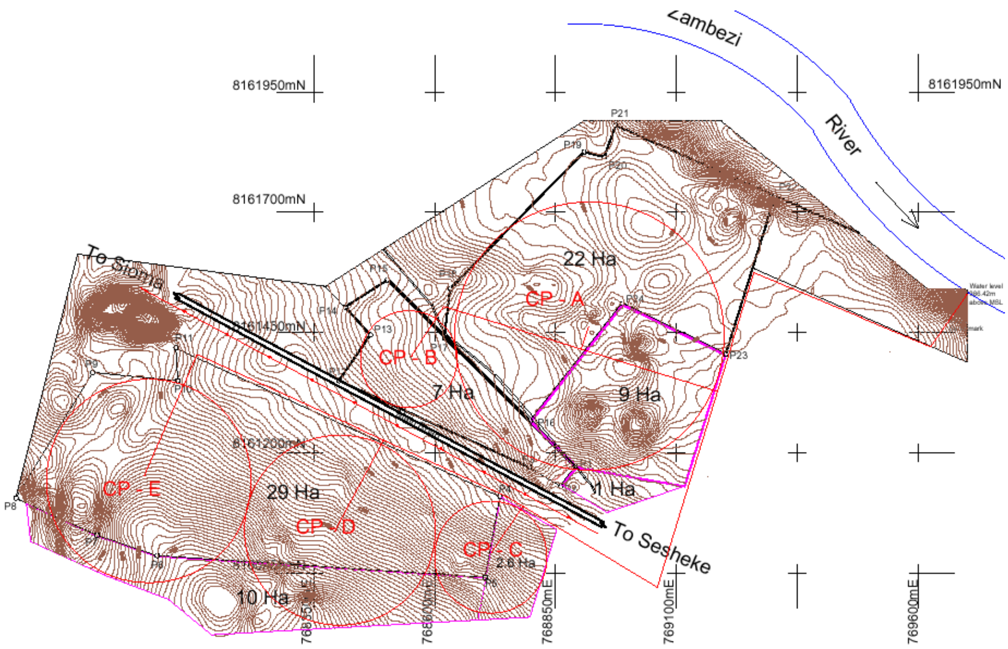


Figure 6 **Proposed Centre Pivot Layout**

Table 2 Description of centre pivots

Pivot Description	Length of Tower (m)	Command Area (ha)
CP-A	278	24.3
CP-B	100	3.1
CP-C	115	4.2
CP-D	197	12.2
CP-E	211	14.0
Total		***57.8***

Cost Estimates

The total engineers' estimate for furrow irrigation infrastructure development covering the 57.8-hectares is USD **797,317.40** –shown in **Annex C**, and broken down as follows:

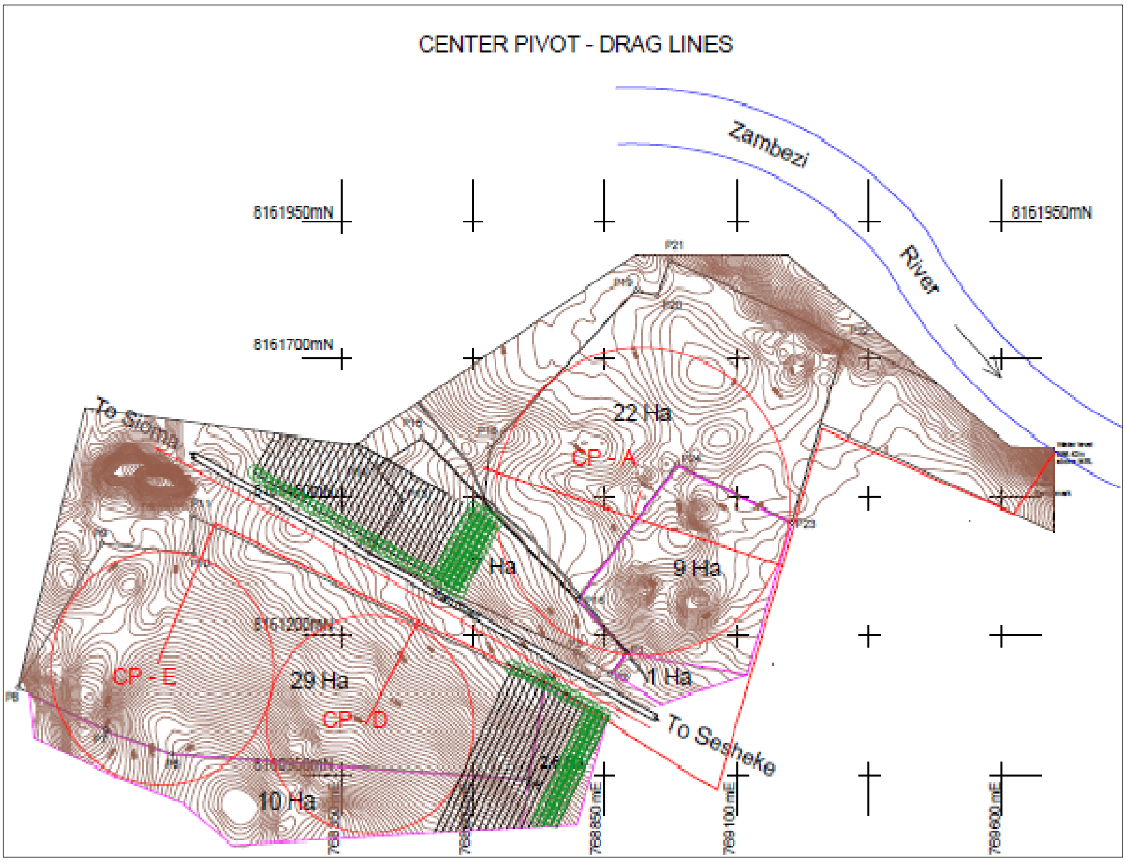
- Intake works and Pumping station $ 366,005.00
- Conveyance pipelines $ 72,342.40
- Irrigation and drainage Infrastructure $358,970.00
    - TOTAL **$797,317.40**

Sub Option (ii): Centre Pivot and Drag Hose

Description of Layout

The intake and pumping station will be the same as that described under above sections on bulk water supply infrastructure. From the pumping station, the water is conveyed directly to three pivots and 2 sets of drag lines installed to replace the two small pivots, CP-B, and CP-C in all pivot layout described above. Each of the drag lines is fitted with a sprinkler at the end. To protect the pipelines from excessive operating pressure, pressure relief valves shall be installed in valve chambers located along the pipelines to centre pivots. The irrigation layout for pivots in combination with drag hose is shown below 8.

Figure 7 **Layout of Sprinkler Irrigation Scheme -Centre Pivots with Drag Hose**



Cost Estimates

The total engineers' estimate for infrastructure development for centre pivots in combination with drag hose, covering the 57.8-hectares is USD 716,322.40, as shown in **Annex D**, and broken down as follows:

- Intake works and Pumping station $ 366,005.00
- Conveyance pipelines $ 72,342.40
- Centre Pivots $ 250,000.00

- Drag Hose infrastructure $ 27,975.00
    - TOTAL $ 716,322.40

Sub Option (iii): Drag Hose

Description of Layout

The intake and pumping station will be the same as that described under above sections on bulk water supply infrastructure. From the pumping station, the water is conveyed through a 200-mm uPVC pipe line directly to drag lines located in the irrigation area, as shown in Figure 8 (note the layout on this figure applies to both the Drag Hose option, as well as the Quick Move Sprinkler System).

Cost Estimates

The total engineers' cost estimate for Drag Hose irrigation infrastructure development covering the 57.8-hectares is USD *491,921.80*, shown in **Annex E** and broken down as follows:

- Intake works and Pumping station $ 366,005.00
- Conveyance pipelines (mains and sub-mains) $ 64,416.80
- Drag Hose infrastructure $ 61,500.00

TOTAL ***$ 491,921.80***

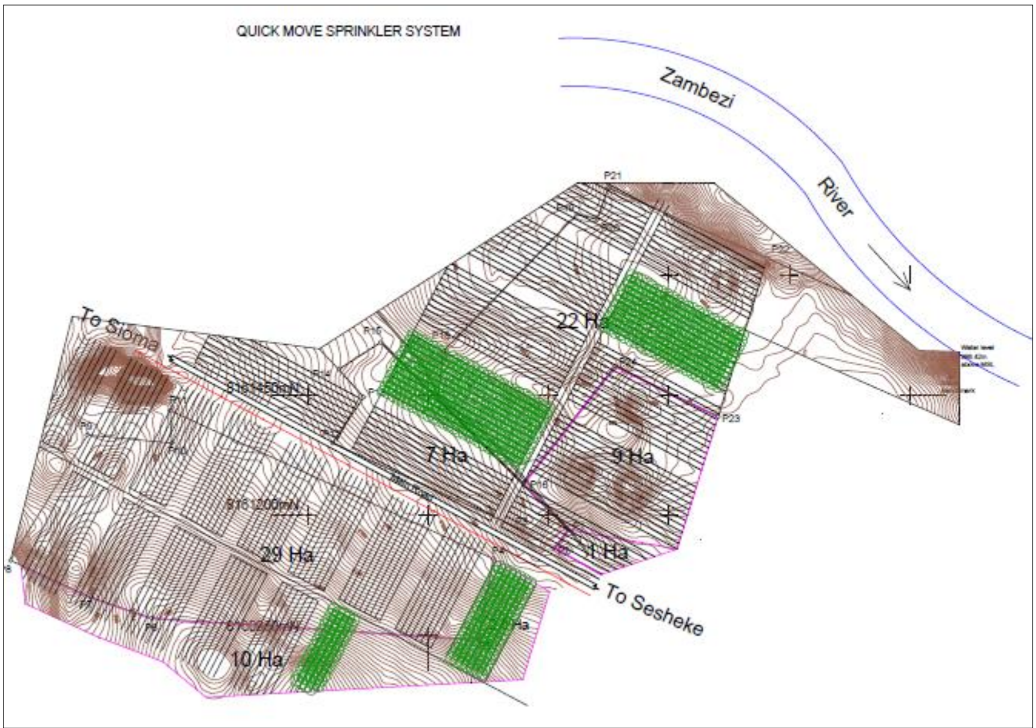


Figure 8 **Lay-Out of Sprinkler Irrigation Scheme -Drag Hose**

Sub Option (IV): Quick Move Sprinkler Irrigation System

Description of Layout

The bulk water supply and irrigation infrastructure lay out is similar to that in Sub-Option (i), and (ii) above. The pumping station is fitted with two pump units, and a control panel. From the pumping station, the water is conveyed directly to pivots through a 200-mm uPVC pipe line. However, the centre pivots are replaced with quick move sprinkler systems. To protect the pipelines from excessive operating pressure, pressure relief valves shall be installed in valve chambers located along the pipelines to centre pivots. The layout is as shown in Figure 8 (note the layout on this figure applies to both the Drag Hose option, as well as the Quick Move Sprinkler System).

Cost Estimates

The total engineers' estimate for infrastructure development for a quick move irrigation system covering the 57.8-hectares is USD **821,971.80** as shown in **Annex F** and broken down as follows:

- Intake works and Pumping station $ 366,005.00
- Conveyance pipelines (mains and sub-mains) $ 62,916.80
- Quick move infrastructure $ 393,050.00

TOTAL ***$ 821,971.80***

4.2.7 Consolidated Summary of Cost Estimates of all Irrigation Options

No	Cost Item	Irrigation Option				
		Option 2: Furrow	**Option 3: Sprinkler**			
			Sub-Option-I: Centre Pivot	**Sub-Option II: Centre Pivot/ Drag Hose**	**Sub-Option III: Drag Hose**	**Sub-Option IV: Quick Move**
1	Intake works and Pumping station	366,005.00	366,005.00	366,005.00	366,005.00	366,005.00
2	Conveyance pipelines, and night reservoirs	417,928.80	72,342.40	72,342.40	64,416.80	62,916.80
3	Irrigation and drainage Infrastructure	215,816.40	358,970.00	277,975.00	61,500.00	393,050.00
TOTAL		**999,750.20**	**797,317.40**	**716,322.40**	**491,921.80**	**821,971.80**

4.2.8 Analysis of the Irrigation Options

Eight parameters were used as basis for evaluation of the three irrigation options. These are:

(a) Resilience to effects of climate change

(b) Water management

(c) Suitability to local soil conditions

(d) Investment Cost

(e) Community Engagement

(f) Operation and maintenance

  i. Farmer Managed

  ii. Lifespan

  iii. O&M

  iv. Need for outside management

(g) Marketing and Institutional Support

The parameters were stratified by means of weights ranging from 1 to 10, where 1 signifies the Least Important / worst, and 10 the Most Important / best. The Irrigation method scoring the highest would be the best option.

Table 3 Evaluation of Irrigation Options

Evaluation Parameter	Max Weight	Irrigation Option					
		Score					
		Option-1: Rain Fed	Option-2: Furrow Irrigation	Option-3: Sprinkler Irrigation System			
				(i) Centre Pivot	(ii) Centre Pivot and Drag Hose	(iii) Drag hose	(iv) Quick Move
Resilience to effects of climate change	10	1	4	8	8	8	8
Water demand management	10	2	4	9	9	8	8
Suitability to local soil Conditions	10	2	5	9	9	8	8
Investment Cost	10	8	4	5	6	8	6
Community engagement	10	8	7	4	5	7	7
Operation and maintenance							
(a) Farmer managed scheme	10	7	5	3	4	6	6
(b) Lifespan	10	7	7	7	5	5	6
(c) O&M	10	5	6	4	5	7	7
(d) Need for outside management	10	8	6	3	3	7	7
Marketing and institutional support	10	6	6	3	4	6	6
Total	**100**	33	30	20	21	31	32

All scores indicate positive and negative impacts i.e. for without marketing and institutional support there is limited impact on traditional systems but for centre pivots there is a major impact.

2.3 Preferred Option Design

Option-1: Rain Fed

Resilience to effects of climate change: (1) this option offers no resilience to climate change.

Water demand management: (2) as this is purely rain fed there is no control over water supply

Suitability to local soil Conditions: (2) Soils are sandy with little water holding capacity, so drought stress likely in year when rain fall is sporadic

Investment Cost: (8) Traditional method with no investment cost except to expand their area.

Community engagement: (8) The community manage their fields independently.

Operation and maintenance

(a) Farmer managed scheme: (7) No O&M costs

(b) Lifespan: (7) No life span, but production declining as rain fall declines

(c) O&M: (5) No need

(d) Need for outside management: (8) No need for management but if rain fed agriculture were to develop they would require some support

Marketing and institutional support: (6) no marketing as production is primarily for household consumption. Some institutional support for provision of inputs and advice.

Option-2: Furrow Irrigation

Resilience to effects of climate change: (4) the amount of water for furrow irrigation is greater than for sprinkler systems especially on sandy soils. Although drawing water from the Zambezi should not be a limiter, pressure to reduce water utilisation could affect access to water

Water demand management: (4) this would be harder to regulate than sprinkler systems

Suitability to local soil Conditions: (5) the sandy soil conditions means that water usage would be high.

Investment Cost: (4) These are the highest at just under $1 million

Community engagement: (7) the community would have to be engaged in the management of the scheme as this is a labour intensive approach

Operation and maintenance

(a) Farmer managed scheme: (5) much of the management could be done by the farmers, but the central pumping may require additional support

(b) Lifespan: (7) this method is considered reasonably robust

(c) O&M: (6) many of the activities can be undertaken by farmers

(d) Need for outside management: (6) many of the activities can be undertaken by farmers

Marketing and institutional support: (6) a range of crops could be grown depending on the local market demand and what can be marketed outside the area. The famers would need some institutional support for seeds and advice.

Option-3 (I): Sprinkler Irrigation System Centre Pivot

Resilience to effects of climate change: (8) this approach utilises the water efficiently and would provide good climate resilience to the farmers.

Water demand management: (9) Farmers would need to be organised as there is limited flexibility to adjust water application.

Suitability to local soil Conditions: (9) Water would require to be applied on a regular basis due to the sandy soils

Investment Cost: (5) The investment costs are high and it is likely only a limited number of land owners would benefit. Additional costs would need to be covered for mechanisation.

Community engagement: (4) Community engagement would be limited as it would only benefit a few land owners.

Operation and maintenance

(a) Farmer managed scheme: (3) this is unlikely to offer the potential to be a farmer managed scheme

(b) Lifespan: (7) the lifespan can be good if managed by a competent manager, however without one its life span would be very limited.

(c) O&M: (4) for this system to work then there needs to be outside support to manage the system.

(d) Need for outside management: (3) the sourcing of a manager may be difficult due to the remote location.

Marketing and institutional support: (3) crops will need to grown in larger blocks then marketing becomes more critical.

Option-3(II): Centre Pivot and Drag Hose

Resilience to effects of climate change: (8) this approach utilises the water efficiently and would provide good climate resilience to the farmers.

Water demand management: (9) Water demand management for the main centre pivots would need to be centrally coordinated, with the small areas being controlled by the small holders.

Suitability to local soil Conditions: (9) Water would require to be applied on a regular basis due to the sandy soils

Investment Cost: (6) The investment costs are high and it is likely only a limited number of land owners would benefit. Additional costs would need to be covered for mechanisation.

Community engagement: (5) Community engagement would be limited as it would only benefit a few land owners. A few additional community members may be involved in the drag hose areas.

Operation and maintenance:

(a) Farmer managed scheme: (4) this is unlikely to offer the potential to be a farmer managed scheme

(b) Lifespan: (5) the lifespan can be good if managed by a competent manager, however without one its life span would be very limited. The drag hoses may need frequent repairs, but this can be accomplished by trained farmers.

(c) O&M: (5) for this system to work then there needs to be outside support to manage the system.

(d) Need for outside management: (3) the sourcing of a manager may be difficult due to the remote location and the small size of the irrigated area.

Marketing and institutional support: (4) as crops will need to grown in larger blocks then marketing becomes more critical. Support will have to be given to farmers to help identify markets. Limited options for subsistence cropping

Option-3(III): Drag hose

Resilience to effects of climate change: (8) this approach utilises the water efficiently and would provide good climate resilience to the farmers.

Water demand management: (8) Water would require to be applied on a regular basis due to the sandy soils, but can be managed by each plot holder depending on the crop requirements

Suitability to local soil Conditions: (8) Water would require to be applied on a regular basis due to the sandy soils

Investment Cost: (8) The initial investment costs are lower, but O&M costs are higher. As plots will be small most famers can cultivate by hand or with animal traction.

Community engagement: (7) the option would have the highest community engagement as plot sizes would have to be small.

Operation and maintenance

(a) Farmer managed scheme: (6) this would be managed by the farmers who determine their own cropping preferences.

(b) Lifespan: (5) although replacing hoses and couplings may be more frequent, famers are capable of doing this with a small amount of training.

(c) O&M: (7) this is not as necessary as with centre pivots

(d) Need for outside management: (7) this is not as necessary as with centre pivots

Marketing and institutional support: (6) a range of crops could be grown depending on the local market demand and what can be marketed outside the area. The famers would need some institutional support for seeds and advice.

Option-3 (IV): Quick Move

Resilience to effects of climate change: (8) this approach utilises the water efficiently and would provide good climate resilience to the farmers.

Water demand management: (8) Water would require to be applied on a regular basis due to the sandy soils, but can be managed by each plot holder depending on the crop requirements

Suitability to local soil Conditions: (8) Water would require to be applied on a regular basis due to the sandy soils

Investment Cost: (6) These are higher than for drag hoses, but are easier to move and adjust. They are only marginally higher than centre pivots

Community engagement: (7) more community members will benefit from small plot sizes.

Operation and maintenance

(a) Farmer managed scheme: (6) this option is suitable for management by farmers

(b) Lifespan: (6) the life span is better than for drag hoses

(c) O&M: (7) this is not as necessary as with centre pivots

(d) Need for outside management: (7) this is not as necessary as with centre pivots

Marketing and institutional support: (6) a range of crops could be grown depending on the local market demand and what can be marketed outside the area. The famers would need some institutional support for seeds and advice.

Recommended Design Option

A review of the irrigation options was undertaken to assess the system that is most appropriate for the community in Sioma, which is a remote location in Western Province of Zambia. The options considered were centre pivots for the entire area, centre pivots and drag hose irrigation for the small areas, drag hoses, a quick shift system and flood irrigation. Consideration was taken including how appropriate the irrigation systems were to be resilient to climate change, water usage, soil conditions, infrastructure costs, community engagement and marketing and institutional support. How the farmers would be able to manage the schemes, the lifespan of the scheme were also considered. Taking these all into consideration it is recommended that a *drag hose system should be the preferred option*. This will offer a system that can be managed by the local farmers, will enable a range of different crops for home consumption and for marketing to be grown and will provide livelihoods to the largest numbers of beneficiaries. Centre Pivots were considered inappropriate as they would require support from a farm manager who would have to be recruited, would only benefit a limited number of individuals and would exacerbate marketing problems as large quantities of a limited number of crops would be grown that would require specific marketing arrangements. These proposals were put to the community in early November 2015 and were endorsed by the community at a separate meeting where the community were free to discuss the proposals put to them without interference of the design team.

2.4 Operation and Maintenance Plan

As discussed above, it is recommended that a drag hose irrigation system be installed, as this would be the easiest for the farmers in terms of Operation and Maintenance. However even this system will require the farmers to form a committee to ensure that funds are collected to cover the recurring O&M costs.

The committee will have to manage the operation of the pumps, including collecting funds to cover the electricity costs. This role should be given to a member, with some small remuneration. Failure to collect funds from all of the members will lead to the Project quickly collapsing so there must be strong commitment from all of those that have sought plots, with options of replacing those that do not comply with the rules and regulations. An option to control debt is the use of prepaid meters, which are topped up on a daily basis by those that will be receiving their water allocation for the day.

A period of support will be required to establish these systems and ensure that the members fully understand them. Some working capital should also be made available at the start to cover the initial costs until harvesting and sale of some crops have been achieved.

Fuller consideration needs to be given to the support that will be required to be given to the farmers so that they can establish themselves into a functioning unit.

The Government, through various ministries, will continue to provide vital services in areas of agricultural extension, health, education, environment, recreation, gender, and water resources management.

2.5 Identification of Permits Required

The permits required for the Projects are as follows:

(i) The Environmental Impact Assessment (EIA) authorisation. The EIA process as outlined in the EIA Regulations, S.I. No.28 of 1997. According to the EIA regulations, since the proposed project Irrigation project covers an area of 50 Ha or more, a full EIA is required. The application is done at the Zambia Environmental Management agency.

(ii) Water Permit: Water use is regulated by the Water Resources Management Act No.21 of 2011. Under the act a permit is required for abstraction of water for various water uses that includes irrigation. Application for the water permit is done at the Water Resources Management Authority.

2.6 Production Systems and Cropping Schedule Analysis and Recommendations

Land and Soils

The area covered by the proposed project (see Figure 4) is fairly uniform and even. The area lends itself to trickle or overhead application of water on most areas. All the land for irrigation lies upstream of the selected lifting and abstraction point, meaning that mechanical lift is required for water application.

The topography is generally even and with average slope about 1%. The need for adequate soil conservation measures to be put in place is therefore critical, although the land will have a good natural soil cover due to the crop.

Soils

The dominant suitable irrigable soils in the project and their physical properties are summarised in Table 4. There is minor soil variability across the proposed irrigation scheme. The soils are in the main Kalahari sands, with pockets of loams. This is to be confirmed by a soil survey.

Table 4 Soil types for Sioma

Soil type	Soil depth	Available soil moisture	Readily available moisture	Effective root depth	Total available moisture	Theoretical cycle	Suggested cycle	Suggested stand time
Units	cm	Mm/m	Mm/m	mm	mm	days	days	Hours
Factor			50%			6.5		

Sand	>100	80	50	600	24	3.7	4	6
Loamy sand	>100	80	50	600	24	3.7	4	6
Sandy loam	>100	<100	65	600	39	6	5	10

Land Conservation

The SIS lies in an area where land slope is around one percent. The area has sandy soils, which are prone to erosion. Cultivated land will thus have a high risk of erosion therefore it is important that particular attention be given to soil protection measures. The soil conservation measures serve three purposes, namely to:

i. Conserve the soil;
ii. Promote water infiltration into the soil; and
iii. Regulate run-off resulting from rainfall/irrigation.

A number of ways used singly or in combination will help achieve the above, as in the following:

i. planting crops along the contour;
ii. constructing contours at appropriate intervals, as facilitated by the scheme design

These practices are proven technology that has been used elsewhere with success. Broad based contours on land with less than 5% slope are recommended. A 2-metre wide channel, 0.3 metres deep will suffice. No trees should be planted in the channel to allow for safe disposal of runoff.

Individual pieces of land shall be treated on their own merits. The vertical interval between contours will depend on such factors as slope, soil type, and probability distribution of rainfall intensity. In all cases the services of a conservation expert must be sought for design of appropriate works. Required conservation works should be indicated on a layout drawing of the scheme as part of the design.

Agricultural Development Plan

A wide range of crops are currently grown around the Sioma area. This is consistent with the diverse climatic conditions that prevail in the low altitude area, as well as the subsistence nature of agricultural practice. Due to scarcity and variability of rainfall, farmers fail to produce a viable yield under dry-land farming conditions in most years.

Cropping

At present most of the crops are grown under rain-fed conditions, with some small irrigated gardens for vegetables on the Zambezi River banks. Crops that are grown in the project area include, bananas, maize, sugar beans, sorghum, millet, groundnuts, paw paws and various leaf vegetables / fresh crops like cabbages and tomatoes in gardens near the Zambezi River. Figure 9 is an example of a small banana

garden at the Sioma Village at the District Commissioners (DCs) offices.

Figure 9 **Banana and Paw paws in garden at District Commissioners offices**

Since the project concept for the area was conceived on the premise of crops that are best suited to irrigation, farmers were consulted on the types of crops they wanted to grow. Table 5 indicates crop preferences by crop family.

Table 5 Preferred crops by crop family

Crop family	Preferred crops for irrigation	Cultivation Scenario
Cereals/ grasses	Maize, Wheat, Barley	Rotation crop in summer and winter
Legumes	Beans, groundnuts, peas, soybeans.	Legumes for rotation and fertility build up
Solanum	Potatoes, tomatoes, okra, egg plant	Potato is a possible main anchor crop if a good market can be established. Staggered planting of 2 ha every month to even out supplies and avoid market saturation

Oilseeds	Sunflower, cotton, soybeans	Optional crops for rotations
Citrus	Oranges	Planted on boundaries of irrigated fields
Tropical fruits	Banana, pawpaw	
Leaf vegetables and other fresh crops,	Carrots, cucumber crops, tomatoes, Cabbage, Kale, Cauliflower, spinach, Onions, Garlic	Household crops that will be used for home consumption and sold on the local market

The general preference of other crops includes maize, a major staple food crop, sugar beans, wheat, tomatoes and leaf vegetables.

Whilst potatoes were viewed as an interesting crop, farmers are concerned about the marketing channels and sites, given the distance from major centres and fluctuating potato prices on the markets and hence are uncertain about its future. However they remain committed to the project objectives regardless of the current state of affairs.

The farmers in the meetings expressed an interest to operate as separate individual farms where each farmer is independent of others.

This would suggest that there would be quite a range of crops grown each season. The irrigation will supplement normal precipitation during each rainy season. The scheme could base their cropping programmes on the following indicated crops in Table 6. In place of sugar beans, Michigan pea beans and peas are also recommended as winter crops.

Table 6 Suggested crops and varieties for annual production planning

Season	Recommended crops
Summer	Potatoes, Groundnuts, Maize, Sugar beans, soybeans, Leaf vegetables
Winter	Michigan pea beans, peas, Sugar Beans, Wheat, Barley, Oats, Vegetables, Green mealies, (late winter)

Crop Management Practices

This section presents general crop husbandry principles applicable to the range of crops likely to be grown in the scheme.

- *Land preparation*

Oxen are extensively used at present for cultivation of land. As the soils are sandy then ploughing is easier than on heavy land. Most households own oxen and so this will be the most appropriate form of cultivation in the scheme. Ox carts are also common and this will form the main means of transportation to the road or the nearby town of Sioma for local marketing.

- *Seeds /Seedlings*

Whilst farmers are generally aware of the need to use certified seed in most crops, some of them continue to plant non-certified seeds in their fields. The issue of cost and sometimes unavailability were cited as the major reasons for this. It is recommended that farmers use certified seed of varieties suited to their areas as recommended by the local extension personnel. The provision of inputs has taken away commercial approaches and initiatives from farmers. Extension support will be required to build this resilience.

It is also important to match the quantity of seed procured with the area to be planted so that the correct plant population can be achieved. For plantation crops, it is important to source well raised seedlings of the correct variety for the area. The inputs support scheme from agencies and working partners of MAL is providing assistance in this regard and it is recommended that farmers use this facility. The company also provides technical advice on plantation crops.

- *Fertilization*

Currently although all farmers interviewed do use limited amount of fertilisers, it seems quantities applied are below recommendations because of costs. Most farmers do not use chemical pesticides and herbicides.

Fertilizer is an expensive input, which farmers cannot do without. It is therefore important that the right type is sourced in correct quantities that match the size of land and crop on which it is to be applied. In most cases the extension department has general recommendations for the area which farmers should make use of. However, should farmers wish to get land specific recommendations, soil samples must be sent for analysis to reputable laboratories for analysis. This should be part of the start up costs of the scheme.

The Fertiliser Support Program (FSP) is a potential scheme for provisioning of inputs.

Although water stress is less likely because of the availability of water, it would be appropriate to build up the organic content of the soil. This will ensure that crops can handle periods when water may not be available due to break down of irrigation equipment. It will also promote healthier plants that can tolerate pests and diseases more successfully.

- *Weed Control*

It is important to control weeds in all crops to minimise competition for nutrients. Weeds may also harbour pests. Control can be manual, mechanical or through chemical means. The method used will depend on the extent of the problem and also the economics of engaging such a practice. However, the irrigation scheme will necessitate improvements in this area, particularly as this may need to be tied in with mechanisation.

- *Pest and disease control*

This aspect is critical in the production of potatoes and horticultural crops like tomatoes. The all year round humid conditions coupled with the evergreen vegetative environment from the irrigation are conducive to the prevalence of some diseases and pests hence the need to secure the right type of chemicals in adequate quantities to control relevant pests and diseases.

The sandy soils in the project area are subject to root-knot nematodes (*Melodogyne spp*). The solanaceous crops are particularly susceptible, hence the 4 year rotation proposed. There are also indications of termites in some parts of the fields.

Crop Performance

Current crop yields in the Sioma, Zambezi Valley are very variable. However average yield data collected by MA over the years indicates that there is a wide gap between what farmers are currently realising and what could be realised under good management. There is wide room for improvement for all crops.

The main reason for getting below optimum yields was widely cited as lack of inputs particularly seed, fertilisers and chemicals. In some cases, lack of irrigation facilities was observed as one of the factors limiting attainment of optimum yields. Table 7 shows rough estimates of current average yields by crop from interviews with farmers, and those envisaged under optimum management conditions.

Table 7 : Estimates of current crop yields under those expected under optimum management.

Crop	Current Average Yield (kg/ha)	Expected Yields (kg/ha)
Maize	1200	7000
Sugar beans/ soybeans	No estimate	1800
Potatoes	Not applicable	25 000
Wheat	Not applicable	5500
Sunflowers	Not applicable	2500
Groundnuts	600	2500

It is expected that the yields obtained by farmers, shall increase with time as they get more experience with the crops and the irrigation system. The training programme will also contribute to improved yields.

Access to credit

Focused group discussions during the site visit of 27-28th November 2014 with the potential beneficiary farmers showed that one of the important factors constraining agricultural production is limited access to farm inputs, and by inference, finance. This results in limited use of improved seed, fertilizers or chemicals. The incidence of pests and diseases affects both yields and quality of end products, resulting in less incomes accruing to the farmers.

Evidence abounds from experience that correct fertilizer use alone can result in significant yield increases. This underscores the need for farmers in the proposed scheme to have access to adequate quantities of inputs in time for requisite cultural operations. This can be achieved through deliberate farm input support arrangements for the scheme. Various schemes could be tried to impact positively on agricultural production.

Food Reserve Agency

- *Other crops*

FRA is one of the many institutions through which GRZ implements input support programme for various commodities. In view of the importance of crops such as maize, wheat, soya beans and sugar beans all of which farmers said they wished to grow under irrigation, input support should be accessible through this channel. Available inputs include seed, fertilizers, chemicals and packaging materials. Experience has shown that the efficiency and effectiveness of the scheme is low, as inputs are supplied late, and farmers do not always get full requirements.

Proposed Cropping Programme

Irrigation will even out water supplies to the land in the irrigated area throughout the year. This makes it possible to introduce new crops in the area, which would otherwise be high risk without an assured water supply, and also improves on the production of existing crops. Table 8 and Figure 10 indicate the crops and cropping programme recommended for the scheme. This builds upon farmer's preferences, but also being cognisant of the cultural limitations. These crops are justified for the project on the following grounds.

i. The grains, maize and wheat are staple food crops on which government maintains strategic reserves. Thus, a stable market exists on these crops, with base prices offered by millers.
ii. Sugar beans have a steady market throughout the year.
iii. Soybean has a local and export market for the oil and stock feeds Industry. It is also good for rotation with wheat.
iv. The main crops have a long shelf life to reduce losses due to spoilage
v. Horticultural crops, primarily edible crops are important for local consumption. For planning purposes, vegetable production was limited to 5 % of the land because of the perishable nature of these crops, fluctuating prices on the market currently in existence, and general quality requirements on the market which farmers are unlikely to meet at an early stage in the project.
vi. Potato is a crop to be introduced in the area to promote industries.
vii. The recommendation for plots to be bordered with banana plants should be adopted on project implementation. Benefits of environmental management and fruit supply need to be weighed against the likely problem of rats that bananas might cause. A cost must be allowed for this item in the costs estimates and bill of quantities.

Cropping Programme

The suggested crops were used to devise a cropping programme, used for estimation of crop water requirements. This cropping programme is not fixed for all production, but is the base for planning. After project implementation, farmers will draw up relevant annual production plans, keeping in mind market requirements for agricultural products at that time.

The proposed cropping programme for planning takes into account sustainability of production through use of correct rotations and cultural practices to reduce soil degradation and avoid build-up of pests and diseases. Farmer's experience on some of the crops like maize will contribute to the success of the project, especially during the early stages. Figure 10 shows the proposed cropping programme.

Crop Rotations

The basic winter crop is wheat with mixed vegetables as an option. Hence the cropping programme has two systems, one for the wheat crop and one for the potato crop. The basic rotation is shown on the cropping calendar in Figure 10 and Table 8. The four lines in the program entail a sub-division of land into 4 blocks to accomplish rotations.

The practices on cropping were sourced from the Zambian Farm Management Handbook, Oil Seeds Production Handbook, the Grain Production Handbook, and the Cereal Production Handbook.

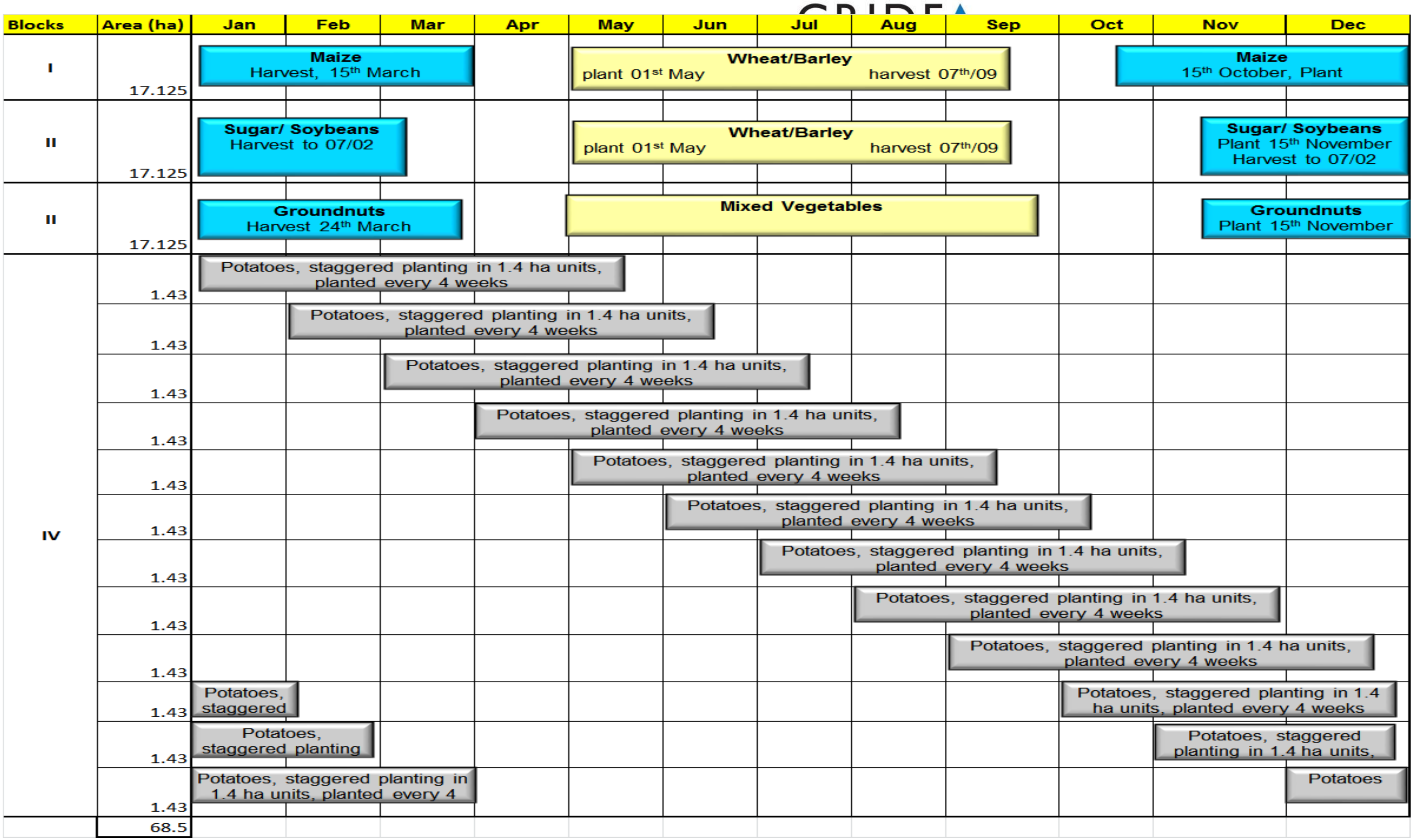


Figure 10 **Cropping Programme and Rotations**

Table 8 Proposed crop rotation for Sioma Irrigation Scheme

Blocks Number	Area	% of total area	Year1		Year2		Year3		Year4	
			Summer	Winter	Summer	Winter	Summer	Winter	Summer	Winter
I	14.45	25%	Maize	Wheat/ Barley	Sugar beans or Soybeans	Wheat/ Barley	Groundnuts	Other vegetables or Green maize	Potatoes	Potatoes
II	14.45	25%	Potatoes	Potatoes	Maize	Wheat/ Barley	Sugar beans or Soybeans	Wheat/ Barley	Groundnuts	Other vegetables or Green maize
III	14.45	25%	Groundnuts	Other vegetables or Green maize	Potatoes	Potatoes	Maize	Wheat/ Barley	Sugar beans or Soybeans	Wheat/ Barley
IV	14.45	25%	Sugar beans or Soybeans	Wheat/ Barley	Groundnuts	Other vegetables or Green maize	Potatoes	Potatoes	Maize	Wheat/ Barley
Total	57.8	100%								

Target yields under irrigation

The target yields for production are based on current levels in other schemes in the area, and on farmers' current production. Table 9 shows the target yields for optimum conditions after introduction of irrigation.

Table 9 Planting and harvesting dates and anticipated yields for crops

Crop	Planting Date	Harvest Date	Period (Days)	Yield (T/Ha)	Market Unit	Ha Units
Wheat	Early May	Early Oct	150	4	50 kg	80
Gr/maize	Early Oct	Late Mar	150	5	50 kg	100
Soya	Mid Nov	Late Mar	125	2	50 kg	40
D/beans	Early Jan	Early Apr	120	2	50 kg	40
Potato	Mid Oct	Late Feb	140	25	15 kg/pkt	1500
Onions	Early Apr	Mid Sept	180	30	15 kg	2000
Banana	Varies	Varies	380	20	kg	20000
Tomato	Early Apr	Mid July	120	25	15 kg	1666

The earnings are given in Table 10, with the following assumptions.

Assumptions on Budget

1. The ZMK to USD has been on a declining rate from 2006. See http://www.xe.com/currencycharts/?from=ZMK&to=USD&view=10Y,
2. Prices for commodities quoted in ZMK
3. Sources of prices include http://www.farmprices.co.zm/index.php
4. 1 USD = 7,454.00 ZMK
5. Assume 200% cropping achieved
6. Conservative estimates of yields applied
7. Distance to markets factored in by narrowing margins between crop revenue and productions costs

Table 10 Earnings per hectare

Crop	Land Allocation %	Yield	Unit	Unit price ZMK	Gross Income	Variable costs factor	Variable Costs	Gross Margin/ha
Maize	25%	5	tonnes	1 250	6 250	0.800	5 000	1 250
Sugar/ Michigan Beans	25%	2	tonnes	2 500	5 000	0.700	3 500	1 500
Wheat/Barley	25%	4	tonnes	3 500	14 000	0.850	11 900	2 100
Soya Beans	25%	2	tonnes	2 600	5 200	0.700	3 640	1 560
Potatoes - Summer	25%	25	tonnes	745	18 635	0.850	15 840	2 795
Potatoes - Winter	25%	25	tonnes	745	18 635	0.850	15 840	2 795
Groundnuts	25%	3	tonnes	2 800	8 400	0.700	5 880	2 520
Other crops - Vegetables								
Green Mealies	5%	30000	cobs	0.10	3 000	0.650	1 950	1 050
Leaf vegetables and tubers (crucifers, carrots, etc)	5%	25	tonnes	1 100.00	27 500	0.800	22 000	5 500
Tomato	5%	25	tonnes	1 100.00	27 500	0.800	22 000	5 500
Onions - Dry	5%	30	tonnes	1 200.00	36 000	0.800	28 800	7 200
Total income per hectare					170 120		136 350	33 771

Prices from http://www.farmprices.co.zm/index.php

Irrigation Water Requirements

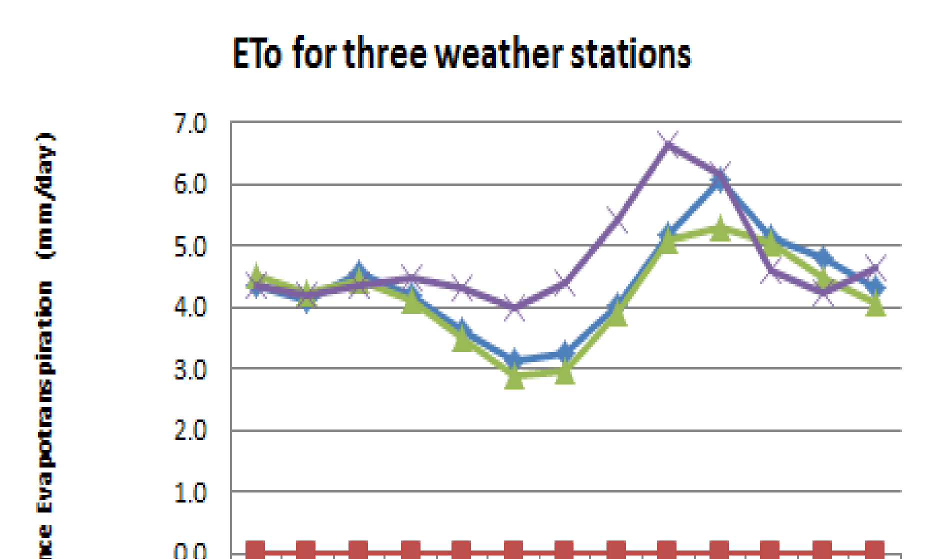
Crop water requirements were estimated for the project based on the cropping programme. The Penman-Monteith method was used for calculation of ETo, based on long term data available in ClimWAT. The summary of the crop water requirement (CWR) calculations for Sesheke is given in Table 11, and those for Mongu and Livingstone in Figure 11. The following criteria were applied:

i. Monthly data were used for estimation of irrigation water requirements
ii. Crop factor values were taken derived from FAO publication 24 and other relevant literature
iii. Those crops with the highest demand for water expected to be planted are used in the estimate of crop water requirements;
iv. The estimated is weighted based on the area occupied by the crop
v. An adjustment factor of 1.1 was applied
vi. On the cropping programme 50% of land is allocated to wheat 25% to potatoes and 25% to combinations of vegetables and green mealies. For calculation of water requirements, it is assumed 75% of land is under wheat crop.
vii. Where a crop fills part of the month in planting or harvest, it has been the CWR estimate is for the whole month, except for potatoes in April
viii. Effective dependable rainfall was calculated using the FAO/ALGW method, which tends to be more conservative than the United States Department of Agriculture (USDA) Soil Conservation Service (SCS) method. This lowered the total effective rainfall by some 75% for Sesheke and Livingstone, and 91% for Mongu. The effect is to increase the hydro-module.
ix. Leaching requirements were not included as no chemical soil analysis for electrical conductivity was conducted. Also upward flow into the root zone excluded due to the predominant sandy texture of the soil.
x. Due to the sandy soils of the area that would require frequent light irrigations, the method of irrigations is assumed to be sprinkler or drip. Although sprinkler with a centre pivot are potentially easier to manage and more efficient, for this project they are not the preferred option. For this reason the efficiency of 75% was adopted for drag line sprinklers.
xi. Effects of wind would be managed by the real-time scheduling and the planting of fruit trees around the boundaries of the irrigation blocks.

Due to lack of data at Sioma, three estimates were done for Mongu, Sesheke and Livingstone, for the same cropping programme. The summary of the results for Reference crop Evapotranspiration (ETo) and Crop Evapotranspiration (ETc) are presented in Figure 11.

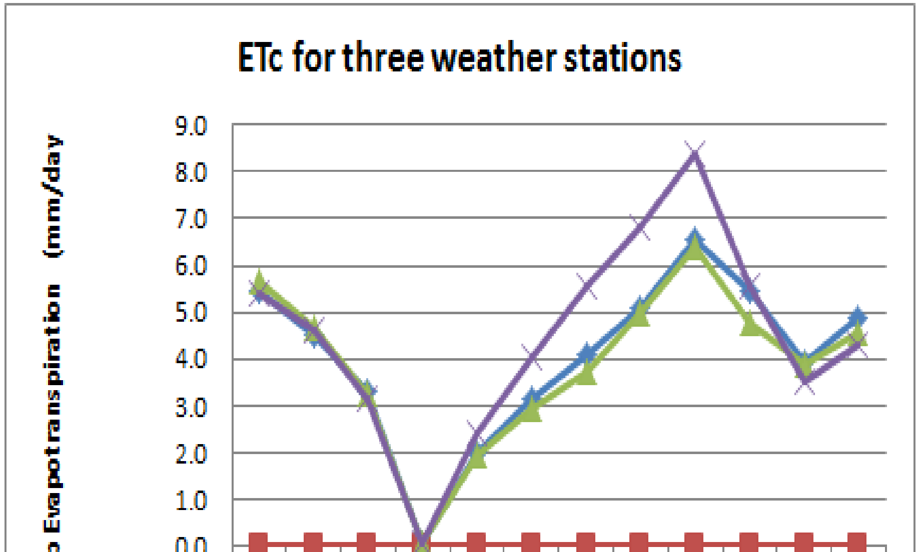
A peak **ET_c of 6.5 mm/day** is proposed for Sioma Irrigation Scheme for design purposes, based on the Sesheke and Livingstone weather data and derivations. The net estimated demand is **10 133 m^3/ha** for the scheme. A gross of **13 511 m^3/ha/annum** is required at 80 % efficiency of sprinkler irrigation, equivalent to a flow of **1.0 litre/s/ha** occurring in September and total scheme demand of **925 504 m^3/annum**.

For surface application, which is **not** recommended, the gross requirement is **20 267 m^3/ha/annum** at 50 % efficiency, and a flow of **1.5 litres/s/ha**, for a total scheme demand of **1 388 290 m^3/annum.**



	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
Livingstone	4.4	4.1	4.6	4.2	3.6	3.1	3.2	4.0	5.2	6.1	5.1	4.8	4.3
Sioma	0	0	0	0	0	0	0	0	0	0	0	0	0
Sesheke	4.5	4.2	4.4	4.1	3.5	2.9	3.0	3.9	5.1	5.3	5.1	4.5	4.1
Mongu	4.3	4.2	4.4	4.5	4.3	4.0	4.4	5.4	6.6	6.1	4.6	4.2	4.6

(a) Peak ETo in September and October



	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Livingstone	5.5	4.5	3.3	0.1	2.0	3.2	4.1	5.1	6.6	5.5	3.9	4.9
Sioma	0	0	0	0	0	0	0	0	0	0	0	0
Sesheke	5.7	4.7	3.2	0.1	2.0	2.9	3.7	5.0	6.4	4.8	3.9	4.6
Mongu	5.4	4.6	3.2	0.1	2.4	4.0	5.6	6.8	8.4	5.5	3.5	4.3

(b) Peak ETc in September for three stations for the proposed cropping programme

Figure 11 **Evapotranspiration estimates for three stations**

Other weather data suggest that the higher peak for Mongu is attributable to the higher wind speed experienced in the area

Table 11 Crop water requirements for Sesheke (Interpolated for Sioma Irrigation Scheme)

MONTH-------->	% area	January	February	March	April	May	June	July	August	September	October	November	December	Total
ETo (mm/day) - ***Sesheke***		4.52	4.24	4.44	4.10	3.50	2.88	2.95	3.92	5.07	5.30	5.06	4.46	
Days		31.00	29.00	31.00	31.00	30.00	30.00	31.00	31.00	30.00	31.00	30.00	31.00	366.00
ETo (mm/month)		140.12	122.96	137.64	127.10	105.00	86.40	91.45	121.52	152.10	164.30	151.80	138.26	1538.65
k_c values														
Grain maize	25%	1.15	0.60	0.35							0.45	0.60	0.95	
Groundnuts	25%	1.10	1.10	0.60								0.55	0.90	
Sugarbeans/ Soybean	25%	1.15	1.15	0.55								0.50	0.90	
Potatoes - Summer	25%	1.15	1.15	1.15	1.15						1.15	1.15	1.15	
Potatoes - Winter	25%					1.15	1.15	1.15	1.15	1.15				
Wheat/Vegetables/Mealies	75%					0.30	0.85	1.15	1.15	1.15	0.56			
ETc (mm/month)														
Grain maize	25%	161.14	73.78	48.17	0.00	0.00	0.00	0.00	0.00	0.00	73.94	91.08	131.35	579.45
Groundnuts	25%	154.13	135.26	82.58	0.00	0.00	0.00	0.00	0.00	0.00	0.00	83.49	124.43	579.90
Sugarbeans/ Soybean	25%	161.14	141.40	75.70	0.00	0.00	0.00	0.00	0.00	0.00	0.00	75.90	124.43	578.58
Potatoes - Summer	25%	161.14	141.40	158.29	9.74	0.00	0.00	0.00	0.00	0.00	188.95	174.57	159.00	993.09
Potatoes - Winter	25%	0.00	0.00	0.00	0.00	120.75	99.36	105.17	139.75	174.92	0.00	0.00	0.00	639.94
Wheat/Vegetables/Mealies	75%	0.00	0.00	0.00	0.00	31.50	73.44	105.17	139.75	174.92	92.01	0.00	0.00	616.78
Corrected ETc (mm/mon)														
Grain maize	25%	177.25	81.15	52.99	0.00	0.00	0.00	0.00	0.00	0.00	81.33	100.19	137.91	630.83
Groundnuts	25%	169.55	148.78	90.84	0.00	0.00	0.00	0.00	0.00	0.00	0.00	91.84	130.66	631.66
Sugarbeans/ Soybean	25%	177.25	155.54	83.27	0.00	0.00	0.00	0.00	0.00	0.00	0.00	83.49	130.66	630.21
Potatoes - Summer	25%	177.25	155.54	174.11	10.72	0.00	0.00	0.00	0.00	0.00	207.84	192.03	166.95	1084.45
Potatoes - Winter	25%	0.00	0.00	0.00	0.00	132.83	109.30	115.68	153.72	192.41	0.00	0.00	0.00	703.93
Wheat/Vegetables/Mealies	75%	0.00	0.00	0.00	0.00	34.65	80.78	115.68	153.72	192.41	101.21	0.00	0.00	678.46
ETc Peak (mm/day)		5.66	4.66	3.24	0.09	1.97	2.93	3.73	4.96	**6.41**	4.78	3.90	4.57	
Add leaching requirement														
Add drainage requirement														
Effective Rainfall (mm/mon) (FAO/AGLW method)		**112.00**	**113.60**	**55.20**	**5.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**5.60**	**26.60**	**108.80**	**426.80**
Irr.req(mm/month)														
Grain maize	25%	65.25	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	75.73	73.59	29.11	243.68
Groundnuts	25%	57.55	35.18	35.64	0.00	0.00	0.00	0.00	0.00	0.00	0.00	65.24	21.86	215.46
Sugarbeans/ Soybean	25%	65.25	41.94	28.07	0.00	0.00	0.00	0.00	0.00	0.00	0.00	56.89	21.86	
Potatoes - Summer	25%	65.25	41.94	118.91	5.72	0.00	0.00	0.00	0.00	0.00	202.24	165.43	58.15	657.65
Potatoes - Winter	25%	0.00	0.00	0.00	0.00	132.83	109.30	115.68	153.72	192.41	0.00	0.00	0.00	703.93
Wheat/Vegetables/Mealies	75%	0.00	0.00	0.00	0.00	34.65	80.78	115.68	153.72	192.41	95.61	0.00	0.00	672.86
Irr. req (mm/ha/month)		63	30	46	1	59	88	116	154	192	141	90	33	1013
Irr. req (m^3/ha/month)		633	298	457	14	592	879	1157	1537	1924	1412	903	327	10133
Gross irr.req [m^3/ha]														
80 % Efficiency	0.8	792	372	571	18	740	1099	1446	1922	2405	1765	1129	409	13511
50 % Efficiency	0.5	1267	595	913	29	1184	1758	2314	3074	3848	2824	1806	655	20267
Net flow [l/s/ha]		**0.24**	**0.11**	**0.18**	**0.01**	**0.23**	**0.34**	**0.45**	**0.59**	**0.74**	**0.54**	**0.35**	**0.13**	
Gross flow [l/s/ha]														
80 % Efficiency		0.33	0.15	0.23	0.01	0.30	0.45	0.60	0.79	**0.99**	0.73	0.46	0.17	
50% Efficiency		0.49	0.23	0.35	0.01	0.46	0.68	0.89	1.19	**1.48**	1.09	0.70	0.25	

Marketing Plan

Formally structured and functional agricultural markets are vital for the success of irrigation schemes for sustained rural economic growth. Such markets would comprise the entire marketing chain of infrastructure, operating rules, and information systems that lower transaction costs and risks. Such a market situation does not exist for Sioma Irrigation Scheme. Hence, a concerted effort must be made to assist and develop the farmers in marketing as they embark on irrigation.

Among other factors, a long term view of the project from a marketing perspective is required. Hence the suggestion of an anchor crop from which possible value addition local industries could develop in the area. This must of course be possibly coupled with further plans to expand irrigated area in the Region to provide feedstock for the nascent industries. The marketing plan proposed herein serves as a guideline in achieving this objective.

Market Structure

Zambia's agricultural sector is characterized by an inherent dichotomy in agricultural marketing, with smallholder traders facing an underdeveloped *informal* marketing system, and the more advanced large-scale traders and processers being part of a *formal* marketing system. While the formal system provides a broader set of risk management and mitigation mechanisms (such as commodity exchanges, forward contracting, and advanced storage technology), the informal sector, with which most of the smallholder farming community is associated, does not have such linkages. Improved access to these hedging facilities and linkages with local and international commodity exchanges can bolster agricultural marketing in Zambia (*Tembo et al*).

The market requirements for all most all produce from Sioma Irrigation Scheme can fit into this framework.

The primary producer is the Sioma Irrigation scheme. Processors could be millers for grains, crisps and frozen food producers for horticultural crops, drying, storage and packaging facilities for products like beans, onions and garlic.

The major consideration is to identify the role and level at which the producers operate for the different crops to be produced. The attached matrix gives suggestions for Sioma.

Marketing Constraints

The following marketing system constraints were identified during gathering of primary project data, viz:

- Lack of reliable transport in the Sioma, Zambezi Valley area. Any produce marketed outside the area must be transported by hired trucks;
- Good road condition in the area to Livingstone, but long distances to markets

- Limited consumption market in the local area due to small population and the large production base from the area, depressing prices locally; and
- Increased competition among small-scale producers who produce similar types of crops in different parts of the country
- Lack of market information

The interventions on marketing as the project evolves must address the above and other to be identified constraints.

The crops, which farmers will produce in the scheme are aimed at improving farmers' income through produce sales. It is envisaged that the crops will be marketed through some of the avenues described in Figure 12 and Table 12.

Figure 12 **General scheme for agricultural marketing**

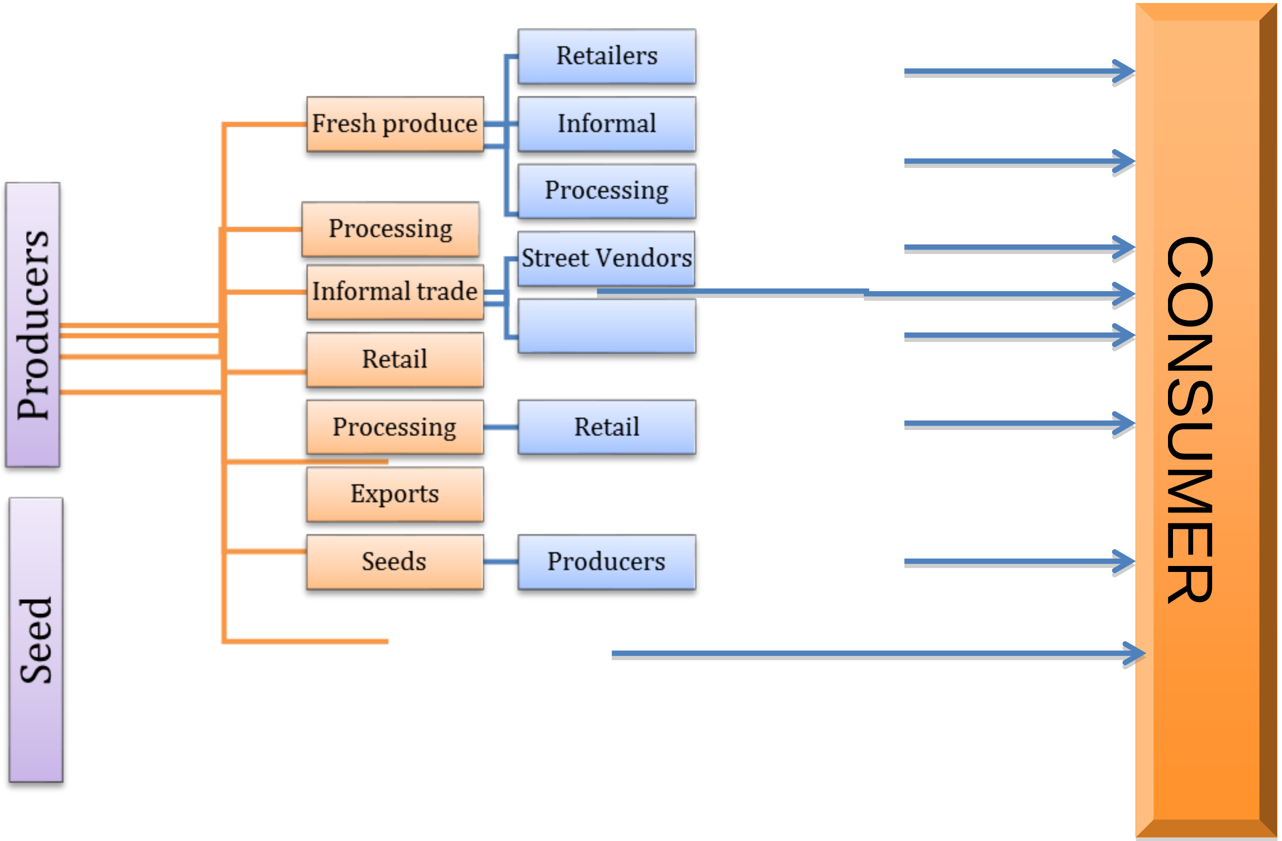


Table 12 Proposed marketing avenues for crops

No	Crop	Characteristics	Comments on crop	Suggested markets
1	Potatoes	Medium shelf life	Potatoes are mainly grown in rotation with maize and wheat. Planting of the crop can be done throughout the year at Sioma. There is a continuous supply and demand of potatoes throughout the year. The potato industry contributes the following to the economy: Creation of job opportunities Large downstream and upstream effect through industry linkages Export earnings for the country Empowerment of traders in the informal sector Food to neighbouring countries Improved welfare of the population through productivity increases Opportunities for emerging small-scale farmers Income generation in small towns and rural areas	• Fresh produce markets through formal and informal routes locally and to urban centres, undertake own packaging, branding, • Processing into products like crisps and frozen chips for local industry development at Sioma village
2	Maize	Long shelf life	Due to the current small land sizes and tillage problems, not many farmers produce enough grain for year-round family needs. Intra-household maize distribution would ensure food security among families in and outside the schemes.	• Food Reserve Agency (FRA) • Millers
3	Wheat /Barley	Long shelf life	Wheat has a market with millers and is a crop that is fully supported by the Government input programme. There is local demand for smaller quantities, as more and more families prefer to bake their bread at home	• Millers • Local consumption

No	Crop	Characteristics	Comments on crop	Suggested markets
4	Groundnuts	Can be sold as fresh or dry Long shelf life	Local knowledge to produce crop exists among the farmers.	• Process to extract oil • Process for peanut butter for sale within and outside Sioma
5	Soybeans	Long shelf life	Export crop for oil extraction and stock feeds Mechanical equipment for harvesting required should large area be cultivated	• Process facilities for oil extraction and feed formulation • External markets/ Export
6	Sugar beans	Long shelf life	There are a number of private commercial companies and individual traders that buy beans for resale in towns. Experience with large irrigation schemes reveals that these companies offer competitive prices. The local market is also very strong with the crop being the main source of protein for many households.	• Local consumption for nutrition and protein supplement • Markets external to Sioma • Packaging industry at Sioma possible
7	Mixed vegetables and green maize	Short shelf life	Onions can be dried to achieve long shelf life for sale in other areas Leaf vegetables supplement food range. Ready markets are locally available at growth points, towns and cities. This applies to all other types of horticultural products grown by farmers. Green maize - This crop can realize high returns if marketing is done efficiently. Marketing can be done on the roadside on day-to-day basis in the local area	• Local consumption for nutrition and protein supplement • Markets external to Sioma

3. Technical Analysis of Potable Water Supply Scheme

At the time of CRIDF's site mission in November 2014, Malombe was being served by two sources of water, namely river and borehole sources. The borehole was drilled under the National Rural Water Supply and Sanitation Programme (NRWSSP) in the period 2010 - 2012 and is equipped with an Indian MK hand pump. At the time of the visit, the pump was operational and was used for domestic purposes. The majority of the community use river water for both domestic and bathing purposed due to the fact there is only one borehole in the area and they have to walk long distances to fetch potable water. The water from the river is prone to pollution and has greatly contributed to the high water borne disease outbreaks in the area.

Sioma was given a district status two years ago and a township layout plan had been developed. The survey revealed that Malombe community will lie just 2 kilometres from the proposed township boundaries. Though the situation may impact positively on the viability of the proposed irrigation scheme, it also has a negative effect on the encroachment of the community. The growth of Malombe may dissolute into unplanned peri-urban settlement.

In light of the foregoing, CRIDF decided to undertaken pre-feasibility study to upgrade the potable water supply to Malombe community. The provision of such a supply would also negate the risk of the community using the water supply from the irrigation scheme for drinking purposes.

3.1 Options Analysis

A technical pre-feasibility assessment for the infrastructure development was conducted for the provision of potable and sustainable water supply to the Malombe community. The objective of this task was to:

- Undertake water resource planning protocol to assess the possible water resource augmentation option available
- Analyse the status of the existing water infrastructure, including the aspects of capacity, performance and condition
- Identify various technical options required to meet with the project objective and then analyse the Description of Options Considered

Two infrastructure development options were considered for supplying water to the Malombe community based on two water sources namely ground and surface. The options are outlined below, and were assessed according to the following criteria:

- System design
- Cost
- O&M

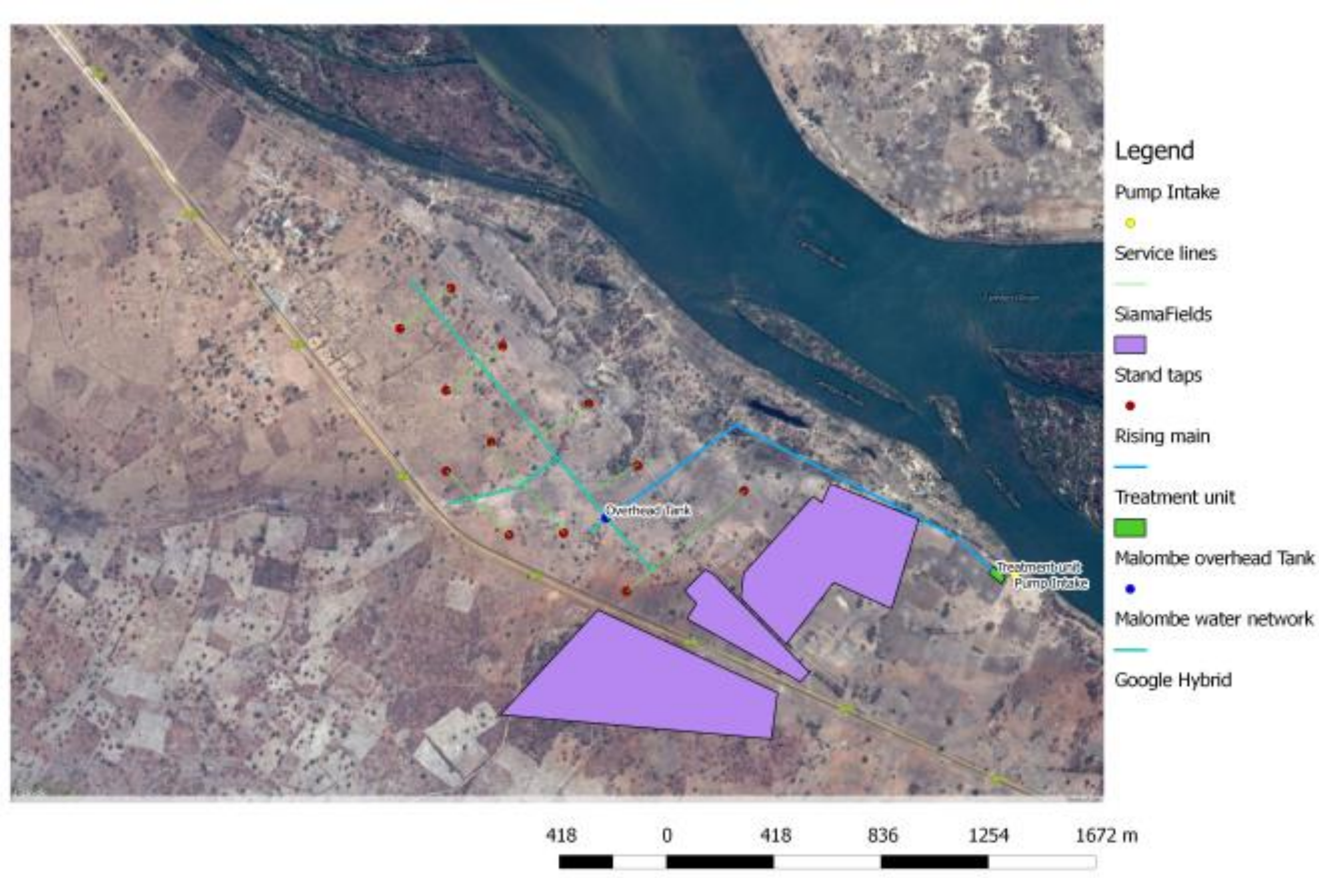
- Management requirements

Option 1: Surface water - Piped Water Supply

The source of water for the proposed option shall be Zambezi River and raw water will be abstracted by one duty and one standby pump. The water will require treatment before supplying it the community.

The water will be pumped to storage tanks mounted on the tower and then distributed by gravity. Stand taps will be installed where the community will draw water point.

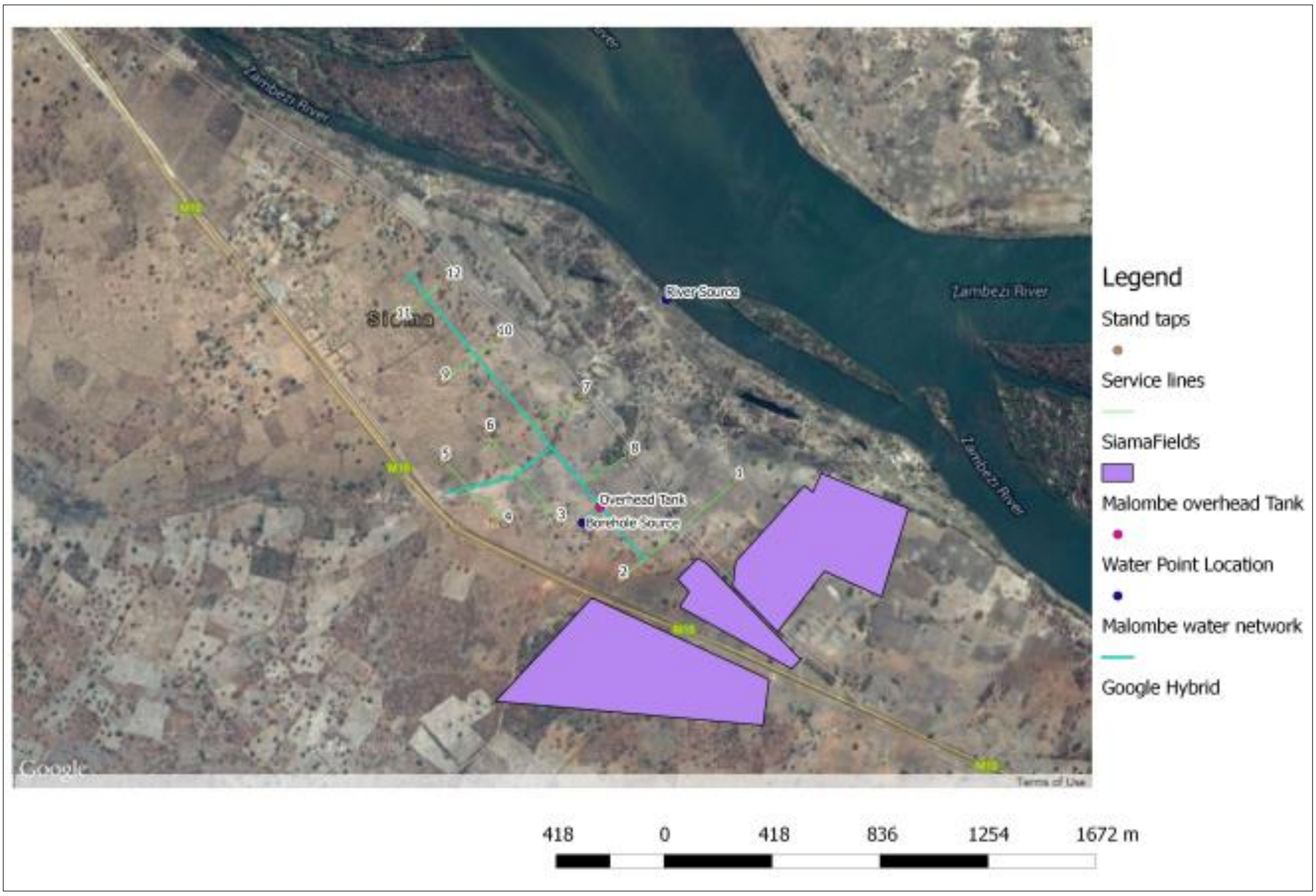
Figure 13 **Option 1 : Surface Water Piped Water Supply**



Option 2: Ground water Supply - Piped water

This option will comprise drilling 8"production borehole and installing 6"casing pipe for the depth not exceed 100m. The drilled borehole shall yield a minimum of 3 litre per second continuous pumping for 6 hours. A submersible pump with a minimum discharge of 2 litres per second will be installed and will operate on the solar unit with a photovoltaic array and the control system. The pump will lift the water from the borehole into the elevated tank which will be mounted to distribute the water by gravity to the supply points. Stand taps will be installed where the community will draw water point.

Figure 14 **Option 2: Ground water Supply - Piped water**



3.2 Conclusions

- The study has revealed that the Malombe community is experiencing water supply problem owing to the fact there is only one water facility serving the entire community compounded by water quality concerns from the water drawn from the river. In considering the foregoing problem it is clear that the development of the water infrastructure is urgently required and will address the water needs of the Malombe community in line with the National Rural Water Supply and Sanitation Programme's objectives of increasing water supply coverage

- Whist the need for rural water supply coverage increase is the ultimate goal of Government through Ministry of Local Government with full stakeholder participation, the management of the water systems is community based and the sustainability is based on the prevailing socio-economic status of the community especially willingness and ability to pay. It is generally considered that the majority of the households of the Malombe community area predominately rural in nature and would not pay for the stand tap connection other than drawing water from the river, owing to the high poverty levels. It is expected that the upgrade of the households from the rural set-up to the peri-urban would be a gradual process over time as proposed new township will be only 2 km from the scheme.

- Recent developments in the area have led to the requirements for potable water by the community to be alleviated. Two boreholes with solar powered submersible pumps have been installed for the community next to proposed irrigation development site. It is therefore no longer a primary concern for the community. CRIDF therefore should not provide additional water.

3.3 Recommendations

1. In considering the development of potable water supply Option 2(Ground water – piped water) is recommended for further development.
2. Subsequent to the completion of this report and a recent site visit to Sioma on the 16th November 2015 it has been found that a local NGO (Umbuntu) has drilled two boreholes and installed solar powered submersible pumps. Although these do not provide the quantities of water envisaged in this study they are provided good potable water to the community around Malombe.
3. **It is therefore recommended that no further work be done to provide additional potable water at Malombe, however some other site still require potable water such as at Kazangula and if funds are available these should be reconsidered.**

4. Analysis of Key Stakeholders and Institutions

4.1 Key Stakeholders

CRIDF's role in the Project is strictly one of preparation support. The table below provides an outline of the key stakeholders involved in the Project development, implementation, and operation. The Project area (located in Western province) is influenced by two parallel institutions, namely the formal government system and the traditional system of governance. Inevitably, the Malombe community is subjected to these systems. Figure 15[2] below shows the parallel administrative structure.

Institution	Description	Project role
Ministry of Energy and Water Development (MEWD)	World Bank financial support recipient	Potential project grant financing & procurement lead
Ministry of Agriculture (MA)	CCAP Zambia implementing Ministry	Project implementation and oversight
Sioma District Council (SDC)	Local Government Authority	Development coordinator; project support
Zambia Wildlife Association (ZAWA)	Project partner	Technical support; wildlife fencing
Project Steering Committee *(yet to be formed)*	Local technical steering committee led by MA, also comprising SDC, ZAWA and other key representatives	Local project implementation coordinator; technical support
Malombe Community	Project owners & beneficiaries	Land contribution; maintenance; labour
Malombe Irrigation Committee	Community management committee	Community facilitation and representation
Malombe Irrigation Company *(yet to be formed)*	Irrigation scheme owners	Scheme operation, maintenance and management

[2] **Adapted** from Madzudzo et al (2013) A Governance Analysis of the Baroste Floodplain System, Zambia: Identifying Obstacles and Opportunities Available at *http://www.worldfishcenter.org/resource_centre/AAS-2013-26.pdf*. Accessed 16/01/2015

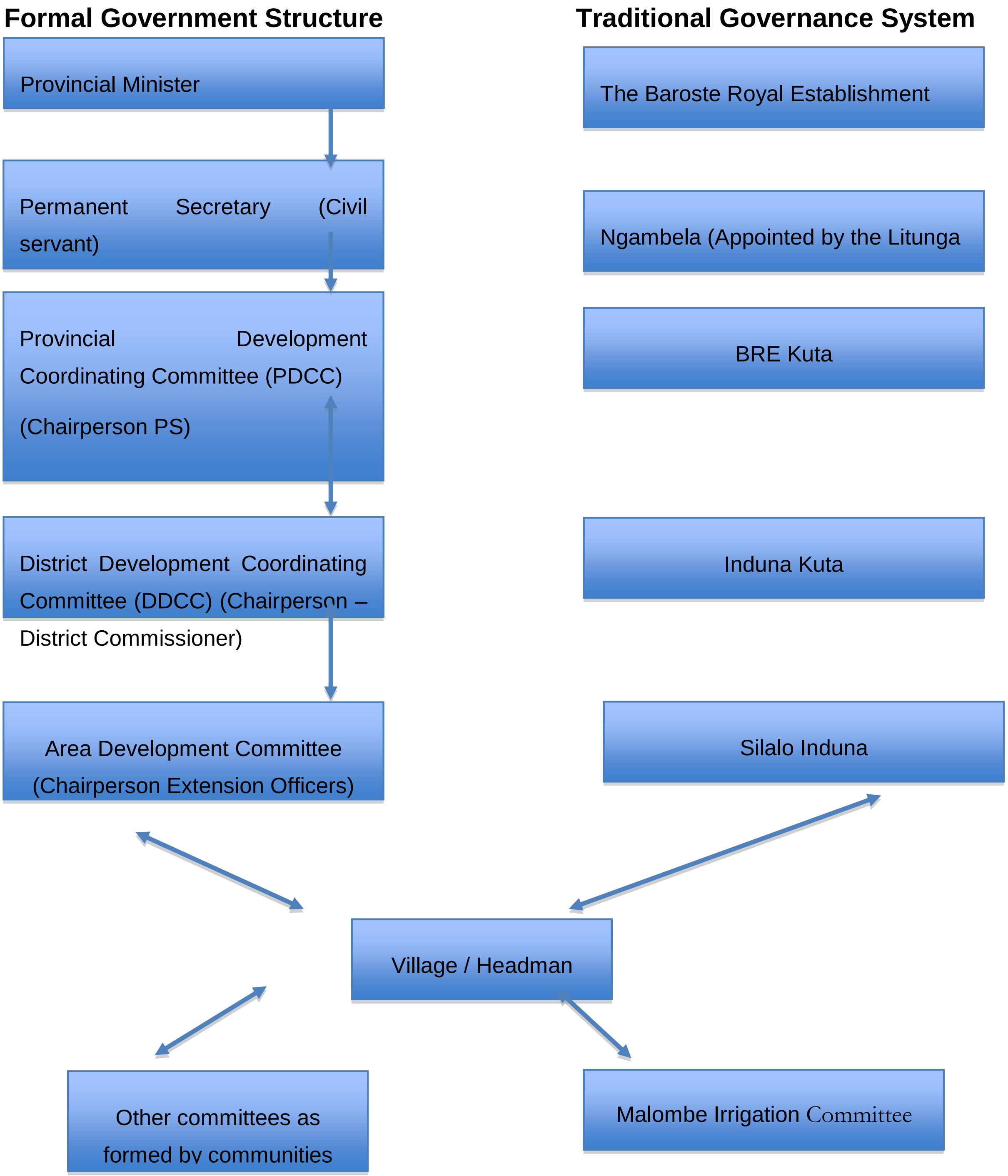


Figure 1: Local Institutional Context Structures

Formal Government Administration

The Malombe community falls under Sioma ward in Sioma Constituency within the newly established Sioma district. The district is headed by the District Commissioner who reports to the Provincial Minister and the Permanent Secretary (PS) who heads the provincial administration. At this level, development activities are coordinated by the Provincial Development Coordinating Committee (PDCC) chaired by the PS. All the provincial government ministries at the provincial level belong to this committee. Similarly, at the district level the

District Commissioner chairs the District Development Coordinating Committee (DDCC) which is responsible for coordinating development plans and programmes from all the government and Non-Governmental Organisations in the district. The District council is the secretariat of the DDCC and is responsible for all municipal functions. These functions include district strategic and investment planning, provision of both urban and rural water supply, natural resource management, issuance of licenses, public health and so on. Outside the district council planning jurisdiction development activities are facilitated by camp extension officers in Area Development Coordinating Committees (ADCC).

The implication of this administration is that MA reports on its activities including the irrigation project activities to the Provincial Agricultural Coordinator (PACO) and to the DDCC. This system of reporting ensures that all the district government departments, NGOs and the district council are aware of the major developmental activities in the district.

In order to maintain government recognition of the irrigation scheme and ensure sustainability, district MA officers who are the facilitators are the entry point for any partner interested in the irrigation project. MA will have to maintain an oversight role, provide required technical assistance and continue to mobilise resources for the irrigation scheme.

Traditional Administration

Given that the irrigation scheme is located on customary land, the local leadership plays a significant role in the administration of community affairs as whole. The Barotse Royal Establishment (BRE) represents an informal traditional system of governance based on the norms and values of the Lozi people. This traditional authority operates through chiefs who constitute a Kuta (same line as a parliament) presided by the Chief administrator (entitled the Ngambela) of the BRE. In the case of Malombe, Chief Lukama is the Silalo Induna who represents Sioma area in the BRE Kuta. Induna Imunonoko and the Vice are the headmen of Malombe community representing the community in the Silalo Induna’s Kuta.

Further Malombe community affairs are discussed and resolved at the local level by a local Kuta consisting of the Induna Imunonoko, the Vice and the Secretary. The irrigation Committee members have a direct link to the local Kuta where issues are discussed and decisions made. However, the entire community is involved in discussions to ensure broader participation. Below is an illustration of the institutional context.

4.2 Land tenure system

As indicated above, the Malombe settlement land is held in trust for the people by the local traditional leadership in the name of the BRE. Customary land under the jurisdiction of the BRE is regulated by the Barotse Royal Establishment Act of 1971 Section 6 (1) (B), which provides for traditional means of administration. The Act legitimises the traditional system of administration. Under this act, the BRE has the power and responsibility over land administration and natural resource utilisation except at household level. This includes land allocation and demarcation of boundaries, settling land-related disputes, collection of land taxes and royalties as well as enforcing associated rules and regulations governing access to natural resources such as water bodies, i.e. lakes, rivers, streams, grass, plains, forests, dambos, lagoons, grazing land and forests.

In addition, the national Land Policy and Act provide for State-owned land and Traditional land. Under this Act all the land in the Barotse Floodplain falls under the traditional authority of the Barotse Royal Establishment. Furthermore, the government allowed the BRE to administer land outside the council planning jurisdiction.
To access traditional land, an application is made to a Senior Headman in the area (Silalanda), who conveys the application to the Litunga through a Silalo Induna. Once approved, the applicant can apply to the Chief for a traditional title deed at a small fee. The power to approve the application and issue a permit lies with the Litunga. When an individual is granted land, he does not own it but has exclusive access to it for as long as he/she occupies his position within the village. The individual can delineate the land in question to family members, but not sell or mortgage it. Land is also passed on to family members through inheritance.

The gender dimension entails that the land is passed on to the first-born child regardless of the sex, making females eligible to land (non-gender biased system of land tenure). This practice has resulted in a long tradition of land inheritance along kinship lines. The BRE representatives can only allocate land that no longer belongs to a particular family. If a man re-locates to another village with all his family members, the abandoned piece of land is re- allocated to other people by the Silalo Induna (GRZ 2014).

Malombe Irrigation Land Ownership

As a result of this land inheritance system, much of the land leased to the irrigation scheme belongs to individual families who have inherited the asset from their ancestors over generations. Notably, there is evidence of dual land ownership which is common in Western Province. Nearly all the families interviewed owned land in two places, one in the lower land along or near the Zambezi River and the other in the upland (commonly known as Kwamushitu) area. Most of the families use the upland for food crops such as maize, beans, and groundnuts. The lower land is usually used for sorghum and millet and rarely for maize. It was observed that most of the respondents have placed their lower pieces of land under fallow.

At present a total of 25 individual families would lease their family land totaling 80.35ha to the irrigation scheme. Family land is usually owned by adult members of the family who are expected to pass it on to the next generation. This extended family ownership presents problems to the scheme in that there is need for consensus on how the irrigation system shall be managed. There was emphasis that land could not be apportioned to other external family members. During the survey nearly all respondents expressed concern on how developers would ensure that each family retained its land.

Further, there is need to establish actual hectarage and boundaries of each piece of land that would leased to the scheme. A record of these measurements should be part of the legal documents for the scheme. Families leased different amounts of land to the scheme, therefore there was need to understand how benefits would be attributed to each family. Although estimations of land leased are more than the actual it ranged from 1 to about 10 hectares.

4.3 Ownership, operation and management structures

The project owners will ultimately be the Malombe farmers that buy into the scheme through a contribution of land. The land allocated to the scheme is either privately owned or was given to households by the traditional leadership and as such, cannot be sold by the beneficiaries. The latter makes up the vast majority of the land.

The management model adopted by the project owners will be fundamental to the commercial viability and sustainability of the Irrigation Scheme. Various management method options were discussed with the Community Irrigation Committee and community. The starting point of the discussion was whether it was preferred to individually farm small plots or consolidate land and farm at a larger scale. There was some debate around this point, with the advantage of individual plots being that farmers are accountable to themselves and there is no threat of moral hazard often associated with cooperative type arrangements. It was however widely accepted that in order to transition to a scale of commercial production, and effectively operate centre-pivot type irrigation infrastructure, cultivation and operations have to be consolidated. The Irrigation Committee with the farmers therefore agreed to complete and finalise an equitable Irrigation Scheme membership register based on land contributions as part of the participatory project development process.

The subsequent management options discussed for the operation of the scheme were, government management; full community (Irrigation Committee) management; or a company – being either an external company, or an internal company formed by the community (in each case with the farmers getting an appropriate share of the profits). It was concluded by those present in the community meeting that the most preferable option was for the community to register a company, in which farmers will have shares in line with their relative land contribution, and for a skilled manager to be appointed to operate the scheme.

The community however stressed their desire to be exposed to a similar irrigation (centre pivot) scheme and management model on a 'learning visit' in order to make fully informed decisions, and increase their understanding and knowledge of such infrastructure and associated management arrangements.

Much of this discussion has however subsequently been overtaken as an approach using Drag Hoses and managed by the community rather than through a management company has been advocated as it was deemed that for the size of the area and the remoteness of the site a project managed by an outside agency was not likely to materialise. It has also been argued that the benefits accruing to a centrally managed scheme would only benefit a few individuals rather than the wider community. This would not achieve the poverty alleviation objectives of the project and would not alleviate the food and nutritional shortages that are currently a common occurrence in these parts.

This approach will require that some farmers will give up land that they currently farm in favour of the broader community. Initially this was a sticking point and some farmers were reluctant to sign up to the scheme which resulted in an irregular shaped irrigation area. However subsequently other farmers have agreed to join in and are prepared to have their land included in the scheme.

The redistribution of land to over 100 households has been a major focus of recent community discussions and initially only land from community members who were willing to incorporate their lands were included in designing the irrigated area. Through community discussions and a realisation for the broader benefits to the original land owners and the other community members, there is now broad consensus that plots should be limited to about 0.5ha (2 limas) each thus benefitting the maximum number of people and providing enough scope for them to be able to produce enough for household consumption and a surplus for sale. Section 5 on stakeholder re-engagement details the community's consensus.

The marketing of the surplus for sale will however need support from the MA or another organisation to initially help identify markets and opportunities. It should also identify the most appropriate crops for sale. This support should then help the farmers through training to maximise their potential yields for these crops so as to gain the best returns from their crops and so they are able to generate enough income to cover the ongoing operation and maintenance costs. This approach was endorsed during recent discussions with the MA.

5. Stakeholder Re-engagement

Prior to finalising the detailed designs (as outlined in Chapter 2 above) the design options and final design choice needed to be presented to the Malombe community for final endorsement. The re-engagement provided them with an opportunity to ask questions about the design options, and fully understand what would be expected of them in each instance. An overview of these engagements (spanning 18th and 19th November 2015) is provided below.

5.1 Report back from Stakeholder Re-engagement

During the two days at Malombe several stakeholder meetings were held. These included the support services stakeholders, the irrigation management committee and a wider community meeting of potential beneficiaries. A separate meeting was also held with the female community members.

Support Services Stakeholders

The revised feasibility study was presented to the meeting attended by those named in the table below. Mr Gillett presented the basis of the revised design, whilst Mr Kanchense described the different irrigation systems that were considered. Ms Litumelo Mate presented some of the institutional and gender issues that would need to be resolved. The rational was clearly explained as to why the team had made the recommendation that a drag hose system be installed. This was to ensure that the maximum number of households would benefit; that it was a system that could largely be managed by the community with the least outside support; and that it would enable the community to have household crop production and also marketable crop production.

Table 13 Re-engagement meeting attendees

Name	Position	Organisation
Mwangala Mukela	District Administration Officer	District Administration
Belvin Muntanga	DACO	MA
George Sibolile	A/Agronomist	MA
Lackson Ng'andu	Warden	ZAWA
Evans Simangola	Field Officer	CFU
Goodhope Kaputa	Ag/DIC DO	Community Dept
Errol Pietersen	Tech Advisor SNNP	ZAWA

Michele Pietersen	Community Liaison	KAZA
Mwangane Nawa	A/Assistant	MA
Ross Masiye	Chairperson	Malombe Irrigation Committee
Mayanwa Mututwa	Secretary	Malombe Irrigation Committee
Simataa Mukingwa	Ward Councillor	Malombe Irrigation Committee
C Lwakala	Second Induna	Malombe Irrigation Committee
	Area Induna	Malombe Irrigation Committee
Sepiso Simasiku	District Information Officer	ZANIS
Patrick Kanchense	Water Engineer	CRIDF
Litumelo Mate	Sociology and Institutions Expert	CRIDF

The meeting attendees largely accepted the proposal, but were concerned about the durability of the system. Mr Kanchense assured the meeting that the drag hoses were durable, but would still need to managed carefully.

It was appreciated that if the farmers were to be able to manage the system they would require a lot of support during the initial years. The District Agricultural Officers would provide some of this, but other support from outside would also be required. The cost of this support would need to be included in the final cost of the Project. This support would have to include:

- Marketing support;
- Operations and Maintenance training and support for the irrigation system;
- Advice on crop production under irrigation;
- Water allocation and management systems;
- Savings for future maintenance;
- Community management and support to liaise with neighbouring communities not benefitting from the scheme; and
- Credit schemes to enable farmers to purchase seed and other inputs

In addition, funding should be made available to cover the initial costs of electricity for pumping water until farmers were able to generate enough revenue to cover these costs. This however should be limited to one year at most.

The representatives from the Zambian Wildlife Authority (ZAWA) were keen to hear of the scheme. They pointed out that funds would need to be allocated to build a game fence that would keep out elephant and hippo, which are fairly common to the area. By having a large area of green growth, elephants and hippo would still be attracted to the area and even though they may not gain access to the irrigated area, they could do substantial damage in the surrounding area. This would have to be managed for those areas outside the protected irrigation plots.

Once the game fence is constructed the community would also have to take on the responsibility of managing and looking after the fence. Failure could cause major losses very quickly.

The need for an EIA was stressed as the scheme and the permission by WARMA for water extraction could not be approved without it.

The DAO thanked those that came and said that he was very supportive of the scheme which hopefully would be seen as a pilot for other investment in the future.

5.2 Community Consultations

Five of the committee members were met with on the afternoon of the first day so that they could discuss things with other members before the main meeting with the community, which was held on the 18th November 2015. In total about 50 people attended the main meeting. The attendance would have been higher but there was a funeral taking place which meant that some beneficiaries were unable to attend. At present there are 98 households that have registered an interest in being part of the scheme.

Mr Gillett again outlined the major aspects of the Feasibility Study and the need to amend the initial desire of the community for a centre pivot irrigation system. He then asked Mr Kanchense to brief the community about the various options and the benefits of each system. The diagrams used to explain these options are attached in **Annex G**. Mr Kanchense distributed further copies of the design options and discussed in full with the community members.

Some issues that were raised during the discussions:

- **Total number of participants**: Mr Gillett explained because the system advocated would divide the irrigation into plots each household would be allocated 0.5 ha (2 limas). This would accommodate all of the 98 registered households and have plots available that could be allocated to other households. It would be up to the committee to decide who these plots should be allocated to. Any land that was found to be sitting idle would also be reallocated. A list of potentially interested farmers should therefore be prepared.
- **Total Area and Shape of Scheme**: Mr Gillett explained that the total area and the shape of the scheme was as a result of the land made available by the initial interested group of landowners. This shape is not ideal and covers some areas that would require infilling. The total area is unlikely to increase as these set the parameters for the amount of water required and subsequently the size of the pumps. It also will affect the cost of installing the system. However it may be possible to revise the layout if neighbouring farmers were willing to be part of the scheme provided there was scope to include them.
- **Drag Hoses**: the community was concerned that these were common garden hoses. Mr Kanchense explained that these were not common garden hoses, but high quality hoses designed especially for this purpose. They would be durable.

- **Pump Maintenance**: Concern was expressed about how they would repair the pump before they had built up a cash sink. Mr Kanchense again explained that there would be a period of guarantee where the suppliers of the pumps would have to maintain the pumps. There would also be two pumps so that if one pump broke they would have a back up.
- **Electricity Costs**: Mr Gillett explained that in the first year funds should be committed as part of the scheme costs to cover the initial electricity costs. However the community should be aware of these costs as they would have to cover them in year 2.

Mr Gillett also explained how a community had come up with a solution to ensure that funds were always available to cover the electricity costs. In Namibia a community rotated irrigation every 3 days. To cover the cost of pumping a prepaid meter was installed. The third of the community who would get water for that day put funds into the meter to cover the costs for that day and this would be used up on that day. The following day the next third would do the same. In this way the community was able to ensure that those who were using the water were covering the cost and no debts were built up.

The community were then asked to consider endorsing the scheme. They said they would. However Mr Gillett suggested that they defer this until all of the potential beneficiaries could attend a meeting and they could discuss it without being pressurised. This meeting did take place several days after the CRIDF team departed; the meeting was minuted and written endorsement from the DACO (on behalf of the beneficiaries) was received on 3rd December 2015. This letter will form part of the submission to MEWD and is attached as **Annex H**.

6. GESI Assessment

6.1 Gender challenges

A number of focussed group discussions were held with women and girls within the Sioma community on some of the following pressing issues.

High levels of poverty

Women complained of the high levels of poverty caused by the lack of viable income generating activities. Some of the activities that women have been engaged in included gardening and field crop agriculture, selling brewed beer, and small animals such as chickens. They however complained that each of these sources of income have inherent challenges.

For instance – gardening is conducted along the Zambezi River banks where there is continuous threat from crocodiles and destruction of crops by hippos and elephants. This deprives households of food for consumption and sale. Any hours spent guarding the gardens draws labour away from other activities.

Like elsewhere in Zambia, field crop production is rain fed dependant and women complained of the erratic rainfall, which has been affecting crops yields over the years. Most women revealed that the last maize harvest only lasted for 4 months and households have to depend on other staple foods such as sorghum and buying maize. This has affected both their food security and revenue base, as they have to spend more on purchasing food. Similarly field crop harvests are lowered by the constant wild animal destruction.

Other challenges included the lack of agricultural inputs such as seeds and fertilisers. Without financial resources to buy equipment, seed and fertilizer, any farmer would have minimal opportunity to enhance and sustain her/his productivity. The current government-organized fertilizer loans are normally distributed through cooperatives, and since women membership in cooperatives is generally very low, these loans are mainly distributed to male-headed households.

Lack of sustainable income generating activities

Although the women revealed some of the activities that have sustained them over the years, they had a general feeling of helplessness given the challenges they are faced with. They felt they were locked in a vicious cycle of poverty where the current income generating activities are no longer viable due to the increasingly harsh climate.

High Illiteracy levels

Although Malombe community is in close proximity to one secondary and two primary schools, majority of the women were illiterate. The major reasons forwarded were the following i) parent’s failure to pay school fees; ii) parents did not see the value of educating their children as there were no employment opportunities in Sioma given the remoteness of the area; iii) early marriages and teenager pregnancies. The community has not fully utilised the re-entry policy that provides an opportunity for girls to continue with their education even after falling pregnant.

Early marriages and teenager pregnancies

Linked to the above statement, this was a major problem amongst the girls in the community. It was observed that there was a blame game between the parents and girl children. Whilst children were blaming their parents for failure to pay school fees, parents were also blaming the girls for indiscipline and deviant behaviour.

6.2 Opportunities available for gender equality

Unlike other parts of the country, Malombe community has the following opportunities that can hasten the process of satisfying not only women and girls needs but also that of the community as a whole.

Gender Mainstreaming

Ministry of Agriculture is one of the ministries that has progressed significantly in terms of the gender mainstreaming. For instance, the current Malombe dam committee has an equal membership of men and women. In addition, the Climate Change Adaptation Project (CCAP) enshrined gender inclusion where all the different committees formed had equal membership.

Traditional Land Tenure System

Although the Lozi tribe and other tribes of the Western Province are patrilineal societies where inheritance runs through the males, the Malombe community have rendered equal land rights to both male and female children. Land belongs to the families and each member is entitled to a portion regardless of the sex. In addition, land under traditional leadership can be allocated to any member of the community. Women admitted that they had no problem with land ownership.

Maternal headship

It can be deduced that women will be part of decision-making processes, as the village is practising a matrilineal system as most married women remain in their maternal homes. Subsequently they also retain family land. It was evident during both community and focussed group discussions that a significant number of women had assumed household headship and were independent to make decisions.

Extended family care

In relation to the rights and care of vulnerable groups such as the elderly and orphans, women revealed that these persons belong to respective families and are taken care of by their kith and kin.

6.3 Gender Needs

In view of the above challenges and opportunities, the following were some of the expressed needs of women.

Viable income generating activities

They acknowledged that with their minimal literacy levels, agriculture was their mainstay and they were committed to continue using agriculture as a source of household food needs and income for other household requirements. Therefore they laid all their hopes on the irrigation scheme, in that it would provide water and security for their crops.

Water for productive use

Although the Malombe community reside along the banks of the Zambezi River, they could not utilise the abundant water for productive use. Women therefore felt that the irrigation scheme would be an opportunity for them to utilise the water for growing crops that would contribute to family nutrition and become a form of employment for them.

6.4 Contribution of the irrigation Scheme to Women and Girls

Employment creation

The SIS shall not provide alternative income opportunities but shall assist in resolving the existing bottlenecks of wildlife destruction and the lack of freedom to use the Zambezi River for irrigation. Availability of water throughout the year would create some form of employment for the entire community, as they would spend much of their time in the gardens.

Capacity development and entrepreneurship training

The irrigation project package should include capacity development in different skills that contribute to the efficient and effective management of the scheme. This would provide all the women and men who are illiterate with an opportunity to acquire knowledge and skills that can improve their lives. Further interaction with external markets will also expose them to different settings.

Access to Markets

Establishment of the new Sioma district has played to the advantage of the community, as they will have easy access to markets where their products would fetch a higher price. Higher incomes contribute to improvement in living conditions.

Outreach and Establishment of Gender Based Organisation

The process of conducting an ESIA provides a platform for requesting support from other organisations such as gender based organisation – which is important given the problem of early marriages and teenager pregnancies. Organisations such as Non-Governmental Organisation Coordinating Committee (NGOCC), Women for Change, and Young Women's Christian Association (YWCA) would be encouraged to include Sioma district amongst their operational areas.

6.5 GESI Operations and Ratings Table

In addition to the above findings, information has also been drawn on from both the Cost Benefit Analysis and Technical Analysis components of the report to complete CRIDF's GESI Rating Tool below, which aims to ensure that the Project i) adqeuatly **analyses** gender issues; ii) puts in place **action points** to address any issues; and iii) has the systems in place to **monitor** the implemetnion of these actions.

Dimensions	Criteria: The Activity …	Checklist: Does The Project …	Check	Score	Rating
Analysis	Includes analysis and/or consultation on gender related issues	• Identify and analyse gender issues *relevant* to the project objectives or components?	✓		
		• Report findings of country/regional gender diagnostics (gender assessment, poverty assessment, etc.) as part of a social, economic and/or environmental impact assessment	✓[3]		
		• Reflect the result of consultations with women/ men/ girls/ boys/ indigenous groups/marginalised groups and/or NGOs that focus on these groups and/or their specific line ministries?	×		

[3] Covered primarily in the Cost Benefit Analysis narrative

			If at least one check above (yes)	**YES**	
			Significance rating (relevant, evidence-based & numerical/proportional significance) (none = 0; weak = 1; modest = 2; encouraging = 3; and significant = 4)		**4**
Actions	Is expected to narrow gender disparities, including through specific actions to address the distinct needs of women/ girls and/or men/ boys/ and/or marginalised or vulnerable groups and/or to have positive impact(s) on gender equality and/or social inclusion	• Include specific or targeted actions that address the needs of women	✓		
		• Propose gender specific and/or social inclusion safeguards in a social/environmental assessment or in a resettlement framework	✓		
		• Show how interventions are expected to narrow existing gender disparities	✓		
If at least one check above (yes)				**YES**	**4**
			Significance rating (relevant, evidence-based & numerical/proportional significance)		

(none = 0; weak = 1; modest = 2; encouraging = 3; and significant = 4)					
Monitoring & Evaluation	Includes mechanisms to monitor gender impact and facilitate gender disaggregated analysis	• Include specific gender and sex-disaggregated indicators in the results framework?	✓		
		• Propose an evaluation which will analyse the gender specific impacts of the project?	✗		
If at least one check above (yes)				**YES**	
Significance rating (relevant, evidence-based & numerical/proportional significance) (none = 0; weak = 1; modest = 2; encouraging = 3; and significant = 4)					**3**
RATINGS					
Overall Score	In how many dimensions does the project score 1?			**3/3**	
GESI-informed	Does the document score in at least one dimension			**Y**	
GESI significance	In how many dimensions does the project demonstrate a contribution to GESI results				**3/3**

Significance Score	What is the total score across all three dimensions related to demonstrating a contribution to GESI results (none = 0; weak = 1; modest = 2; encouraging = 3; and significant = 4)	**11/12**

The high ‘significance’ scoring (11/12) of this Project indicates that overall the feasibility study has i) adequately analysed and assessed GESI issues in the Malombe Community; ii) factored these GESI findings into the final Project design and Cost Benefit Analysis; and iii) taken into consideration the need to monitor and evaluate gender issues through the engagement with gender based NGOs, with a specific focus on collecting gender disaggregated data.

7. Environmental Assessment

The Environmental Management Act (2011); followed by Statutory Instrument No. 28 of 1997 (EIA Regulations) states that: "A developer shall not implement a project for which a project brief or an environmental impact assessment is required under these regulations, unless the project brief or an environmental impact assessment has been concluded in accordance with these regulations and the Council has issued a decision letter."

The Second Schedule of the EIA Regulations lists projects for which an Environmental Impact Statement (EIS) is required. Included are Irrigation schemes covering an area of 50 Ha or more. The Sioma CCAP falls into this category.

Since the proposed project falls under the Second Schedule, a scoping exercise was undertaken out of which the ToR for the EIA study and hence the EIS has been developed. These shall be submitted to the Zambia Environment Management Agency (ZEMA) for approval.

The scoping exercise, was conducted as required by the principal environmental Act, the Environmental Management Act No 12 of 2011, in conjunction with the EIA Regulation (1997), the environmental policies, international conventions and protocols.

Summary of Initial Environmental Scoping Report

Stakeholders who comprised Government officials and the local community were consulted by the environmentalist, sociologist and other team members between November and December 2014. Interviews using a checklist of environmental and social issues enabled the stakeholders to express their concerns and expectations which were duly incorporated into the project design and implementation. Preliminary baseline conditions, based on professional knowledge and judgement were recorded.

Stakeholders consulted during field surveys of responded positively that it should go ahead albeit the long delay since the conceptualisation of the project in 2008. Possible environmental and social impacts of the project have been evaluated in its area of influence. The impacts are all positive, except for loss of aesthetic value of the wild land nature, in part of the land (34.5 ha) which is on the fringes of the West Zambezi GMA No1. Although reversible with mitigation measures, it will not adversely affect areas beyond the Irrigation Scheme. Means have been sought to improve project design and implementation by preventing, minimising, mitigating or compensating for adverse impacts, and enhancing positive impacts. MA shall commit itself to implement Environmental Management Plans and to enforce strict monitoring procedures in order to eliminate or compensate for adverse effects or reduce these to acceptable levels.

MA and its agents will implement best practice environmental, health and safety procedures during project construction, as outlined in the Agriculture Policy, in order to foster environmental sustainability. MA will monitor the project management's compliance to these practices through a weekly construction supervision effort.

The finalised, full EIA ToR has been loaded as suppoting documentation to this report.The EIA ToR has been written in accordance with Zambia's Environmental Management Act, (EMA) No.12 of 2011, and the Environmental Impact Assessment (EIA) Regulations SI No 28 of 1997. The aim of the ToR is to:

> *Provide specific and detailed guidelines for the assessment and management of social and environmental risks and impacts during the implementation of the Zambia Malombe Irrigation Project.*

The approach to conduct EIA work

An initial review of documents was undertaken in order to collect relevant information concerning the EIA study. This was followed by open-ended interviews involving the study team and the affected stakeholders in order to brainstorm potential impacts due to Project-related activities, thereby promoting inter-sectoral linkages between various GRZ departments in the affected areas, in addition to ensuring full participation of all the affected and interested parties. Thirdly, the study team conducted field visits to, among others; consider the roles, on-going activities and capacity of Government departments in the districts to the extent that their engagement will contribute towards validating the efficacy of mitigation measures to be proposed.

A checklist/questionnaire was used as a tool of communication involving environmental and social attributes followed by stakeholder input recordings. Upon ZEMA's approval of the EIA ToR, a team of experts (appointed/approved by ZEMA) will conduct baseline studies in the Project area of influence.

8. Climate Change Risk Assessment

According to the CRIDF Climate Resilience Strategy, climate resilience should be practically integrated into all CRIDF Projects, at Programme, Project and Activity levels. The definition of resilience used by CRIDF is:

"*CRIDF will prepare infrastructure projects, leverage finance and/or engage with stakeholders at regional, national, sub-national or local (community) levels that better enable the most vulnerable people, to predict, manage, and/or adapt to the impacts of climate related events and climate variability (droughts, floods, and ecological and social behaviours). This may include both adaptation and/or mitigation options.*"

The key questions that this section aims to answer are:

- Have we identified the possible risks and climate change poses to the project and local communities and associated response measures?
- Have we identified and documented in a systematic way the resilience benefits that CRIDF activities bring to project recipients?

Scope of Review

The scope of this review includes the following project components and outcomes.

Climate risk screening on the following project components:

- Intake works, main canal and pumping station (including the supply and delivery of electricity to the pump house)
- Irrigated fields
- Drag hose irrigation infrastructure for approximately 57.8 ha of land
- Elephant-proof fencing of approximately 15km (calculated on a perimeter of 70 ha of land)

Identification of resilience benefits of the following project outcomes:

- Provision of assured water supply for irrigation
- Provision of water infrastructure O&M extension support
- Provision of agricultural extension support, including access to markets
- Protective fencing for irrigated area

2. Climate vulnerability mapping

CRIDF's bespoke rapid climate vulnerability assessment tool helps inform CRIDF's approach to undertaking Track 1 climate risk and resilience screenings.[4] The tool has been applied to this Project site. Detailed findings from this application are outlined in Annex A.

Climate Vulnerability Tool Indicators

Table 14 below presents the level of the climate vulnerability indicators for the project area according to the climate vulnerability assessment tool. For some indicators a range is presented, which reflects the differences in vulnerability amongst sites. Further guidance on what the indicators mean is presented in Annex J.

It should be noted that, while this tool is useful in providing contextual information at an early stage of the Project cycle, it is not always accurate (and in some instances data is not available) and information therefore needs to be augmented with information from the Project Team and local stakeholders who have visited the site.

Table 14 Climate vulnerability indicators

Indicator	Outcome
Future risks to people	Moderately High
Water risk under climate change	High
Climate change pressure	High
Baseline risks to people	Medium
Resilient population	Medium
Population density	25.0 people per km^2
Household and community resilience	0.43 Moderately less resilient
Groundwater stress	Low (<1)
Upstream storage	No major reservoirs
Drought severity	Medium to high (30-40)
Flood FREQ MINM	No data
Seasonal variability	Extremely High (>1.33)
Inter-annual variability	Low to medium (0.25-0.5)
Baseline Water Stress	Low (<10%)
CRIDF Basin	ZAMBEZI

[4] The CRIDF Climate Vulnerability Assessment is available online at: http://geoservergisweb2.hrwallingford.co.uk/CRIDF/CCVmap.htm

The vulnerability indictors that stand out for this area are: Seasonal variability – *Extremely high*; Drought severity – *Medium to high*; Climate change pressure – *High*; and Household and community resilience – *Moderately less resilient*. It is clear from these indicators that the Sioma community cannot continue to rely on rain-fed agriculture due to the increasing effects of climate change pressures in the area, particularly drought. The proposed irrigation scheme addresses this issue by drawing water directly from the river – providing the community with a reliable system to support their agricultural activities year-round.

3. Climate projections

This section presents on overview of the latest climate trends and projections that were used to inform the climate change scenarios developed for the project area. This Phase 1 review makes use of CRIDF's regional projections and impact table to understand how the future climate change might impact the project.

Figure 15 **Climatic Zones in SADC**

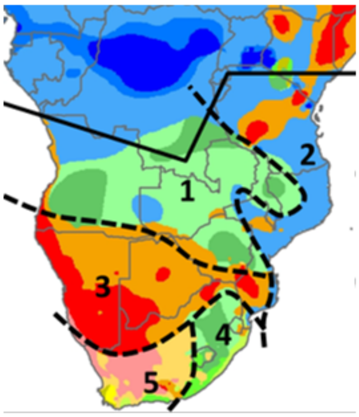


Figure 1: Climatic Zones in SADC

- **Region 1, Summer ITCZ (Intertropical Convergence Zone) region**. Angola, Zambia, and Malawi, central and NE Zimbabwe - This is a temperate/tropical region with dry winters (subtropical high pressure cells) and rainy summers (tropical lows driven by seasonal migration of the ITCZ).
- **Region 2, Summer Indian Ocean cyclone/monsoon zone.** Mozambique, Tanzania - Tropical/seasonal monsoon climate characterized by incoming cyclones from the Indian Ocean.
- **Region 3, Arid descending arm of Hadley cell.** Namibia, Botswana, SW Zimbabwe, S Mozambique - This region has a negative hydrological balance, low and variable precipitation and seasonally high temperatures.
- **Region 4, Temperate cyclonic zone**. E South Africa, Swaziland, and Lesotho - This region has a wet summer regime with thunderstorms and subtropical cyclones.
- **Region 5, Semi arid/winter rainfall zone.** W South Africa - This region is characterized by a steppe climate inland with winter rainfall and fog at the coast.

Climate Trends Overview

The Project falls in the transition zone between **Region 1** and **Region 3**. Observations from site missions indicate that the sandy soil characteristics and weather patterns align more closely with Region 3, and the following impacts presented in **Table 15** have been identified.

Table 15 Climate projections for project area

Region	Climate change trend	Impacts	
		By 2025	**By 2055**
3	Precipitation variability	Continuing aridity of desert and semiarid environments. For planning purposes it is best to work on decreased annual rainfall, especially to the west, with any decrease perhaps reaching 20% in parts; increases are unlikely in the west but may reach 10% in the east.	Continuing aridity of desert and semiarid environments; increased wind erosion, migration of sand dunes, decreased air quality and pollution, health effects, due to land surface aridity; episodic thunderstorms may result in soil erosion, flooding, especially in coastal areas; increased borehole extraction will result in decreased groundwater table, some ephemeral rivers will become permanently dry, perennial rivers may become ephemeral. Groundwater recharge will be reduced under all scenarios. For planning purposes it is best to work on decreased annual rainfall, especially to the west, with any decrease perhaps reaching 20%, or even 30%, in parts; increases are unlikely in the west but may reach 10% in the east. Water supply will decrease under all future scenarios.
	Temperature variability	Continuing trend of increased MAAT. Likely increase of MAAT by 0.5^{o}C to 2.0°C, but lower/higher values cannot be excluded; some increase in length of warm/drought spells and reduced frequency of cold periods.	Continuing trend of increased MAAT, heatwaves inland, increased thunderstorm activity. Likely increase of MAAT by 0.5^{o}C to 4.0°C, but lower/higher values cannot be excluded; almost certain increase in length and severity of warm/drought spells and reduced frequency of cold periods.
	Extreme events	Increased frequency of drought and heatwave events.	Increased frequency and magnitude of drought events and soil moisture anomalies, which will have significant impacts on agricultural systems and sustainability.
	Agriculture	Food insecurity arising from climatic instability	Increased aridity may result in increased food insecurity, spread of invasive plant and insect species, locusts?, loss of rainfed agriculture and subsistence agricultural systems become less viable, decreased food production in some areas
	Health	Health effects mainly as a result of short term problems with food production due to climatic variability	Health and nutrition effects, mainly as a result of longer term decreases in food production due to increased aridity, deflation of dry soils from the land surface, episodic soil erosion; food and water insecurity will increase, may be health impacts of increased pests and diseases; health impacts due to decreased water and air quality. Decreased surface water availability results in increased health and sanitation risk.

4. Review results

Following the review of the vulnerability indicators for the area and the climate trends, the Project Director and CRIDF Manager identified, at a high level, climate risks and resilience benefits of the project.

Climate Risks

The project comprises of a number of physical infrastructure components, that were identified and screened at a high level against a series of relevant climatic threats for the area such as flooding, drought, cyclones (where applicable), sea level rise (where applicable) etc. An overview of the project's components along with the threats that the team screened the project against are presented in the following Table.

Table 16 Project components and climate threats

Project component	Climatic threats
• Intake works, main canal and pumping station • Irrigated fields • Drag hose irrigation infrastructure • Elephant-proof fencing	• **Flood**: Flooding along the banks of the Zambezi is a risk during peak rainy season. The pump station will need to built above high flood levels or be able to accommodate rising water • **Drought**: Drought is an issue in the area and is likely to intensify with climate change • **Fire**: Prolonged drought and higher temperatures due to climate change will make fires more likely. The irrigation area is however largely devoid of bush and is a low fire risk

A summary of the outcomes of the process is presented in the following table along with a series of risk management options.

Table 17 Climate Risk Matrix

Project component	Flood	Drought	Fire	Risk mitigation options
Intake works, main canal and pumping station	**Medium**: Fluctuating water levels, heavy flow and/or debris may damage pump/intake infrastructure	**Low**: Low sensitivity/no structural impacts. Unless extreme drought water supply assured.	**No/low risk**: Low sensitivity/no structural impacts	**Flood**: Review design to ensure electrical and mechanical components of pump house and intake works are suitable for potentially rising/fluctuating water levels
Irrigated fields	**Low**: Project component away from potential flooding area	**Low**: Amount of water withdrawn from source is very small compared to water available (see hydrological analysis of main report)	**Medium/Low:** Some fires in the area, but unlikely to impact fields as area will be cleared of biomass prior – preventing the potential for fires to spread	**Fire:** Ensure that in conjunction with extensive land clearing prior to implementation, regular biomass clearing maintenance is also carried out. If necessary, fire breaks could also be built around plots.
Drag hose irrigation infrastructure	**Low**: Project component away from potential flooding area	**Low**: Low sensitivity/no structural impacts	**No/Low risk:** Fires unlikely to impact infrastructure as area should be cleared of biomass prior to implementation	
Elephant-proof fencing	**Low**: Project component away from potential flooding area	**Low**: Low sensitivity/no structural impacts	**Medium:** If uncontrolled, a fire could damage wooden fencing materials.	**Fire**: Ensure that in conjunction with extensive land clearing prior to implementation, regular biomass clearing maintenance is also carried out. If necessary, fire breaks could also be built around plots.

Resilience benefits

The project delivers a series of outcomes that enhance the resilience of project recipients to climate change. An overview of the project's outcomes along with a list of resilience benefits that the project delivers are presented in the following Table.

Table 18 Project outcomes and resilience benefits

Project outcomes	Resilience benefit categories
• Provision of assured water supply for irrigation • Provision of water infrastructure O&M extension support • Provision of agricultural extension support, including access to market • Wildlife fencing	• Livelihoods • Health & nutrition • Gender • Education • Environment • Governance • Safety

A summary of the outcomes of the process is presented in the following table.

Table 19 Climate Resilience Benefits Matrix

Project outcomes	Livelihoods	Health & nutrition	Gender	Governance	Education	Environment	Safety
Provision of assured water supply for irrigation	High: Increasing livelihoods options by supporting high value, year-round crop production. Irrigation greatly reduces risk of crop failure.	Medium: Improved nutrition	High: Opportunity for women to engage in smallholder plots. And, reduced time spent by women fetching water from the river for gardening	Medium: Community ownership and management structures put in place to ensure water usage is adequately monitored	High: Children can spend more time at school instead of fetching water from the river for gardening purposes. Improved incomes to pay for education	Medium: Land cover will be almost continuous reducing erosion.	High: Water for agricultural activities no longer collected from the river – reducing risk of drowning and/or wildlife encounters
Provision of water infrastructure O&M extension support	Medium: Training local community on O&M of WSS could provide work opportunities in the future as Sioma District expands		Medium: Water point committee must have equal male and female members, with fair distribution of roles and responsibilities	Medium: Empowering local community through establishment of community-led water point committee with clear roles and responsibilities		Medium: Extension support includes training on the use and management of the water source – i.e. ensuring withdrawals are not excessive, and irrigation carried out at appropriate times of the day	
Provision of agricultural extension support, including access to markets	High: Higher value and wider variety of crops can be grown, with assured production	High: Increased yields translate to higher nutritional value. Access to markets enables people to generate money for medicine	Medium: Opportunity for women to engage in market activities and earn money		Medium: Access to markets enables people to earn money and send children to school	Low: Training includes education on farming techniques appropriate for soil types	

Project outcomes	Livelihoods	Health & nutrition	Gender	Governance	Education	Environment	Safety
Wildlife fencing	High: Increased production due to lower losses from elephant damages	Medium: Side benefits of nutrition due to decreased production losses					High: Less likely to have encounters with wildlife

Recommendations and Next Steps

The Track 1 CCRA showed that the project brings a number of high resilience benefits to the project recipients for most resilience categories – especially *livelihoods*. The review also identified a number of risks in relation to the associated infrastructure and risk-mitigating actions which if implemented will improve the resilience of the project itself to climate change risks. The Project Director is responsible for ensuring that the actions below are implemented.

Flood

Flood risk exists along the banks of the Zambezi, and is likely to intensify with climate change. While the irrigated land is at a safe distance (and elevation) from the river bank, the intake/pump infrastructure is exposed to this. That is;

- While flooding along the river bank is infrequent, it can be very intense and there is therefore a risk that fluctuating water levels, heavy flow and/or debris may damage pump/intake infrastructure

Actions and Next Steps

- The intake works and pump station designs and siting must be reviewed to ensure electrical and mechanical components are suitable for potentially rising/fluctuating water levels

Fires

Prolonged drought and higher temperatures due to climate change will make fires more likely in the area giving rise to the following risk:

- If uncontrolled, fires could destroy crops and damage wooden fencing materials.

Actions and Next Steps

- In conjunction with extensive land clearing prior to implementation, the farmers must also carry out regular biomass clearing maintenance. If necessary, fire breaks could also be built around plots.

9. Cost Benefit Analysis

The full Cost Benefit Analysis can be found in **Annex I.** Below is an executive summary of the key findings and results from the analysis.

Through the provision of capital investment of GBP 456,329, the SIS is anticipated to result in significantly improved livelihoods for 100 households (with an approximate population of 435 people), through irrigated food gardens of around 58 hectares. The project will provide much needed capital investment for a large portion of households in the Malombe community, and it is anticipated to indirectly benefit the entire community, as well as the Sioma ward, through economic development and multiplier effects. In addition to the financial benefits that stem from crop sales, further economic benefits from the project are expected to include climate resilience, food security, lower levels of human-wildlife conflict, and health improvements through diversified diets. These are all possible with minimal opportunity cost to water supplied due to the fact that the Zambezi River remains a relatively untapped resource.

This chapter summarises the Cost-Benefit Analysis that was undertaken to investigate the financial and economic justification for the Project, aiming to capture and compare its benefits and costs and assess whether there is sufficient profitability from the proposed intervention to cover its on-going operations and maintenance. The technical infrastructure solution that is assessed (outlined earlier in this report), proposes water supply for irrigation and associated irrigation infrastructure for the community.

Specifically, the project includes the procurement and installation of the following:

- Intake works, main canal and pumping station (including the supply and delivery of electricity to the pump house)
- Drag hose irrigation infrastructure for approximately 57.8 ha of land
- Elephant-proof fencing of approximately 15km (calculated on a perimeter of 70 ha of land)

The CBA provides a holistic and multi-faceted assessment of the feasibility of the Project. For a project of this nature, it is unlikely that it will attract private sector investment due to low expected financial returns, potential risks or a combination of both. However, given that the Project aims to provide a number of fundamental public goods to the community, if the economic rationale for the Project is clearly demonstrated, external financial support for the Project can be justified.

The CBA is conducted from the perspective of the local community who will participate in the Scheme. Households who select to participate will become the owners of the infrastructure - accruing direct benefits through crop production. In return, they would make their family land available to the irrigation scheme and be responsible for its operation and maintenance costs, at least in the medium and long term (it is recommended that start-up and O&M costs in the first year be included as part of project financing, as will be discussed later). As it is a rural water supply project, the communities will not be charged water tariffs for the use of the river water. However, it is critical to the infrastructure that adequate operations and maintenance costs are covered.

Thus, the institutional mechanism of how the farmers pay for use of the equipment will be a determining factor of the success of the Scheme and must be explicitly set out before implementation.

The results of the financial appraisal indicate that the Project is financially viable, with a FNPV of GBP 85,406, and a FIRR of 14%. This return is higher than the discount rate of 11.5%, indicating that the Scheme is financially profitable. In terms of the Scheme's operational sustainability, the Project demonstrates positive returns each year, even when production is assumed to be only 50% of optimal production in the first year of production and increasing by 10% each year (thus only reaching 100% capacity in the 6th year of operation). This is demonstrated by a financial BCR of 4.5 when the capital cost is excluded from the analysis, indicating strong operational sustainability. It should be noted that this value represents the *operational* costs and benefits only. With capitcal costs included, the financial BCR is 1.15 – as indicated in the summary table below.

The economic appraisal component of the CBA assesses a wider spectrum of costs and benefits relative to the financial appraisal. Both quantitative and qualitative costs and benefits are included within the economic appraisal in order to provide a holistic view of the expected net socio-economic impact of the project. However, in order to capture the quantitative economic benefits of the Project, 'shadow pricing', or an estimation of the true value of the goods and services supplied or used in the Scheme, are used. These result in an ENPV of GBP 293,555 (at a social discount rate of 10%) and GBP 808,286 (at a social discount rate of 3.5%), with an ERR of 18%. The BCR is 1.48 and 2.15 respectively, depending on which discount rate one uses, and demonstrates that there is social justification given the project's cost to the community. Qualitative economic benefits, including climate resilience, lower levels of human-wildlife conflict, positive gender impacts and enhanced economic development would inflate these figures but are not included in the calculation due to limited data available and difficulty in their objective quantification. However, the combination of quantitative results, bolstered by the significant qualitative benefits, provides a robust justification for implementing the project from a socio-economic perspective.

It is unlikely that private sector investors will be willing to fund the project due to its remote location and high risk nature. External grant financing is therefore required to cover the capital investment to make the Project viable. Additionally it is recommended that grant funding should cover at least one year of operations and maintenance (O&M) costs so as not to overburden the farmers with costs, coupled with a small grant to finance agricultural training and startup costs. The total grant proposed in this CBA is therefore GBP 456,952. The section on 'Project Funding Scenarios' in the table below compares the FNPV and FIRR with and without this grant funding.

Executive Summary Table

Budget	
• Capital costs	Intake and pump costs: £237,446 Conveyance pipelines: £41,790 Drag hose infrastructure: £39,898

	Wildlife fencing: £18,072 **TOTAL: £337,206**
Suggested expenditure financed by grant	Capital: £337,206 Start-up costs (including agricultural training, equipment and agricultural inputs for year 1): £102 885 O&M for year 1: £16, 860 **TOTAL: £456,952**
Beneficiaries	
Direct beneficiary households	100
Direct beneficiary population	435
Indirect beneficiary households	Households and local industry in the Sioma district which will benefit from economic multiplier effects as a result of increased cash in circulation, as well as growth in local agribusiness activity and the potential for further growth in agricultural beneficiation such as packaging and processing. Additionally, the Sioma ward will benefit from diversified produce in the market, with associated improvements in health. It is anticipated at the entire Malombe settlement will directly or indirectly benefit from this scheme – bringing the anticipated total number of indirect beneficiaries to 1,150 households (that is, 5,708 beneficaires, consisting of 2,737 males and 2,971 females).
Lifespan of benefits	20 years
Economic Benefits	
Food security and climate resilience	Irrigated agriculture will drastically reduce the risk of crop failure in periods of drought. Current framing practices in the Malombe village are primarily rain-fed. Past experience highlights the risks of rain-fed agriculture due to variable weather patterns. The proposed infrastructure will enable the community to have consistent water-flows to their crops, thus building resilience to climate shocks. Additionally, it is expected that the initial agricultural training will provide climate-smart agriculture training which will promote crop rotation, soil management and minimize

	erosion
Health	While malnutrition is not a major issue in the area, a diversification the kinds of crops grown by the community will see health improvements through a diversification of diets and better knowledge around food variation. The crops proposed are a combination of staple foods such as maize and other vegetables, including beans, onions, tomatoes and other leafy greens. The Scheme however is designed to insure that only limited amounts of the horticultural crops are grown because of their perishable nature, fluctuating prices and marketing challenges. It is envisaged that these crops will mostly be consumed locally.
Positive gender impacts	Benefits will fall disproportionally on women in the community due to increased revenue generated from their crops and diversified diets (especially for children)
Lower wildlife conflict	As a result of elephant-proof fencing, it is expected that there will be a reduction in crop destruction
Cash injections into the rural economy	Many of the rural communities within the Sioma district have no formal income and survive from subsistence crops alone. Being able to sell additional agriculture provides a valuable cash injection to the community, which in turn has multiplier effects in stimulating further growth and development in the area
Financial appraisal performance indicators	
Financial Net Present Value (FNPV)	£85,406
Financial Rate of Return (FRR)	14%
Financial Benefit-Cost Ratio (BCR) incl. capex	1.15
Financial Benefit-Cost Ratio (BCR) excl. capex (i.e. operational costs *only*)	4.5
Financial Net Benefit/Investment Ratio (F-N/K Ratio)	0.26
Economic appraisal performance indicators	

	(3.5% SDR)	(10% SDR)
Economic Net Present Value (ENPV)	£808,286	£293,555
Economic Rate of Return (ERR)	18%	18%
Economic Benefit-Cost Ratio (EBCR)	2.15	1.48

Project Funding Scenarios

	FNPV (GBP)	FIRR (%)
Project alone	85,406	14%
Full grant funding	495,228	43%

Sustainability

The project appraisal was conducted from the perspective of the local communities as they will become the project owners, accruing project revenues that stem from improved water supply. They will also, however, be responsible for the on-going O&M. It is vital that the project generates sufficient revenues to cover its on-going costs.

The financial appraisal calculates whether the entire value of crop production is sufficient to cover the costs of the project, and, as demonstrated above, indicates that the project is financially viable. However, it is realistic to assume that a portion of the crops will be consumed by the farming households themselves and will thus not present an actual financial inflow into the community. While these consumed crops certainly have a value (and best estimated at market prices as done in the financial appraisal), the approach taken in estimating the realistic operational sustainability of the Scheme assumes that only 50% of production is sold[5]. If this is the case, then the project demonstrates an operational BCR of 2.26, indicating that the net present value of benefits is double that of its ongoing costs.

The ability of the community to maintain the infrastructure is thus assumed to be robust even when only 50% of their produce is consumed locally. This is in addition to the assumption that production begins at 50% of optimal productions suggested in the agronomic model and increases at 10% each year (reaching full capacity in year 6 only).

[5] Following discussions with the project's supervising engineer after site visits

10. Analysis of Potential Funders and Planned Procurement Route

10.1 Analysis of Potential Funders

The initial CCAP Zambia was funded by the Least Developed Countries Fund (LDCF), a UNFCC Fund managed by the Global Environment Facility (GEF) through the United Nations Development Programme (UNDP) in Lusaka. The Ministry of Agriculture (MA) is the main implementing partner working in collaboration with other institutions. The total CCAP budget is USD 4,070,000 for an implementation period of four years from 2010 to 2013, with an 18 month extension to June 2015.

CCAP identified eight pilot sited for potential infrastructure interventions. The CCAP budget was however not sufficient to support all proposed infrastructure and activities envisaged at the pilot sites, hence CRIDF, with the MA, shortlisted three of the sites for CRIDF support (including assistance in leveraging capital finance for implementation).

CRIDF initiated discussions with the World Bank (the Bank) office in Zambia with respect to the possibility of leveraging finance for the three CRIDF-supported CCAP projects from the Bank's existing support to the Ministry of Energy and Water Development (MEWD). A loan of USD 50million extended to the MEWD from the Bank is operational; of this USD 30million has been allocated to small scale water infrastructure for the rural poor. The Bank indicated in initial discussions that about USD 10million might be used to support implementation of the infrastructure at the three CRIDF supported CCAP sites (being Sioma, Kazungula and Mashili).

The World Bank office in Zambia has indicated their support for such an allocation of funds to the relevant Ministries in Zambia; however ultimately the MEWD is responsible for the management of these funds and spending (with a no objection sign off from the World Bank).

Subsequently, CRIDF and MA engagement with the MEWD indicated that they had no objection to using the Bank funds to support the CCAP projects, but that preliminary cost estimates and further project detail is required to inform spending decisions.

If this financing route comes to fruition, the procurement process would likely require a national competitive bid, and the MEWD will be responsible for leading the procuring process.

Since the early contacts with MEWD and MA there has been on-going dialogue about the inclusion of the three CCAP and the additional Project of Mashili. Although Sioma does not satisfy the criteria adopted by MEWD for their projects, which was focusing on new dams, renovation of dams and the development of canals, discussions held between MEWD, MAL, WB and CRIDF suggested that they would still consider Sioma for funding.

An additional project partner and potential source of financial support to the Sioma Irrigation Scheme is KAZA supported by KfW. Working with ZAWA, the Sioma Ngwezi KAZA Project Proposal to KfW aims to protect an large area along the Zambezi River by implementing an elephant restraining line. It is envisaged that there will be two phases to this project, the first will involve an assessment of wildlife corridors, and community engagement around voluntary relocation and associated livelihoods concerns; the second phase will be implementation. ZAWA indicated in engagements with CRIDF that there is a significant amount of overlap between the KAZA work and Sioma Irrigation Scheme in terms of promoting sustainable livelihoods in conjunction with decreasing human-wildlife conflict.

10.2 Procurement

Since CRIDF is only responsible for preparing the feasibility studies, once these have been signed off they will be handed over to MEWD. It will be MEWD's responsibility to examine these and if in agreement take these proposals forward for funding. If this is the case then MEWD will be responsible for all of the procurement processes.

In the procurement of contractors for the implementation of the project, MEWD will follow the WB procedures and be fully responsible for all procurement for the project. These will follow the "Guidelines for the Procurement of Goods, Works, and Non-Consulting Services, Under International Bank of Reconstruction and Development (IBRD) Loans and IDA Credits & Grants By World Bank Borrowers" 2014.

These shall ensure;

a) the need for economy and efficiency in the implementation of the project, including the procurement of the goods, works, and non-consulting services involved;
b) the Bank's interest in giving all eligible bidders from developed and developing countries the same information and equal opportunity to compete in providing goods, works, and non-consulting services financed by the Bank;
c) the Bank's interest in encouraging the development of domestic contracting and manufacturing industries in the Borrowing country; and
d) the importance of transparency in the procurement process.

The procurement will include;

- detailed design of all infrastructure,
- the construction of the infrastructure;
- support services including training and marketing support;
- materials required the beneficiaries to undertake cultivation;

In addition funding should be made available to support the community during the initial period to:

- cover O&M costs during the 1st year;
- credit for inputs required during the 1st year for inputs;
- support services for technical advice on crop production under irrigation; and
- marketing of the crops.

Ultimately some of these support services will be taken over by government support services such as the District Extension Services under the DACO. However during the initial phase it is anticipated that these should be contracted in.

11. Risk Register

Risk Event	Potential Impact	Current Risk Level			Risk Management Strategy	Responsibility
		L	C	I		
Management Risks						
The Sioma Irrigation Scheme is not financially viability	Failure to generate sufficient revenue will mean that the community aren't able to operate and maintain the irrigation scheme.	3	3	M	The CBA has shown the scheme is financially and economically viable, however support will still need to be given to the community to ensure that they are able to produce and market sufficient goods that will generate the funds required for O&M. The agronomic model is being developed to ensure the operational sustainability and profitability of the scheme through the optimization of an appropriate cropping programme. The O&M costs for the first year should be covered by the project.	CRIDF / Project Economist
Institutional management capacity	The scheme will have over 100 beneficiaries / members and if they are unable to cooperate then it will be difficult to ensure the O&M of the project.	3	3	M	A participatory project development process is necessary with extensive community facilitation, sensitization and training. This must focus on both the methodologies of irrigation and management.	MA /DACO/ MMEWD
Despite the preparation of the feasibility study funding of the scheme proves problematic	Failure to secure funds will mean that scheme is not built and the farmers will have to continue to exist through rain fed agriculture.	2	3	M	The MA and MMEWD have been engaged and although the scheme does not form part of their priority funding criteria, they are supportive of the scheme and have indicated that they will include it on the list of projects scheduled for funding. WB have been very supportive of the scheme in previous meetings. If however funding remains and issue CRIDF should seek to identify alternative funding.	MMEWD / WB / CRIDF

Risk Event	Potential Impact	Current Risk Level			Risk Management Strategy	Responsibility
		L	C	I		
Technical Risks						
The increased production of goods fails to identify a suitable market.	Failure to market all of their produce will result in famers not being able to be financially viable and be able to pay for the O&M costs of the scheme	3	3	M	A core assumption of the agronomic model and expected crop income is a secure market. The development of the agronomic model and choice of crops, takes into account the market potential and market access needs. Support through the DACO's office and the Ministry of Agriculture should support the farmers identify appropriate markets and promote production of crops to suit these markets. Support should be given to the scheme to provide support during the initial stages which will including finding markets and adjusting the crops to suit potential markets.	DACO /MA
Crops damaged by wildlife	If the scheme is not protected then it is likely to be targeted by wildlife especially elephants and hippos.	2	3	M	Discussions have been held with ZAWA and KAZA who will support the construction of a wildlife protection fence round the site. Additional support may be required to support those outside the fence to ensure they are not unduly affected by the increased attraction of green foodstuffs to the wildlife	DACO / ZAWA /KAZA
Yield potentials are not attained	If the farmers do not achieve high yields they may find it difficult to reach their financial targets.	2	3	M	Support will be given to the farmers to train them in how best to farm their land under irrigation. Credit lines should also be established to help them secure the required inputs. They should also be advised on the need to improve the soil quality by increasing the organic matter in the soil.	DACO
The scheme requires an EIA in order for permission to extract	Failure to get approval to extract water will prevent the scheme from being	3	3	M	A draft ToR for the EIA has been prepared. This will be submitted to ZEMA when funding for the scheme has been secured. It is unlikely that a water extraction permit will be refused but an EIA	

Risk Event	Potential Impact	Current Risk Level			Risk Management Strategy	Responsibility
		L	C	I		
water	constructed. An EIA is required as the scheme will be over 50ha.				will need to be completed.	
Lack of Electricty will disrupt the ability to irrigate	Zambia is going through a period of extensive power cuts which have had major impacts on many irrigation projects in Zambia. This could seriously affect production levels.	3	3	M	The local electricity supplier is Western Power which is regarded as a more reliable source of power than ZESCO at present. Wetsern Power are aiming to boost power production with a number of new generating proposals. Solar was considered but without storage capcity to allow gravity fed irrigation it is not regarded as viable. This is considered an acceptable risk.	
Social Risks						
Farmers outside the scheme feel aggrieved that they are not benefitting.	Despite being asked to join the scheme many farmers have declined. Once they see the benefits they will feel aggrieved.	3	2	M	The scheme has been designed to benefit the most amount of households. All of the existing people who have signed up for the scheme will be able to be part of the scheme and there is potential that some of those that have resisted joining will also be able to benefit. There will however be some who are disappointed. The management committee and the tribal leadership must manage this carefully. Through the consultative process undertaken more of the community have become committed to the scheme and at present there is wide consensus that the community will work together and manage any dissatisfaction. Part of the support provided to the community during the early stages of implementation will strengthen the community management of the irrigation scheme to reduce potential conflict.	

Risk Event	Potential Impact	Current Risk Level			Risk Management Strategy	Responsibility
		L	C	I		
Although the site is close to the Zambezi and some boreholes exist many households spend considerable amounts of time securing water for their household needs.	Households spend valuable time collecting water when this time could be more fruitfully used. Existing sources are not adequate and some ill health has been noted amongst potential beneficiaries.	2	2	M	Plans were developed to supply additional water to these communities. However between the time the plans were prepared and now a local NGO has sunk two new boreholes in close proximity to the irrigation site which is providing a good source of potable water. There is therefore no need for CRIDF to provide additional water to these communities. Some livestock water may be provided through the irrigation scheme if this is found to be beneficial and reduce the risk of crocodile predation.	

Key:

L - Likelihood
C - Consequence

I – Impact

				Temporary delay **Resource Intensive**	**Short period, isolated impact**	**Impacts across a number of activities**	**Suspension of program** **Loss of creditability**	**Termination of Program**
				Consequence				
				Insignificant	**Minor**	**Moderate**	**Major**	**Severe**
	Expectation:			**1**	**2**	**3**	**4**	**5**
Likelihood	Is expected to occur in most circumstances	**5**	**Almost certain**	**M**	**H**	**H**	**E**	**E**
	Will probably occur at some stage	**4**	**Likely**	**M**	**M**	**H**	**H**	**E**
	Might occur at some time in the future	**3**	**Possible**	**L**	**M**	**M**	**H**	**E**
	Could occur but doubtful	**2**	**Unlikely**	**L**	**M**	**M**	**H**	**H**
	May occur but only in exceptional circumstances	**1**	**Rare**	**L**	**L**	**M**	**M**	**M**

E - Extreme risk – Unacceptable – detailed action plan required

H - High risk - Unacceptable – requires attention from MC

M – Medium risk – Acceptable – management aware of risk

Annex A: BoQ for Pumping Station

A. Preliminary and General

Item	Description of Works	Unit	Quantity	Rate US$	Amount US$
1.00	Mobilization, demobilization, contractor's camp, and signboards				101,400.00
	TOTAL (Preliminary and General)				**101,400.00**

B. Intake works, main canal and pumping station

Item	Description of Work	Unit	Qty	Rate US $	Amount US$
2.00	Construction of Head works and Canal	-	-	-	360.00
2.21	Excavations	-	-	-	15,450.00
2.30	Concrete Work	-	-	-	11,500.00
2.40	Miscellaneous	**-**	-	-	13,925.00
Sub-Total					41,235.00
3.00	**Pumping Station** -				
3.10	**Earthworks and Excavations for Main Pumping Station** -				
3.1.1	Clear site, remove top soil, and excavate. Transport, Spread, Place and Compact	m2	-	-	9,450.00
	Sub-Total				**9,450.00**
3.20	Concrete: Provide all materials, mix, place, vibrate and cure concrete.				
3.2.1	Plain concrete grades 15, 25, and Grade 30 (base slab).	m3	-	-	6,700.00
3.2.2	Vertical Wall C 30			200.00	5,000.00
	Sub-Total				**11,700.00**
	Shuttering				-
3.30	**Rough Shuttering**				-
3.3.1	External wall below finished ground level, and sides of base slabs	m2	20.00	86	1,720.00
	Wood float finish				-

3.3.2	Wood float finish and steel float finish	m2	3.00	200	600.00
	Sub-Total				**2,320.00**
3.40	**Reinforcement**				-
3.4.1	supply, cut, bend and fix steel reinforcement	LS	0.30	8,000	2,400.00
	Sub-Total				**2,400.00**
3.50	**Builders Work**				-
3.5.1	Supply material, construct and finish building works including all block work	LS	1.00	80,000	80,000.00
	Sub-Total				**80,000.00**
6.0	**Pumping Units**				
6.1	Supply, deliver, and install the horizontal mounted centrifugal pumps				-
6.1.1	(Flow: 50.0 litres/sec, Head: 70.00-m, Motor power about: 47-kW)	No	2.00	35,000	70,000.00
6.1.2	Supply & deliver pump spare parts	No.	1.00	5,000	5,000.00
6.1.3	Supply & deliver submersible dewatering pump complete with piping system; Q = 15 litres/sec; H =10m	No.	1.00	4,200	4,200.00
	Sub Total				**79,200.00**
6.2	**Fittings, pump spare parts and other accessories**				
6.2.1	Valves and fittings on the suction and delivery side of the pumps	Sum	1.00	10,500	10,500.00
6.2.2	Supply a set of spares as recommended by the manufacturer for running period of 5 years	sum	1.00	3,000	3,000.00
6.2.3	Pump Station overhead monorail hoist: Supply, deliver to site, and install an overhead monorail hoist	Set	1.00	2,000	2,000.00
6.2.4	Weed screen: Supply and deliver to site a weed screen according	No.	1.00	2,000	2,000.00
6.2.5	Steel Works and Anchor Bolts: Supply and deliver to site all steel works	sum	1.00	1,000	1,000.00

	Sub-Total				**18,500.00**
7.0	**Electrical Equipment**				
	Supply and deliver to the site the following				
7.1	Control Panel:- Supply and deliver to site Control panel including incoming and outgoing feeders, and control, protection equipment, and the electrical single line diagram	no	2.00	7,000	14,000.00
7.2	Power and Control Cables:				-
7.2.1	Supply and deliver to site: Power and control cables complete with cable trays and conduits. Only incoming power cable from transformers shall be provided and installed by ZESCO.	sum	1.00	1,000	1,000.00
7.3	Electric Lighting:-				-
7.3.1	Supply and deliver to site: interior and emergency lighting equipment	sum	1.00	1,000	1,000.00
7.4	Earthing:- Supply and deliver equipment to site	sum	1.00	300	300.00
7.5	Spare Parts for Control panel:-				-
7.5.1	Supply and deliver to site, set of spare parts for the control panel	sum	1.00	1,200	1,200.00
	Sub-Total		-	-	**17,500.00**
8.0	Maintenance and Repair tools				
8.1	Supply and deliver maintenance and repair tools	Set	1.00	800	800.00
8.2	Expenses of Erection, Commissioning and testing of the Pumping Station	sum	1.00	500	500.00
8.3	Provide O&M manuals	sum	1.00	1,000	1,000.00
	Sub Total				**2,300.00**
	Sub – Total (Intake works and Pumping Station)				**264,605.00**
	GRAND TOTAL (P & G, INTAKE				**366,005.00**

	WORKS, AND PUMPING STATION)				

Annex B: BoQ for Option 2 – Furrow Irrigation Scheme

A. Conveyance Pipelines

4.00	Pipeline Construction				
Item	**Description**	**Unit**	**Qty**	**Rate USS**	**Amount USS**
4.10	**Excavation**				
4.1.1	Clear 2.5m wide working strip for a trench for a single pipe along pipeline route including bush, vegetation, and trees	m	0.80	3,478	2,782.40
4.1.2	Excavate and dispose unsuitable material for ND 200mm uPVC pipes for depth not exceeding 1.5m	m	1.00	3,478	3,478.00
	Sub - Total				**6,260.40**
4.20	**Backfilling and Compaction**				
4.2.1	Backfilling with selected backfill material, compact to 95% Mod AASHTO to 300mm above top of the pipe, and with in-situ material compacted to 95% Mod AASHTO from 300mm above pipe to ground lever	m	2.00	3,478	6,956.00
	Sub Total				**6,956.00**
4.30	**Pipework**				
	Supply, deliver to site, distribute, lay, bed and join water tight uPVC pressure pipes Jointing: Fluidite Joints. Sealing: pre-inserted lip ring seals. Operating pressure Max: 10 bars				
4.3.1	Pipe ND 200mm PVC	m	15.00	3,478	52,170.00
	Pressure testing	m	2.00	3,478	6,956.52
	Sub - Total				**52,170.00**
4.40	**Pressure Testing**				
4.4.1	ND 200mm uPVC	m	2.00	3,478	6,956.00
	Sub - Total				**6,956.00**

	TOTAL (PIPELINE CONSTRUCTION)				**72,342.40**

B. Construction of 4-No. New Night Storage Tanks

Item	Description of Works	Unit	Qty	Rate US$	Amount US$
1.00	**Construction of 4-No. Storage Tanks**				
1.1.1	Site clearance: Clear vegetation, trees of 1m girth and remove any other obstructions, and top soil to depth 150-mm	m2	0.40	3,600	1,440.00
1.20	Excavation Works: Excavate in all materials for 4No. Night Storage Tanks, new inlet and outlet structures and stockpile or dispose of	m3	4.00	1,800	7,200.00
	Sub - Total				**7,560.00**
1.30	Compaction: Compact in-situ material under side slopes and bases of new ponds up to depth of 200mm to 95% MOD	m2	6.00	1,800	10,800.00
	Sub - Total				**10,800.00**
1.40	**Embankment Protection**				
1.4.1	Provision and laying of 0.1m x 2m x 1.2m Concrete protective slabs (reinforced with one layer of Conforce 256mesh) on bottom portions of new ponds	m2	13.00	10,800	35,100.00
1.4.2	Provision and laying of 0.75m x 2m x 1.2m. Concrete protective slabs (reinforcement with one layer of conforce 86mesh) on upper portions of embankment slopes	m2	12.00	14,400	43,200.00
	Sub - Total				**78,300.00**
1.50	**Concrete Works for Inlet and Outlet Structures**				
1.5.1	**Specified Mix Concrete**				
1.5.1.	Grade 15 concrete for 50 mm thick blinding	m2	3.60	15	54.00
1.5.1.	Grade 20 mass concrete for benching	m3	21.48	150	3,222.00
1.5.2	**Strength WR Concrete**	-	-	-	0.00
1.5.2.	Grade 30 for Inlet and Outlet structures	m3	4.60	200	920.00
1.5.3	**Reinforcement**	-	-	-	0.00
1.5.3.	High tensile steel bars up to 16 mm dia	L	0.90	1,600	1,440.00
1.5.4.	Inlet and Outlet Structures walls, inside and top outside walls ,slabs etc	m2	150.00	6.40	960.00

1.5.4.	Inside and top outside walls ,slabs etc	m2	30.00	6.48	194.40
	Sub - Total				**6,790.40**
1.6.1	**Excavation**				
1.6.1.	Exceeding 0-m but not exceeding 1.0-m	m	2.00	18.00	36.00
1.6.1.	Exceeding 1.0 m but not exceeding 2.0-m	m	4.00	10.00	40.00
	Sub - Total				**76.00**
1.6.3	**Pipe Work on Inlet and Outlet Structures**				
1.6.3.	200 mm Overflow Pipes	m	80.00	40.00	3,200.00
1.6.3.	200 mm diameter Pressure Pipes	m	80.00	36.00	2,880.00
	Sub - Total				**6,080.00**
	TOTAL				345,586.40

C. Irrigation and Drainage Infrastructure

	MAIN CANALS				
2.1	**MAIN CANALS - 1,500m**				
2.1.1	Clear site, and strip topsoil to depth 150mm	m2	1.00	1,500	1,500.00
2.1.3	Cutting, stumping and disposal of trees	No	30.00	25	750.00
2.1.4	Excavate soft material and place in embankment, Haulage not exceeding 1000m	m3	3.00	1,500	4,500.00
2.1.5	Excavate material borrow pits and place in embankment, Haulage not exceeding 1000m	m3	4.00	1,500	6,000.00
2.1.6	Form/compact embankments and trim to profile.	m3	5.00	1,500	7,500.00
	Sub-Total				20,250.00
2.3b	**SECONDARY CANALS - 4,190m**				-
	Construction of secondary canals	m	10.00	4,190	41,900.00
	Sub-Total				**41,900.00**
	DRAINS				-
2.4	**MAIN DRAIN - 3600m**				-
2.4.4	Excavate soft material and place in embankment, haulage not exceeding 1000mm	m3	3.00	500	1,500.00
	Sub-Total				1,500.00
2.5	**SECONDARY DRAIN - 4200m**				-
2.5.1	**Clear site,** Strip top soil, 150mm depth	m2	0.50	4,000	2,000.00
2.5.3	Excavate soft material and place in embankment, haulage not exceeding	m3	3.00	10,300.	30,900.00

	1000mm				
	Sub-Total				32,900.00
	FARM SERVICE ROADS				-
4.1	**SERVICE ROADS - 700m**				-
4.1.1	Clear site	m2	0.50	7,000	3,500.00
4.1.2	Strip top soil, 150mm depth	m2	0.50	7,000	3,500.00
4.1.3	Cutting, stumping and disposal of trees, girth	No	30.00	20	600.00
4.1.4	Excavate soft material and place in embankment, haulage not exceeding 1000mm	m3	3.00	980	2,940.00
4.1.5	Form/compact embankments and trim to profile	m3	4.00	980	3,920.00
	Sub-Total				14,460.00
	FLOW CONTROL STRUCTURES				
3.2	**TURNOUT STRUCTURES**				
3.2.1	Excavate for structure, and for culvert	m3	3.40	10	34.00
3.2.3	Backfilling to structure including compaction	No	5.00	8.2	41.00
3.2.4	Reinforced concrete to structure class A	m3	2.00	200	400.00
3.2.5	Mass concrete to structure class B	m3	3.40	200	680.00
3.2.6	precast reinforced concrete pipes ND 200mm	m	12.40	50	620.00
3.2.7	High tensile steel reinforcement	kg	2.00	108	216.00
3.2.8	Tipped rock class F, 300mm	m3	0.60	100	60.00
3.2.9	Rough formwork to vertical concrete earth face	m2	6.60	20	132.00
3.2.10	Fair-faced formwork to vertical exposed face	m2	8.60	20	172.00
3.2.11	Control steel gate G1 for pipe ND 200mm	No.	2.00	50	100.00
	Sub-Total				**2,455.00**
	TOTAL (IRRIGATION AND DRAINAGE INFRASTRUCTURE)				**215,816.40**

Annex C: BoQ for Option 3 (I) Sprinkler Irrigation - Centre Pivot

A. Conveyance Pipelines

4.00	Pipeline Construction				
Item	Description		Unit	Rate (US$)	US$ Amount
4.10	Excavation				-
4.1.1	Clear 2.5m wide working strip for a trench for a single pipe along pipeline route including bush, vegetation, and trees	m	0.8	3,400	2,720.00
4.1.2	Excavate and dispose unsuitable material for ND 200mm uPVC pipes for depth not exceeding 1.5m	m	1.00	3,400	3,400.00
	Sub - Total				6,420.00
4.20	Backfilling and Compaction				-
4.2.1	Backfilling with selected backfill material, compact to 95% Mod AASHTO to 300mm above top of the pipe, and with in-situ material	m	2.00	3,400	6,800.00
	Sub Total				6,800.00
4.30	Pipework				-
	Supply, deliver to site, distribute, lay, bed and join water tight uPVC pressure pipes complete with DIN, BS, ISO, SANS, ZBS or equivalent standards. Jointing: Fluidite Joints. Sealing: pre-inserted lip ring seals. Operating pressure Max: 10 bars				
4.3.1	Pipe ND 200mm PVC	m	15.00	3,391.5	50,872.50
4.3.2	Provide reinforced concrete thrust blocks	m	5.00	350	1,750.00
	Sub - Total				59,550.00
4.40	Pressure Testing				-
4.4.1	ND 200mm PVC	m	2.00	3,400	6,800.00

	Sub - Total				**6,800.00**
	TOTAL (Pipeline Construction)				**72,342.40**

B. Centre Pivots

Item	Description of Works	Unit	Qty	Rate US$	Amount US$
5.0	**Centre Pivots**				
5.1	Supply, deliver to site and install the following centre pivot irrigation equipment with accessories :-				
5.1.1	CP-A: (24.3-hectares). Span length of 278-m, and ND 167mm lateral diameter	No	1.00	120,000	120,000.00
5.1.2	CP-B: (3.10-hectares). Span length of 100-m, and ND 167mm lateral diameter	No	1.00	15,500	15,500.00
5.1.3	CP-C: (4.20-hectares). Span length of 115-m, and ND 167mm lateral diameter	No	1.00	21,000	21,000.00
5.1.4	CP-D: (12.20-hectares). Span length of 197-m, and ND 167mm lateral diameter	No	1.00	60,000	60,000.00
5.1.5	CP-E: (14.00-hectares). Span length of 211-m, and ND 167mm lateral diameter	No	1.00	70,000	70,000.00
	Sub Total				**286,500.00**
	TOTAL (Centre Pivots)				**286,500.00**
	GRAND TOTAL				**358,970.00**

Annex D: BoQ for Option 3 (II) Sprinkler Irrigation –Centre Pivot and Drag Hose

A. Conveyance Pipelines

4.00	**Pipeline Construction**				
item	**Description**	**Unit**	**Qty**	Rate US$	
4.10	**Excavation**				$ -
4.1.1	Clear 2.5m wide working strip for a trench for a single pipe along pipeline route including bush, vegetation, and trees	m	0.80	3,400	2,720.00
4.1.2	Excavate and dispose unsuitable material for ND 200mm uPVC pipes for depth not exceeding 1.5m	m	1.00	3,400	3,400.00
	Sub - Total				**6,420.00**
4.20	**Backfilling and Compaction**				-
4.2.1	Backfilling with selected backfill material, compact to 95% Mod AASHTO to 300mm above top of the pipe, and with in-situ material	m	2.00	3,400	6,800.00
	Sub Total				**6.800.00-**
4.30	**Pipework**				-
	Supply, deliver to site, distribute, lay, bed and join water tight uPVC pressure pipes complete with DIN, BS, ISO, SABS, ZBS or equivalent standards. Jointing: Fluidite Joints. Sealing: pre-inserted lip ring seals. Operating pressure Max: 10 bars				
4.3.1	Pipe ND 200mm PVC	m	15.00	3,391	50,872.40
4.3.2	Provide reinforced concrete thrust blocks	m	5.00	350	1,750.00
	Sub - Total				**59,550.00**
4.40	**Pressure Testing**				-
4.4.1	ND 200mm PVC	m	2.00	3,400	6,800.00
	Sub - Total				6,800.00

	TOTAL (Pipeline Construction)				**72,342.40**

B. Centre Pivots, Pump Units and Electro-mechanical Equipment

Item	Description of Works	Unit	Quantity	Rate US$	Amount US$
5.0	**<u>Center Centre Pivots</u>**				
5.1	Supply, deliver to site and install the following centre pivot irrigation equipment with accessories :-				
5.1.1	CP-A: (24.3-hectares). Span length of 278-m, and ND 167mm lateral diameter	No	1.00	120,000	120,000.00
5.1.2	CP-D: (12.20-hectares). Span length of 197-m, and ND 167mm lateral diameter	No	1.00	60,000	60,000.00
5.1.3	CP-E: (14.00-hectares). Span length of 211-m, and ND 167mm lateral diameter	No	1.00	70,000	70,000.00
	Sub Total				**250,000.00**
	TOTAL (Centre Pivots, and Electro-mechanical Equipment)				**250,000.00**

C. Drag Hose Equipment

Item	Description of Works	Unit	Quantity	Rate US$	Amount US$
9.0	**<u>Piping</u>**				
9.1	Supply, deliver to site and install the following drag hose irrigation equipment with accessories :-				
9.1.1	Supply, deliver to site, distribute, lay, bed and join water tight 100-mm diameter 50-meter rolls of Class-6 Poly pipes complete with fittings conforming to DIN, BS, ISO, SABS, ZBS or equivalent standards. The pipes shall be installed following the manufacturer's instructions.	Rolls	18.00	500	9,000.00
9.1.2	High pressure 32-mm x 163-m hose pipes for drag lines	No	50.00	142	7,100.00
9.1.3	High pressure 32-mm x 250-m hose	No	50.00	150	7,500.00

	pipes for drag lines				
9.1.4	Risers: 1.5-m x 2-inch galvanised iron pipes	No	18.75	100	1,875.00
9.1.5	Brass 2-nozzle impact sprinklers	No	25.00	100	2,500.00
	TOTAL (Drag Hose Equipment)				**27,975.00**
	GRAND TOTAL				***716,322.40***

Annex E: BoQ for Option 3 (III) Sprinkler Irrigation - drag hose irrigation system

A. Conveyance Pipelines

1.00	Pipeline Construction				
Item	**Description**	**Unit**	**Qty**	**Rate US$**	**Amount US$**
1.10	**Excavation** 1,591m mainline, and 1,980m sub-main line				-
1.1.1	Clear 2.5m wide working strip for a trench for a single pipe along pipeline route including bush, vegetation, and trees	m	0.80	3,571	2,856.80
1.1.2	Excavate and dispose unsuitable material for ND 200mm uPVC, and 100-mm poly pipes for depth not exceeding 1.5m	m	1.00	3,571	3,571.00
	Sub - Total				**6,427.80**
1.20	**Backfilling and Compaction**				-
1.2.1	Backfilling with selected backfill material, compact to 95% Mod AASHTO to 300mm above top of the pipe, and with in-situ material	m	2.00	3,571	7,142.00
	Sub Total				**7,142.00**
2.30	**Pipework**				-
	Supply, deliver to site, distribute, lay, bed and join water tight uPVC pressure pipes complete with DIN, BS, ISO, SANS, ZBS or equivalent standards. Jointing: Fluidite Joints. Sealing: pre-inserted lip ring seals. Operating pressure Max: 10 bars				
2.3.1	Pipe ND 200mm PVC	m	15.00	1.591	23,865.00
	Pipe ND 100mm Poly	m	10.00	1,980	19,800.00
2.3.2	Provide reinforced concrete thrust blocks	m	5.00	350	1,750.00
	Supply, deliver to site, distribute, and install 1.5-m x 2-inch risers complete with hydrant valves	No	15.00	150	2,250.00

	Sub - Total				**47,665.00**
2.40	**Pressure Testing**				-
2.4.1	ND 200mm uPVC	m	1,591.00	2.00	3,182.00
	Sub - Total				**3,182.00**
	TOTAL (Pipeline Construction)				**64,416.80**

B. Drag Hose Equipment

Item	Description of Works	Unit	Qty	Rate US$	Amount US$
4.0	**Piping**				
4.1	Supply, deliver to site and install the following drag hose irrigation equipment with accessories :-				
4.1.1	Supply, deliver to site, distribute, install hydrant bends complete with reducing sockets and accessories	no	150	60	9,000.00
4.1.2	Supply, deliver to site, distribute, install 32-mm diameter x 250-m High pressure drag lines	rolls	150	250	37,500.00
4.1.5	Supply, deliver to site, distribute, install brass 2-nozzle impact sprinklers on stands complete with fittings	no	150	100	15,000.00
	TOTAL (Drag Hose Irrigation Equipment)				**61,500.00**
	GRAND TOTAL				***$491,921.80***

Annex F: BoQ for Option 3 (IV) Sprinkler irrigation - Quick Move Sprinkler Irrigation System

A. Conveyance Pipelines

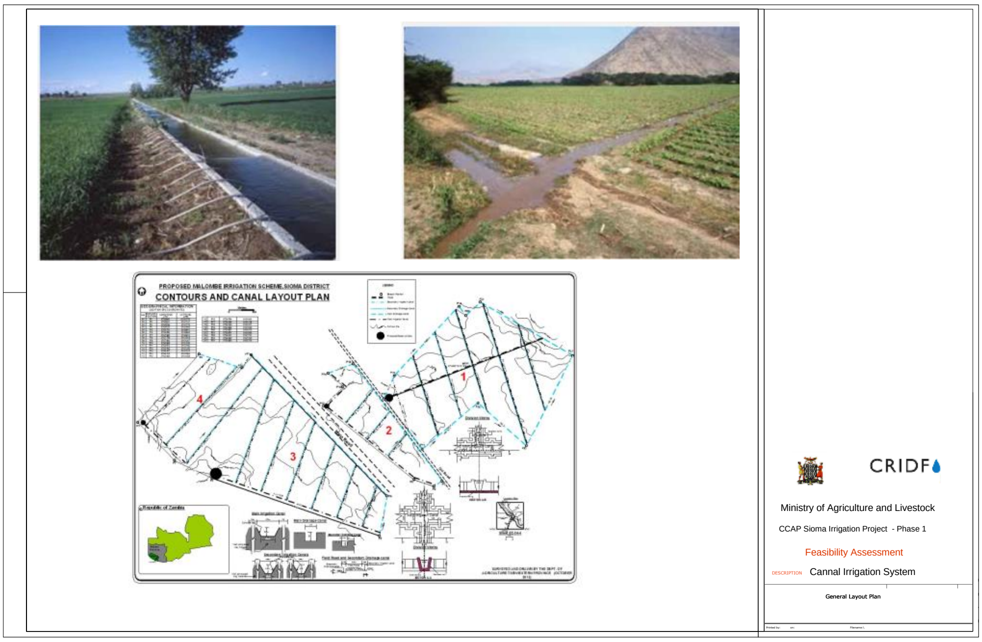
1.00	Pipeline Construction				
Item	**Description**	**Unit**	**Qty**	**Rate US$**	**Amount US$**
1.10	**Excavation** 1,591m mainline, and 1,980m sub-main line				-
1.1.1	Clear 2.5m wide working strip for a trench for a single pipe along pipeline route including bush, vegetation, and trees	m	0.80	3,571	2,856.80
1.1.2	Excavate and dispose unsuitable material for ND 200mm uPVC, and 100-mm poly pipes for depth not exceeding 1.5m	m	1.00	3,571	3,571.00
	Sub - Total				**6,427.80**
1.20	**Backfilling and Compaction**				-
1.2.1	Backfilling with selected backfill material, compact to 95% Mod AASHTO to 300mm above top of the pipe, and with in-situ material	m	2.00	3,571	7,142.00
	Sub Total				**7,142.00**
1.30	**Pipework**				-
	Supply, deliver to site, distribute, lay, bed and join water tight uPVC pressure pipes complete with DIN, BS, ISO, SANS, ZBS or equivalent standards. Jointing: Fluidite Joints. Sealing: pre-inserted lip ring seals. Operating pressure Max: 10 bars				
1.3.1	Pipe ND 200mm PVC	m	15.00	1,591	23,865.00
	Pipe ND 100mm Poly	m	10.00	1,980	19,800.00
1.3.2	Provide reinforced concrete thrust blocks	m	5.00	350	1,750.00
	Supply, deliver to site, distribute, and install 1.5-m x 2-inch risers complete with hydrant valves	No	15.00	50	750.00

	Sub - Total				**46,165.00**
1.40	**Pressure Testing**				-
1.4.1	ND 200mm uPVC	m	2.00	1,591	3,182.00
	Sub - Total				3,182.00
	TOTAL (Pipeline Construction)				**62,916.80**

B. Quick Move Irrigation Equipment

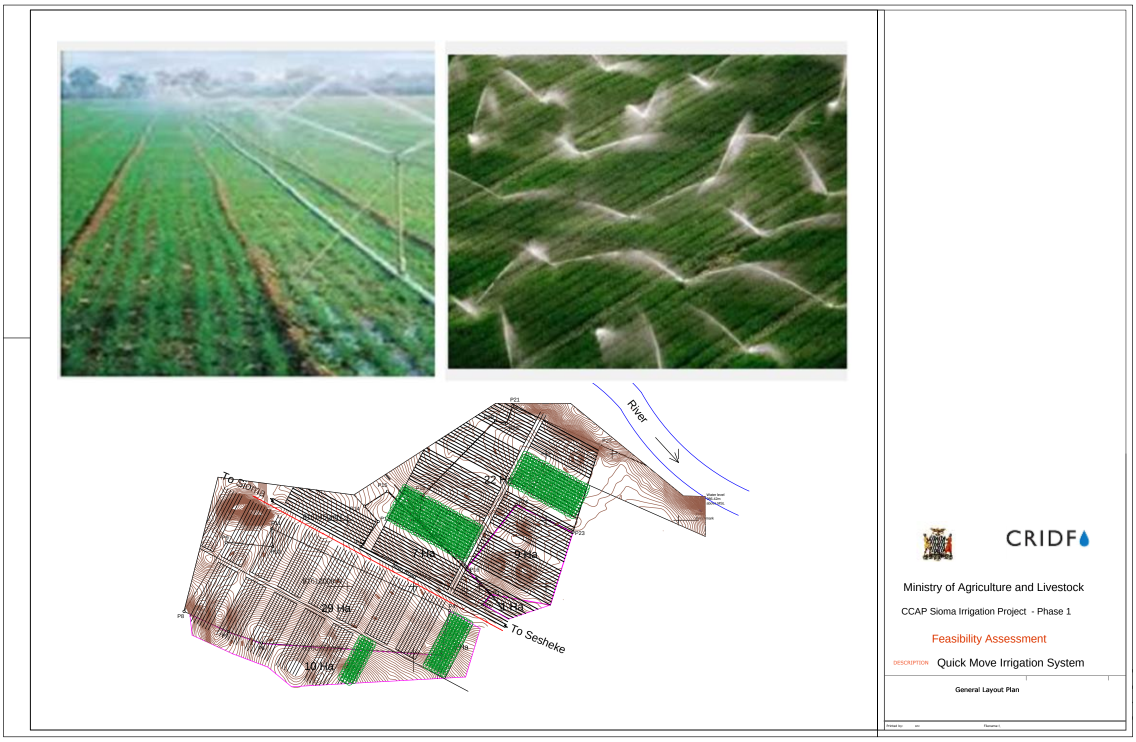
Item	Description of Works	Unit	Qty	Rate US$	Amount US$
1.0	**Piping**				
1.1	Supply, deliver to site and install the following drag hose irrigation equipment with accessories :-				
1.1.1	Supply, deliver to site, distribute, install hydrant bends complete with reducing accessories	no	50	60	3,000.00
.1.2	Supply, deliver to site, distribute, install 3-inch diameter x 6-m plain and perforated aluminium laterals pipes	rolls	250	1,189	297,250.00
1.1.1	Supply, deliver to site, distribute, install ¾-inch x 1.5-m G.I. pipe risers with fittings	no	60	580	34,800.00
1.1.5	Supply, deliver to site, distribute, install brass 2-nozzle impact sprinklers on stands complete with fittings	no	100	580	58,000.00
	TOTAL (Quick Move Irrigation Equipment)				**393,050.00**

Annex G: Irrigation Design Options




Zambezi
River
To Sioma
22 Ha
CP - A
9 Ha
Ha
29 Ha
CP - E
CP - D
1 Ha
To Sesheke
10 Ha
Ministry of Agriculture and Livestock
CCAP Sioma Irrigation Project - Phase 1
Feasibility Assessment
DESCRIPTION
Centre Pivot and Dragline System
General Layout Plan


Zambezi
River
To Sesheke
Ministry of Agriculture and Livestock
CCAP Sioma Irrigation Project - Phase 1
Feasibility Assessment
DESCRIPTION
Dragline Irrigation System
General Layout Plan



River
To Sioma
22 Ha
7 Ha
9 Ha
29 Ha
3 Ha
10 Ha
To Sesheke
CRIDF
Ministry of Agriculture and Livestock
CCAP Sioma Irrigation Project - Phase 1
Feasibility Assessment
DESCRIPTION Quick Move Irrigation System
General Layout Plan

Annex H: Community Endorsement Letter

Communications should be addressed to

In reply please quote:………

The District Agricultural Co-ordinator.

REPUBLIC OF ZAMBIA

MINISTRY OF AGRICULTURE AND LIVESTOCK

Office of the District Agricultural Co-ordinator,

P.O. Box 920117

SIOMA

3rd December, 2015

The Principal Irrigation Engineer

Ministry of Agriculture and Livestock

LUSAKA

RE: COMMUNITY APPROVAL OF TYPE OF IRRIGATION SYSTEM FOR MALOMBE COMMUNITY OF SIOMA DISTRICT

The above subject matter refers.

Malombe community is found in Sioma Agricultural Camp of Sioma District in Western Province. The Malombe community is the one where the UNDP/GRZ Climate Change Adaptation Project activities were being implemented.

One of the earmarked activities at the pilot site was the construction of an irrigation scheme. However, this could not materialize due to inadequate funds from the funding agency. As such, UNDP/GRZ partnered with the Climate Resilience Infrastructure Development Facility (CRIDF), who conducted a feasibility study of putting up an irrigation scheme for the Malombe community.

30 farmers from Malombe community were also taken for a study tour to Southern Province (Sinazongwe, Kalomo and Mazabuka) to check on the different irrigation types available and the management systems. The community settled for the Centre Pivot system. However, of the five (5) options considered by CRIDF, the Dragline system was selected to be put up at Malombe.

The community members were then informed of the proposed type of irrigation system and accepted the recommended type after a community meeting.

The office therefore seeks for the construction consideration of the Dragline Irrigation system for the Malombe community of Sioma District

Yours Sincerely

Signed

Muntanga Belvin

District Agricultural Coordinator – Sioma

c.c. Principal Agricultural Officer – Western province

c.c. The Director - CRIDF

Annex I: Cost Benefit Analysis

Key assumptions

- With the appropriate maintenance, it is expected that the project will have an economic life of 20 years. No residual value for the infrastructure is included in the analysis as this would inflate the benefits accruing to the community.
- The financial discount rate represents a time-preference for money and can be equated to the next best return on capital in the market. A real interest rate of 11.5% was used in the financial analysis, suggested by the AfDB in their 2013 study done on irrigation infrastructure in the Kafue sub-basin[6]. This rate represents the average cost of capital in the market and represents the opportunity cost of using money for this particular project.
- For the economic analyses, the social discount rate used is 3.5% and 10%. This discount rate was chosen in line with the World Bank and European Bank for Research and Development's standard conventional cut-off rate. The cut-off rate is the rate of return below which a project is considered unacceptable; in the economic analysis the cut-off rate is the Economic Opportunity Cost of Capital (EOCC). This rate is already adjusted for inflation.
- Prices used in all the analyses are constant 2015 prices. It is assumed that inflation is general, meaning that all prices rise at the same rate; hence adjusting prices for inflation would mean compounding all the costs and benefits by the same factor. The discount rates used above are thus adjusted for inflation.

Table 1: **Key Assumptions**

Assumptions	
Financial Discount Rate	11.5%[7]
Exchange Rate	USD 1.00 = GBP 0.65[8]
Constant Versus Current Prices	Constant 2015 prices
Project lifespan	20 years
Number of Households	100

[6] African Development Bank (2013). Strengthening Climate Resilience In The Kafue Sub-Basin. Appraisal Report. Online: http://www.afdb.org/fileadmin/uploads/afdb/Documents/Project-and-Operations/Zambia_-_Strengthening_Climate_Resilience_in_the_Kafue_Sub-Marin_-_Appraisal_Report.pdf

[7] African Development Bank (2013). Strengthening Climate Resilience In The Kafue Sub-Basin. Appraisal Report. Online:http://www.afdb.org/fileadmin/uploads/afdb/Documents/Project-and-Operations/Zambia_-_Strengthening_Climate_Resilience_in_the_Kafue_Sub-Marin_-_Appraisal_Report.pdf

[8] Oanda Currency Converter (2015). Online: http://www.oanda.com/currency/converter/, accessed 9 November 2015

Average Household Size	4.35
Population size	435
Social Discount Factors	3.5% and 10%
Annual income per hectare of land under irrigation	USD 1,735[9]

Source: CRIDF, 2015

Options Appraisal

There have been numerous iterations of the technical design of the project. While the pump and intake works are similar between designs, irrigation infrastructure can take on numerous forms, each with their own pros and cons. Centre pivots for the entire area, centre pivots and drag hose irrigation for the small areas, drag hoses, a quick shift system and flood irrigation were all options considered during technical feasibility. While initially centre pivots were identified as most water efficient, their operation would require the outsourcing of operations and maintenance. Centre pivots would also require the establishment of a company – of which participating farmers would be given shares.

Given the small size of the proposed scheme, the reality of the community's needs and capacity to manage such an arrangement indicated that a most affordable and simpler scheme should be proposed which could be managed by the farmers themselves. Consideration was taken in the Scheme's use of water, appropriateness to soil conditions, infrastructure costs, community engagement and institutional support.

Table 2: **Cost Estimates of Various Irrigation Options**

	Furrow irrigation	Centre pivot	Centre pivot & drag hose	Drag hose
Pump & irrigation infrastructure cost (GBP)	648,588	517,259	464,714	319,134

Source: CRIDF, 2015

Coupled with the cost of the infrastructure, a drag hose system was recommended. The community will be able to manage the infrastructure without the need for hiring a farm manager and each plot will be able to grow different crops due to the fact that different levels of water can be applied to different plots within the Scheme. Community members had expressed concern about a centrally-managed scheme, and would prefer individually managed plots. Centre Pivots would exacerbate the current limited marketing opportunities facing the village as large quantities of the same crop would need to be grown.

[9] Agronomic model, Sioma Technical Report

Financial Appraisal

Project costs

The total engineers' estimate for infrastructure development costs for the water infrastructure covering the 57.8 ha is GBP 319,134.

Additionally, it is suggested that 15 km of elephant-proof fencing is required for the irrigation site. Zambia Wildlife Association (ZAWA) indicated that approximately GBP 18,072[10] would be needed to cover this cost.

The table below presents a summary of the capital costs. These costs include:

- River intake channel and sump
- River pump station
- Electricity transformers at head-works and infield of a pivot is installed
- Mechanical and electrical equipment at the river pump station
- Irrigation mains, sub-mains, and infields
- Scheme access and haulage roads

Table 3: **Project Development Costs**

Cost component	GBP
Intake works and pumping station	237,446
Conveyance pipelines (mains and sub-mains)	41,790
Drag Hose infrastructure	39,898
Sub –Total	**319,134**
Wildlife fencing	18,072
Total capital costs	**337,206**

Source: CRIDF, 2015

On-going O&M costs

O&M costs are assumed to be 5% of the total capital cost annually, and would include maintenance of the irrigation system, water supply infrastructure and fencing. These annual costs include only O&M of the capital investment itself, and not on-going costs of the agricultural inputs. Annual O&M costs are estimated to be GBP 16,860.

Start-up costs

[10] This cost is considered generous and indicates sufficient fencing for 70 ha of land (see Sioma Technical Report)

Currently there is limited infrastructure that could be directly utilised for the project. Farmers practice dry-land agriculture, using hand labour to cultivate between 0.5 and 4 ha per households. Households are poor and lack the resources to purchase inputs such as fertiliser and seed. It is thus unrealistic to assume that they will be able to afford the inputs needed for intensive farming proposed under the new Scheme. Start-up costs include:

- Equipment and gear
- Fertiliser
- Pest control
- Seed costs

Bar the costs for equipment and gear, the costs listed above are included in the agronomic model's calculation of gross margin and are thus not included as an annual cost item in the CBA. Including them in the start-up cost of the project guarantees that farmers will be able to afford to operate the Scheme in its first year (before they have received any income from the sale of the crops). Start-up costs have been estimated in this CBA, amounting to GBP 102,885, the estimation of which is presented below.

Equipment and gear

The Malombe community currently has insufficient tools to manage the proposed intensive irrigation project and it is therefore suggested that there will be a ned for equipment start-up costs too. CRIDF has designed a similar irrigation scheme in Mayana, Namibia, for 50ha (100hh) and the equipment cost estimates from this study have therefore been used as estimates for the SIS too.

The table below provides a list of the basic tools for general agronomic operations.

Table 4: **Tools and Equipment**

Item	Quantity	Unit cost GBP	Total cost GBP
Garden tools			**1,374**
Wheel barrow	3	400	56
Spade	3	150	21
Digging fork	3	300	42
Garden rake	3	80	11
Weeding hoe	5	150	35
Hand spade	3	50	7
Hand fork	3	50	7
Knapsack sprayer	1	350	16

Irrigation equipment	1	25000	1,157
Protective clothing			**106**
Gum boots	4	7	28
Hand gloves	4	2	9
Overall	4	12	46
Face masks	4	2	200
Respirators	4	3	280
Tools and clothing total			**1,456**

Source: CRIDF, 2015

Fertiliser

The fertiliser cost per plot was calculated given the guidelines supplied in the Mayana report. While similar, the Mayana community is located in the Namibian portion for the Okavango basin. These values should therefore be viewed as ball-park figures for a plot of land approximately 50 ha in size. However, both communities face degraded soils due to over-utilisation and limited crop-rotation, with predominantly sandy soils. The transferability of costs is therefore likely, taking cognisance of the fact that these prices will change from time to time. The agronomic model provided in the Sioma Technical Report suggests the crop breakdown as indicated in the table below, from which the total fertiliser cost can be computed.

Table 5: **Fertiliser Costs**

Crop	Land Allocation %	Fertiliser cost per ha (GBP)	Proportional cost per ha (GBP)
Maize	25%	182	45
Sugar/ Michigan Beans	25%	173	43
Wheat/ Barley	25%	172	43
Soya Beans	25%	173	43
Potatoes - Summer	25%	232	58
Potatoes - Winter	25%	232	58

Groundnuts*	25%	192	48
Green Mealies	5%	182	9
Leaf vegetables and tubers (crucifers, carrots, etc.)	5%	189	9
Tomato	5%	243	12
Onions - Dry	5%	236	12
Total cost per hectare			381
Total cost 57.8 ha			22,045

Source: CRIDF, 2015

**The fertiliser costs for groundnuts were taken from the costs for butternuts in the absence of this data*

Pest control

It is suggested that pest control cover a range of pests, including worms, aphids, flies, mites, caterpillars and mole rats. Further clarification on pest control in the area should be included in agricultural extension training and an integrated pest management programme should be followed in consultation with a technical adviser with a crop rotation programme which will keep chemical crop protection measures limited.

Table 6: **Pest Control Costs**

Crop	Land Allocation %	Pest control cost per ha (GBP)	Proportional cost per ha (GBP)
Maize	25%	16	4
Sugar/ Michigan Beans	25%	19	5
Wheat/Barley	25%	14	4
Soya Beans	25%	19	5
Potatoes - Summer	25%	46	12
Potatoes - Winter	25%	46	12
Groundnuts*	25%	28	7

Green Mealies	5%	16	1
Leaf vegetables and tubers (crucifers, carrots, etc.)	5%	14	1
Tomato	5%	46	2
Onions - Dry	5%	14	1
Total cost per hectare			**51**
Total cost 57.8 ha			**2,972**

Source: CRIDF, 2015

**The pest control costs for groundnuts were taken from the costs for butternuts in the absence of this data*

Seed costs

Seed costs are also drawn from the Mayana report, but applied to the specifications of the Sioma Scheme as defined by the agronomic model. The break-down of seed requirements per crop and the associated cost are represented below in Table 8.

Table 7: **Seed Requirements and Costs**

Crop	Land Allocation %	Seed need per ha	Unit	Cost per unit (GBP)	Proportional cost (GBP)
Maize	25%	25	kg	95	24
Sugar/ Michigan Beans	25%	300000	seeds	694	174
Wheat/Barley	25%	150	kg	111	28
Soya Beans	25%	300000	seeds	694	174
Potatoes - Summer	25%	2 000	tubers	926	231
Potatoes - Winter	25%	2 000	tubers	926	231
Groundnuts	25%	1 500	grams	69	17
Green Mealies	5%	300000	seeds	95	5
Leaf vegetables and tubers (crucifers, carrots, etc.)	5%	3 000	grams	69	3

Tomato	5%	20 000	seeds	185	9
Onions - Dry	5%	4 500	grams	1 239	62
Total cost per hectare					**958**
Total cost 57.8 ha					**55,382**

Source: CRIDF, 2015

**The seed costs for groundnuts were taken from the costs for butternuts in the absence of this data*

Land preparation

The on-going cost of labour in the Scheme is absorbed by the community in this CBA due to the fact that they would transfer their current labour activities (or a portion of these) to the Scheme. According to the Camp Officer, most households have cattle, which average around 5 cattle per household. Oxen tilling is very common in the area and is the main means of cultivation. Some tilling is done by hand to make ponds (a form of conservation agriculture to promote better water retention), but the first till is usually by oxen.[11] It is thus assumed that households will be able to farm their pieces of land without additional support. However, some land preparation support may be required by the community at the commencement of the project for activities such as land clearing and tilling.

Assuming that land preparation includes land clearing, land preparation and soil conservation works, it is estimated that 2 hours are needed to prepare a 1000 m^2 plot. Therefore 20 hours would be needed to prepare a 1 ha plot. Using the minimum wage of GBP 86.30 per month[12] (an hourly wage of GBP 0.6) for unskilled agricultural labour, the additional land preparation costs are estimated to be GBP 623.

Training costs

Given the current low yields in the rain-fed agriculture in the area, it is expected that the infrastructure will see a dramatic change in the way the land is managed. Vegetable production is a labour intensive enterprise which requires basic training in agronomic principles. Additionally some managerial skills are also important and can enhance business competitiveness of the farmers' enterprises.

It is suggested that farmers are provided with up-front training prior to the commencement of irrigated agriculture. The cost of such training is estimated in this CBA following work done in the quantification of agricultural extension work done in the KAZA region in Zimbabwe. It is suggested that agricultural training would cost approximately GBP 25 per household, and that with 100 households, the total cost for the Malombe irrigation scheme would be GBP 2,530. This would include transport, materials and time of an agricultural expert from the area.

[11] Site visit, 2015
[12] Council for International Development Cooperation (2015). Zambia Labour Market profile 2014.

This cost is not representative of on-going training costs of the scheme and an effort should be made to secure on-going extension training. The Ministry of Agriculture (MA) is the main implementing partner for CCAP and is well placed to provide such on-going support. In the technical report, MA is identified as an institution able to provide implementation best practice on environmental, health and safety procedures. MA is also mandated with providing project oversight. MA's involvement and role should be secured before project implementation.

Table 8: **Summary of Project Costs**

Cost Factor	Description	GBP
Capital costs		**337,206**
	Intake works and pumping station	237,446
	Conveyance pipelines (mains and sub-mains)	41,790
	Drag hose infrastructure	39,898
	Wildlife fencing	18,072
Start-up costs		**102,885**
	Seeds	55,382
	Fertiliser	22,045
	Extension training	2,530
	Tools and protective gear	19,333
	Pest control for first year	2,972
	Land preparation cost	623
Total capital & start-up costs		**440,092**
Annual O&M costs		**16,860**

Source: CRIDF, 2015

Enterprise revenues

The agronomic model indicates a net income of GBP 100,292 per annum for the whole Scheme. Calculations to arrive at this figure are presented in the table below. This equates to approximately GBP 1,735 per hectare of land cultivated.

In this CBA, it is conservatively estimated that production levels will only reach the optimal levels set out in the agronomic model in the 6th year of operation. This is to account for the fact that farmers will take time adjusting to new crops and new production systems. It is assumed that crop production will be 50% of the optimal levels in year 1, increasing by 10% per year and reaching optimal production levels in year 6.

Table 9: **Crop Revenues**

Crop	Land Allocation %	Yield	Unit	Unit price (ZMK)	Gross Income/ ha	Variable costs factor	Variable Costs/ha	Gross Margin/ ha (ZMK)
Maize	25%	5	tonnes	1,250	6,250	0.8	5,000	1,250
Sugar/ Michigan Beans	25%	2	tonnes	2,500	5,000	0.7	3,500	1,500
Wheat/Barley	25%	4	tonnes	3,500	14,000	0.85	11,900	2,100
Soya Beans	25%	2	tonnes	2,600	5,200	0.7	3,640	1,560
Potatoes - Summer	25%	25	tonnes	745	18,635	0.85	15,840	2,795
Potatoes - Winter	25%	25	tonnes	745	18,635	0.85	15,840	2,795
Groundnuts	25%	3	tonnes	2,800	8,400	0.7	5,880	2,520
Green Mealies	5%	30000	cobs	0.1	3,000	0.65	1,950	1,050
Leaf vegetables and tubers (crucifers, carrots, etc.)	5%	25	tonnes	1,100	27,500	0.8	22,000	5,500
Tomato	5%	25	tonnes	1,100	27,500	0.8	22,000	5 500
Onions - Dry	5%	30	tonnes	1,200	36,000	0.8	28,800	7 200

Total earnings per hectare (ZMW)								33,771
Total earnings for 57.8 ha (ZMW)								1,951,964
Total earnings for 57.8 ha (GBP)								**100, 291**

Source: CRIDF, 2015

Taking the NPV of the project's financial costs and benefits allows one to estimate the project's financial performance. This financial model is presented in the table below.

Table 10: **Sioma Irrigation Scheme Financial Appraisal Summary (GBP)**

Year	Capital Costs	Start-up Costs & annual O&M	Crop revenue	Net Benefit
0	(337,206)	(102,885)		(440,092)
1		(16,860)	50,146	33,286
2		(16,860)	60,175	43,315
3		(16,860)	70,204	53,344
4		(16,860)	80,234	63,373
5		(16,860)	90,263	73,402
6		(16,860)	100,292	83,432
7		(16,860)	100,292	83,432
8		(16,860)	100,292	83,432
9		(16,860)	100,292	83,432

10		(16,860)	100,292	83,432
11		(16,860)	100,292	83,432
12		(16,860)	100,292	83,432
13		(16,860)	100,292	83,432
14		(16,860)	100,292	83,432
15		(16,860)	100,292	83,432
16		(16,860)	100,292	83,432
17		(16,860)	100,292	83,432
18		(16,860)	100,292	83,432
19		(16,860)	100,292	83,432
20		(16,860)	100,292	83,432
FNPV (11.5%)				**85,406**
FIRR				**14%**
BCR (11.5%)				**1.15**

Source: CRIDF, 2015

The project yields a financial rate of return (FIRR) over the course of the project's economic lifetime of 14% and a financial net present value (FNPV) over the 20-year period of GBP 85,406 (discount rate of 11.5%). Based on the model assumptions, the financial model results therefore indicate a reasonably viable return on the project investment. However, given the potential risks associated with the project (such as ensuring revenue collection, establishing a company), it is unlikely to be able to attract private finance.

The operational sustainability of the project requires that the revenue stream that is realised by the community (as a result of the intervention), be more than the annual costs of running the intervention. Operationally, the project shows robust revenues streams which are sufficient to cover the on-going costs of operating the Scheme. The operational costs and revenues have a BCR of 4.5, indicating that the NPV (discounted at the same rate of 11.5%) of benefits are five times higher than the on-going costs. This is due to the fact that the project makes positive net revenues from year 1 of its operation, even when crop production is assumed to be only 50% of that set out in the agronomic model.

Project funding

Although the project demonstrates a financially viable investment, with a return only slightly higher than the average cost of capital and with risks being high, the project is unlikely to be funded by the private sector. Additionally, the community is unable to afford the upfront capital cost due to their significantly limited access to finance and high poverty levels. It is thus essential that the upfront costs are covered by an external grant.

The same can be said for the start-up costs of the project (including training), which will be a strong driver of how well the infrastructure is taken up by the community and to ensure adequate maintenance of the Scheme. Lastly, it is suggested that O&M costs for at least one year are covered in the upfront grant to the community so that the small-scale farmers will be able to have one or two season's worth of additional sales before they are required to pay for the operation and maintenance of the Scheme. Potential funding scenarios are shown in the table below.

As expected, including grant financing for the above results in a significant improvement of the FIRR from 14% to over 40%, and will ensure that the community is able to sustainably manage the proposed infrastructure.

Table 11: **Project Funding Scenarios**

Scenarios	FNPV (GBP)	FIRR (%)
Project alone	85,406	14%
Full grant funding	495,228	43%

Source: CRIDF, 2015

Sensitivity analysis

A sensitivity analysis is an important way to analyse whether the key input assumptions for the project have a material impact on its outcomes, particularly those of its overall viability. The objective is to identify the factors that have the largest impact on the project's sustainability and returns. The sensitivity analysis looks at the main factors that could impact the project's costs, as well as the factors affecting the project's revenue generation. The sensitivity analysis for the financial model is shown in the table below.

The financial sensitivity analysis shows that the scheme is clearly operationally sustainable (that is, if capital costs are excluded as would be the case if a grant was given) – even in the case that revenues decrease by 10% in total value and O&M costs simultaneously increase by 10%, the revenues are sufficient to cover the costs by a multiple of 3.7. It is important to note, however, that the value of revenues has the largest bearing on the financial performance of the scheme – a decrease in revenues by 20% has a larger effect on the Scheme's profitability than a combined change of an increase in costs of 10% and a decrease in costs of 10%.

The sensitivity analysis serves to highlight how vulnerable the success of the Scheme is to the ability of farmers to sell their produce – a risk which will be discussed under the section Risk Analysis later on in the report.

Table 12: **Sensitivity Analysis**

Parameter	Change	FIRR before change	FIRR after change	FNPV before change (GBP)	FNPV after change (GBP)
Cost increase (capital, O&M and start-up)	+10%	14%	12%	85,406	28, 397
Cost increase (capital, O&M and start-up)	+20%	14%	11%	85,406	-28,611
O&M costs increase (effect on operational sustainability)	+10%	-	-	585,930	571,436
O&M costs increase (effect on operational sustainability)	+20%	-	-	585,930	556,942
Revenues decrease	10%	14%	12%	85,406	19,857
Revenues decrease	20%	14%	10%	85,406	-45,692
Scenario approach: costs increase, revenues decrease	10%	14%	10%	85,406	-37,151

Source: CRIDF, 2015

Sustainability Analysis

Once a project is sustainable from a social, political and environmental perspective, it must be both financially and economically viable and have sufficient cash flow to meet annual operational requirements at a minimum. Unless a project is financially viable, the project will not be sustained over the course of its economic lifetime, and hence the economic benefits to society will not materialise. The financial analysis of the irrigation component showed that the increased crop income can adequately cover the costs of operating and maintaining the irrigation system and water pumping requirements, even when crop production levels start at only 50% of the optimal production level indicated in the agronomic model. In terms of the operational sustainability of the project, drag hose irrigation can be effectively managed by the community independently and is thus operationally suitable.

However, the above is based on the assumption that all crops produced by the farm are sold and generate income. It would be reasonable to assume that households do not sell all their produce but instead consume a portion of it themselves. The sustainability analysis of this CBA therefore also investigates the case where the community only sells 50% of the produce (while the remaining 50% is consumed locally). While these consumed crops have a value (which is best estimated at market prices as done in the financial appraisal), this value is excluded here. The approach taken demonstrates an operational BCR of 2.26, indicating that the net present value of benefits is double that of costs. The ability of the community to maintain the infrastructure is thus assumed to be robust even when only 50% of their produce is sold and generates revenue.

The project, however, faces risks of revenue realisation. The sustainability of the project will depend on whether or not the beneficiary communities can adequately realise and manage revenues to cover their annual expenditure. Therefore, the project must include adequate training and capacity building for the use of the infrastructure as well as in business and marketing activities. Community members must be provided with a sense of ownership for the project, so that they do not lose interest. This risk has already been limited due to the fact that farmers in a drag-hose scheme will be able to manage their own small piece of land (and do not have to grow crops collaboratively). Market limitations are, however, a very real risk to the success of the scheme. Following discussions with the engineer, it was noted that approximately 50% of the crops grown in the proposed design will be locally consumed, and that the markets for maize are relatively stable due to the Food Reserve Agency (FRA). Given the food security risks in the area, the FRA is seen as a guaranteed buyer of staple crops. It is, however, strongly recommended that such a guarantee agreement is finalised between the farmers and the FRA (or local mills) prior to the implementation of the project. It is also suggested that a separate piece of work is done on building supply chains in the area which can link the Sioma district to larger towns like Kazungula. This is especially important for potato production which would benefit from sale to the potato processing plant in in Kazungula.

Well defined institutional / organisational arrangements need to be supported on the ground to manage the process. In this regard the Ministry of Agriculture (MA) will remain an important stakeholder in the project and should support the development of such chains.

Economic Appraisal

The purpose of the economic analysis is to determine whether there is an economic rationale for the irrigation scheme; that is, whether it results in a net positive social benefit, notwithstanding its financial viability and profitability. The economic appraisal values the infrastructure at its real benefits to society, as opposed to the financial revenues that could accrue to the project beneficiaries. These include economic benefits of the project which can be quantified and valued (these are included in the quantitative analysis and directly compared to quantitative costs); and the benefits which can either not practically be quantified or valued in monetary terms (these are discussed in the qualitative analysis).

The financial analysis presented above was limited to the costs and benefits of the project in terms of project expenditures and incomes at market prices, and gives an indication of the pressure the project will place on the project budget, and the degree of subsidisation it may require to be financially viable and/or sustainable. The economic analysis, on the other hand, assesses the costs and benefits of the project at their real cost/value to society. The true value of the project should capture the value the project gives to the community – through improved incomes, health, resilience, empowerment and economic development. Ideally, these values are captured through willingness-to-pay surveys which aim to determine how much such a project would be valued by the community. However, surveys of this kind are expensive and are themselves often prone to behavioural biases, such as anchoring and framing.

Instead, the methodology used in this CBA applies ‘conversion factors’ to market prices to correct for market distortions and attain relevant ‘shadow prices’ of inputs and outputs. If a conversion factor is less than one it indicates that the true value of that price is less than its market price. An example would be an imported product which is subject to exchange rate commissions and VAT. These are transfers in the economy and not true indications of value – hence they should be removed from its market price. If a market price is higher than one, it indicates that the true value of that price is higher than its associated market value. An example would be the cost of water in a rural area where its price is subsidised due to affordability concerns, but that its true value is far higher (possibly even as high as the value of life).

At present, Zambia has no generally available guidelines for shadow prices; therefore conversion factors suggested by FAO (2002) are used in the economic analysis here, as shown in the table below[13].

Table 13: **Economic Conversion Factors**

Input / Output	Economic conversion factor
Grain maize	3.14
Wheat	1.76
Groundnuts	4.82
Perishable horticultural crops*	1.00 (free market price)
Non-perishable locally-marketed crops**	1.00 (free market price)
Seed	0.97
Fertiliser	2.26
Irrigation equipment	1.03
Repair and maintenance	0.94
Energy costs	0.96
Chemicals	3.50

[13] FAO Sub-Regional Office for East and Southern Africa (2002). Financial and Economic Appraisal of Irrigation Projects

Road transport	1.00
Skilled labour	1.00
Unskilled labour	0.40

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

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

Source: FAO Sub-Regional Office for East and Southern Africa (2002)

Economics Costs

The table below converts the financial project costs into economic costs using the relevant conversion factors above, and discarding those payments that are simply transfers within the economy (such as taxes). In the event that an item does not have a conversion factor, its market price was assumed to be the best indicator of its true value.

Table 14: **Economic Costs using Conversion Factors**

Item	Financial cost (GBP)	Conversion factor	Economic cost (GBP)
Capital costs	**337,206**		**346,781**
Intake works and Pumping station	237,446	1.03	244,569
Conveyance pipelines (mains and sub-mains)	41,790	1.03	43,044
Drag Hose infrastructure	39,898	1.03	41,095
Wildlife fencing	18,072	1.00	18,072
Start-up costs	**102,262**		**128,626**
Seeds	55,382	0.97	53,721
Fertilizer	22,045	2.26	49,821
Extension training	2,530	1.00	2,530
Tools and protective gear	19,333	1.00	19,333
Pest control for first year	2,972	1.00	2,972
O&M costs	**16,860**	0.94	**15,849**

Source: CRIDF, 2015

Economics Benefits

The economic benefits included in the quantitative model are the crop revenues appropriately adjusted by the economic conversion factors (as set out in the Economic Conversion Factor Table above). These adjustments, like those applied to the financial costs of the project, aim to capture the true benefit of the crops to the community. This benefit includes local consumption of food, as well as economic value of crops sold.

The FAO (2002) indicate high conversion factors for maize, wheat and groundnuts, indicating high demand for these foods and reflective of their value as staple crops in a largely food insecure region. In addition, there are multiple other economic benefits which stem from the project – including health benefits from diversified diets and heightened economic development among others, but these are not included in the quantified benefits represented in Table 16 below. Rather they are discussed qualitatively and are expected to strengthen the economic performance indicators indicated below significantly.

The benefit of improved livelihoods created by the irrigation scheme is measured by the increased yield from the target 57.8 ha and associated income from the crops produced. This benefit is calculated as the incremental net income compared to the without-project situation. The current situation is defined by subsistence agriculture in which farmers traditionally grow a restricted range of subsistence crops (mainly maize). The Technical Report indicates that soil quality is low due to repeated farming of maize crops and that these crops are used almost entirely for consumption by the households who grow them.

The Technical Report indicates that, on average, current crop production (which is a combination of maize and groundnuts) is approximately 4 times less profitable than that of optimal production, using the same amount of land under adequate irrigation. Current production income is thus estimated to be GBP 35, 390, which is four times lower than the economic optimal crop production value of GBP 141,561 calculated in the table below. In the absence of the project, these crop production values are expected to be even lower than the current base case due to increasing pressures of climate change.

The incremental benefits of the with-and-without project scenario are included as the final indication of improved livelihoods to the community, estimated to be GBP 106,171[14].

It is useful to note that the current level of crop income is expected to fall as rains become more variable with climate change and that without irrigation infrastructure, this community would see increasing vulnerability in crop production levels.

Table 15: **Quantified Economic Benefits**

Crop	Land Allocation %	Gross margin (ZMW)	Economic conversion factor	Economic gross margin
Maize	25%	1,250	3.14	3,925

[14] Calculated as the incremental improvement in incomes to the community of (GBP 141,561 – GBP 35,390)

Sugar/ Michigan Beans	25%	1,500	1.00	1,500
Wheat/Barley	25%	2,100	1.76	3,696
Soya Beans	25%	1,560	1.00	1,560
Potatoes - Summer	25%	2,795	1.00	2,795
Potatoes - Winter	25%	2,795	1.00	2,795
Groundnuts	25%	2,520	4.82	2,146
Green Mealies	5%	1,050	1.00	1,050
Leaf vegetables and tubers (crucifers, carrots, etc.)	5%	5,500	1.00	5,500
Tomato	5%	5,500	1.00	5,500
Onions - Dry	5%	7,200	1.00	7,200
Total income per hectare ZMK per annum		33,771		47,667
Total income for scheme (57.8 ha) ZMK per annum	195%	1,951 964		2,755,176
Total income for scheme (57.8 ha) GBP per annum	**195%**	**100,292**		**141,561**

Source: CRIDF, 2015

Quantitative Results

The results of the quantitative economic appraisal, as summarised in the table below, indicate that the project is economically attractive at both a 3.5% and 10% discount rate, with positive ENPVs and reasonably high Benefit-Cost Ratios (BCRs). The economic rate of return (ERR) for the overall project is calculated at 18%.

At a 10% social discount rate, the project has an ENPV of 293,555, whereas at a 3.5% discount rate, the ENPV amounts to GBP 808,286. The respective BCRs are 1.48 and 2.15. These results show a strong social justification from the project at both of the discount rates recommended by the CRIDF CBA Guidelines even before the qualitative impacts of the project are included. The significant improvement in the economic results in moving to a lower discount rate indicate that the project's long term benefits are expected to be high.

The project meets the requirements in that the ENPVs are strongly positive, the ERR is larger than the discount rate of 10% and importantly, the Benefit Cost Ratio is greater than one. A BCR of over 2 demonstrates that the social benefits to the project are more than double as large as the costs of the project. While the former BCR falls between one and two (and is somewhat marginal in respect of CRIDF guidelines), it is important to note that there are significant economic benefits which are excluded from this quantitative analysis due to difficulties in the estimation. These benefits, which are discussed below, are expected to increase this BCR above this threshold.

Table 16: **Economic Appraisal Results Summary**

Indicator	3.5 % discount rate	10 % discount rate
ENPV (GBP)	808,286	293,555
ERR (%)	18%	18%
EBCR	2.15	1.48

Source: CRIDF, 2015

Additional socio-economic project benefits

There are a wide range of important economic benefits that are not captured in the analysis above due to difficulty in their objective quantification. Benefits such as health improvements are often measured through pre-and-post project implementation surveys, rather than in a CBA, due to the fact that there is often great uncertainty in an ex-ante study such as this. These benefits can, however, be described qualitatively. Emphasis is placed on the reader not to discount their value due to the fact that they remain qualified and not monetised.

Food security and diet diversification

While malnutrition is not a major issue in the project area, diet diversification is a priority. This requires an increase in the availability of different crops as well as better knowledge around food variation and health benefits. The Sioma Mission Clinic stressed that their role in the Scheme would be to encourage a diversification of crops and local consumption of these. The suggested cropping programme under the project takes account of this need, and suggests that framers should grow green mealies, beans, wheat, soya beans, potatoes, onions and tomatoes, along with some leafy vegetables in addition to the staples currently grown in the area (specifically maize).

While markets for these diversified crops are uncertain at present, it is suggested that they are grown in moderation and that almost all of this production is eaten locally. The agronomic model shows these vegetables' production as limited in the cropping programme because of their perishable nature, fluctuating prices and marketing challenges; however, they are still included to a small degree in the project design primarily to cater for local consumption. As such, the Sioma Irrigation Scheme will contribute significantly to variation in the local population's diet and improved nutrition.

Irrigation also guarantees water supplies to crops, thus drastically reducing the vulnerability of food production (and income level fluctuations) to climatic vulnerability. Health impacts in times of drought will be reduced, along with stresses on the general welfare of a currently climate-vulnerable community during these times of hardship. The economic value of food security can be estimated by the avoided cost that government / the economy would have to incur through the provision of social protection or food aid. According to the Camp Officer, a limited amount of food aid is supplied to the District, which includes around 2,000 x 50kg bags of mealie meal. A lot of this is given to those farmers in the bush away from the maize mills so only a little will be given to the farmers around Sioma.[15] Due to a lack of data as to whether the beneficiary community has received food aid in the past, this impact is included here only qualitatively.

Social productivity, economic opportunity and multiplier effects

The direct and indirect benefits of food security and diversified diets translate into higher labour productivity and improved educational outcomes over a long period of time. Additionally, increased economic activity in the Malombe community will see an inflow of cash and economic activity in the area, which is expected to have significant knock-on effects for the community through further spending.

It is recognised that the economic knock-on effects of the project will be largely felt in the surrounding communities of the Sioma district itself, as opposed to national income. These include increased consumption of goods which will support local industries, higher ability to pay school fees, and more disposable income in circulation in the local economy.

The food production derived from the irrigation scheme has wider economic benefits, such as:

- Increased activity in markets through the greater selling of produce; and
- Attracting skills and the subsequent transfer of knowledge in farming practices
- More reliable household livelihood which would allow for economic spill-over effects, such as construction/creation of school, clinic, etc.

Gender impacts

Although it is unclear how many of the hundred beneficiary households are female headed, the project is expected to provide significant benefits to women. Women in both male and female-headed households are often those responsible for tending the fields, as well as those which have the additional responsibility of providing for their children (food and school fees being two major requirements). Women also bear the burden of inadequate food or a limited diversity in diets in children, with malnourishment being highlighted as particularly severe in the Sioma district. The Scheme is expected to result in revenue generation for the beneficiary households and improved diets for the whole of the Sioma district.

[15] Site visit, November 2015

The value of the water produced

While farmers will not pay for the water they use, there is still incremental value of this water given the fact that that there is currently no irrigation scheme in the area. One possibility of valuing this resource is at the current tariff rate for bulk water supply in Zambia. This was not, however, the approach taken in this report. A water tariff of this nature would only represent a transfer payment in the economy – from farmer to local government and would thus not in itself be representative of value being added to the economy. The other alternative is to value water at its intrinsic value – that is, water's value that is independent of who is paying for or who owns it. Again this value in not included in this CBA due to the fact that the economic benefits captured in the quantified evaluation above aim to proxy this exact value. Without water, the scheme would have no value – and thus the willingness-to-pay for its construction would be zero.

Human wildlife conflict

Elephant proof fencing, as well as a reduction in the need for small-scale farming on the river banks, is expected to reduce human-wildlife conflict of the community. No crops in the new development should be lost due to fencing, while a reduction in the need for river-bank farming is expected to reduce the risk of human life loss from crocodile attacks.

Sensitivity analysis

An important factor in the estimation of economic benefits is that of the incremental benefits from improved crop production. The sensitivity of the economic appraisal to this assumption is investigated in the table below.

Table 17: **Economic Sensitivity Analysis (at the 10% SDR)**

Parameter	Change	EIRR before change	EIRR after change	ENPV before change (GBP)	ENPV after change (GBP)
Increase in incremental revenues	10%	18%	21%	293,555	383,944
Decrease in incremental revenues	10%	18%	16%	293,555	203,166
Decrease in incremental revenues	20%	18%	13%	293,555	122,777
Scenario: Costs increase and revenues decrease	10%	18%	14%	293,555	142,133

Source: CRIDF, 2015

The results of this analysis show that the project is economically viable regardless of an increase in costs of 10% or a decrease in economic benefits to the community of 10%, as well as in the unlikely case that both occur simultaneously. The sensitivity analysis however indicates that the positive results are quite sensitive to a decrease in gross margins. In fact when the gross margins are reduced by 20%, it has a larger impact on the

Scheme than in the scenario where costs increase by 10% and revenues decrease by 10%. Therefore, it is essential to ensure that the farmers are adequately supported, particularly through market access, so that the required margins are realised.

Risk Analysis

The risks associated with the project appear to be primarily related to revenue generation and marketing limitations, as well as related to the institutional arrangements of the project. In the absence of strong institutional and governance arrangements, it is likely that O&M may not be sufficient and in turn this may result in the infrastructure depreciating faster than it should. This would negatively impact the ability of farmers to generate future revenues from crop production and would further exacerbate these challenges.

It is felt that there is much scope to minimise these risks through implementing appropriate risk mitigation arrangements at an institutional level and sufficient training done during project implementation.

Table 18: **Risk Analysis**

Risk	Mitigation Level
Inadequate O&M invested by the community Risk level: High	• Facilitate establishment of community water supply committee(s) within the irrigation scheme, with strong institutional arrangements that are embedded in existing structures • Cover O&M costs for year one until the community starts to realize the benefits from agricultural produce • Ensure that user tariffs applied to the use of the infrastructure are fair and equitable, and ensure these are done before project implementation • Get community buy-in for on-going fees by demonstrating the need for continual O&M work • The community to commit to deploy adequate and appropriate staff on site and to invest in regular maintenance of the infrastructure
Revenues are not realized due to market limitations, while long run economic development is lower than anticipated due to limited further involvement in the community Risk level: High	• A separate project should be initiated to build supply chains in the area, with a specific focus on small-scale farmers • Economic development in the area has the potential of being major if value-added processes are built in the community – these could include packaging, processing, transportation and cold storage

	developments, none of which currently exist locally
Permits (water, environmental) are not applied for/granted due to financial restraints or mismanagement Risk level: High	• Seek permit approval during detailed design • Source financial and capacity support for community to access these permits • Engage community in permit approval process so that they understand the importance of adequate water demand management and environmental management
Risk of community using the infrastructure for domestic water supply and in doing so damages its ability to provide irrigation water (electricity provision should also be considered in this risk) Risk level: Medium	• The infrastructure does not provide domestic water supplies despite the apparent need identified in the Technical Report. However, since the drafting of the Technical Report, an alternative water supply has recently been provided to the community (in the form of a borehole) • The community should be encouraged to only use this alternative source for their domestic water supply needs, and an effort should be made to ensure this source of water is sufficient for their requirements • An additional investment which provides electricity to the community from the same source as the pump infrastructure should also be considered
Implementation costs higher than expected Risk level: Medium	• The estimation of costs do not include contingencies and therefore may be higher than expected • Sensitivity analysis indicates that changes in capital costs do not fundamentally alter viability • Prior to implantation, ensure that capital budgets are sufficient to cover detailed design
Community lacks the capacity to farm this land intensively without further mechanization and development Risk level: Medium	• It is argued that households will be able to manage plots between 0.5 and 1 ha in size, however, if larger plots are to be managed by the community, they may require further mechanization (such as a tractor), or more oxen • Further budgets should be set aside for mechanization or livestock purchase should there be larger plots • If production levels increase and the community cannot

	sell the produce rapidly enough, a cold storage unit may be required in the community
Vandalism of the system Risk level: Low	• Community members have self-selected themselves into the Scheme through their contribution of land. It is unlikely that there should be dissonance in the community (either from those households that are part of the Scheme or those who chose to not take part in it) • Promote community education, awareness campaigns and promotion of social capital
Fair and reasonable local institutional agreement Risk level: Low	Ensure that in the case where a farmer is genuinely unable to pay user fees, there is a contingency in place to cover this shortfall through an agreement that charges those that
Community to continue to rely on unsafe sources Risk level: Low	• Ensure that the CHC approach educates the community on the dangers of using unsafe water • Emphasize the ease, time savings and reliability of using the proposed system

Source: CRIDF, 2015

Conclusions and recommendations

The Sioma Irrigation Scheme involves the construction of drag-hose irrigation infrastructure and water supply to roughly 100 households in the Malombe community. This community is currently highly vulnerable to the impacts of climate change through the impact on food production – primarily due to changes in rainfall patterns – despite living near a vats source of water, the Zambezi River.

Through the implementation of this infrastructure, the Malombe community will be able to diversify their crop production patterns, produce additional crops to sell at market and so benefit from improved livelihoods. This CBA aimed to analyse the financial and economic viability of the proposed infrastructure by comparing the costs and benefits (explicit and implicit) of the project.

Overall, the project is financially viable at a discount rate of 11.5%. The FNPV is positive, at GBP 85,406 (with a FIRR of 14%). However, the project is unlikely to attract private sector financing due to risks involved with revenue collection and its remote location. Given its strong operational sustainability however, where revenues are five times larger than O&M costs, the project demonstrates high additionality.

It is therefore suggested that grant financing is sourced to cover the upfront capital costs of the project and the project's start-up costs, along with O&M costs of year one of its operation. The latter is due to the fact that the community themselves will not have sufficient resources to cover these ongoing costs until at least one year of harvest have been realised. The total grant proposed in this CBA is therefore GBP 456,952, the inclusion of which pushes the financial model's return of the project up to 43.33%.

Economically the project is justifiable and economically viable at both the 10% and 3.5% social discount rates (with an ERR of 18%). Moreover, there are significant qualitative and long-term benefits from the project as a whole, which have not been fully quantified and valued. As a pilot project within the CCAP suite of projects, and with demonstrable value to the community at relatively low cost, it is concluded that there is sufficient socio-economic justification for the implementation of the project.

In terms of value for money, the Scheme sees the provision of 925,504 m^3 per annum, at a cost of GBP 0.36 per cubic meter per year. In terms of the cost per member, the proposed design will cost approximately GBP 3,372 per household. When noted that each of these households represent approximately 4.5 people, this cost is more realistically estimated to be around GBP 749 per beneficiary.

The table below suggests that crop gross margin per hectare may be slightly underestimated in the case of Sioma compared to a number of other similar CRIDF irrigation schemes, but that despite this Sioma displays strong financial and economic results.

Table 19: **Financial viability comparison of other small-scale CRIDF irrigation projects**

	Sioma	Mayana	Kufandada	Bindangombe
Crop revenue per hectare (GBP)	1,735	2,958	1,800	2,475
FIRR	14%	39.49%	10%	15%
ERR	18%	42%	19%	31%

The following recommendations arise from the CBA:

- There is the urgent need for improved food security in the area, the absence of which is expected to have significantly negative impacts on the local community through health and welfare impacts
- Support should be provided for the accessing of permits for the Scheme (water and environmental), along with start-up agricultural training support
- Due to the project's strong operational sustainability but limited attractiveness to the private sector, a grant of GBP 456,952 is proposed. It is suggested that CRIDF provide this grant.

Annex J: Climate Vulnerability Indicators

Baseline Water Stress

This indicator refers to water withdrawals divided by mean available blue water. Areas with available blue water and water withdrawal less than 0.03 and 0.012 m/m2 respectively are coded as arid and low water use. Baseline water stress measures total annual water withdrawals (municipal, industrial, and agricultural) expressed as a percent of the total annual available flow. Higher values indicate more competition among users.

Inter-annual variability

This indicator is the standard deviation of annual total blue water divided by the mean of total blue water. Inter-annual variability measures the variation in water supply between years.

Seasonal variability

Standard deviation of monthly total blue water divided by the mean of monthly total blue water (1950-2008). The means of total blue water for each of the 12 months of the year were calculated, and the variances estimated between the mean monthly values.

Flood Occurrence

Number of flood occurrences (1985-2011). Flood counts were calculated by intersecting hydrological units with estimated flood extent polygons.

Drought Severity

Drought severity is the mean of the lengths times the dryness of all droughts occurring in an area. Drought is defined as a contiguous period when soil moisture remains below the 20th percentile. Length is measured in months, and dryness is the average number of percentage points by which soil moisture drops below the 20th percentile. Drought data is resampled from original raster form into hydrological catchments.

Upstream Storage

Upstream storage measures the water storage capacity available upstream of a location relative to the total water supply at that location. Higher values indicate areas more capable of buffering variations in water supply (i.e. droughts and floods) because they have more water storage capacity upstream.

Groundwater Stress

Groundwater footprint divided by the aquifer area. Groundwater footprint is defined as A[C/(R ? E)], where C, R, and E are respectively the area-averaged annual abstraction of groundwater, recharge rate, and the groundwater contribution to environmental stream flow. A is the areal extent of any region of interest where C, R, and E can be defined. Groundwater stress measures the ratio of groundwater withdrawal relative to its recharge rate over a given aquifer. Values above one indicate where unsustainable groundwater consumption could affect groundwater availability and groundwater-dependent ecosystems.

Household and community resilience

The extent to which individuals and communities are affected by natural hazards depends, in part, on their own resources, existing health and nutrition levels, access to health and sanitation services, and levels of education.

Population density

This indicator is a measurement of population per unit area or unit volume; it is a quantity of type number density.

Resilient Population

This layer indicates the resilient population. This indicator has been calculated by combining population density, the CCAPS governance layer and the CCAPS household and community resilience layer.

Baseline Risk to People

This layer indicates the baseline risks to people. This indicator has been calculated by combining the resilient population layer and the AQUEDUCT physical water quantity risk.

Climate Change Pressure

Climate data from the Met Office HadGEM2 - AO model has been used to calculate the climate change pressure in Africa. This layer indicates where the consequences of climate change are expected to have the greatest impacts for people and the environment. This indicator has been calculated using the average rainfall and temperatures from 2006 to 2026 of the low emissions scenario (RCP 2.6) and compared this to the average rainfall and temperatures from 2080 to 2100 of the high emission scenario (RCP 8.5). To calculate a climate change pressure indicator the change in temperature was subtracted from the change in rainfall, multiplied by two. These values have been rescaled linearly to a scoring system of 1 to 5.

Water Risks under Climate Change

This layer indicates the water risk under climate change. This indicator has been calculated by combining the climate change pressure layer and the physical water risk layer.

Future Risks to People

This layer indicates the future risks to people under climate change. This indicator has been calculated by combining the baseline risks to people layer, the climate change pressure layer and the physical water risk layer.

CRIDF