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KAZA Water Infrastructure for Livelihoods Intervention - Phase III (Zambia), FP20

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Disclaimer

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Contents

List of acronyms

Acronym	Long-Form
AEO	Agricultural Extension Officer
AEW	Agricultural Extension Worker
APM	Area Pump Minder
BCR	benefit cost ratio
CA	conservation agriculture
CBA	cost-benefit analysis
CBNRM	community-based natural resource management
CBO	community-based organisation
CLTS	Community Led Total Sanitation
CRB	Community Resource Board
CRIDF	Climate Resilient Infrastructure Development Facility
CWR	Crop Water Requirements
DDF	District Development Fund
DFID	Department for International Development
D-WASHE	District Water and Sanitation, Hygiene Education
ECZ	Environmental Council of Zambia
EIA	Environmental Impact Assessment
EIS	Environmental Impact Statement
EMA	Environmental Management Act
ENPV	economic net present value
EPCCA	Environmental Protection and Pollution Control Act
ESA	Eastern and Southern Africa
ET_{Crop}	Crop Evapotranspiration
ET_o	Reference Evapotranspiration
FAO	Food and Agricultural Organisation
FNPV	financial net present value
GBP	British Pound
GESI	gender equality and social inclusion
GM	gross margin

GMA	Game Management Area
GRZ	Government of the Republic of Zambia
ha	hectare
HBC	Hygiene Behaviour Change
HRH	His Royal Highness
HWC	human-wildlife conflict
ICRISAT	International Crops Research Institute for the Semi-Arid Tropics
IP	Implementing Partner
JICA	Japan International Co-operation Agency
KAZA TFCA	Kavango Zambezi Transfrontier Conservation Area
KII	key informant interviews
KLO	KAZA Liaison Officer
km	kilometre
MOA	Ministry of Agriculture
nd	not dated
no	number
NGO	non-governmental organisation
NTFP	non-timber forest products
O&M	operation and maintenance
ODF	open defecation free
RCT	randomised control trial
RWSS	rural water supply and sanitation
SADC	Southern African Development Community
SDR	social discount rate
SIWI	Stockholm International Water Institute
TFCA	Trans-Frontier Conservation Area
TNC	The Nature Conservancy
USDA (SCS)	United States Department of Agriculture - Soil Conservation Service
VAG	Village Action Group
VHW	Village Health Worker
V-WASHE	Village Water, Sanitation and Health Education
WASH	Water, Sanitation and Hygiene

WATSAN	water and sanitation
WHO	World Health Organisation
ZEMA	Zambia Environmental Management Agency
ZMW	Zambian Kwacha

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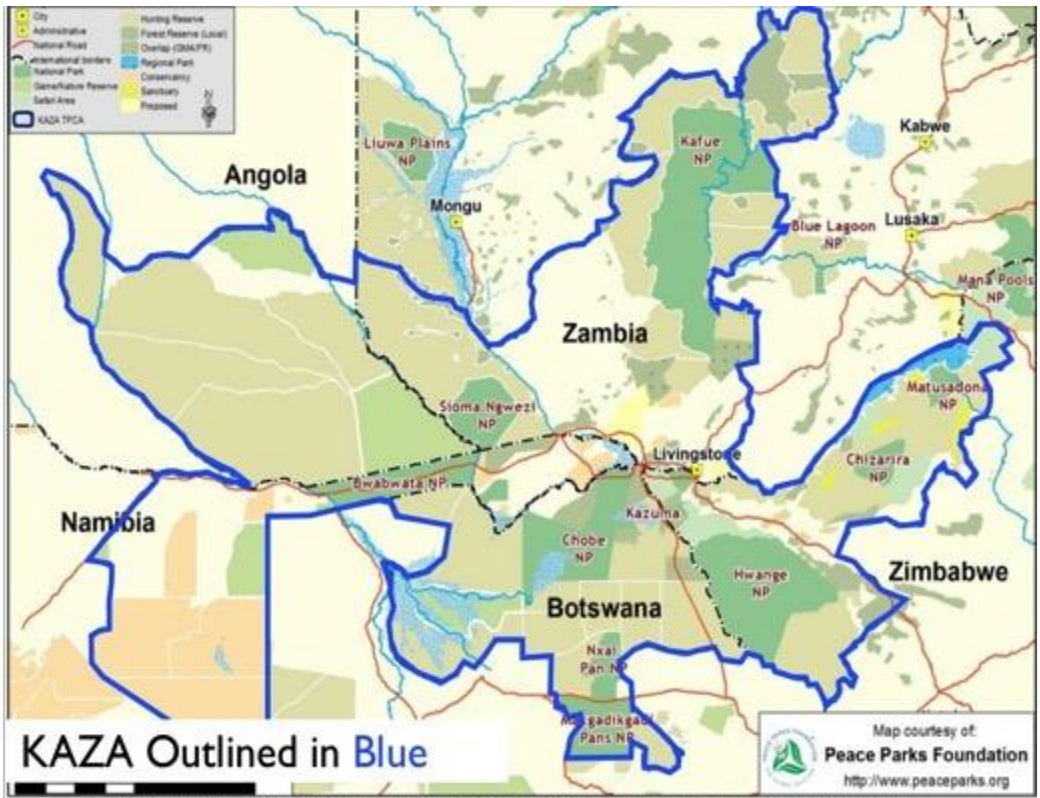
1 Introduction and Background

1.1 The KAZA TFCA

The Kavango Zambezi Trans Frontier Conservation Area (KAZA TFCA) was formalised by the Heads of State of Angola, Botswana, Namibia, Zambia and Zimbabwe who signed its Treaty on 18 August 2011. The process of establishing this TFCA, however, dates as far back as 2003 when the Tourism Ministers of the five countries agreed in principle to establish a major new TFCA (with emphasis on conservation and tourism development) in the Okavango and Upper Zambezi River Basins. In 2006, the Ministers of Environment, Tourism, Natural Resources and Wildlife of Angola, Botswana, Namibia, Zambia and Zimbabwe signed a Memorandum of Understanding, agreeing to establish the KAZA TFCA. The KAZA Secretariat is in Kasane, Botswana.

Covering approximately 444,000 km², the KAZA TFCA (Figure 1 below) is set to become the world's biggest conservation area, encompassing 36 formally proclaimed protected areas, comprising national parks, game reserves and game/wildlife management areas as well as conservancies and communal areas. It is also home to an estimated three million people, many of whom live in poverty and most of whom are dependent on agriculture and other natural resource use for their livelihoods. A recent socio-economic baseline survey of the KAZA pilot area found that human-wildlife conflict is a major livelihood problem, causing overall losses of 32% of crops, 18% of cattle and 50% of goats.

Figure 1 Broad Outline of the KAZA TFCA area in SADC



http://newswatch.nationalgeographic.com/2011/08/29/five-african-nations-sign-up-for-conservation-zone-the-size-of-california/kaza-transfrontier-conservation-area-map/

KAZA is therefore committed to enhancing the livelihoods of those who live in the area, with particular emphasis on those most directly affected by wildlife. In some areas, KAZA is working to facilitate biodiversity conservation through the enhancement of wildlife movements in dispersal zones between protected areas in the various countries. Those living in or near these areas are often badly affected by wild animals attacking people, eating their crops and killing their livestock. Many communities in the water-stressed Mulobezi Game Management Area (GMA) of Zambia – part of the KAZA TFCA – face these problems (sections 1.4 and 3.2.4 below).

Part of the hardship that many KAZA residents face is lack of water for domestic and livestock use. People and their livestock must often travel great distances to obtain water, especially in the dry season. If they adjust their residence patterns to move away from wildlife dispersal areas, they must find new, permanent water sources.

1.2 CRIDF and the KAZA TFCA

CRIDF is a UK-funded southern African regional programme that is being implemented in 11 countries. At community level, it aims to improve the resilience of communities in mitigating the impacts of climate change. To this end, the key objectives of CRIDF are:

- to deliver climate change resilience to communities in a pro-poor manner and to improve the livelihoods and food security of these communities;
- to provide environmentally sustainable engineering solutions; and to ensure that any identified negative environmental impacts are mitigated for, both in the construction and operation phase of the projects at reasonable cost; and
- to ensure that the projects are financially and economically viable.

It will be noted that the key objectives of CRIDF are rooted in a pursuit of judicious management and protection of the environment, as well as full consideration of potential negative environmental impacts in the design, construction and operation of the Project.

For CRIDF, the KAZA TFCA offers an excellent opportunity for a strategic partnership. Most of the TFCA is located in a semi-arid area that is vulnerable to the impact of climate change. The pursuit of sustainable water and natural resources utilisation by communities in the TFCA dovetails well with the core objectives of CRIDF. CRIDF therefore entered into discussions with the KAZA TFCA to explore areas of co-operation. In these discussions, the two programmes identified the opportunity for joint efforts to enhance rural water and sanitation facilities in selected TFCA communities that are strongly affected by wildlife and nature conservation activities.

1.3 CRIDF Activity FP20

As part of its efforts to secure more sustainable livelihoods for area residents, the KAZA project has thus negotiated the potential for funding through CRIDF, either directly or through alternative funding identified by CRIDF. This potential has so far been explored in selected areas of the TFCA in Namibia (Phase I), Zimbabwe (Phase II) and Zambia (Phase III). It focuses on the provision of safe domestic water supplies and improved household sanitation facilities for residents in selected communities within these areas; livestock watering points and small irrigated garden development may be associated with the new water sources that would be developed. Planning for CRIDF-facilitated KAZA water and sanitation interventions in these areas is at different stages of development. In each country, the plan is for an initial scoping visit to be followed by more detailed field assessments by technical teams, leading to a series of deliverables that set out technical design, environmental and economic assessment and design of support services such as sanitation and horticultural extension programmes. These series of activities and tasks are incorporated into the CRIDF project FP20 - KAZA 'Water Infrastructure for Livelihoods Intervention'.

Within this programme, Activity FP20-011 – "KAZA Zambia Bankability" - comprises the second, detailed stage of planning for the proposed infrastructure in the Mulobezi GMA, Zambia. It comprises four outputs:

i. Preliminary technical report (D01a), including detailed analysis of water resources, settlements, population and water demand; recommendations and specifications for provision and maintenance of water supply infrastructure; proposals for ensuring appropriate sanitation measures to accompany the improved domestic water supply; and analysis and recommendations regarding crop and livestock production and related support systems.
ii. Final technical report – this report (D02) – which includes the technical material originally presented in D01a as well as institutional, social, environmental, financial and economic and climate vulnerability and risk assessments, together with procurement recommendations.
iii. Stakeholder engagement report (D03), to be prepared after the stakeholder endorsement events scheduled for 22 – 24 March 2016.
iv. Final bankability report (D04).

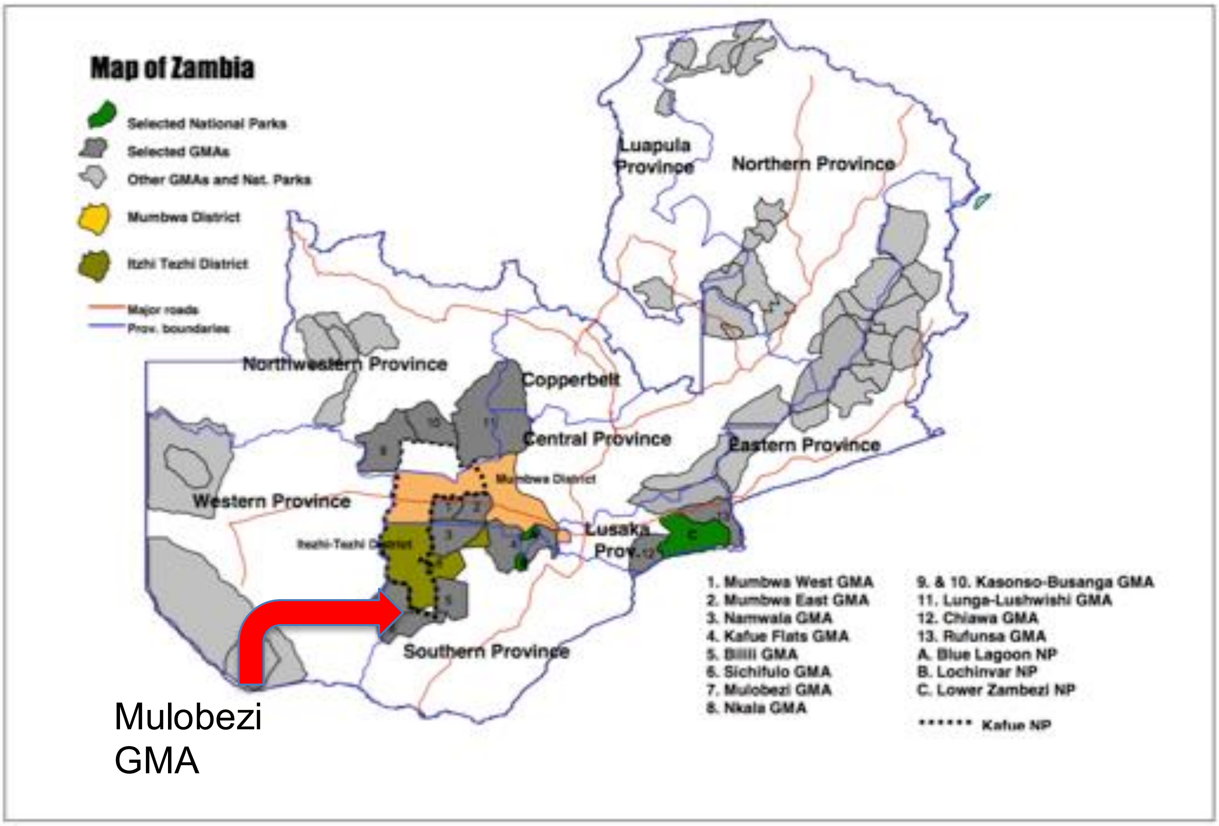
In addition to the four outputs identified above, CRIDF has prepared an outline business case for the proposed intervention in the Mulobezi GMA (FP20-011 D01b).

1.4 The Mulobezi GMA

Mulobezi GMA, lying south west of Kafue National Park, is experiencing a rapid degradation of its natural resources, as well as high levels of rural poverty. It is the fifth largest buffer zone in the Kafue ecosystem, with an area of approximately 3,430 square kilometres (TNC, 2012). Since 2000, the area has experienced rapid decline in its natural resources, in particular its wildlife and teak forests, caused primarily by poaching and poverty. These challenges are common across the KAZA TFCA. The high dependence on agriculture, coupled with the relatively high prevalence of poverty, has resulted in significantly vulnerable communities within the region. Climate change and water scarcity are exacerbating factors in this vulnerability. The area is also prone to human-wildlife conflict (HWC). While KAZA is committed to enhancing the livelihoods of those who live in the area, with particular emphasis on those most directly affected by wildlife, resources for such activities are limited.

HWC results in a loss of crops, livestock and sometimes even human life. A recent socio-economic baseline survey of the KAZA pilot area found that HWC is a major livelihood problem, causing annual overall losses of 32% of crops, 18% of cattle and 50% of goats (Mosimane *et al.*, 2014). HWC is especially a concern in the dry winter months; during these times, some of the communities must share water supplies with wildlife, leading to higher HWC. It is during this period when communities living in the KAZA area move their livestock towards water bodies (e.g. rivers and dams) when water closer to them dries up.

Figure 2 Location of Mulobezi GMA



The area is largely poor, with the population within the GMA surviving off subsistence agriculture, as well as some other low-income generating activities, such as the brewing and selling of traditional beer, the collection and sale of munkoyo roots, craft production and carpentry (Chemonics, 2011). In the household survey carried out as part of a situational and livelihoods analysis of the area, nearly all households in the Mulobezi GMA faced challenges in meeting their obligatory expenses, and almost none generated any cash surpluses. A lack of funds was also found to be the main determinant of a lack of farming inputs used by local farmers, including fertilizer, improved seed, tools and equipment. In many cases some children were unable to attend school because of cash shortages (Chemonics, 2011). The study reports that while poaching of wildlife is illegal and consequently severely under-reported, there is clear evidence that poaching wild meat is a common occurrence and serves as a means of generating food or cash for struggling households.

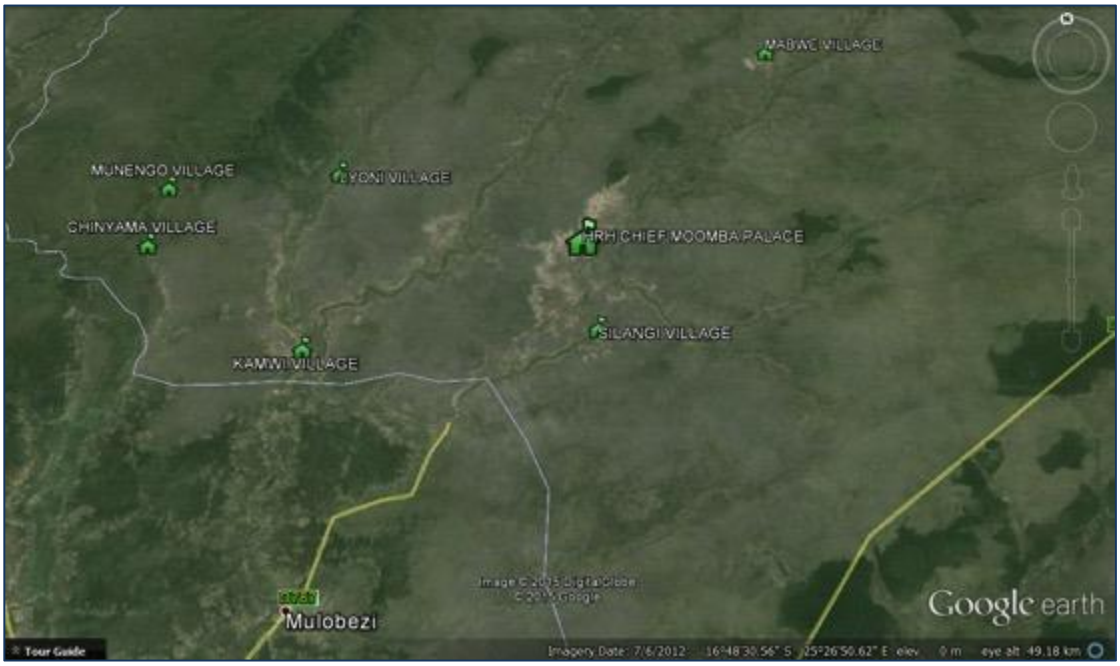
1.5 Sites

The project aims to improve livelihoods through the provision of domestic and livestock water supply, as well as small garden irrigation facilities in the following village locations in the Moomba chiefdom, which is coterminous with the Mulobezi GMA, Southern Province.

Table 1 **Proposed sites in Mulobezi GMA**

Village Community	Geographic Reference	Ward Name
Silangi	16°40'21.10"S 25°19'41.97"E	Moomba
Munengo	16°34'02.47"S 25°06'41.61"E	Moomba
Chinyama	16°35'56.31"S 25°06'02.55"E	Moomba
Lyoni	16°34'12.22"S 25°12'10.69"E	Moomba
Mudobo	16°33'37.76"S 25°26'13.49"E	Moomba
Kamwi	16°39'53.27S 25°10'45.24"E	Moomba

Figure 3 Location and distribution of project sites



The distribution of project sites is shown in the excerpt from Google Earth imagery in Figure 3 above. Due to lack of surface water bodies, the source of water for all the selected sites will be groundwater through the provision of boreholes. Communities through their village heads from each village sited the preferred locations for the proposed boreholes at central locations with respect to the distribution of homesteads in the respective villages. The final locations of the boreholes will depend on the results of a detailed geophysical survey. CRIDF consultants undertook two separate visits in March[1] and December 2015 to inspect the sites and carry out technical and environmental technical assessments. After the field visits, preliminary evaluation of groundwater

[1] FP20-007 D01.

availability was undertaken for each site based on ground observations of the respective dominant geologies and results from previous studies. In particular, reference was made to the Zambia National Water Resources Master Plan of 1995. The findings on general groundwater potential in the project areas are discussed in chapter 4.

1.6 Consultations

As explained in the March 2015 scoping report, consultations in the Mulobezi GMA have been facilitated by The Nature Conservancy (TNC), an international NGO active in the area that has a small field office in Mulobezi. A meeting with community representatives at the palace of His Royal Highness Chief Moomba on 17 March 2015 led to identification of the sites presented in that report. During the December site visit, a senior official from the palace was deputed to accompany the CRIDF team, having alerted communities in advance about the planned visits. At each community, meetings were held with local headmen and community members. A further meeting was also held at the palace to inform Chief Moomba about the progress and plans.

During the December 2015 site visit and community consultations, a number of adjustments were made to the site identification set out in the March 2015 scoping visit report. These were based on further investigation in the affected communities and areas, and will lead to a more effective water supply programme for the Mulobezi GMA, taking into account likely available resources. The changes made are set out in the discussion of each site in chapter 2 below.

1.7 Technical issues

The Mulobezi GMA is remote from engineering and extension services. Road access is poor. The population have very little disposable income. Borehole pumps should therefore offer maximum reliability combined with minimum operating costs and maintenance requirements. In addition these boreholes should be drilled to an appropriate depth that will ensure climate resilience. This requires deeper boreholes than the existing ones and should be at least 50 meters, but will depend on the hydrogeological surveys. Solar pumps are therefore recommended for this initiative. Zambia has less experience than some other countries in the KAZA area with solar technology for water supply, but it is feasible to install and operate such pumps. Hand pumps have proved unreliable in the area (due also to poor borehole installation). Diesel pumps would not be affordable and could not be maintained. Electricity is unavailable.

Livestock production is an important element of local livelihoods, and livestock watering is a major challenge – not least because of potential predation by wildlife. It is therefore important to include livestock watering capacity and simple facilities in the scheme.

Beneficiaries' livelihoods can be significantly enhanced and made more climate resilient by increased production of garden vegetables. Irrigation from borehole water can facilitate this. Costs must be kept low, however, and only the simplest technology is likely to be feasible and sustainable. Large-scale irrigated production and sophisticated irrigation systems are not practicable.

Global good practice requires that no rural water supply scheme should be developed without appropriate attention to enhanced sanitation and hygiene.

The proposed initiative in the Mulobezi GMA therefore consists of the following:

- drilling of new boreholes to a depth of at least 50 meters and fitting them with solar pumps;
- provision of limited water reticulation infrastructure from the water source to delivery points for domestic use, livestock watering and irrigated gardens;
- provision of small (1 ha) fenced community vegetable gardens that will derive water from the developed water sources;
- promotion of appropriate latrines to improve the sanitation of the communities;
- promotion of and improving the understanding of the need for improved hygiene; and
- support services to improve agricultural production from the irrigated plots and to improve the communities’ understanding and use of sanitation and hygiene.

CRIDF

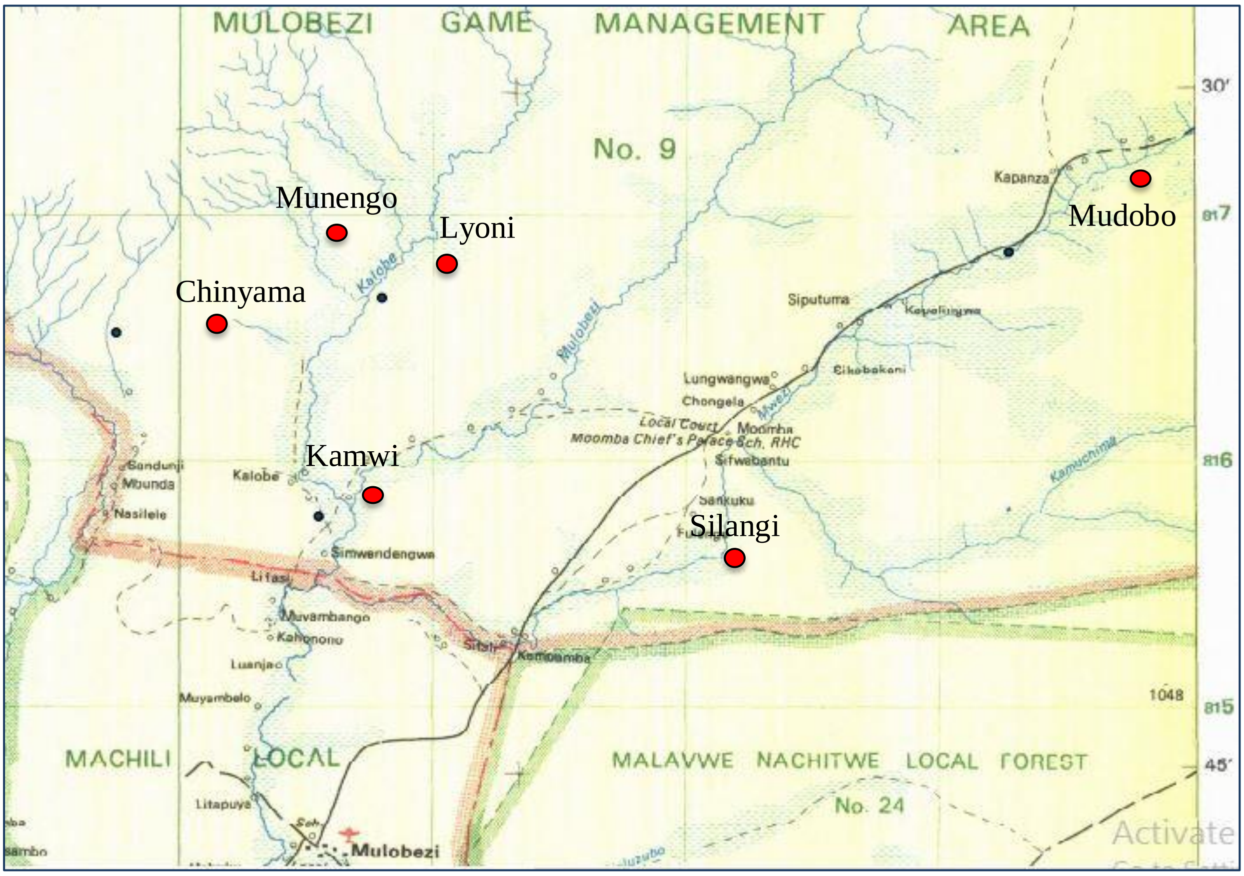
2 Settlements, population and water demand

2.1 Settlements

In general, settlements in all the project areas are rural in nature and characterised by scattered homesteads that exhibit a high level of unplanned development. The existing villages are expanding into the forests to create fields for subsistence agriculture, resulting in substantial deforestation. This settlement pattern, which is typical of rural settlements in Mulobezi District, is not conducive for the cost-effective provision of piped water supply infrastructure. Other villages are also being opened very far from existing hand pumped boreholes.

A description of settlements at each project site is given in the following subsections with the aid of Google Earth imagery dated 2012. Due to the passage of four years since the Google earth imagery was taken, the photographs do not depict actual conditions on the ground. Project area population has been based on household sizes published in the 2010 National Census Report projected to the current period, while livestock have been estimated from average ownership per household as advised by the villagers. The excerpt from the 1:250,000 Surveyor General Map in Figure 4 below shows the general project area within which the proposed beneficiary villages of Lyoni, Silangi, Munengo, Chinyama, Mudobo and Kamwi are located.

Figure 4 Location of sites



2.1.1 Lyoni village

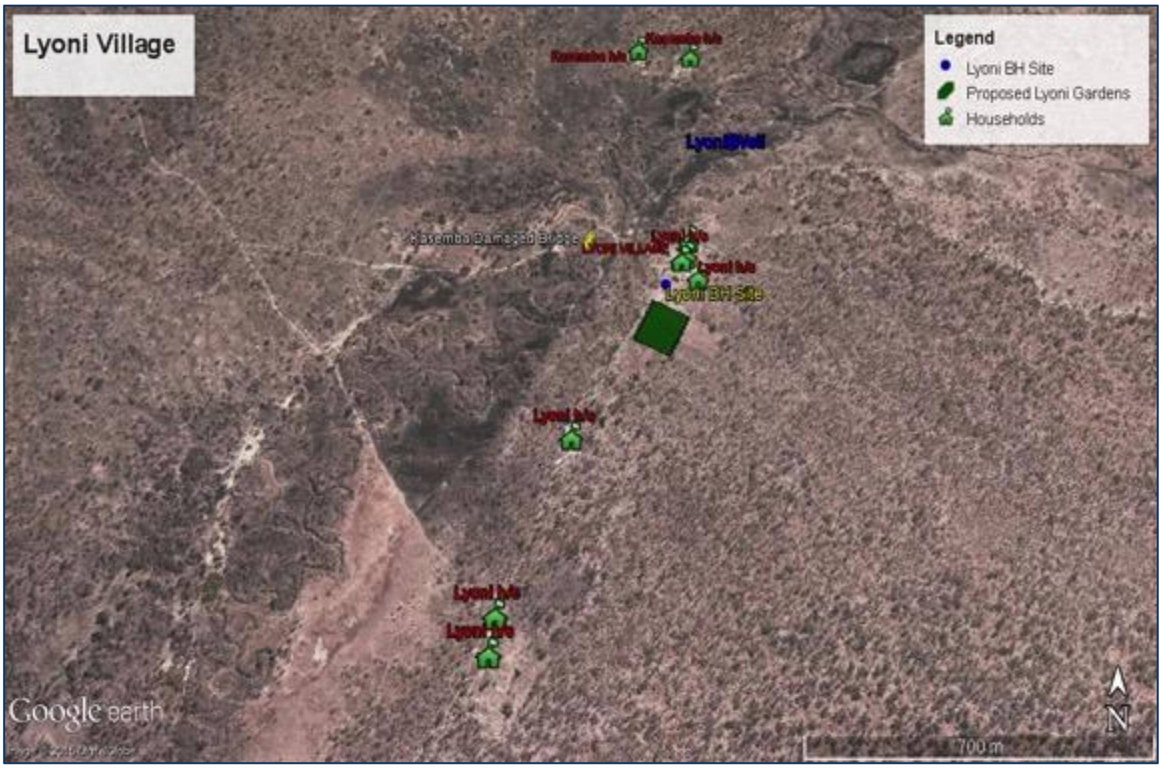
The project area is located approximately 15 km to the north-west of His Royal Highness (HRH) Chief Moomba's palace. Access to the site is by unsurfaced and poorly maintained narrow tracks through deep sand, making it very difficult and arduous.

The distribution of settlements is shown in the 2012 Google Earth imagery in Figure 5 below, and does not include all existing households in the area. The scattered settlement pattern is evident, with the majority of households situated along the road. It is proposed to site the new boreholes at the location shown in the Google Earth image around which the majority of the household are situated.

The proposed project will benefit a total of 44 households from Lyoni, Kasempa, Sidambi, Mudenda and Chipangole villages. The maximum walking distance to the borehole site is approximately 2.5 km for homesteads to the south-west of the proposed water source. Currently villagers fetch water from Kalobe River, which Kasempa villagers would have to cross to reach the borehole – potentially causing difficulties in the rainy season.

Land around the borehole site that can be utilised for the development of irrigated gardens has been identified. However, the final site for the garden will be selected in consultation with the traditional leadership.

Figure 5 Lyoni settlement pattern



2.1.2 Silangi village

The Silangi Village project area is located approximately 6 km to the south of HRH Chief Moomba's palace. The 2012 Google Earth image given in Figure 6 below illustrates the general distribution of households in the project area. Isolated homesteads straddle a river, forming two main clusters situated to the north-west and south-east of the waterway. A few households are located outside the two main village clusters to the north and south. The absence of a bridge across the main waterway makes it difficult to cross from one village to the other during the rainy season.

General access to the site is by poorly maintained unsurfaced tracks. The selected location for the proposed new borehole is shown in Figure 6. The site is located reasonably centrally to the majority of households. However, villagers to the west of the waterway have difficulty in accessing water during the rainy season due to the absence of a bridge across the river. The outdated 2012 Google Earth imagery indicates the general settlement pattern but does not show the exact number of households. The headman confirmed that the number of households in the area is 23. The maximum walking distance to the borehole site is approximately 1.5 km for homesteads to the west of the proposed source of water.

Land around the borehole site that can be used for the development of irrigated gardens has been identified. However, the site will be finalised after consultations with the traditional leadership.

Figure 6 Silangi settlement pattern

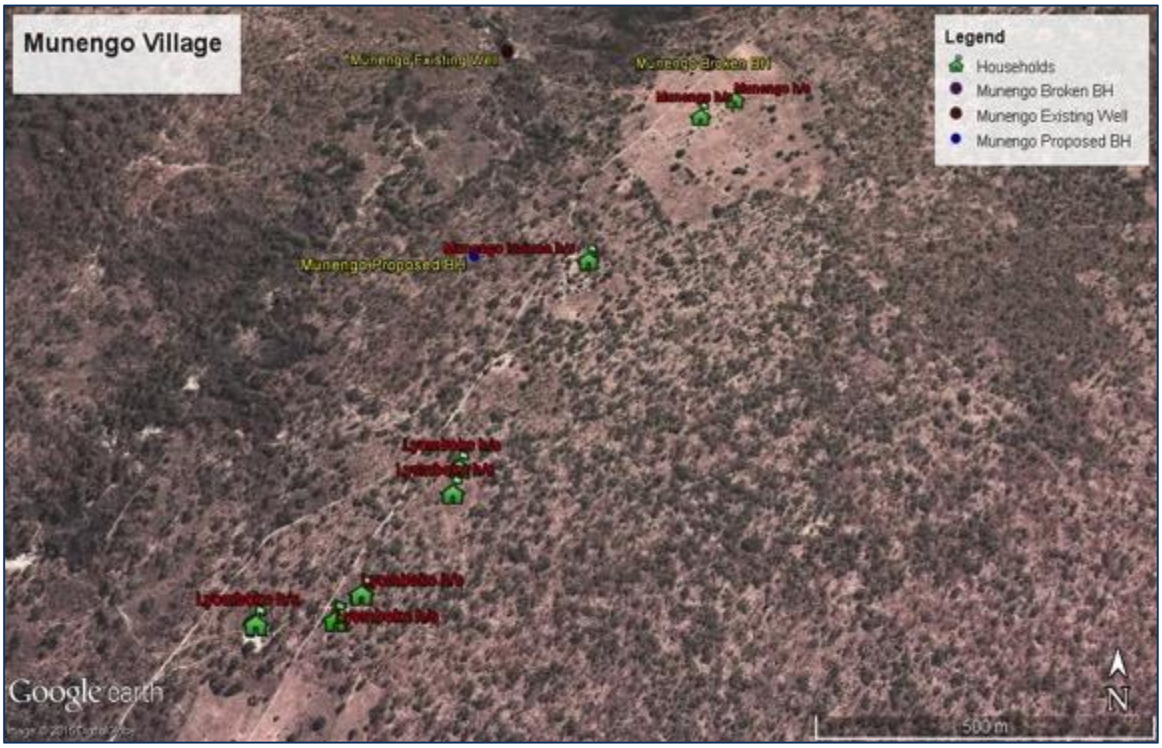
2.1.3 Munengo village

Munengo project area (referred to as Namuse in the March 2015 scoping report) consists of two separate villages, Munengo and Lyomboko. The area is located approximately 10 km to the west of Lyoni village. Similar to Silangi and Lyoni villages, access to the area is served by a poorly maintained track.

The 2012 Google Earth imagery in Figure 7 below illustrates the distribution of settlements, with the majority of households located along the main road. The selected location for the new borehole is located near an existing excavated dam where garden activities take place, using water from the dam when it is available. The majority of the households are located to the north-east of the proposed borehole site. The project area has a total of 65 households comprising 40 from Munengo village in the north-east and 25 from Lyomboko village in the south east. The maximum walking distance to the borehole site is approximately 2.5 km for a few homesteads to the north-east of the proposed borehole site and gardens, while the majority of homesteads are within 1 km of the borehole site. Currently the villagers fetch water from hand dug wells along Namuse River.

Land around the borehole site that can be used for the development of irrigated gardens has been identified. However, the site will be finalised after consultations with the traditional leadership.

Figure 7 Munengo settlement pattern



2.1.4 Chinyama village

Chinyama village project area is located just south of Munengo village and approximately 10 km to the west of Lyoni village. The area is served by a poorly maintained access road. It was added during the December 2015 site visit, having been identified as in severe need of an accessible safe water supply and too far from the proposed Munengo supply to be served by it.

The 2012 Google Earth imagery in Figure 8 below illustrates the settlement pattern in the project area, which is very sparse, with most households located along the main road. A few isolated households are found in the north-east of the village. The proposed new borehole will serve approximately 39 households, with the furthest villagers travelling about 2.5 km to the proposed water source.

Land has been identified close to the proposed borehole site for the development of irrigated gardens, subject to consultations with the traditional leadership and affected land owners.

Figure 8 Chinyama settlement pattern

2.1.5 Kamwi project area

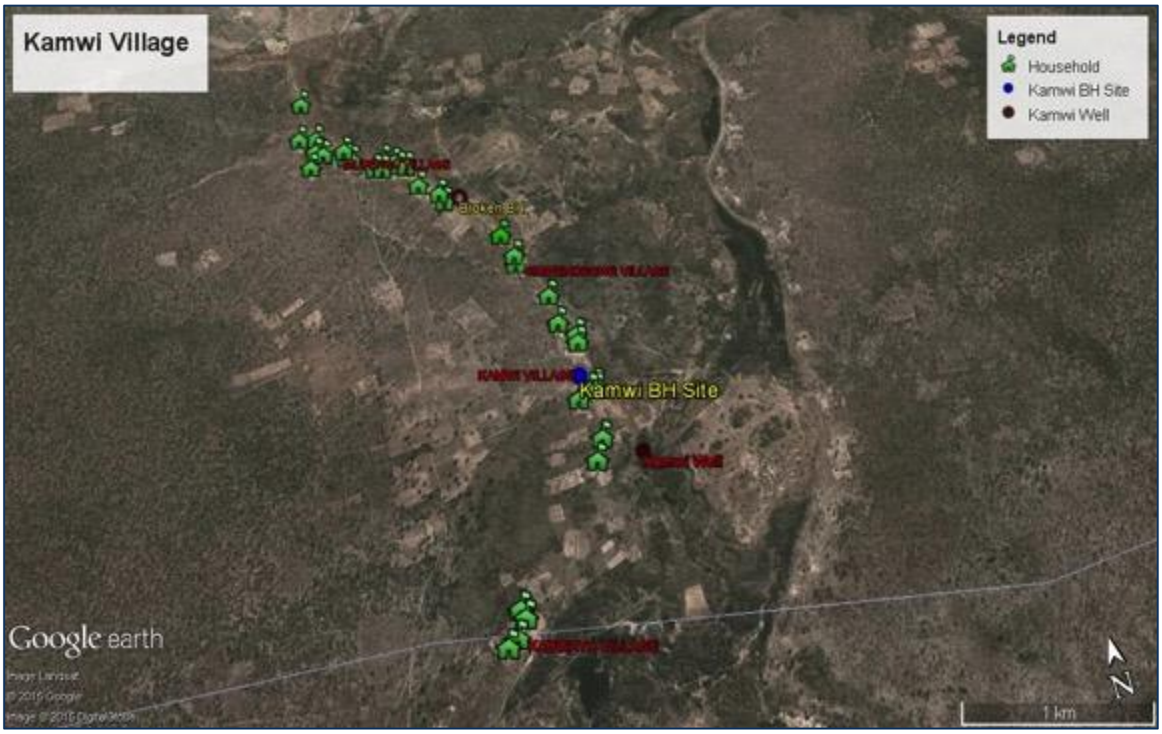
Kamwi project area spans the villages of Mupengu, Simwendengwe, Kabwaya and Kamwi villages, located 10 km south of Lyoni village. The area has approximately 60 households, most of which are located along the main road as shown in the 2012 Google Earth imagery in Figure 9 below.

A hand pumped borehole was installed in 2005 but collapsed after a week’s utilisation. Reports were made to the District Council but no investigations were done to find the cause of the collapse. Currently the villagers are fetching water from shallow wells along the Kalobe and Mulobezi rivers.

The site of the proposed borehole, shown in the Google Earth image in Figure 9 below, has been agreed between heads from all the four villages as being the most central to allow reasonable access by most of the villagers. It is not the site shown to the March 2015 scoping mission, which was at Mupengu and had reportedly been identified in earlier discussions between the local VAG and the District Council. However, consultations during the December 2015 site visit confirmed the community preference for the site now identified.

Land has been identified near the proposed borehole site for the development of irrigated gardens, subject to consultations with traditional leadership and affected land owners.

Figure 9 Kamwi settlement pattern



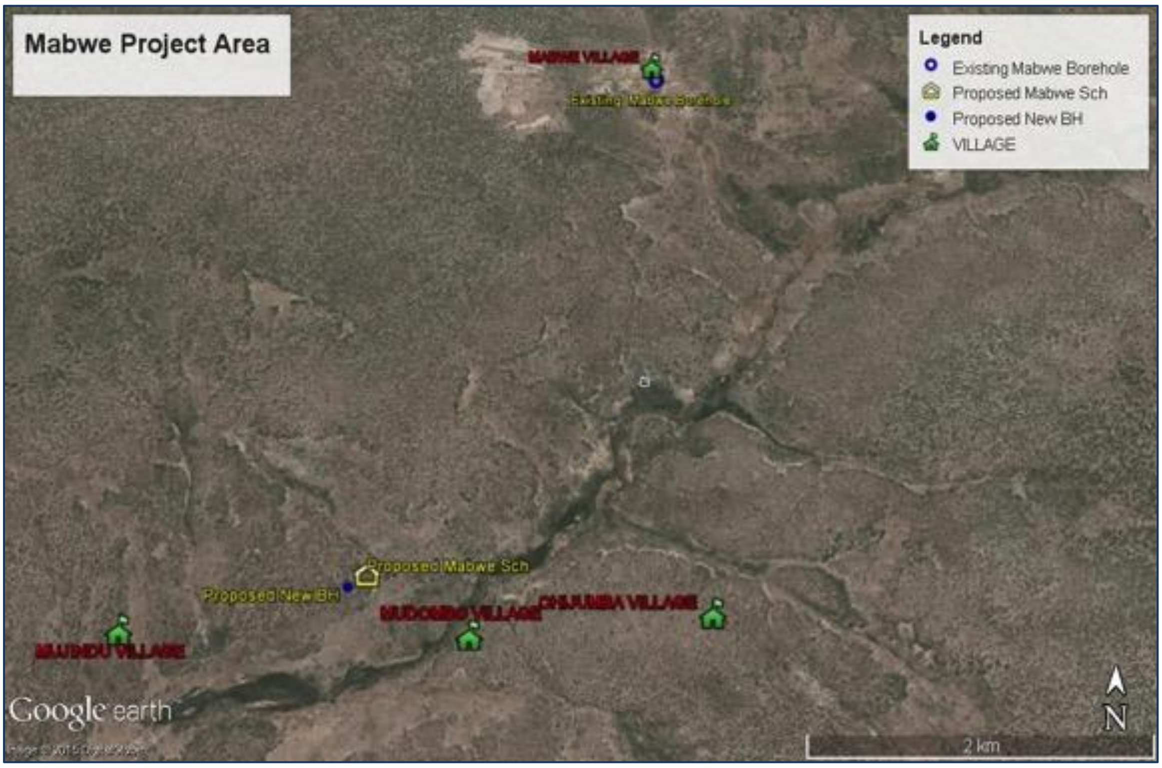
2.1.6 Mudobo project area

During the March 2015 scoping visit, community representatives identified a proposed borehole site in undeveloped bush at a point where a proposed new community school was to be constructed. The main village of Mabwe is located some 4 km north of this site and has an operational borehole and community school. There has reportedly been discussion about moving the Mabwe community school from there to the new site, which is some 750 m from Mudobo village. This seems impractical. Meanwhile, there is no clarity as to when a school might actually be constructed at the new site.

Mudobo village was identified as a suitable site for a borehole to serve that community, Chijumba (ten minutes' walk to the north) and Munchindu (15 minutes' walk to the south). The borehole would currently serve 34 households in these three communities, although new homesteads are reportedly being developed in the area. The 2012 Google Earth imagery in Figure 10 below shows the general location of the three project area villages, as well as the main village of Mabwe to the north. Due to the long distance of the three villages to the nearest boreholes (Mabwe to the north and Mungambwa 4 km to the south), residents have to rely on untreated water from the nearby Mwezi River,

During the site visit, village heads from the area endorsed the positioning of a new borehole at at Mudobo, with the concurrence of the local area induna (based at Mungambwa). It is proposed to develop a small irrigated garden in a suitable area near the borehole.

Figure 10 **Mudobo settlement pattern**



2.2 Population and water demand

2.2.1 Population estimates

Population estimates for all the project sites have been undertaken based on the reported number of households in the vicinity of the proposed sources of water in combination with the household sizes given in the 2010 census report. According to the 2010 National Census Report, the average household size in the Southern province is 5.4, with an average rural population growth rate for the Southern Province for the period 2000-2010 estimated at 2.8%. This growth rate has been used for the projection of population at all the project sites over 20 years to 2035.

Table 2 below gives a summary of the current and projected population at each site.

Table 2 **Population in the project area**

Village	Household size	No .of households		Population	
		2015	2035	2015	2035
Lyoni	5.4	44	69	238	373
Silangi	5.4	23	36	125	195
Munengo	5.4	65	102	351	551
Chinyama	5.4	39	61	211	330
Kamwi	5.4	60	94	324	508
Mudobo	5.4	34	53	184	287

The estimation of livestock population in the project areas has been based on the average number of cattle per household in the Moomba area. Information from the District Situation Analysis Report of 2005 indicates that there are 1,400 cattle in Moomba area, which gives an estimated average of 4 cattle per household based on a total of 360 households in the area. The population of other domestic animals is insignificant compared to cattle. Table 3 below gives the population of livestock cattle for each of the project areas.

Table 3 **Estimated number of cattle in the project area**

Project area	Household (2035)	No of cattle (2035)
Lyoni	69	276
Silangi	36	144
Munengo	102	408
Chinyama	61	244
Kamwi	94	376
Mudobo	53	212

2.2.2 Domestic and livestock water demand

The estimated domestic and livestock water demand in the project areas, has been based on the 2035 projected human and livestock populations and per capita consumption of 20 l/d/person and 30 l/unit respectively, and is summarised in Table 4 below.

Table 4 **Human and Livestock water demand**

Project area	Water demand (2035) in m^3/day		
	Human	Livestock	Total
Lyoni	7.5	8.3	15.8
Silangi	3.9	4.3	8.2
Munengo	11.0	12.2	23.2
Chinyama	6.6	7.3	13.9
Kamwi	10.2	11.3	21.5
Mudobo	5.7	6.4	12.1

2.2.3 Garden irrigation water demand

Irrigation water demand analysis has been carried out based on a variety of crops and water application systems. A review of the situation indicates that sprinkler irrigation, although preferable, would not be ideal for the small irrigation plots, for the following reasons.

- The allotments per household will be too small to allow for individual operation of sprinklers, which normally have a wetted perimeter of about 15 m on average. Cropping preferences and variability by irrigators would create numerous operational problems.
- The proposed configuration of the water supply system will consist of pumping from a borehole into an elevated tank with a maximum height of 7 m using solar power. Sprinkler irrigation would require an

additional booster bump to generate the 30 m of head required to operate the nozzle. The use of wind power for pumping has been discounted due to reported low wind speeds in the region.

Appropriate types of irrigation systems for the small gardens could be either simple hosepipes connected to stand pipes, or drip irrigation systems. The former will be simpler and cheaper to implement for the small gardens, with far fewer operational problems.

Notwithstanding the above observations, garden irrigation water demand has been based conservatively on that computed for sprinkler irrigation systems. To simplify planning, and recognising that the primary function of the schemes is domestic and livestock water supply, an irrigated garden area of 1 ha per scheme is proposed.

Irrigation water demand for each area based on the analyses undertaken for the Agronomy component is summarised in Table 5 below.

Table 5 **Irrigation water demand**

Village	Water demand m^3/hr	**Water Demand** m^3/day
Lyoni	10	80
Silangi	10	80
Munengo	10	80
Chinyama	10	80
Kamwi	10	80
Mudobo	10	80

2.2.4 Total water demand

Total water demand includes domestic, livestock and irrigation water demand and is summarised in Table 6 below.

Table 6 **Total water demand**

Project area	Water demand in m^3/day			
	Human	Livestock	Irrigation	Total
Lyoni	7.5	8.3	80	95.8
Silangi	3.9	4.3	80	88.2
Munengo	11.0	12.2	80	103.2
Chinyama	6.6	7.3	80	93.9
Kamwi	10.2	11.3	80	101.5
Mudobo	5.7	6.4	80	92.1

3 Socio-economic context

3.1 Livelihoods

The project area is classified under the Mulobezi Woodlands livelihood Zone 9 (Zambia Vulnerability Assessment Committee, 2004). This zone is characterised by rainfall of 600 – 700 mm per annum, and Kalahari sands, which are infertile soils. Infertile soils and low rainfall are some of the constraining factors that affect the livelihoods of the people in the project area. Further, the zone is an ecological landscape dominated by miombo woodlands interspersed with dambos, grassy plains and teak forests. This was the main pull factor for the establishment of the Mulobezi Saw Mill Company, a parastatal that was privatised in the early 1990s. Prior to 1990, the GMA had a high wildlife population and teak forests, which have been in decline due partly to the restructuring of the National Parks and Wildlife Services to the Zambia Wildlife Authority. The other reason for deforestation is the rapid migration of farmers from other parts of the province in search of agricultural land.

Given that most livelihood assets and activities are dependent on the climatic conditions, communities of Moomba chiefdom (the Mulobezi GMA) have striven to combine their capabilities, skills and knowledge to survive. Some of the main livelihood activities include the following.

3.1.1 Agricultural production

Food security for residents in the Mulobezi GMA is a major socio economic challenge. As in most rural areas of Zambia, project site beneficiaries are smallholder farmers depending on rainfed crop production. Their agricultural activities revolve around crop and animal husbandry. Common field crops grown include maize, sorghum, millet, cassava, sweet potatoes, groundnuts and beans. Some households own seasonal gardens cultivated from March/April to August/September. Some of the crops grown include rape, okra, Chinese cabbage, tomatoes and green maize.

Although the project area is within a GMA where tsetse flies are a possibility, livestock rearing is important due to abundant pastures in wetland areas. The main animals kept are cattle - usually raised for milk, draught power and transportation of agricultural products, timber and people. A number of households keep donkeys for the purpose of transportation of goods to far away markets. Cattle and donkeys are an essential means of transportation as the project area is located far from the main centres. Women reported that chickens were mainly reared for sale and as a source of protein in the household. Other small animals reared include ducks and pigeons.

3.1.2 Trading ventures

Trading has emerged as one of the major sources of income for many households. Given the project sites' location in a GMA, natural resource base incomes are derived from sale of timber, high value non-timber forest products (NTFP) and agricultural produce. Timber and firewood are sold to Zambezi Sawmills in Mulobezi and households respectively. The NTFP sold include: i) wild roots, tubers, and fruits ii) seasonal mushrooms; iii) mopane worms; vi) honey, and v) thatch and palm fronds for basket and mat making. Of interest is the munkoyo wild root that is a major source of income for many women at the project sites. Agricultural produce sold includes vegetables, seasonal fruits (mangoes), cow milk, small animals, maize and sorghum. Other foodstuffs sold are fish and local opaque beer. Although the area is far from commercial centres, items mentioned above are sold in Mulobezi, Sesheke, other Southern Province districts and as far as Lusaka.

3.1.3 Skills

The educational level attained is one of the key determinants of the availability of skills in the project area. The level of education attained by household members as revealed by the 2014 baseline study (Muyengwa *et al.*, 2014) indicated that 38% had no education and 44% had some primary education. Further, 6% and 5% had completed primary and secondary education respectively. This illustrates that there are low literacy levels among community members in the Mulobezi GMA. The low literacy levels have to be taken in to account in the selection of technology and level of operation and maintenance of water systems under the proposed project.

Nevertheless, some skilled community members available include technicians such as Area Pump Minders (APMs), carpenters (some highly skilled in wood carving), weavers (reed mats), and saw millers. Some community members have knowledge of agriculture (due to long term experience), fishing and timber preserving, while others are retirees with assorted skills and knowledge. Availability of APMs is critical to rural water supply projects, as they have basic training on the operation and maintenance of borehole pumps.

3.1.4 Wage employment

One major livelihood strategy employed in times of crisis is wage employment, which attracts men, women and the youth. Most adult household members obtain short-term wage employment in farms, either locally or in neighbouring districts. Payment is usually in the form of cash or maize.

Among community members met during the December 2015 site visit, none were in formal employment. The baseline study (Muyengwa *et al.*, 2014) indicated that 61% of the respondents in Mulobezi GMA were farmers, 26% of the labour force was unemployed and only 4% were in full time employment. The rest are engaged in part time wage employment and trading.

3.1.5 Assets

According to the baseline study report (Muyengwa *et al.*, 2014), physical capital assessed includes housing, farming implements and other household items. As regards housing, it was reported that 85% of the people live in traditional thatch and grass buildings. The report revealed that 45% of respondents own a plough (essential for cultivation), 26% own bicycles and another 26% own ox drawn carts useful for transporting goods, people and water supplies. Other high ranking assets included radios (31%), television (11%) and sledge (11%) used for hauling timber and other heavy items. Other assets owned by few households included vehicles (5 households), canoes (3 households), hammer mills (3 households), and tractors (2 households).

3.1.6 Energy

The project sites are not connected to the national grid. Institutions such as the school, clinics and the Chief's palace use a combination of solar power and diesel or petrol generators. Households also use small solar power systems (a panel connected to a battery) and candles for lighting, and firewood for cooking purposes.

3.2 Gender

The general background to gender issues at the national level has not changed much since the adoption of the National Gender Policy in 2000. It is well understood that socio economic development can only be attained when there is equal participation of both men and women in the development process. With this realisation the Government of Zambia's vision on gender is contained in the "Vision 2030". The National Gender Policy addresses the need to build and strengthen national capacity for advocating and mainstreaming gender in the developmental process. Under the guidance of the Ministry of Gender and Child Development, all government ministries have appointed and trained gender focal persons from headquarters through to the provincial and district levels.

The Kazungula District Development Strategic Plan 2015-2019 presents a number of gender-specific programmes aimed at advancing gender mainstreaming in all district plans and programmes. The current status of rural water and sanitation in the Mulobezi GMA, however, presents serious challenges to gender equity through the burdens and risks that they impose on women and girls (sections 3.4.1 and 3.4.2 below). Other livelihood challenges for women are presented in the sections below.

3.2.1 Inability to secure farming implements and inputs

Women interviewed during the December 2015 site visit reported that they frequently use maize, groundnuts, sorghum and pumpkins seeds from the previous season. This is a traditional system, which is perpetuated by the lack of money to buy certified seeds. This has led to low production, reduced incomes and wasted effort.

Women in the Munengo area revealed that households that engage in horticulture use certified seeds purchased from Mulobezi and Kasima, where they sell their produce. However, they were not able to buy certified maize seed as it was expensive at ZMW 250 for a 10kg bag. This in comparison to large quantities of vegetable seeds purchased at a lower price of less than ZMW 20.

3.2.2 Dependence on non-timber forest products

The sale of NTFP is one of the key sources of income. All the women interviewed revealed that a wild root (munkoyo) was a lucrative product that most households relied upon. It was revealed that a three year ban (starting 2016) has been placed on the extraction of this product. This is in an effort to replenish the depleted root that is also a source of food for wild animals. This was a great source of concern for women whose major source of income has been curtailed.

The Forestry Department is implementing a project on the domestication of wild tubers and roots. If possible, the domestication of munkoyo should be a major target for this project, due to its income generating potential for local women.

3.2.3 Distance to social services and commercial centres

Most project sites are located far away from the health, education and commercial facilities (sections 3.3 and 3.5 below). This makes it difficult for community members to access services in good time. For instance it takes three hours for women of Lyoni site to walk to Moomba for health and educational services. This is a significant opportunity cost for household livelihoods.

Trading as a major source of income for most households is also negatively affected, as it can only flourish if there is easy access to commercial centres. In all focus group discussions, women complained of the long distances to the main commercial centres. These long distances are not favourable for hauling perishables, and the trend has been to start off around 4 a.m. The problem of distance is exacerbated by the lack of vehicular transport; community members largely travel by bicycles, carts and/or walking.

Given the challenge of long distances and lack of vehicular transport, most community members sell their products locally at lower prices. The implication for the project is that households would have to factor in the form of transport and markets available.

3.2.4 Human-wildlife conflicts

Women in Silangi, which is located at the edge of the GMA, complained of frequent animal raids, which exacerbated food insecurity and reduced household incomes. Notorious animals mentioned are elephants that raided maize fields, and duikers and wild pigs that are problematic in bean fields. In certain instances animals even broke through the fencing. Adult household members, including women, were reported to be spending considerable time trying to ward off these wild animals.

3.2.5 Lack of women's development activities

During focus group discussions, all women complained of inactivity and lack of community development activities. Although the Department of Social Welfare was implementing the Social Cash Transfer scheme in the area, their interaction was limited to beneficiaries of the programme. The absence of the Department of Community Development (probably due to the remoteness of the area and budget constraints) has deprived the area of community development activities such as formation of groups, clubs and associations. These structures are opportune entry points for women's empowerment and training in different developmental activities.

3.2.6 Gender roles and responsibilities

It was evident from the discussions on site that both male and female household members have specific activities within household livelihoods. For example, among the Tonga and Toka leya ethnic group certain crops grown and revenues generated by either a woman or man are kept by that respective woman or man. Food crops such as groundnuts, beans, okra, pumpkins and other domestic crops are largely grown by women, and earnings from these crops are retained by them. Cultivation and earnings from cash crops such as maize, sunflower, cotton and so on are the responsibility of males. Despite this divide, there is interdependence in some tasks such as land preparation, weeding and harvesting.

While gardening is mainly a female venture, field cultivation requires both male and female participation due to the tasks involved. As regards trading, male members predominantly harvest, make and sell thatch, reed mats, and harvest honey, whilst women sell wild roots and fruits, mushrooms and caterpillars.

The implication of this division of responsibilities to the proposed project is that there would be two main tasks namely i) technical maintenance of infrastructure that might be assigned to male members; and ii) drawing water and cultivation which would be the responsibility of women, girls and younger boys. However in order to promote gender equity, both male and female members should participate to ensure that activities proceed even in the absence of the other gender for any reason. Gender equity should also be promoted in the membership of committees that are formed.

3.3 Social services

3.3.1 Education

The majority of pupils in the project sites attend Moomba primary school, which is located within a 7 km radius of the sites. Other schools included Kasima primary school, located in Mulobezi district, and one community school. Moomba primary school is not easy for pupils from Kalobe VAG area to reach, as they have to walk long distances. This is particularly difficult for younger pupils in lower grades. The 1 x 3 and 1 x 2 classroom block school has about 300 pupils from grades 1 to 7. The headmaster reported that the school had a record of good performance with a number of pupils qualifying for enrolment into secondary schools. The school has seven male teachers. This gender imbalance is largely due to remoteness of the area, which tends to be unattractive to female teachers.

Some of the problems revealed at the school were absenteeism, as pupils cover long distances to go to school. Other problems included inadequate textbooks and insufficient toilets for pupils. During 2015, three cases of teenage pregnancies were recorded. The school headmaster stated that teenage pregnancies at the school were not common.

3.3.2 Health

The project sites lie within the catchment of the Moomba Clinic. The clinic is located next to Moomba primary school; therefore it is the same distance from the proposed project sites. Community members access the clinic either by bicycles, ox drawn carts or by walking. The clinic consists of an outpatient section and one delivery bed. Patients with serious ailments are referred to Sichili mission hospital in Sesheke district. The baseline study report (Muyengwa *et al.* 2014) revealed that major diseases in Mulobezi GMA, in order of high to low incidence, include malaria, diarrhoea, HIV infections, tuberculosis, pink eyes and malnutrition. It was observed that these diseases were related to poverty and lack of access to primary health care, hygiene and clean water.

3.4 Water and sanitation

3.4.1 Domestic water supply

The 2014 baseline study (Muyengwa *et al.*, 2014) showed that 58.4% of respondents in Mulobezi access water from a well, compared to 39.7% who draw water from streams and rivers. These results confirm the CRIDF team's findings during the December 2015 site visit, where during the transect drive five functional boreholes (three community and two school boreholes) and two dysfunctional boreholes were spotted. Further, the baseline study showed that 71% of respondents in Kalobe VAG were reported to not have clean water supplies. These results match the expressed needs to which this project would respond, with three of the project sites (group of villages) falling within Kalobe VAG.

In sites without borehole water, the current water sources were certainly unfit for human consumption. These domestic water supply issues are a major challenge, making these project sites high priorities in the GMA. Similarly, provision of water for productive use is also an urgent need as women complained of limited agricultural activities in the dry season.

Villages are located along streams and wetlands where the land is fertile and water sources are relatively close. The major complaint was the insufficient quantities and poor quality of water. The quality of water is not suitable for human and, in some cases, animal consumption. As regards quantities, women often have to wait more than 30 minutes to draw a 20 litre container of water. A household of six members would require about 5 x 20 litres of water per day, which means that one has to wait for 2 hours 30 minutes. This has an effect on the other daytime chores that women need to carry out, so in order to gain on time women either draw water early in the morning (around 5 a.m.) or reduce on the quantities of water drawn. Insufficient water supplies lead to poor hygiene. This situation has forced women to walk longer distances in search of sufficient water supplies, as is the case of the woman in the photograph below.

The photo illustrates the multiple activities that have to be performed away from home, with impacts on time and effort that cause a strain on family life. This woman and her daughter, from Sialwindi village in the Munengo area, were on the way to Machila River where she was going to wash clothes, bathe and draw water. The load on her head is a bag of maize grain that she would drop at a grinding mill on her way to the river. On her back is a bundle of clothes that she would wash while at the river. She would use the green bucket to wash clothes, bathe and draw water. Walking to and from the river would take about 3.5 hours. This excludes the time she would take to perform other activities at the river.

Figure 11 Water and domestic chores

Women complained of the high incidence of gastric and diarrhoea cases, particularly in the Kalobe VAG where the water supplies are a source of great concern. Suggestions to boil the water before use were challenged, with women claiming that the water evaporated off, leaving sludge. In the absence of home filtering systems, households have no option but to drink the murky water.

Figure 12 A woman from Munengo Village drawing water from an unprotected hand dug well

3.4.2 Sanitation

Results of the 2014 baseline survey (Muyengwa *et al.*, 2014) showed that 45.8% of respondents had access to a pit latrine and the remaining 54.2% used the bush. Analysis of availability of sanitation facilities within the Village Action Groups (VAG) showed that, out of the five VAGs, Moomba Central VAG had the highest number of households with pit latrines (49%) and Mulanga VAG had the lowest number of households with pit latrines (22%). The number of those without latrines is very high. Improved water supplies will not achieve their full potential benefits for users' health if sanitation remains so inadequate.

3.5 Administrative, commercial and other services

3.5.1 Administrative and commercial services

The main trading centre is Moomba Central, where the Chief's Palace, Moomba primary school, Moomba clinic and a small market are located. There are a number of stores and market stalls owned by local community members, mainly from Moomba Central villages. It also hosts the Moomba Central VAG office where Moomba chiefdom development issues are discussed.

Other trading areas accessed by residents of the Mulobezi GMA include the Mulobezi centre, which is 26 km from Moomba and is a slightly more urban centre. This centre hosts a number of government and parastatal facilities such as the Ministry of Tourism, Arts and Culture, Zambezi Sawmills, a primary and secondary school and a railway service. The other centre utilised by residents of project sites like Lyoni and Kamwi villages is Kasima, which is 4 km from Kamwi village. Kasima centre, located in Mulobezi district, is a built up area with stores and market stalls and a primary school.

3.5.2 Other services

A gravel road that extends from the Livingstone – Sesheke road junction via Mulobezi centre is used to access the Mulobezi GMA. The area can also be accessed by rail (an affordable means of transport) from Livingstone to Mulobezi centre. There is no private bus service between Mulobezi centre and Moomba Central and a few community members rely on utility vehicles owned by Moomba teachers and the Chief. The majority of community members use bicycles, ox drawn carts, and donkeys for transportation and others walk to the administrative and commercial centres. There is some cell phone coverage, although reception is quite difficult in most places.

4 Water resources

4.1 Introduction

The project area lies in the southern part of Zambia and falls under Climatic Region IV where the climate is generally hot and dry. The area is characterised by rainfall in the range of 600 – 700 mm per annum. Topography is generally flat, resulting in a poor river network. The main drainage network consists of the small rivers of Kalobe and Mwezi, which are tributaries of the Mulobezi River. These smaller rivers generally dry up soon after the rainfall season whose duration in recent years has been shortening, most likely due to the effects of climate change. Water holes that remain are usually shared between humans and wild animals resulting in conflict. Communities largely depend on groundwater for their domestic water requirements. A few boreholes have been drilled in the area but due to the scattered and sparse distribution of settlements, many villagers walk long distances to the nearest sources of potable water supplies.

4.2 Geology of the project area

The geology of the area falls under the Tertiary Kalahari group, where the Barotse formation comprises fine sands, sandstone with clay, chert and quartzite. The sands comprise deep, unconsolidated and well-drained tertiary sands of Aeolian origin. Generally these soils, in combination with a flat terrain, result in high permeability rates with poor runoff. This, in combination with low seasonal rainfall, largely explains the ephemeral nature of river flows in the area.

Observations on the ground and examination of the hydrogeological map of Zambia indicate that the Moomba area lies in the Kalahari sands and sandstone belts. Typical groundwater yields in the two geological formations are discussed in the following subsection.

4.3 Groundwater potential at the project sites

The groundwater potential in Zambia was studied as part of the National Water Resources Master Plan in Zambia project by Yachiyo Engineering in 1995. A review of the hydrogeology section of the Master Plan was carried out for the Kalahari sand hydrological unit. It indicated the following groundwater scenario.

4.3.1 Groundwater potential and water quality in Kalahari Sand Aquifer

Groundwater Potential

The unit comprises a thick sequence of fine to medium-grained Aeolian sands that become consolidated at depth to form pipe sandstone. The sequence is indicated as saturated. The aquifer is unconfined with water tables generally at a depth of about 10-20 m below ground level.

Drilling in the formation is difficult due to unconsolidated sand and requires special drilling techniques as well as the screening and gravel packing of boreholes. Experience and reports from locals also indicate the tendency for casings to collapse during drilling where the unconsolidated sands are too deep (see below). Locals in

Kamwi village advised that a borehole in the village collapsed one week after installation due to suspected poor casing.

Key aquifer characteristics are summarised below:

Productivity	medium to high
Transmissivity	5 to 50 m^2/day
Specific Capacity	10 – 100 m^3/day
Average sustainable borehole output	4 – 40 m^3/hr from boreholes 70m to 100 m deep

Experience in drilling in the formation indicates that yields can reach up to about 20 m^3/hr for borehole depths in the range of about 50 m to 80 m. Recommended drilling is by means of mud rotary techniques. Boreholes may be sited anywhere provided there is adequate sand depth. The potential for groundwater development is high, with water resources suitable for primary piped water supply and irrigation schemes.

Collapse of borehole casings due to abnormal conditions during drilling

Conditions that are encountered in the Kalahari sand formation coupled with inappropriate drilling practices and inadequate casing thickness often lead to the collapse of boreholes during drilling or operation of water supply boreholes. This phenomenon has been experienced on a number of occasions when drilling in the Kalahari Sands in and around the project area. A common cause of casing collapse is the rapid bailing of fluid from the borehole during drilling, which results in a high net hydrostatic pressure on the casing wall. To avoid this, bailing should be undertaken at a controlled rate that limits the level of the pressure differential on the casing wall.

The drilling contractor will need to compute the minimum net hydrostatic pressure required to cause casing collapse for a given material thickness, and ensure that this is not exceeded. This collapse pressure will also depend on the thickness of the casing wall. Structural analysis for casing buckling will be required to ensure the selection of adequate casing thickness for the most severe draw down likely to be experienced in the borehole, both during its drilling and operation.

Water Quality

Currently, many of the villagers in the project areas source their water from shallow wells, which they share with domestic animals such as cattle and donkeys. The wells are vulnerable to contamination by both humans and animals. At some of the well sites, water turns muddy during withdrawal due to churning, with users having to wait for hours before improvement in turbidity. Figure 13 below gives visual comparisons of the turbidity of water fetched from five village water point sites. Picture 1 shows a sample of water used for domestic purposes at Lyoni village sourced from an unprotected shallow well. Picture 2 shows rust coloured water from a domestic water supply borehole at Siyamwanja village (4 kilometres to the north-west of Silangi village). The water is initially clear when fetched from the borehole, with the rusty colour gradually developing after standing due to the oxidation of iron salts. Samples from water points at Mabwe village and Kamwi village are shown in Picture 3 and Picture 4 respectively.

Due to time limits and logistical constraints during the course of the site visit, no water samples were taken for testing in a water quality laboratory.

Figure 13 Water samples

Picture 1: Lyoni village water sample

Picture 2: Siyamwanja village water sample

Picture 3: Mabwe village water sample

Picture 4: Kamwi village water sample

Figure 14 Water point, Lyoni

The domestic water supply and cattle watering point at Lyoni village are shown side by side in Figure 14 above. The risk of contamination of the unprotected hand dug domestic water supply well is evident.

4.4 Implementation options and costs

Table 7 **Indicative borehole drilling costs**

Activity	Unit Cost (GBP)	Units
Siting	420	Per borehole
Drilling	70	Per metre
Capacity testing	350	Per hour
Plain casing	60	Per metre
Mileage for siting	1.05	Per km
Mileage for drilling	1.05	Per km

4.5 Borehole permit application

Applications for borehole drilling permits must be made to the Kazungula District Council, through the Community Resource Board (or water point committee, if the structure exists). TNC has committed to assisting the beneficiary communities with this paperwork. Information will be drawn from this report to inform the application – including recommended borehole locations, required yield to support proposed livelihoods activities etc.

Prior to applying for the permit, the community needs to raise ZMW 1,500 to cover future O&M costs.

4.6 Considerations for solar pumping

Solar pumping for water supply in rural communities is a technology that is making inroads in most Sub-Saharan countries including Zambia. However, information on implemented projects in Zambia is difficult to obtain. In Zimbabwe, various projects for pumping water in rural areas have been implemented and commissioned to date. CRIDF is implementing two projects in Zimbabwe with one of them consisting of a 63kW submersible pump delivering 1,400 m^3/day. Zambian suppliers have the capability to install solar pumping units for water supply in the Mulobezi GMA projects

If the solar pumping option is adopted, the costs for equipping with hand pumps will be replaced by the solar installation costs. Solar panels generally come with a minimum of 20 year life.

4.7 Conclusions and recommendations

a. Boreholes can be drilled in the targeted villages with average expected safe yields of approximately 20 m^3/hr. However, the fragile geological formation of Kalahari sands and Karoo sandstones calls for expert drilling companies.
b. Combined contracts for siting are recommended. While only a few organisations offer such services, the liability of failed holes moves to the contractor as the client only pays for successful work.
c. The minimum depth of good boreholes in the area is 50m. Given that water tables are receding (possibly due to climate change), it is recommended that the boreholes be drilled to deeper depths.
d. Solar powered boreholes are recommended as they are more environmentally sustainable and cheaper to operate in the long term. They also use ‘smart energy’, which is in line with CRIDF objectives.
e. There is need to take water samples for water quality tests before final commissioning.

5 Provision and maintenance of water supply infrastructure

It is proposed to drill boreholes at all the six sites to provide water for small-scale garden irrigation, domestic and livestock consumption. Estimated total water demand at each site is summarised in Table 6 above. Analysis of groundwater potential at each of the sites based on the occurrence of a Kalahari sand aquifer at the six sites, against estimated water demand at each site, indicates that in general boreholes of up to 80 m deep will be adequate to supply the required yield.

All boreholes in the Kalahari sand aquifer will be gravel packed, with a diameter of 500 mm. A 150 mm diameter internal casing will be provided to house the pump, and a Johnson type stainless steel well screen fitted to the bottom of the casing over a distance of approximately 12 m. Graded gravel and course sand will be filled into the annulus between the outside and inside casings. The grading of the gravel and sand will be designed to prevent fines from being washed from the Kalahari layer into the borehole. The procedure for drilling boreholes in Kalahari aquifers to avoid the collapse of casing is as outlined in sub-section 4.3.1 above.

At each site, water will be pumped from the borehole using a solar powered submersible pump and delivered to elevated storage. The water will gravitate from the elevated storage to supply small irrigation gardens, standpipes for domestic water consumption and livestock watering troughs for cattle and other small domestic animals. Fencing will be provided around each garden.

Due to the limited garden areas and small individual plot allotments, coupled with low installed gravity head from the overhead tank, the operation of sprinkler irrigation system may not be feasible. It is proposed to install ordinary garden taps for the delivery of water to the crops. The latter would be equipped for connecting to hosepipes.

The number of standpipes provided for domestic water supplies will be based on 1 standpipe per 25 households. Cattle trough storage has been based on 1/3 the total herd daily requirement.

A description of infrastructure at each site is briefly outlined in the following sub-sections.

5.1 Lyoni

Lyoni project area consists of 44 households. There is no potable water supply serving the project area and villagers fetch water from the wells along Kalobe River.

Lyoni is located in Kalahari sands. Based on the estimated total water demand of 13.686 m^3/hr, a minimum borehole depth of about 70 m will provide the required yield. It is proposed to drill an 80 m deep, gravel packed borehole at Lyoni at a site to be confirmed by a geophysical survey. Water will be pumped from the borehole to an elevated tank from where it will gravitate to a fenced garden, public standpipes and a cattle trough.

The project will consist of the following components:

1. 1 No 500 mm diameter, 80 m deep gravel packed borehole
2. 1 No solar powered submersible pump rated at 95.8 m^3/day.
3. 1 No 10 m^3 elevated tank on a 7 m structural steel tank stand
4. 1.0 ha fenced garden.

5. Standpipes to irrigate 1.0 ha
6. 2 No standpipes for domestic water supplies
7. 2 No cattle 1 m^3 cattle trough

5.2 Silangi

There are 23 households around the Silangi project area. At present, villagers fetch water for domestic use from shallow wells dug in the river. The proposed borehole site was identified by all the beneficiaries and the exact site will be confirmed by a geophysical survey.

Silangi is located in Kalahari sands. Based on the estimated total water demand of 12.600 m^3/hr, a minimum borehole depth of about 70 m will provide the required yield. It is proposed to drill an 80 m deep, gravel packed borehole at Silangi at a site to be confirmed by a geophysical survey. Water will be pumped from the borehole to an elevated tank from where it will gravitate to a fenced garden, public standpipes and cattle troughs.

The project will consist of the following main components:

1. 1 No 500 mm diameter, 80 m deep gravel packed borehole
2. 1 No solar powered submersible pump rated at 88.2 m^3/day.
3. 1 No 10 m^3 elevated tank
4. 1.0 ha fenced garden.
5. Standpipes to irrigate 1.0 ha
6. 1 No standpipes for domestic water supplies
7. 1 No 1 m^3 cattle tough

5.3 Munengo

Munengo project area has 65 households. The existing borehole, which initially had a good yield, collapsed leading to a drastic reduction in yield. There is an existing excavated pan that is used for the irrigation of a small patch of gardens. It dries out around September.

Munengo is located in Kalahari sands. Based on the estimated total water demand of 14.743m^3/hr, a minimum borehole depth of about 70 m will provide the required yield. It is proposed to drill an 80 m deep, gravel packed borehole at a site to be confirmed by a geophysical survey. Water will be pumped from the borehole to an elevated tank from where it will gravitate to a fenced garden, public standpipes and cattle troughs.

The project will consist of the following main components:

1. 1 No 500 mm diameter, 80 m deep gravel packed borehole
2. 1 No solar powered submersible pump rated at 103.2 m^3/day.
3. 1 No 10 m^3 elevated tank
4. 1.0 ha fenced garden.
5. Standpipes to irrigate 1.0 ha
6. 2 No standpipes for domestic water supplies
7. 2 No 1 m^3 cattle troughs

5.4 Chinyama

The Chinyama project area is located just south of Munengo Village.

The area is situated in Kalahari sands. Total water demand for the area is estimated at 13.414 m^3/hr, including small garden irrigation and livestock.

The project will consist of an 80 m deep gravel packed borehole at a centrally located site. Water will be pumped from the borehole to elevated tanks from where it will gravitate to fenced gardens, public standpipes and cattle troughs.

The project will consist of the following main components:

1. 1 No 500 mm diameter, 80 m deep gravel packed boreholes
2. 1 No solar powered submersible pump rated at 93.9 m^3/day.
3. 1 No 10 m^3 elevated tanks per site
4. 1.0 ha fenced garden
5. Standpipes to irrigate 1.0 ha of garden
6. 2 No standpipes for domestic water supplies
7. 2 No 1 m^3 cattle troughs

5.5 Kamwi

There are 60 households around the Kamwi project area. At present, villagers fetch water for domestic use from shallow wells dug in the river. The proposed borehole site was identified by all the beneficiaries and the exact site will be confirmed by a geophysical survey.

Kamwi is located in Kalahari sands. Based on the estimated total water demand of 14.500 m^3/hr, a minimum borehole depth of about 70 m will provide the required yield. It is proposed to drill an 80 m deep, gravel packed borehole at Kamwi at a site to be confirmed by a geophysical survey.

Water will be pumped from each borehole to elevated tanks from where it will gravitate to the fenced gardens, public standpipes and cattle troughs.

The project will consist of the following main components:

1. 1 No 500 mm diameter, 80 m deep gravel packed boreholes
2. 1 No solar powered submersible pump rated at 101.5 m^3/day.
3. 1 No 10 m^3 elevated tank
4. 1.0 ha fenced garden.
5. Standpipes to irrigate 1.0 ha garden
6. 2 No standpipes for domestic water supplies located at each borehole
7. 2 No 1 m^3 cattle troughs located at each borehole

5.6 Mudobo

There are 34 households around the Mudobo project area. At present, residents of the three villages of Munjindu, Mudombo and Chijumba fetch water for domestic use from shallow wells dug in the river. The proposed borehole site was identified by all the beneficiaries and the exact site will be confirmed by a geophysical survey.

The project area is located in Kalahari sands. Based on the estimated total water demand of 13.157 m^3/hr, a minimum borehole depth of about 70 m will provide the required yield. It is proposed to drill an 80 m deep, gravel packed borehole at a site central to the three villages to be confirmed by a geophysical survey.

Water will be pumped from each borehole to elevated tanks from where it will gravitate to the fenced gardens, public standpipes and cattle troughs. The project will consist of the following main components:

1. 1 No 500 mm diameter, 80 m deep gravel packed boreholes
2. 1 No solar powered submersible pump rated at 92.1 m^3/day.
3. 1 No 10 m^3 elevated tank
4. 1 .0 ha fenced garden
5. Standpipes to irrigate 1.0 ha
6. 2 No standpipes for domestic water supplies.
7. 2 No 1 m^3 cattle troughs

5.7 Preliminary cost estimates

Preliminary cost estimates have been based on the drilling of large diameter gravel packed boreholes at the six sites occurring in Kalahari sand. Equipment costs for all sites have been based on the installation of solar powered pumps and drip irrigation systems (the latter is a conservative approach, given that hosepipe irrigation is actually planned). These high level cost estimates have been developed in the absence of surveys and detailed design of components of the scheme.

It is estimated that the KAZA project in Zambia, exclusive of the provision for irrigation start-up (Table 13 on page 59), will cost **GBP 206,726** broken down as summarised below.

Table 8 **Cost estimates per site**

Project Area	Cost GBP
Lyoni	34,316
Silangi	33,280
Munengo	35,491
Chinyama	34,316
Kamwi	35,007
Mudobo	34,316
Total	**206,726**

5.8 Operation and maintenance

In Zambia in theory the maintenance of all rural water points in communal areas is the responsibility of District Councils. The District Councils are meant to hold and control maintenance budgets for all water points in communal areas. However, according to reports in the Moomba area, the area is marginalised and few services are provided in the area. For example, a broken down hand pump in Kamwi has never been repaired since 2005 despite efforts by the community to report the matter to the Council. A technical team from the Council is reported to have visited the borehole in 2013 to assess but never came back to repair. The communities are encouraged to establish water management committees whose responsibility is to collect and save maintenance funds that the users contribute. During interviews with the communities, they showed commitment to pay funds for general maintenance of the water supply infrastructure.

The solar systems proposed for this CRIDF intervention are virtually maintenance free if properly installed and fitted with a lightning arrester and surge protector. Considering that the solar system will not have batteries (which generally cost large sums of money), no funds will be required for replacements. The only maintenance required is cleaning of solar panels at regular intervals of say one month. A worst-case scenario is damage to the pump controller, which would be very rare if the pump unit is properly protected. The pump itself is very robust and is unlikely to suffer damage provided the boreholes are sand free. Gravel packing the boreholes in Kalahari sands and their adequate development before pump installation should ensure sand free operation.

Infield equipment for drip systems would be likely to require regular maintenance due to the accidental damage of plastic pipe fittings during land preparation, weeding etc.

Table 9 below presents a conservative estimate of the likely maintenance costs for the entire scheme over two years. It includes the cost of an average one site visit per month by a fitter from the District Council to carry out any necessary repairs. The maintenance budget would only be required once the retention period on the installation contracts has expired.

It is proposed that the project will fund the first two years' potential maintenance costs while the sanitation and agricultural extension programme works with user communities to establish local structures that can take over responsibility for collecting and managing maintenance funds.

Table 9 **Operation and maintenance budget for water infrastructure: all sites: two years**

Description	Quantity	Unit	Rate GBP	Cost GBP
Borehole pump				
Spare pump controller	1	no	771	771
Total for	**6**	**units**		**4,626**
Hose pipe irrigation				
Connectors	265	no	1.05	278
20 mm dia hose pipe	300	m	0.84	252
Sub total				530
Total for	**6**	**ha**		**3,181**

Domestic water supply				
25 mm brass tap	44	no	14.02	617
Ball valve for trough	6	no	84.10	505
Ball valve for reservoir	6	no	84.10	505
Total for	**6**	**systems**		**1,627**
Visits by RDC fitter				
Visit to a site	24	visits	140	3,360
Total				**12,793**

6 Sanitation

6.1 Introduction

The 2014 livelihoods study of the Mulobezi GMA found that 54% of respondent households in the sample survey relieved themselves in the bush, while 46% had access to a pit latrine. Within the GMA, access to a pit latrine was lowest in the Mulanga Village Action Group (VAG) at 23%, and highest in the Central VAG area (66%; Muyengwa *et al.*, 2014: 30). The project will therefore require a substantial level of effort to achieve access to latrines of an appropriate standard for all those benefiting from the new water supplies – without which the benefits of those water supplies are significantly impaired.

6.2 Approach

The foundations for that effort have already been laid by the Kazungula District Council. It is one of the many local authorities in Zambia that have now adopted the Community Led Total Sanitation (CLTS) approach, which was first introduced in the country through a successful pilot in Choma in 2007 (Mwanza, 2012: 2; UNICEF, nd[2]). CLTS is a low-cost social mobilisation process that uses direct and sometimes shocking methods to encourage all households to cease open defecation, build latrines with simple hand washing facilities and achieve open defecation free (ODF) status for their communities. It has now been adopted as national policy, with 2020 as the target date for an ODF Zambia (IDS, 2015). The Kazungula District Council has already identified and trained four 'champions" to drive CLTS campaigns in the Moomba chiefdom, and provided them with bicycles. However, the campaigns have not yet started in earnest, and it will be necessary to provide local stimulation, co-ordination and support to the 'champions' and their target communities if these communities are to achieve ODF status and transfer fully to the use of appropriate latrines and 'tippy-tap' or similar hand washing facilities.

CLTS involves no subsidy to households for latrine construction. However, a local co-ordinator would be required in the Moomba chiefdom to support the 'champions' in a 12 month campaign to achieve ODF status in the target communities.

> *It is important to note that even though CLTS involves zero hardware subsidy, significant investment is still required for training, follow-up, data management, progress monitoring and evaluation.*

Zulu *et al.*, 2010: 138.

It is proposed that TNC, which has some of the required local infrastructure, employ this individual, to work in close technical consultation with the Kazungula District Council. The campaigning, advocacy and triggering processes will follow the standard approach of CLTS in Zambia.

[2] nd: not dated

6.3 Costs

Because of the lack of existing support frameworks, the remoteness of the District Council and the comparatively small number of target households, the cost of this necessary intervention will be significantly higher than the GBP 2.00 per household that was estimated for the Community Health Club approach proposed for the CRIDF rural water and sanitation intervention in Hwange district, Zimbabwe. (The Community Health Club approach is not practised in Zambia). The estimated total cost of the programme is GBP 30,000 for all six sites (section 10.4.1 below).

7 Crop and livestock production

7.1 Introduction

The communities in the Mulobezi Game Management Area, as has been mentioned, are in a remote part of Zambia with poor access to markets and services.

In many of the communities production is limited as few inputs are available; and if they were available, most households could not afford them. For these reasons the majority of the households interviewed used seed that they had saved themselves and did not apply any chemical fertilisers to boost their yields.

Production of maize is rain fed on fields that will be cultivated for up to three years before new fields will have to be cleared which are more fertile and not burdened by weeds. This form of shifting agriculture has however changed over the years due to the shortage of new land around the villages and so old fields are being re-cultivated after being fallowed for around ten years instead of the traditional 18+ years.

There is, however, a perception by outsiders that there are still large tracts of land available for cultivation, and in recent years there have been a number of farmers arriving from other parts of Southern Province, looking for – and in some cases obtaining – land to farm.

7.2 Current cropping

7.2.1 Crops

Crops grown in Mulobezi GMA are mostly under rain-fed conditions. Maize is the major crop, but as this is prone to drought stress, small quantities of sorghum and millet are also grown. Intercropping is common, as a drought risk mitigation strategy common in subsistence farming.

Along some of the river banks and dambos (flat areas that are inundated with water in the wet season) a very limited amount of cropping is undertaken especially in the drier months from April through to November. Water is drawn from shallow wells or seepage areas to water these crops (see photos below). As such the areas grown are small and are usually used to augment household food sources. The crops grown in these small gardens include green maize, pumpkins, tomatoes, sweet potatoes and chillies. These gardens are generally small measuring from 10m x 10m to around twice that size. As they are some of the only green crops around during the dry season they have to be protected from wildlife and domestic animals by forming a fence from brush and sticks (see Figure 15 below).

The area of land cultivated depends on whether the farmer has access to oxen to cultivate the land or it has to be done by hand. If a farmer has oxen then she or he will cultivate approximately 2 ha of land, but if the cultivation is done by hand this will be limited to about 0.5 ha (2 limas).

Figure 15 Dry season gardens

Figure 16 Collecting water from unprotected shallow well

As mentioned above, yields are constrained by poor rainfall, very sandy soils, poor seed quality and the difficulty of gaining access to fertiliser. These problems are exacerbated the further the villages are away from Mulobezi town (see Figure 3 on page 17). Yields were difficult to assess as there are many determinants, but in Western Province in 2013 yields of maize were only about 860kgs / ha. In very dry years this could be far less and could even be complete failures. In 2013 average maize yields in Zambia were 1.93 metric tonnes/hectare. Crop yields in the area are generally low due to the low and erratic rainfall and poor soils in the area, since it is Agro-Ecological region 1. Should water supplies be improved, one risk factor could be partially mitigated against.

Table 10 **Expected maize production for the 2012/2013 agricultural season**

Province	Area planted (ha)			Area expected to be harvested (ha)			Expected production (MT)			Yield (MT)		
	2011/2012	**2012/2013**	**% Change**	**2011/2012**	**2012/2013**	**% Change**	**2011/2012**	**2012/2013**	**% Change**	**2011/2012**	**2012/2013**	**% Change**
Zambia	**1,274,983**	**1,312,402**	**2.9**	**1,074,658**	**997,880**	**(7.1)**	**2,852,687**	**2,532,800**	**(11.2)**	2.24	1.93	**(13.7)**
Central	184,048	217,001	17.9	156,386	159,371	1.9	494,215	478,734	(3.1)	2.69	2.21	(17.8)
Copperbelt	95,215	80,196	(15.8)	85,065	71,070	(16.5)	248,624	208,544	(16.1)	2.61	2.60	(0.4)
Eastern	277,625	297,394	7.1	246,611	267,227	8.4	577,525	572,289	(0.9)	2.08	1.92	(7.5)
Luapula	46,827	37,116	(20.7)	43,090	32,927	(23.6)	128,776	94,033	(27.0)	2.75	2.53	(7.9)
Lusaka	36,936	43,667	18.2	33,123	36,334	9.7	96,823	96,907	0.1	2.62	2.22	(15.3)
Muchinga	70,144	71,066	1.3	65,659	64,356	(2.0)	226,989	205,412	(9.5)	3.24	2.89	(10.7)
Northern	98,576	80,429	(18.4)	94,165	72,038	(23.5)	271,380	210,479	(22.4)	2.75	2.62	(4.9)
North-Western	64,305	59,198	(7.9)	60,311	51,052	(15.4)	156,077	132,527	(15.1)	2.43	2.24	(7.8)
Southern	309,557	330,234	6.7	232,584	195,587	(15.9)	573,176	453,532	(20.9)	1.85	1.37	(25.8)
Western	91,751	96,101	4.7	57,664	47,918	(16.9)	79,103	80,343	1.6	0.86	0.84	(3.0)

Figure 17 Field being ploughed with oxen

7.3 Increased agricultural potential

7.3.1 Expansion in productive area

There is an expansion in area under agriculture within the Mulobezi GMA, with the recent influx of farmers from other areas of Southern Province. This has been done using oxen. However, despite the increase in area, if no steps are made to use a farming system that mitigates against poor rainfall, there may not be significant increases in production.

Existing households are unlikely to increase their areas as they are constrained by the availability of oxen for ploughing. They are also risk adverse and do not apply fertiliser or use improved seed. This is not just due to being risk adverse, but also due to the availability of the inputs and the availability of credit to purchase the inputs. The existing householders tend to be poorer than the migrants who are moving in.

Due to the remoteness of the area and the difficulty of travel, extension services are very limited. An officer has recently been assigned to Mulobezi to support conservation agriculture, but his activities have been limited due to the late delivery of inputs and some transport difficulties.

Therefore, without advice in how to increase production, it is unlikely that the farmers will be able to improve production to ensure that they have adequate food.

7.3.2 Irrigation potential

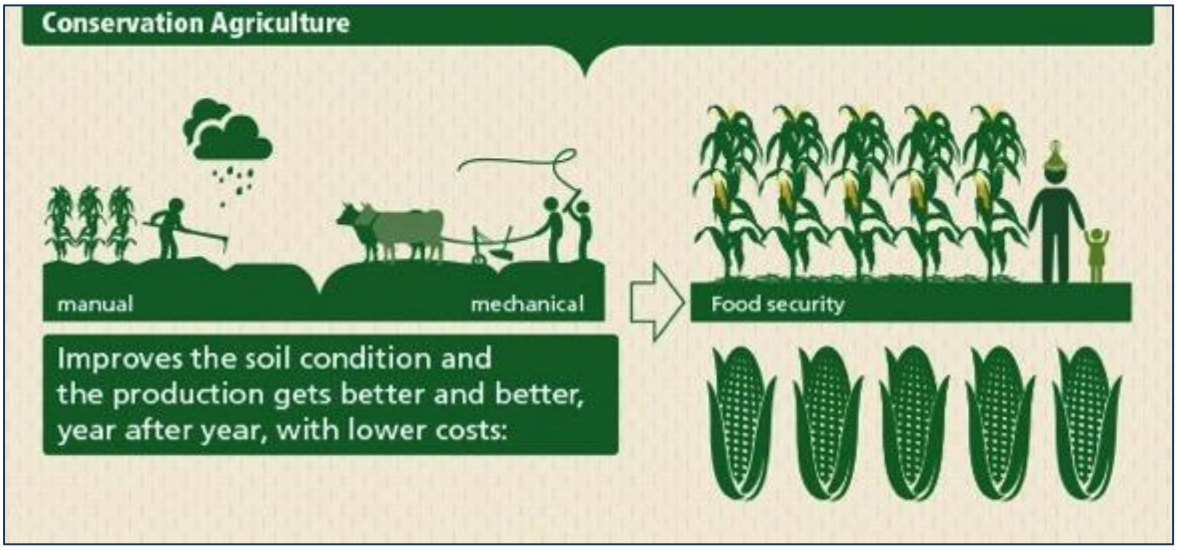
The irrigation potential in this area is very limited. There are a few rivers but most of these dry up as soon as the rains cease. The land is undulating, but there were no places seen where effective dams could be constructed that would hold enough water for major irrigation.

As with the other KAZA sites visited as part of CRIDF's support, the main option for irrigation for these communities would be through water drawn from new boreholes that would be developed and would not only supply the potable needs of the community, but also supply enough to irrigate 1 ha around the borehole. This water would be used to supplement rain in the wet season, but would be the only source of water during the dry season. This would be a welcome boost to nutrition, but will not provide enough food for the families' requirements if the main crops fail.

7.3.3 Conservation agriculture

Conservation agriculture (CA) has only recently been introduced into the area and has the potential to improve production. The results of applying CA in the Mulobezi area could be substantial. In some instances where CA has been trialled, the yield is up to ten times more than the average (when compared to conventional methods), and during drier seasons local communities are still able to harvest (whereas those using conventional methods are unable to do so). The estimated yield increase in this part of the world is around three times the average yield.

Figure 18 Conservation agriculture



CA is an approach to managing agro-ecosystems for improved and sustained productivity, increased profits and food security while preserving and enhancing the resource base and the environment. CA is characterized by three linked principles, namely:

1. Continuous minimum mechanical soil disturbance.
2. Permanent organic soil cover.
3. Diversification of crop species grown in sequences and/or associations.

CA principles are universally applicable to all agricultural landscapes and land uses with locally adapted practices. CA enhances biodiversity and natural biological processes above and below the ground surface. Soil interventions such as mechanical soil disturbance are reduced to an absolute minimum or avoided, and external inputs such as agrochemicals and plant nutrients of mineral or organic origin are applied optimally and in ways and quantities that do not interfere with, or disrupt, the biological processes.

CA facilitates good agronomy, such as timely operations, and improves overall land husbandry for rain fed and irrigated production. Complemented by other known good practices, including the use of quality seeds, and integrated pest, nutrient, weed and water management, etc., CA is a base for sustainable agricultural production intensification. It opens increased options for integration of production sectors, such as crop-livestock integration and the integration of trees and pastures into agricultural landscapes (FAO, 2015).

CA, understood in this way, provides a number of advantages on global, regional, local and farm level.

- It provides a truly sustainable production system, not only conserving but also enhancing the natural resources and increasing the variety of soil biota, fauna and flora (including wild life) in agricultural production systems without sacrificing yields on high production levels. As CA depends on biological processes to work, it enhances the biodiversity in an agricultural production system on a micro as well as macro level.
- No-till fields act as a sink for CO_2. CA applied on a global scale could provide a major contribution to control air pollution in general and global warming in particular. Farmers applying this practice could eventually be rewarded with carbon credits.
- Soils under CA have very high water infiltration capacities, reducing surface runoff and thus soil erosion significantly. This improves the quality of surface water, reducing pollution from soil erosion, and enhances groundwater resources. In many areas it has been observed after some years of conservation farming that natural springs that had dried up many years ago started to flow again. The potential effect of a massive adoption of CA on global water balances is not yet fully recognised.
- CA is by no means a low output agriculture and allows yields comparable with modern intensive agriculture, but in a sustainable way. Yields tend to increase over the years, with yield variations decreasing.
- For the farmer, CA is mostly attractive because it allows a reduction of the production costs and reduction of time and labour, particularly at times of peak demand such as land preparation and planting.

However, for this to have a major impact in Mulobezi GMA, support would have to be given to ensure that the methodologies and inputs required for CA are available. The existing one extension officer should be augmented and supported and support for travel also offered.

Figure 19 Three principles of conservation agriculture

7.3.4 Livestock

Cattle are found in most of the communities visited, though the numbers vary substantially. In some areas, the numbers have declined substantially in recent years through diseases and shortages of water. It was reported in one village that several cattle had died after drinking water that had large quantities of algae. Cattle are vital to the area as they provide most of the power for cultivation and for transporting goods. They also are one of the main signs of wealth. Any reduction in their number is likely to have a profound impact on the levels of poverty found in this area.

Chickens are also fairly common, but they are left to fend for themselves with no housing provided or additional feed. Occasionally laying boxes were seen which were raised off the ground, offering some protection from predators.

No goats or pigs were seen in any of the villages.

There is potential to increase the numbers of cattle and for goats to be introduced. This would, however, require support from outside including veterinary services, which are not found in the GMA.

7.4 Proposed cropping programme

In line with the main focus of the study the potential for agriculture production will focus on crops that can be produced from the proposed small-scale irrigation. This is likely to be an area of about 1 hectare that will be divided to accommodate as many of the community members as possible, but limited to workable plots so a size of around 0.1ha /household is anticipated.

The potential for cropping in the small irrigation plots that would be covered from the borehole water is limited. The primary use for all that is produced will be to support the local nutritional requirements, as there is already a food deficit in the area. Small quantities of goods may be traded within the villages or to neighbouring villages. However, access to larger markets would be limited due to transportation problems and could only be for more durable, high value crops.

Access to seed will also limit what crops can be grown unless a trade can be established that will bring in seed from the commercial centres.

The potential list of crops that could be grown includes:

i. green maize for home consumption and as a cash crop. There is likely to be a high demand and the crop has a low risk in production;
ii. horticultural crops, primarily edible crops including leaf crops, are important for local consumption;
iii. groundnuts and sugar beans are nitrogen fixers, which can be sold fresh or be dried should markets not be forthcoming;
iv. fruit crops, including bananas, citrus, pawpaw and guavas. There is a risk of frost in winter, so mangoes may not be suitable.

As these crops will be used to supplement the main rain fed crops they will grow as appropriate to the season i.e. cauliflowers can only be grown in the cooler months. Farmers however should be trained in some basics such as the need for crop rotations to control disease and pests.

Table 11 **Possible crops for irrigated gardens at project sites**

Crop family	Preferred crops for irrigation	Cultivation scenario/purpose
Cereals/ grasses	Green maize	• Rotation crop in summer and winter
Legumes	Beans, groundnuts, soya	• Legumes for rotation and fertility build up
Solanum	Potatoes, tomatoes, okra, egg plant	• Household use and local markets
Leaf vegetables and other fresh vegetables crops,	Cabbage, kale, cauliflower, spinach, carrots, onions, pumpkin, sweet potato	
Citrus	Oranges	• Planted on boundaries of gardens
Tropical fruits	Banana, pawpaw, guavas	

7.5 Irrigation water demands

7.5.1 Irrigation water requirements

According to CROPWAT calculations, in an average year the amount of water needed to irrigate 0.2 ha (50m x 40m) would be 0.58 m^3/hour (equivalent to 7 mm/day). This would generally apply when day temperatures do not exceed 33˚C and minimum temperatures do not exceed 15˚C. (Climate data from stations in Western and Southern Provinces are presented at Annex 1.)

In extremely hot and dry weather, however, water requirements for production could increase to as much as 1.53 m^3/h (equivalent to 18.4 mm/day). These conditions could occur, for example, in September (39˚C day and 22˚C night temperatures).

Normal practice in the area is to design irrigation systems with a potential to irrigate 8 mm/day or more. A cropping pattern of maize and wheat would generally have a higher water usage than most other cropping patterns, thus an irrigation design that suits a wheat and maize pattern will normally be sufficient for other cropping patterns.

For the villages in the Mulobezi region, it is recommended that water application be between 6 and 8 mm/day.

Table 12 **Irrigation Requirements**

Irrigation	Requirements/day/ha	Requirements/hr for 8hr solar activity
8mm/day/ha	80 m^3/day	10m^3/hr

These volumes to irrigate a full 1.0 ha would go up to 3.3 m^3 per hour for 24 hour irrigation or 10 m^3 per 8 hour period if using solar. These volumes would be in addition to water required for drinking and animal watering.

These volumes will be less in the rainy season, when the irrigation water would only be used to augment the rainfall, and slightly less in the cooler months when water requirements will be less. However the design capacity of the solar pump should take in the peak water requirements.

7.6 Outline costing for economic assessment

The project's outline costs based on the proposed crops are given in Table 13.

Table 13 **Outline costing of irrigated production for financial assessment**

Crop	Land allocation %	Yield	Unit	Unit price GBP	Gross income GBP	Variable costs GBP	Gross margin/ha GBP	Proportional GM GBP
Green maize	33%	25,000	cobs	0.08	1,941.36	543.58	1,397.78	460.99
Sugar beans	33%	1,800	kg	0.60	953.03	235.08	717.95	236.49
Groundnuts	33%	1,500	kg	0.71	1,058.93	235.08	645.94	213.20
Leaf vegetables/ Cabbage	33%	10,000	kg	0.28	2,823.80	1,678.04	1,851.71	610.65
Carrots/ Peppers/ onions	33%	8,000	kg	0.35	2,823.80	1,678.04	1,145.76	285.91
Tomatoes/ Potatoes	33%	20,000	kg	0.14	2,823.80	1,678.04	1,145.76	285.91
	200%							
Total income per hectare based on proportionate allocations								**2,093.14**
Income per household (based on each household gaining access to 0.10ha)								**208.96**

7.7 Irrigation plan

7.7.1 Layout

Depending on the land allocated for the irrigation plot, about 1 ha should be made available by each borehole. Water from the borehole will be pumped into a header tank and from there reticulated to taps for potable water, livestock troughs and irrigation.

In the irrigated area, several taps will be established in a grid to enable all of the land to be irrigated. As there will be little pressure except for the head height of the storage tank, the irrigation will be through hosepipes. It is unlikely that there will sufficient pressure to run sprinklers.

Drippers are not considered suitable for irrigation in these conditions as they may get blocked or damaged and replacements will be difficult to obtain. They would also require more support to manage the scheme.

The layout of the area will be divided in 10 plots of 0.1 ha each. In some instances smaller plots may be supported enabling more households to benefit, but this will be up to the committee that is established to manage the plots.

7.7.2 Water distribution and rotations

As the soils are very sandy, a rotation system of ensuring water is available every 3 days should be established. This will need to be managed by the committee to ensure there is an equitable distribution of water.

7.7.3 Infield structures

The infield structures for the scheme comprise off-takes, taps, control valves and gates.

7.8 Provision of agricultural support services

7.8.1 Extension services

In Mulobezi GMA, support provided by the Ministry of Agriculture is very limited. At the initial site meeting with The Nature Conservancy, one extension agent was introduced. He was newly appointed to boost conservation agriculture. This new officer is based in Mulobezi, which is still a distance from the GMA.

In discussion with various communities it was reported that most had not been visited by extension officers and were not provided with advice or access to inputs including improved seed.

If the communities are to benefit from the additional water from the boreholes, improved extension advice is important.

The responsibility for providing this service would fall under the Ministry of Agriculture and the Ministry of Livestock and Fisheries. However, as is generally the case in remote areas, it may be difficult to get staff to take up their postings in Mulobezi, especially if they are not adequately supported with transportation and materials to enable them to undertake their field activities.

The Nature Conservancy is the main non-governmental organisation working in the area. They provide support on various aspects of development for the GMA, although this is primarily in the field of conservation. The table below shows the cost of employing an extension staff member for 12 months. However, TNC have indicated that their existing staff member in the area could be trained to provide the additional support required by the proposed project, at no incremental cost (section 10.4.1 below).

Table 14 **Extension service support**

Support Required	Units	Unit Cost (GBP)	Total Cost (GBP)
Extension Staff	1 x 12 months	282.38	3,388.56
Supervision	1 x 12 months x 10%	705.95	847.14
Transport –Quad Bikes	2	4,941.65	9,883.30
Quad bike running cost	12	70.60	847.14
Demonstration	10	70.60	705.95
Ripper ploughs (for CA)	10	70.60	705.95
Initial Inputs	10	211.79	2,117.85
Fencing material for each plot	10 x 400 meters	2,824/km	11,295.20
Total			**29,791.09**

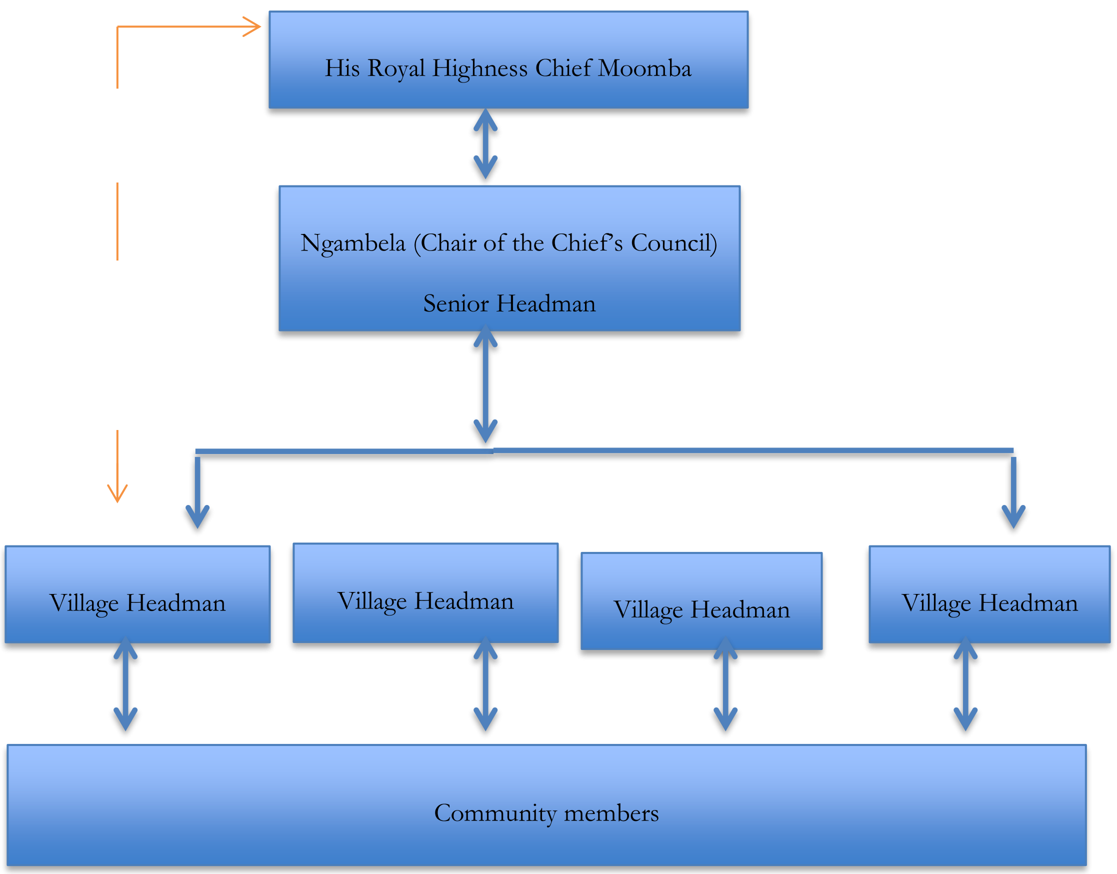
8 Institutional assessment

8.1 Local authorities

8.1.1 Traditional authority

The Mulobezi GMA, which is coterminous with the Moomba chiefdom, is under the leadership of His Royal Highness Chief Moomba who is assisted by senior headmen, one of which is an appointed prime minister (known as Ngambela). A village headman who can also be appointed to the level of a senior headman heads each village regardless of the size. At the lowest level are the community members who channel their developmental issues and grievances through the village headmen. The figure below is an illustration of the Moomba traditional decision-making structure that preserves the local culture, and enhances development in the area.

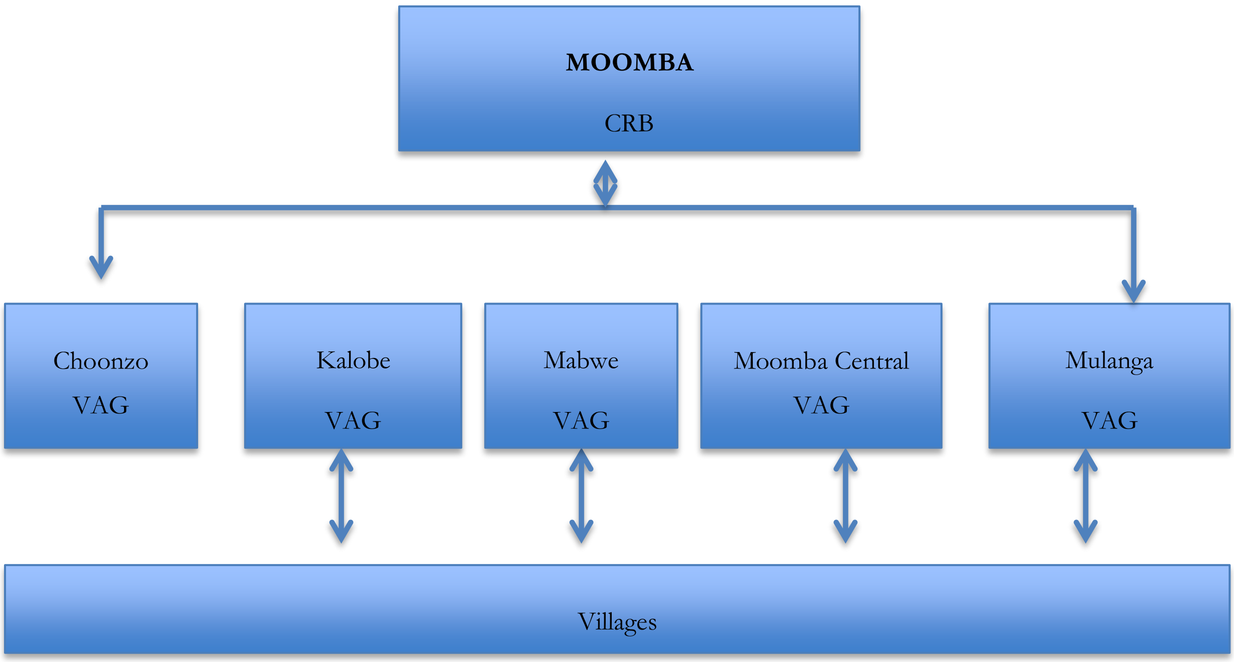
Figure 20 Traditional Authority decision-making structure



8.1.2 Community Resource Boards

As it coincides with the Mulobezi GMA, the Moomba chiefdom has been influenced by the community-based natural resource management (CBNRM) promoted by the National Parks Department (formerly Zambia Wildlife Authority (ZAWA) under the Ministry of Tourism, Arts and Culture. Mulobezi GMA consists of a Community Resource Board (CRB) and Village Action Groups (VAGs). Moomba Chiefdom has one CRB headed by HRH Chief Moomba and 5 VAGs led by senior headmen. The 5 VAGs are Moomba Central, Choozo, Kalobe, Mabwe and Mulanga. The beneficiaries of the proposed water and sanitation project are spread over four VAGs: Moomba Central, Kalobe, Mabwe and Mulanga.

Figure 21 Community Resource Boards Structure



Project beneficiaries reside on customary land and therefore fall under the traditional land tenure system. Village headmen, who are representatives of the Chief, are responsible for land allocations. Once land is allocated the headman files a report to the Chief, through the Chief's Council, for final approval. Under this system, once land has been allocated it is held by the approved recipient who can reallocate it informally to immediate family members only. At the same time, individual family members are free to obtain their own land using the same process. The result of this land tenure system is that although the area is dominated by specific ethnic groups, other tribes from different parts of the country can acquire land and settle in the area. Furthermore, any widowed spouse can remain on the land and live in the community for as long as they intend.

According to TNC's 2014 baseline study (Muyengwa *et al.,* 2014) 98% of respondents reported that they own their land although they do not possess formal title deeds. It was also reported that headmen allocated small plots of about five hectares, mainly for agricultural production. Newly developed plots were observed during the December 2015 field visit, which is an indication of new settlers.

8.1.3 Project relationship with local authorities

Scoping and planning visits to the Mulobezi GMA have been carried out in full consultation with, and with the approval of, the local authorities in the Moomba chiefdom, secured through formal meetings at the Chief's palace. Further steps in the endorsement and development process will be carried out with the same formal recognition of local authorities, facilitating the provision of the required small areas of land for water and irrigation facilities.

8.2 Government and other institutions

8.2.1 National level

At the national level, all functions for rural water supply and sanitation lie with the Ministry of Local Government and Housing (MLGH) under the Department of Housing and Infrastructure Development. Within the department, a Rural Water Supply and Sanitation (RWSS) Unit was established in 2003 to carry out central level functions as provided for in the National Water Policy and supporting strategies to co-ordinate and promote rural water supply and sanitation in the country.

At present the MLGH has developed a National Rural Water and Sanitation Programme that will be financed through a Basket Financing Mechanism (BFM). Under this financing mechanism all co-operating partners are expected to pool their finances in one basket housed at the MLGH. Consolidated plans for water supply and sanitation submitted from the districts to the MLGH would then be financed through the basket. Districts would be responsible for securing contractors who would be paid directly by the MLGH. However, this mainstream sector budget support mechanism does not preclude smaller-scale, local support arrangements like the proposed intervention that CRIDF would facilitate in the Mulobezi GMA.

8.2.2 District level

In compliance with the RWSS institutional framework of 2004, Local Authorities are responsible for rural water supply and sanitation in each district. The same framework provided for the formation of District Water and Sanitation, Hygiene Education (D-WASHE) committees, which are sub committees under the District Development Coordinating Committees.

A D-WASHE Committee is responsible for initiating, overseeing implementing, co-ordinating and monitoring WASHE Projects and activities. They are also mandated to promote formation of Village Water, Sanitation and Health Education (V-WASHE) committees to oversee coordination and implementation of WASHE programmes at community level. The committee normally consists of representatives of the District Council, Department of Water Affairs, District Medical Office, Ministry of Agriculture (MOA), Ministry of General Education, Ministry of Community Development and Social Welfare and NGOs involved in water, sanitation and hygiene education in the district.

Therefore in Kazungula district, the Council, through the D-WASHE committee, facilitates RWSS activities in the district. In order to consistently implement the RWSS activities, the council has a dedicated RWSS Co-ordinator reporting to the Director of Planning. Some of the RWSS functions of Kazungula council include the following:

- formulating a RWSS plan arising from WSS district needs;
- receiving and assessing community water supply requests;
- providing an operation and maintenance budget;
- conducting operation and maintenance training for V- WASHE committees, Area Pump Minders and caretakers. Training activities are expected to be financed from the Council budget. At present the council is coordinating the Sustainable Operation and Maintenance Programme, which stocks water facility spare parts and trains communities in O&M.

The proposed CRIDF-facilitated project in the Mulobezi GMA will have to be harmonised with these co-ordination and governance mechanisms, which also provide an opportunity for mobilising technical expertise from other public and development partners for the Project.

Kazungula District, within which the Mulobezi GMA falls, follows a similar governance and administrative structure as other districts in Zambia. The District Commissioner, assisted by the Administrative Officer, heads the district. The District Secretary and other governmental departments co-ordinate the technical services provided by the district. The main public institutions in the GMA are the Ministry of Traditional Affairs through the Chief, Kazungula District Council, the Ministry of Tourism, Arts and Culture through the Department of National Parks and Wildlife, the Ministry of General Education through the schools in the area and the Ministry of Health through the Moomba clinic. An extension officer from the Ministry of Agriculture had been posted in the area.

It was generally observed during the December 2015 site visit that there was minimal presence of extension officers, particularly from the Ministry of Agriculture, the Ministry of Community Development and Social Welfare, and the Department of Forestry. The Department of National Parks and Wildlife, whose engagement is mainly policing wildlife poaching and resolving human-wildlife conflicts, has a more visible presence than other public institutions. This department, with the mandate from the Wildlife Act, has played a central role in forming the CRBs and auxiliary VAGs. The District Council was reported to be active only when implementing donor-funded projects. The functions and responsibilities of these institutions are shown in Table 15 below.

TNC is the only non- state actor available in the area. The organisation has been implementing community-based programmes jointly with the Department of National Parks and Wildlife. It has been channelling its activities through the well-established CRBs and VAGs. It is envisaged that TNC will help to facilitate implementation of the proposed project, in consultation and collaboration with the district and local authorities, CRIDF and the KAZA TFCA.

Apart from the CRBs and VAGs, other community-based organisations include village water and sanitation groups formed with facilitation from the District Council. These groups are responsible for water point management and collecting user fees for maintenance. They are also trained on how to manage water points and promote basic hygiene in the communities.

Table 15 **Active institutions, roles and responsibilities and relevance to the KAZA Project**

Name of Institution	Entity Roles and Responsibilities
Ministry of Local Government and Housing	Development of overall policy, programmes and mobilisation of financial resources for rural water supply and sanitation. *Relevance to the proposed project: provide high-level support.*
Ministry of Traditional Affairs HRH Chief Moomba Senior Headmen Village Headmen	Preserving traditional systems, structures and authority that unite ethnic groups and enhance development through the preservation of rule of law and protection of natural resources. *Relevance to the proposed project: the Chief plays an important role of collaborating with government ministries, non-state actors and other development partners in the formulation and implementation of programmes and projects in their areas. HRH Chief Moomba is cardinal in mobilizing subjects and land for project activities. Oversee and monitor management of the project to ensure sustainability.*
Ministry of Tourism, Arts and Culture Department of National Parks and Wildlife	*Relevance to the proposed project: Department of National Parks and Wildlife to continue encouraging CBNRM activities and mobilise more resources for livelihood activities, which will benefit wildlife conservation.*
District Commissioner's Office	Coordinating developmental activities in the district. *Relevance to the proposed project: mobilising public institutions and local leadership support for the project and addressing other developmental needs that might arise.*
Kazungula District Council	Responsible for initiating and implementing (i) urban municipal activities within their planning jurisdiction, (ii) and coordinating rural water and sanitation and infrastructure services such as roads and markets in the rural areas of Kazungula district. Also responsible for collecting natural resources levies such as sand as specified in the by laws. *Relevance to the proposed project: The Council has direct responsibility for supporting the project through provision of technical personnel, procedures and training for operation and maintenance. Further the Area Councillor has a responsibility to assist the community in other developmental needs that might arise.*
Ministry of Agriculture, Provincial and District Coordinator's Offices	Responsible for initiating, implementing and monitoring all agricultural programmes and projects. Providing agricultural technical extension services. *Relevance to the proposed project: responsible for providing technical support for the irrigation system. The local Camp Officer would be responsible for providing training in irrigation management and advise of crop production and entrepreneurship.*

Ministry of Health Moomba Clinic	Holds central responsibility for medical and preventive care services through its network of public health institutions countrywide. Moomba Clinic is responsible for provision of health of medical care and environmental health education. *Relevance to the proposed project: should provide background support to sanitation initiatives.*
The Nature Conservancy	Supporting holistic community-based conservation programmes. *Relevance to the proposed project: Jointly with the District Council, support implementation of the project and provide technical support for sustaining the activities. Mobilising specialised expertise to support implementation and operations. Promote other livelihood activities around the water points with full integration of gender issues and vulnerable groups.*
CRB and VAGs	Community mobilisation for development activities. *Relevance to the proposed project: Responsible for providing community members to monitor and assist during construction. Setting up village water and sanitation groups and selecting community members to be trained in skills required by the project. Ensure payment of user fees for operation and maintenance of infrastructure.*

8.3 Community commitment and engagement

8.3.1 Community commitment

Community willingness to engage with the proposed project has largely been influenced by the severity of domestic water deficits, the poor quality of water and the poor conditions for producing crops for both household consumption and for sale.

As reported by women who are responsible for ensuring that water for domestic use is available in the household, water deficit is critical during the dry season months from September to November. In these times, the villages without functional boreholes draw water from unprotected hand-dug wells. In all the areas visited these water points had murky water drawn after a waiting period of over 30 minutes. In the dry season, the main sources with sufficient and clean water are found at a greater distance from the households. Furthermore, women complained that this deficit results in an inability to engage in horticulture, which is a source of household income in the dry season.

The proposed project has been viewed to have significant positive impacts on the health of the community and the economy of the area. The idea of irrigated gardens is seen as something that can increase household earnings throughout the year. Having gardens near the water point will enable communities to be productive throughout the year as they will be positioned in areas where flooding is unlikely. Water supplies would also be used for livestock watering. An added advantage for women is that the gardens would be nearer the households; therefore other household chores can be conducted at the same time.

As regards their commitment to support and participate in the proposed activities, communities were aware of the expected obligations. This is due to the entrenched delivery practice and experiences of previous water and sanitation programmes implemented through the Kazungula District Council in other areas. Some adjoining villages have formed water point committees and households are paying user fees. Although the proposed project activities will be more extensive, this would not be a problem as each participating village would be required to use the same RWSS application procedure (see application form at Annex 3).

However, depending on the design and sophistication of the technology used, it would be important to inform the community and other project implementers on their roles and responsibilities in full consideration of their capabilities.

Several factors should facilitate the introduction and implementation of the proposed project in the Mulobezi GMA. First, the District Council is aware of the project objectives and intentions, and secondly the project is addressing a critical community need. Thirdly, the project has an added component of providing productive water, which is innovative and will contribute to the food security and incomes of households. Given these benefits, traditional leadership has a responsibility of ensuring that land is provided without reservations. During the December 2015 site visit, community meetings were held at the headmen's homesteads and verification and selection of appropriate sites was conducted in conjunction with the leaders and the community at large. There was no resistance to the intervention at an of the project sites, which is an indication of the need for improved water infrastructure – although at two sites further work will need to be done to finalise endorsement of the positions selected (section 10.6.2 below).

8.3.2 Community engagement

In accordance with the RWSS institutional framework, communities are expected to be consulted and participate in the design, development and operational stages of rural water scheme development. In practice many communities form 'V-WASHE committees' or 'Water and Sanitation (WATSAN) committees', which are responsible for managing the operation and maintenance of community-owned water points. Such committees, which can have up to ten members, are normally elected by the community and are responsible for collection of maintenance funds, monitoring of pump performance, routine preventative maintenance and organisation of repairs and replacements. These community-based organisations (CBOs) are often trained in management and maintenance procedures by the implementing agency, and sometimes by the D-WASHE. Communities are encouraged to ensure that women are sufficiently represented on V- WASHE committees.

In order to ensure community-based operation and maintenance, each V-WASHE is required to facilitate the process of selecting private individuals who work as APMs. Each APM is selected by the community and trained by the D-WASHE in pump maintenance and repairs. He or she is provided with a standard and 'special' toolkit (India Mark II toolkit was widely distributed), and is responsible for a zone in which they live and in which several boreholes and water points are located.

With regard to the proposed project in the Mulobezi GMA, the Kazungula District Council should be given an orientation on the different technologies to be used in the project so that they are able to transfer appropriate knowledge to communities. The operation and maintenance knowledge of existing APMs is limited to the India Mark II pump; therefore the scope of training should be expanded to cover operation and maintenance for all proposed technologies for this project.

In addition, the MOA should participate in training to introduce other topics such as irrigation equipment O&M, entrepreneurship training, crop rotation, water management, marketing, and provide oversight in infrastructure management.

The MLGH, through District Councils, and the Ministry of Health, through their network of health facilities, have been facilitating Community Led Total Sanitation (CLTS). Some community members at the proposed project sites have been trained as CLTS champions by the District Council. These champions are expected to undertake extensive community awareness activities and ensure that all households possess a functional pit latrine and had washing facilities. The proposed project will embrace these institutional arrangements and integrate components that are not covered in the RWSS agenda. For example, the irrigation aspect is not part of the VWASHE activities. Nevertheless, the mandate of these social structures can be expanded to include all aspects of the water point activities.

8.3.3 Gender equality and social inclusion

A gender equality and social inclusion (GESI) rating matrix is presented at Annex 2. The high ‘significance’ scoring (10/12) of the proposed project indicates that overall the planning study has i) adequately analysed and assessed GESI issues in the proposed project through a combination of literature review and face-to-face engagements; ii) taken into consideration the need to take advantage of the positive gender opportunities that the project presents.

9 Environmental assessment

9.1 Introduction

According to Zambian environmental law, any proposed infrastructure development must be subjected to environmental impact assessment (EIA) to determine its potential impact on the environment and to devise appropriate mitigation measures for any identified negative impacts. The EIA process begins with an environmental scoping exercise to establish if the scope and nature of the proposed project warrants a full EIA study. This chapter presents findings of a detailed desktop analysis that was carried out on the receiving environment of the Mulobezi GMA water and sanitation project, and further, to document the procedures and outcome of the process undertaken as part of the screening assessment. Ultimately, the purpose of the screening process set out in this chapter is to advise if an EIA would be required under the Zambian law, based on the desktop assessment.

9.2 Scope of project

9.2.1 Location of proposed sites

The proposed borehole sites (section 1.5 above) are areas that are near the community homesteads. Some are close to previous or current water sources. While the communities have proposed preferred sites for sinking of boreholes, the exact sites will be confirmed by geophysical surveys. All sites are in areas underlain by the Kalahari sands geological formation.

The proposed sites are all located in rural residential land and are not located within any designated or protected sites under national legislation. The selection of the sites has also been guided partly by a desire to reduce the distance travelled by community members to fetch water.

9.2.2 Current land use

The current land use in the Mulobezi GMA is mainly communal mixed rainfed crop farming and open lands used for livestock grazing. The sites have been under human occupation for a long time, which has led to extensive clearing of natural tree vegetation cover, leaving most areas with mostly grass cover. All information available to date shows that the habitat is typical of degraded communal lands areas. The sites are not in any way designated for nature conservation, nor do they contain any rare or protected species.

The proposed boreholes, while located within the inhabited villages, are not sited on constructed areas. Thus the boreholes will not displace any houses or infrastructure. As far as can be established from investigations carried out to date, there is no material of cultural heritage or archaeological significance at or near any of the six borehole sites.

9.2.3 Direct utilisation of natural resources

The proposed gardens are only 1 ha each and will require approximately $10m^3/hr$ of irrigation water. The amount of irrigation water and the size are not likely to cause any major waterlogging or to cause excessive leaching. The gardens will be sited on existing arable or cleared land and their establishment will not lead to any clearing of virgin forest, pristine woodland or protected wetlands.

9.3 Legislative context

9.3.1 The Zambian Environmental Management Act

The Zambian Environmental Management Act (EMA) (Act 12 of 2011) is the principal law on integrated environmental management in Zambia. This law was enacted in April 2011 to repeal and replace the Environmental Protection and Pollution Control Act (EPCCA) (CAP 204) and all amendments thereto.

The EIA Regulations that were defined under this Act provide the framework for conducting and reviewing environmental impact assessments for any project carried out in Zambia. They are specified in the Environmental Protection and Pollution Control Act (EPPCA) (Statutory Instrument No. 28 of 1997). The Regulations enacted under the EPPCA are still in force until the Minister enacts new Regulations under the Zambian EMA (Act No 12 of 2011).

The Zambia Environmental Management Agency (ZEMA) is the umbrella environmental institution in Zambia and the main lead agency on matters pertaining to EIAs. ZEMA falls under the Ministry of Lands, Natural Resources and Environmental Protection, and was previously known as the Environmental Council of Zambia (ECZ). It is empowered by the Environmental Management Act (No. 12 of 2011) to determine if a development project or plan requires an EIA and to oversee the adherence of developers to the EIA legislation. The ultimate objective of ZEMA is to ensure the sustainable management of natural resources, the protection of the environment, and the control of pollution, as provided under Article 9(1) of the EMA.

The services provided by the ZEMA specifically in relation to EIA studies include:

- Assisting the developer to determine the scope of EIA studies;
- Reviewing project briefs, terms of reference, and environmental impact statements (EIS) and decision-making;
- Disclosure of the EIS to the public through the media;
- Holding public hearing meetings to discuss the EIS with stakeholders;
- Conducting verification surveys of the affected environment;
- Monitoring the project once implemented;
- Conducting compliance audits of the project between 12 and 36 months after implementation; and
- General administration of all the Regulations under the EMA.

The EMA sets down the types of projects that may require an EIA. In examining the list of projects for which, according to the EMA, EIA is mandatory, it was noted that the proposed boreholes and gardens fall outside the scope for EIA. However, while this water and sanitation project falls outside the mandatory scope for EIAs it was deemed necessary to conduct a screening process, for the purpose of documenting the environmental footprint of the project.

9.4 Assessment of potential impacts

The paragraphs below stipulate the factors and issues that were taken into account in the environmental screening.

9.4.1 Characteristics of potential impacts

Extent of the impact (geographical area and size of the affected population)

The land area directly affected by the boreholes and irrigation gardens was demarcated and examined to determine the kinds of environments that will be affected by the proposed project. It was noted that the geographical footprint of the project is very small and confined to the few square metres of borehole area, the location area of the tank and standpipe and water troughs, as well as the 1 ha fenced vegetable garden. In addition, there will be the length of pipeline trenching, although once dug and buried, the pipeline will have no effect on the environment. Since it carries good water, any leaks therefrom will be environmentally innocuous. The overhead structures and fence will not have any marked footprint on the land; neither will the water tanks.

Magnitude, duration and complexity of the project

The size or scale of the identified potential impact was determined. It was noted that most of the primary impacts of the proposed development will occur during the construction phase, and it was noted that with careful management the impacts of these construction activities will be minimal and relate to the disturbance of the soil. In addition, it was noted that the impacts will tend to be short lived and temporary. In this regard, the main potential impacts will be associated with the construction phase and can be summarised as:

- bringing drilling equipment to site and drilling of boreholes;
- construction of troughs, stand pipes and mounting solar panels;
- digging trenches and laying pipes therein and filling up of the same;
- the establishment and fencing of gardens;
- clearing land in the garden and land preparation in the garden.

The construction of the project will take a short time, not estimated to exceed three weeks per site. Thus, the impacts are mainly due to delivery and placing of materials, excavation and filling up of trenches, associated vehicular activity, noise and the presence of a construction team in the area. Ensuring good controls and environmental management by the contractors can easily mitigate these impacts.

The operation of the project throughout its lifetime is deemed a Positive Significant impact, in that the new boreholes and gardens will provide much needed access to safer water and nutritious gardens. The new boreholes will also reduce the risk of water-borne diseases and contribute to better quality of life for the communities.

The impact of the footprint of the structures is a permanent negative slight impact but will not change the land use or ecology of the area. Slight erosion processes may occur due to agricultural practices but the size of the areas affected will not lead to abnormal or excessive erosion or deposition locally. Further, with good agricultural extension, the erosion can be controlled.

Probability of the impact

In this regard, the probability of an identified impact was determined. Thus, all identified impacts were subjected to a probability of occurrence test.

It was noted that most of the impacts will be short-term in nature. For example, there will be some short-term nuisance due to the presence of contractors along with associated construction traffic during the works.

There will be a positive permanent impact in terms of the provision of potable and irrigation water to the communities.

Frequency and reversibility of the impact

All identified impacts were subjected to a frequency and reversibility test.

It was noted that the proposed boreholes and overhead structures will be semi-permanent structures if not removed, and are to likely have long-term effects. Their effects are reversible, if removed. The gardens can also be removed or relocated at a future stage.

The impacts of the trenching are also reversible.

Cumulative nature of impacts

Impacts that may be considered minor and insignificant can combine with other environmental impacts already present or planned in the project area to create significant and adverse impacts over time. The proposed project was assessed in terms of the 'cumulative' effects.

In this regard, it was noted that impacts caused by the positive impacts of the proposed project in relation to provision of access to water, distances travelled to fetch water, improved health (as people were drinking dirty water) will over time have a positive cumulative effect on the lives of the community and the quality of food and health. The gardens will aid production of fresh vegetables, thus improving nutrition in the villages.

There are no cumulative negative environmental impacts that could be associated with the projects.

The Mulobezi GMA is a rural area with low levels of development. The scattered homesteads exhibit a high level of unplanned rural development. The area surrounding the existing settlements is characterised by isolated settlements that are gradually encroaching into the forests to create fields for subsistence agriculture, resulting in massive deforestation and encroachment into wildlife areas. The proposed developments are on open ground and/or already existing borehole sites. No new areas will be opened up because of this project. There is no planned development known that will affect the current proposed interventions. Consequently there are no cumulative negative impacts here.

The use of natural resources

The natural resources within the study area include the following:

- Plants
- Animals

- Rock resources
- Soils
- Water bodies (streams and groundwater)

Part of the developments includes fencing of land for use as gardens. All fencing materials will be purchased and transported to the area. The processes of drilling for a borehole do not generate any waste but will draw water from the underground resources. Construction of troughs will require very little sand that will be excavated from the nearby rivers. This will not amount to much and pits will be covered by surrounding sand.

There is an abundance of sand in the area and the footprint of the proposed development will not significantly impact on the integrity of the main habitats at these locations.

There is no evidence to suggest that any of the planned activities will be detrimental to natural resources in the area.

- There are no reports, personal or written, that indicate significant loss of protected plant or animal species.
- There will be substantial water abstraction for drinking, livestock and irrigation. The quantities of water required are not huge and should be sustained by the underground resources.
- There will hardly be any removal of soil and subsoil and it is therefore not considered particularly significant given the nature of activities.

Production of waste, pollution and nuisances

There is unlikely to be any significant volume of waste generated by the proposed development.

Vehicles carrying and bringing equipment will open up tracks to the six sites. There are currently existing footpaths and gravel tracks to the sites, although not much used by vehicles. Since the routes are already in use the footprint will be insignificant and short lived.

There is risk of nuisance and pollution by contractors during the works, but this risk can be mitigated by on site controls and good practice, especially for litter disposal.

As such the production of any waste associated with the development would not cause unusual, significant or adverse effects of a type that would, in themselves, require an EIA. The new structures are being provided to provide access to safe water and nutrition.

9.5 Overall assessment of impacts

The proposed works are located in degraded rural lands and will not impinge on any current land uses. The proposed works are not located within any designated national protected site or archaeological sites. The primary geology is the Kalahari sands that are abundant in the area. No rare or protected species were reported, encountered or identified in the project sites.

Accordingly, the development does not fall under projects that require an environmental impact assessment.

The construction works will be short-term and the temporary impacts associated with the construction phase can be managed and mitigation measures can be incorporated into the construction plan for the works.

The permanent impacts of the proposed scheme are both positive and long-term. Table 16 gives an overview of potential environmental impacts and this demonstrates that the proposed project will not have a significant impact on the environment.

In terms of the location of the development and based on the preliminary assessment of the environmental sensitivities of the site, it is considered unlikely that the proposed development will have significant impact on the environment.

Having considered the proposed development in the context of the criteria for determining impacts set out in the EIA regulations we conclude that the proposed development will not have a significant effect on the environment and does not consequently require an EIA. However, it is recommended that contractors incorporate good environmental practice during planning and construction to avoid any unnecessary harm to the environment.

Table 16 **Overview of characteristics of potential impacts**

Environmental Aspect	Extent of the impact		Duration of impact		Magnitude & complexity of the impact		Probability of the impact		Frequency and reversibility of the impact	
	Borehole structures	Gardens	Borehole structures	Gardens	Borehole structures	Gardens	Borehole structures	Gardens	Borehole structures	Gardens
Human Environment	n/a	localised	n/a	Long-term	n/a	n/a	n/a	Low	Temporary	Semi-permanent
Ecology	Localised	Localised	n/a	Long-term	n/a	Impact with low - severity.	n/a	Slight	n/a	Long-term/reversible
Surface Water Quality	Localised	Localised	n/a	During rainy seasons	n/a	Impact with low severity, can be mitigated	n/a	Low	Semi-permanent	Periodically-temporary
Groundwater Quality/quantity	Localised	Localised	n/a	n/a	n/a	Impact with low severity, can be mitigated a	n/a	Slight	N/a	n/a
Soils and Geology	Localised	Localised	n/a	Low impact	n/a	Impact with low severity	n/a	High	n/a	Temporary
Noise	Localised	Localised	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Air Quality	Localised	Localised	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Landscape	Localised	Localised	n/a	permanent	Impact with low severity	Impact with low severity	slight	Moderate	Reversible	Reversible
Archaeology & Cultural Heritage	n/a	Localised	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a

10 Financial and Economic Appraisal

10.1 Introduction

This appraisal aims to investigate the financial and economic costs and benefits of the proposed infrastructure development in the Mulobezi GMA. If this and other small-scale interventions in various parts of the KAZA TFCA are successful, it may be possible for CRIDF to secure funding for larger-scale support. As such, the project cost-benefit analysis (CBA) presented below is intended to provide an evidence base for the financial, economic and social rationale for the implementation of the project.

10.1.1 Approach to the CBA

The CBA is conducted from the perspective of the local communities. They will become the effective owners of the infrastructure – therefore accruing direct benefits through domestic, agricultural and livestock benefits while also being responsible for its operation and maintenance (O&M) costs. As this is a rural water supply project, the communities will not be charged water tariffs, but will be required to collect user tariffs associated with either domestic or enterprise consumption to cover its ongoing costs. There will, however, be direct, tangible monetary benefits that accrue to the community through enterprise development that will be directly attributable to the enhanced and increased agricultural and livestock activity. Comparing these economic benefits to the capital and O&M costs of the project provides an indication of the financial viability of the project.

It is anticipated that a project of this nature is unlikely to be financially viable due to the relatively large upfront capital costs associated with installing new water supply and its associated infrastructure; however, the broader economic and social benefits that the project will unlock will likely increase the welfare of the population significantly. A CBA provides a framework that allows for both financial and economic project appraisal that enables the comparison of future project costs and benefits in present values, thus providing input into the financial and economic viability of a project, and hence input into the decision-making process.

This appraisal follows the CRIDF CBA Guidance, and consists of the following sections: options appraisal; key assumptions; financial appraisal; economic appraisal; sustainability analysis; risk assessment; and conclusions and recommendations. The options appraisal is discussed in more detail elsewhere in this report and is only briefly summarised in this chapter.

10.1.2 Project Objectives

The primary objective of the project is to establish permanent water provision for communities whose livelihoods are stressed by unreliable, inadequate water supplies in the KAZA Zambia region. In addition, the project will also improve the livelihoods of members of the community through a range of benefits that include reduced HWC, health improvements, climate resilience and time savings. Time savings and health impacts have a concentrated impact on the livelihoods of women and children, thus having a beneficial impact on gender equality in these vulnerable communities.

To this end, the project entails delivering the following to each of the six sites:

- New borehole with solar pump;
- Limited water reticulation infrastructure from the water source to storage and then to delivery points for domestic use, livestock watering and irrigated gardens;
- 1 ha fenced garden; and
- Support services to improve agricultural production and hygiene/sanitation practices.

10.2 Options appraisal

This section outlines the selection of options most appropriate for meeting the project objectives outlined above, given the social, institutional, policy, and biophysical characteristics of the KAZA region.

There are three main technical solution options that need to be assessed in the design of this particular project. These are:

1. Water supply options
2. Pump infrastructure options
3. Irrigation equipment options

10.2.1 Water supply options

Groundwater, surface water and rainwater are three possible alternatives assessed for the water supply source for the project. Climatic conditions in the Mulobezi GMA are characterized by relatively low rainfall and ephemeral rivers (Chemonics, 2011). There are a few rivers (such as the Kalobe and Mwezi Rivers) but these dry up as soon as the rains cease (section 4.1 above). The land is undulating, but there were no sites identified where effective dams could be constructed that would hold enough water for major irrigation. This excludes the potential of using surface water as a source of water supply for this project.

Rainwater harvesting is also not considered a viable option for the proposed intervention due to the inter-seasonal variability in rainfall in the Mulobezi GMA; while there is adequate rainfall in the wet months, rainfall in the dry winter months is extremely limited. Additionally, rainwater harvesting does not present a climate resilient water supply option as climate change is expected to increase the variability of rainfall patterns, reducing the effectiveness of rainwater harvesting further in the project area.

For these reasons, groundwater was identified as the only feasible water supply source for the project design. The selection of this option is further reflected by the fact that groundwater is already being utilised as a preferred water supply source for most of the schools in the area (TNC, 2012). The area (which falls within the Kalahari sands aquifer) has medium to high productivity, with an average yield of 20 m^3 for boreholes of approximately 50m deep.

10.2.2 Pump infrastructure options

At present, boreholes in the communities are equipped with hand pumps. Hand pumps do not require additional energy in the form of fuel and/or electricity and are appropriate when yields or recharge rates are low. However, as water levels recede to deeper levels in the dry season, water abstraction by hand becomes a challenge. In such cases, communities abandon the boreholes and revert to other sources, which may involve greater walking distances and/or compromised water quality. In such cases, motorised pumps would be recommended.

There are various pump types, with varying fuel inputs required. Pumps using electricity/diesel are inappropriate due to the project's remoteness and the community's low ability to pay for operations. The proposed option is to utilise solar pumps due to their energy efficiency, low O&M costs and suitability to the climatic conditions of the country. Solar pumping for water supply in rural communities is a technology that is making inroads in most Sub-Saharan countries including Zambia. However, information on implemented projects in Zambia is difficult to obtain (section 4.6 above). In Zimbabwe, various projects for pumping water in rural areas using solar power have been implemented and commissioned to date. CRIDF is implementing two projects in Zimbabwe with one of them consisting of a 63kW submersible pump delivering 1,400 m^3/day. Zambian suppliers have the capability to install solar pumping units for water supply in the Mulobezi GMA projects.

In addition, solar powered pumps provide 'smart energy' to the local communities – energy that is environmentally friendly and with low operational costs - thus representing a climate resilient intervention that is aligned to CRIDF objectives.

10.2.3 Irrigation equipment options

Irrigation solution options analysed in this project include sprinkler, drip and drag-hose systems. While sprinkler irrigation for 1 ha plots indicates the highest crop yields, it is considered inappropriate for the KAZA Zambia sites due to the fact that they would not allow individual farmers autonomy in their crop choices. Instead, farmers would have to operate the full plot as a collaborative venture, something that was flagged multiple times in the community meetings as a risk to successful implementation. In addition, sprinklers would require an additional booster pump to generate enough head to operate a nozzle.

Appropriate types of irrigation systems for the small gardens could be either simple hosepipes connected to stand pipes, or drip irrigation systems. The former will be simpler and cheaper to implement for the small gardens, with far fewer operational problems. Drip irrigation, on the other hand, is prone to blockages through sedimentation, and has high maintenance costs.

10.3 CBA assumptions

The CBA analysis is premised on a number of key input assumptions. The assumptions are drawn from this technical report, observations by the project team in the KAZA Zambia area, and international benchmarks. The tables below provide the detail of the assumptions that form the basis for the CBA analysis.

Table 17 **Key assumptions**

Assumptions	
Financial Discount Rate	11.5%[3]
Exchange Rate	USD 1.00 = GBP 0.69082[4] GBP 1 = ZMW 16 GBP 1 = ZMK 7,398[5]
Constant Versus Current Prices	Constant 2016 prices
Project lifespan	20 years
Number of Households (2015)	265[6]
Average Household Size	5.4 for all 6 project sites
Population size	1,433
Social Discount Factors	3.5% and 10%[7]
Average cost of a cow	£356[8]
Income per hectare of land under irrigation	£2,093[9]

The CBA is carried out on a 'with and without' project basis and hence includes only incremental values for the costs and benefit inputs. This is in an effort to include only the incremental costs and benefits of the project, including variables such as time spent collecting water in the current system versus time spent in the new system. In terms of the financial appraisal, the project sites currently do not have any formal operation and

[3]The financial analysis is conducted using an inflation-adjusted discount rate of 11.5%. This is taken from the AfDB report Strengthening Resilience in the Kafue Sub-Basin (2013). Online: http://www.afdb.org/fileadmin/uploads/afdb/Documents/Project-and-Operations/Zambia - Strengthening Climate Resilience in the Kafue Sub-Marin - Appraisal Report.pdf and represents the average opportunity cost of capital.
[4]Oanda Currency Converter (2016) Online: http://www.oanda.com/currency/converter/, accessed 4 February 2016
[5]The old Zambian Kwacha (ZMK) is used to estimate minimum wage as information is only available in 2012 when minimum wage legislation was passed
[6] Section 2.2.1 above.
[7] In line with CRIDF CBA Guidelines, IF03-006 (2015) DFID uses a standard rate of 3.5% for climate related projects while the World Bank and European Bank for Research and Development use 10% as a standard conventional cut-off rate for water and power projects in Southern Africa
[8] Zambia National Farmers Union (2016) Commodity Prices for Beef, Western Province Zambia. Online: http://www.farmprices.co.zm/index.php
[9] Section 7.6 above.

maintenance costs, although the community is sometimes responsible for the repair of the hand-pumps should they break. Hence, the O&M costs of the new system are included in their entirety.

In terms of agriculture, land on which each of the irrigation systems will be developed is either uncultivated land or under rain-fed agriculture. The entire irrigated agricultural area is included as an incremental benefit, indicating that it should not replace dry-land agricultural gains. This assumption is based on the fact that land is not seen as a constraint to rain-fed agriculture in the area (rather inputs such as seed and labour are perceived to be constraints to communities (key informant interview (KII)). Thus it is assumed that any rain-fed agriculture that is displaced by the small food gardens will move to a new area. Further, the additional economic value derived from having additional livestock due to the availability of water is also taken into account.

10.4 Financial appraisal

The purpose of the appraisal is to identify the financial return to the project infrastructure investment and the operational sustainability of the infrastructure. In the absence of water tariff revenues, the financial appraisal is conducted from the perspective of the local communities, who will be the effective project owners, and will be responsible for the operation and maintenance of the infrastructure in the medium and longer term. The community will also be the direct recipient of the financial benefits that are expected to flow from the infrastructure.

This approach is useful for two reasons. First, the assessment provides a view of the operational sustainability of the project in respect of the local communities by comparing the annual costs of the project with the incremental revenue streams associated with the intervention. By showing that the latter covers the former it is understood that, with the correct institutional design, the community will be able to afford the ongoing costs of the project. Hence if the communities take effective ownership of the water facilities (and, hence, their costs), they should have enough revenue to sustainably operate them, given the estimated recurrent costs. Secondly, the approach shows what amount of grant funding is necessary for the project to be financially sustainable, if it is found not to be.

The costs considered in the financial appraisal include the capital investment for the water supply infrastructure, including domestic, agricultural and livestock use, along with O&M costs and a sanitation and agricultural extension programme run in year 0 of the project. The financial benefits considered include the monetary increase in the value of crops and livestock to the community. Assessing the financial return of the project over its lifespan against the capital and operational costs yields a financial return to the project. The following indicators represent the key outputs of the financial appraisal:

- Financial net present value (FNPV) – the discounted flow of expected investment and operating costs deducted from expected return
- Financial internal rate of return (FIRR) – the financial return on the project. The financial rate of return should be above the cost of capital (discount rate) for the project to be considered financially viable
- Financial net benefit cost ratio (FBCR) – the ratio of the present value of the returns on the project set against the project's costs.

Importantly, should the project not be financially viable on its own, the financial appraisal will set out the amount of subsidy the project will require to make it financially viable. The project's costs and benefits are set out below, before the financial appraisal results are outlined.

10.4.1 Project costs

Capital costs

The project capital expenditure required for all six of the settlements is GBP 206,726 (this excludes further costs of an agricultural and sanitation programme, making the total capital required equal to GBP 265,137). This includes the material, equipment and labour costs for acquisition and installation of:

- 6 boreholes with solar pumps
- 6 water storage tanks
- Fencing for 6 ha of vegetable garden (1 ha per site)
- 6 ha of drag-hose irrigation equipment
- 11 communal standpipes (1 per 25 households), and
- 11 cattle troughs (section 5 above)

The cost of materials and installation for one borehole is approximately GBP 12,020, while the estimated cost of one solar pump is GBP 9,671. Given the similar nature of the irrigation developments, the capital costs are relatively equal across the six sites (see Table 8 above).

Annual O&M costs

O&M costs for the water supply infrastructure comprise the borehole infrastructure, hosepipe irrigation, standpipes and annual visits by District Council fitters. Table 18 gives a detailed indication of the total O&M costs that can be expected over a two year period for all 6 sites. Given the similarity of the intervention designs across the sites, the O&M costs are expected to be the same at each.

Table 18 **Total O&M costs, all project sites over two years (GBP)**

Description	Quantity	Unit	Rate	Cost
Borehole pump				
Spare pump controller	1	no	771	771
Total for	**6**	**units**		**4,626**
Hose pipe irrigation				
Connectors	265	no	1.05	278
20 mm dia hose pipe	300	m	0.84	252
Sub total				530
Total for	**6**	**ha**		**3,181**
Domestic water supply				
25 mm brass tap	44	no	14.02	617
Ball valve for trough	6	no	84.10	505
Ball valve for reservoir	6	no	84.10	505
Total for	**6**	**systems**		**1,627**

Visits by RDC fitter				
Visit to a site	24	visits	140	3,360
Total				**12,793**

The initial technical design of the project incorporated drip irrigation. This has since been revised and replaced by hosepipe irrigation at each project site. This was done for the following reasons:

- First, drip irrigation significantly increases the O&M costs for the project, putting pressure on the project's ability to be financially sustainable;
- Second, besides the cost of drip irrigation components, from a practical point of view the rural and remote location of the project sites means that it is difficult for villagers to access these components and any spares required.

In the new design O&M costs are not driven by any one particular cost factor and are kept lower through the use of hose – rather than drip – irrigation.

The legal and policy framework of the development and management of the water and sanitation sector consists of, amongst others, the Local Government Act (1991), which gives local authorities prime responsibility for the provision of water supply and sanitation services.[10] Limited budgets in the Kazungula District mean that management is the responsibility of the local community. It is thus expected that project site communities establish a local water management structure that collects and saves maintenance funds from infrastructure users to cover the O&M costs established above. The institutional structures are discussed in more detail in chapter 8 above.

Sanitation programme

UNICEF reports that at present, more than one third of the Zambian population does not have access to clean water and more than half lacks access to proper sanitation facilities (UNICEF, 2016). Not having access to clean and safe water leads to diseases like diarrhoea and cholera, among others. To this end, a WASH-centred programme is proposed, with an estimated cost of approximately GBP 20 per beneficiary[11] over a 12 month period. The total annual cost of such a programme is thus GBP 30,000 for all six sites, which includes the cost of field officer and operational inputs for a year.[12]

Agricultural extension programme

As discussed above (section 7.8.1), communities currently receive minimal support from the MOA relating to agriculture extension services. This is a gap that must be addressed for the scheme to be a success.

[10] AfDB (2006). National Rural Water Supply And Sanitation Program. Online: http://www.afdb.org/fileadmin/uploads/afdb/Documents/Project-and-Operations/Zambia_-_National_Rural_Water_Supply_and_Sanitation_Program_-_Appraisal_Report.pdf
[11] There are an estimated 1,431 people living across the six project sites.
[12] KII with TNC, February 2016

In terms of the agricultural component of the project, it is proposed that a once-off training programme is implemented in year 0 of the project while the infrastructure is being developed. The costs of this agriculture extension service support for the project as a whole (all sites) is shown in the table below. The total cost is estimated to be GBP 29,791, working out to approximately GBP 20 per beneficiary[13]. Of importance is that TNC suggested that their existing agriculture officer in the area could be trained to carry out the CRIDF-related agricultural extension work for the proposed irrigated plots, meaning the line item for the employment of agricultural extension staff may not be needed. It is included in this analysis as a 'worst case' cost.

Table 19 **Cost of agriculture extension support services, all project sites (GBP)**

Support Required	Units	Unit Cost	Total Cost
Extension Staff	1 x 12 months	282.38	3,388.56
Supervision	1 x 12 months x 10%[14]	705.95	847.14
Transport (Quad Bikes)	2	4941.65	9883.3
Quad bike running cost	12	70.6	847.14
Demonstration	10	70.6	705.95
Ripper ploughs (for CA)	10	70.6	705.95
Initial Inputs	10	211.79	2117.85
Fencing material for each plot	10 x 400 meters	2824/km	11295.2
Total			**29,791.09**

[13] There are an estimated 1,431 people living across the six project sites.
[14] Assuming 10% of their time is used on this project.

Table 20 **Summary of project costs, per project site (GBP)**

Project Site	Total capital expenditure	Agricultural extension	Sanitation programme	Annual O&M
Lyoni	34,316	4,965	4,770	1,066
Silangi	33,280	4,965	4,770	1,066
Munengo	35,491	4,965	4,770	1,066
Chinyama	34,316	4,965	4,770	1,066
Kamwi	35,007	4,965	4,770	1,066
Mudobo	34,316	4,965	4,770	1,066
Total	**206,726**	**29,791**	**28,620**	**6,397**

10.4.2 Financial benefits

Financial benefits to the communities include income generated from agriculture on the newly irrigated land, as well as livestock benefits due to implementation of the project.

Agriculture

Agriculture falls into two main categories: subsistence agriculture and cash crops. The latter, for the purpose of this report, are classified as crops which are not consumed by the household which grows them, but are rather sold or traded. Financial benefits are thus only derived from cash crops, while subsistence agriculture provides a range of economic benefits that are enjoyed by the household.

The irrigation project components are designed to grow cash crops. In order to value the benefits derived from the project, a market value is assigned to these crops. This essentially assumes that all crops can be/are sold in local markets. While this assumption may not be appropriate for this area due to significantly limited access to the project area, even if a household consumes these crops themselves, the most suitable *value* for the crops is assumed to be their market price. In the affordability section, the effects of varying proportions of crops sold versus consumed are investigated on the communities' ability to maintain and operate their infrastructure. All irrigated areas will be fenced, reducing the likelihood that crops will be lost to HWC.

To value the potential monetary gains from irrigated agriculture, costing was done to demonstrate the total income per ha of land under irrigation and using enhanced agricultural practices. A Gross Margin (GM) per hectare was calculated (see section 7.6 above), which takes into account the planned amount of land allocated for growing different crops and costs associated with growing these. An effort was made to design the cropping pattern to account for community preferences (for growing maize and groundnuts) as well as local market needs (leaf vegetables and other horticultural crops). Due to the fact that there is currently no irrigation in the Mulobezi

GMA, a permanent market for small-scale vegetable production was noted.[15] Crops were also chosen to address the need for nutritional diversity in the area.

As per the project technical design, irrigated gardens of 1 ha will be developed at each of the six sites. The potential financial gain (the project's gross margin) at each site is the same. Gross margin is calculated to be GBP 2,093 per ha per annum, with the total potential revenue across the six sites is being GBP 12,559 per annum. If each household participating in the scheme has access to 0.1 ha, average household income is expected to increase by GBP 209 per annum.

Livestock

Cattle are found in most communities in the area, although numbers tend to vary. Some areas are more affected by water quantity and quality available for livestock than others. At present cattle must often travel long distances to reach drinking water, and which is still often not suitable for consumption. This is particularly severe in the dry season when streams and rivers have stopped flowing. In one village it was found that several[16] cattle died after drinking water containing large quantities of algae. Combined with a shortage of water and the prevalence of disease, cattle numbers have decreased over the past few years.

Livestock are negatively affected by poor water quality; cattle that drink poor-quality water will drink less water and have a diminished feed intake. Cattle that drink less water due to poor water quality are also more prone to heat stress and will spend more time in shade rather than grazing. These factors can result in, among others, lower livestock weights and, eventually, low financial returns when the cattle are sold. It can also diminish the ability to use cattle to plough land for agriculture. Over and above the benefits described above, then, more time to graze rather than walk to water, as well as more water of a sufficient quality available to be drunk at more regular intervals by the animal, will lead to increased livestock quality over time and even greater benefits than those captured here.

Part of the project infrastructure design includes the provision of cattle troughs at all six sites.[17] These troughs will provide water that is readily available and of a sufficient quality for cattle. These improvements in water supply to livestock – in effect an increase in the carrying capacity of the land – are expected to result in a larger herd over time, as well as help avoid losses due to wildlife (both in terms of reducing the number of fatalities from interactions, as well as a reduction in disease passed between animals). Improved water supply and a reduction in HWC are expected to provide financial returns to the owners of cattle.

Additional livestock used for farm labour

Cattle are vital to the livelihood of the project's target communities, providing most of the power for cultivation of crops and transportation of goods. A reduction in their number is likely to increase levels of poverty found in the area. Conversely, the presence of more cattle is expected to increase the wellbeing and social status of target communities.

Households in the GMA are unable to increase the area of rain-fed crops under cultivation as they are constrained by the number of oxen available for ploughing (section 7.3.1 above). It was found that the area of

[15] KII, site visit December 2015.
[16] KII with a herdsman suggested that in 2015, 4 of his herd of 8 cattle had died because of consuming poor quality water.
[17] Refer to Annex 4 for current cattle population.

land cultivated depends on whether the farmer has access to oxen to cultivate the land or whether farming is done by hand. In the former situation, a farmer is able to cultivate approximately 2 ha of land, but can only manage 0.5 ha in the latter. [18] Conservatively it was assumed that only 40% of the *additional*[19] herd would be used for draught power, but that for every one of these animals, an additional 1.5 ha of land could be cultivated as maize. While the area is regarded as food insecure (with communities relying on casual labour and foraging for wild food to supplement their household food production), it was still assumed that only a portion of these crops are sold in the market, generating additional revenue to owners of livestock.

Additional livestock sold

Beyond their use for farming (draught) purposes, some of the additional cattle now supported by the project can also be sold in local markets. It is likely that only a small number of cattle are sold and that rather they act as a means of accumulating wealth. However, even if only a small proportion of additional cattle are sold for meat, this generates additional revenue to owners of livestock. In line with Barrett's work on the value of livestock to rural communities, it was conservatively assumed that only 5% of the *additional* livestock would be sold per year (Barrett, 1991).

Fewer livestock losses

HWC is a problem that occurs in many countries where human and wildlife requirements overlap, as well as regions where there is the potential for direct contact between humans and wildlife. This is particularly the case for communities who live in the KAZA TFCA and who often rely on the same water source as wildlife. Conflicts between people and wildlife are encountered by communities residing in close proximity to protected areas containing large animals such as elephant and hippopotamus. Human-wildlife conflicts are significant because they cause crop losses, livestock losses and a real cost to the residents of these areas. A recent socio-economic baseline survey of the KAZA pilot area found that HWC is a major livelihood challenge, causing overall losses of 32% of crops, 18% of cattle and 50% of goats.

Mulobezi GMA is one of the GMAs around the Kafue National Park that are worst affected by HWC (Chemonics, 2011). This is due to its close proximity to the park and the fact that many of its communities lie within a wildlife migratory corridor.

The proposed scheme aims to provide permanent water supplies to these communities, thus avoiding potential conflict over scarce water. Permanent water supply suggests that communities will no longer have to make movements into wildlife dispersal zones to water their cattle. This reduces the amount of high-risk wildlife conflict time spent travelling to water throughout the year and, ultimately, reduces the number of cattle lost to HWC.

These cattle that are no longer lost are, in effect, additional cattle made available by the project to be used for farming and to be sold, generating additional revenues to the communities that are therefore included in the financial analysis.

[18] KII, site visit December 2015.

[19] It is assumed that there are an average of 4 cattle per household (section 2.2.1 above). Thus, as household numbers increase, so too will the number of cattle, increasing to an additional 1,574 cattle over the 20 year project lifespan. The current cattle population is estimated to be 1,064.

10.4.3 Financial analysis summary

A summary of the financial appraisal for the whole project is presented in Table 21. The potential financial benefit flows for each of the small-scale enterprises are included as project benefits in the analysis. The capital, annual recurrent O&M costs, as well as sanitation and agricultural extension are included as project costs in the analysis.

The net benefit/cost stream yields a financial rate of return (FIRR) of 7% and a financial net present value (FNPV) at 11.5% discount of - GBP 84,739. At constant 2016 prices and a real financial discount rate of 11.5%, the project financial model yields marginally viable returns (a FIRR of 7%), although the final FNPV is negative. Essentially, the FNPV is negative due to the fact that the discount rate of 11.5% is higher than the project's FIRR. The FNPV provides an absolute value of the investment/asset for a given discount rate, while the IRR gives an understanding of the returns in percentage terms. Thus, some investors may find the project desirable by comparing FIRRs (for example, if a weighted cost of capital is assumed to be 6.5%, the project yields a positive FNPV of GBP 11,754). However, being high risk in nature, it is unlikely to be able to attract private finance with a 9% return.

Table 21 **Financial analysis results (GBP, 2016 prices)**

Financial Appraisal Results (11.5% discount rate)	
Financial Rate Of Return (FIRR) Over 20 Years	7%
Financial Net Present Value (FNPV) 20 Years	- £ 84, 739
Financial Benefit to Cost Ratio (BCR)	0.72
Financial N/K Ratio	0.83

Operationally (that is, excluding the capital costs of the project), the project shows significant return to the local communities, with an FNPV of GBP 201,144 and a BCR of 5.7 over its 20 year life span. It must, however, be noted that crops are valued at their market price, and would only be realised if the communities sold them. These agriculture benefits, while not the most significant driver of these results (they account for roughly 33% of the value derived from the project by 2036), are estimated on their market price. Some of these crops may be consumed by the household rather than sold, in which case it may affect the communities' ability to maintain the scheme. This will be discussed in the affordability section below.

10.4.4 Grant funding

The project is unlikely to attract commercial funding as it will not generate the returns to attract commercial investors. Concessional finance (e.g. interest-free loans) paid back over the life of the project are also not feasible given the significant capital costs relative to financial benefits that stem from the project. These revenues generated by the project are insufficient to pay back these costs over the 20 year time frame. The project will therefore require grant funding to proceed.

Table 21 indicates the financial return on the project investment when varying degrees of external grant funding are leveraged. The minimum finance required for the project to have a FNPV of 0 and a rate of return equal to the discount rate (11.5%) – that is, the 'break-even' point of the project - is GBP 94,484. It is suggested that funding is, however, sought for the full capital investment cost of the project, as the beneficiary communities would not be able to finance the additional cost of the project.

Table 22 indicates the financial return on the project investment when varying degrees of external grant funding are leveraged. Importantly, this includes a capital grant as well as the sanitation and agricultural training programme done in year 0 of the project.

Table 22 **Project funding scenarios (GBP)**

	FNPV	FIRR (%)
Project alone	- 84,739	7%
Full grant funding	153,052	31%
Break-even grant funding (£ 94,484)	0	11%

If a grant is provided for 100% of the capital costs, along with the sanitation and agricultural training, the project's financial indicators improve to an FNPV of GBP 153,052 with an FIRR of 31%. Of note is the fact that maintenance costs are only assumed to begin in year three of the project due to the fact that the equipment should be under warranty for the first two years after implementation. If this is not the case, it is suggested that additional grant funding is accessed to cover these costs to allow the beneficiaries to generate some financial returns from the project before having to pay for its maintenance. O&M costs for all sites, for two years, are estimated to be GBP 12,793.

10.4.5 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 affect the project's costs, as well as the factors affecting the project's revenue generation.

The relatively large upfront costs of the project result in its poor overall financial outlook. Increasing the upfront costs of the project by 10% sees a material impact on the project's FNPV from – GBP 84,739 to – GBP 105,412 (a 24% change in the financial outlook of the project). The associated change in the FIRR is from 7% to 6%. The project would require capital expenditure costs to decrease by 41% for there to be a positive FNPV. In this case, the FNPV would be GBP 19, with a FIRR of 12% and a FBCR of 1.00. The results suggest that capital costs play a fundamental role in the overall financial viability of this project but that a relatively large change is required to make the project financially viable.

While capital costs play a role in determining the overall financial viability of the project, it is also necessary to do a sensitivity analysis on the operational sustainability of the project. This is particularly the case for projects that are funded by an external source but will rely on operational sustainability for their ongoing success. In this case, a sensitivity analysis was carried out on the operational flows of the proposed intervention in isolation of the capital costs.

As reflected in Table 23, changes in the O&M costs have some bearing on the BCR; however the BCR ratio remains strongly positive with a 10% increase in the O&M costs. This is indicative of the strong revenue generated by the project, which far outweighs the operational costs. The baseline operational FNPV of the project is GBP 201,144, with a BCR ratio of 5.69.

Table 23 **Sensitivity analysis – cost parameters**

Parameter	Change	Net operational FNPV after change (GBP)	BCR after change
Increase in O&M costs	+10%	196,858	5.17
Decrease in O&M costs	-10%	205,430	6.32

Table 24 **Sensitivity analysis – revenue parameters**

Parameter	Change	Net operational FNPV after change (GBP)	BCR after change
Increase in GM	+10%	221,710	7.7
Decrease in GM	-10%	190,348	5.4
Increase number of livestock	+10%	215,408	6.0
Decrease in number of livestock	-10%	187,729	5.3

The sensitivity analysis confirms that operational sustainability of the project is robust – with an operational BCR ratio significantly higher than 2, the project is able to recover its operation and maintenance costs.

10.4.6 Affordability analysis

The project appraisal is conducted from the perspective of the local communities, as they will become the effective project owners, accruing project revenues that stem from improved water supply. They will also, however, be responsible for the ongoing O&M costs. This is due to the fact that national structures and a lack of fiscal budgets have prevented water improvements in the area being carried out by state institutions. Instead, what is proposed is that the community form what is known as a Borehole Committee as part of the sanitation training of this programme, which is responsible for the maintenance and operation of the infrastructure. It is vital that the community is able to afford to pay for these ongoing costs for operational sustainability.

For the current infrastructure design, communities would be expected to pay on average GBP 1,066 per site annually on O&M costs. The current average number of households across the six villages is 44. Thus, if each household utilised the Scheme (for domestic water supply, food gardens or livestock watering) they would be expected to contribute approximately GBP 24 per year (ZMW 386[20]). Given that revenue in excess of GBP 200 is expected for the households using the food gardens alone, these costs are not seen as prohibitive.

If only the ten households who take part in each irrigation Scheme are expected to pay for the infrastructure (i.e. if they subsidise the domestic and livestock water supply costs), then they would be expected to pay GBP 106 per annum. While this is not recommended due to the fact that the financial return to each household would then only be ~GBP 90 per annum, this demonstrates that affordability is not a significant concern to the Scheme.

In isolation, the project is not financially viable due to its significant capital cost and would require grant funding to cover the capital investment. However, operationally, the project is sustainable as annual revenue exceeds the annual costs of the infrastructure over its project lifespan. The sustainability of the project relies strongly on revenue generating parameters such as the value of livestock and agricultural produce, along with the ability of the community to sell this produce (i.e. to access markets for their produce). Sustainability also relies on the on-going cost parameters of the project, including the operation and maintenance costs of the proposed intervention.

The financial analysis values irrigated crops at their market values, implying that all crops are sold.[21] It may be, however, that the community takes some time in establishing their enterprises, or in establishing supply chains into markets. In this case, the household may consume some of the produce themselves and not actually generate revenues from its sale. This may save them money by replacing food which is bought by the household in the market; however, in essence it will reduce their ability to pay to maintain the Scheme.

In order to account for this risk, an affordability analysis has been carried out on the sale of crops which assumes that crop production begins at only 20% of its full GM potential and increases by 10% over the next 8 years until it reaches 100% of its full revenue generating potential. The results of such an approach demonstrate

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[20] Oanda Currency Converter. Online: http://www.oanda.com/currency/converter/ [Accessed 9 March 2016]

[21] Livestock gains to rain-fed crops (i.e. through additional draught power) are already estimated to only be 50% of their potential in the financial analysis due to the fact that local markets for maize are already utilised and the sale of these crops is expected to be a challenge, while transport from the villages is also a significant challenge to selling produce.

an operational BCR of 4.9, and an FNPV of 165,292 – indicating again that affordability is not a major risk to this project.

10.5 Economic appraisal

The economic benefit of the water and sanitation services that are created through the implementation of the project must be quantified within the economic appraisal at its real value to society, as opposed to the financial revenues that could accrue directly to the project beneficiaries. The purpose of the economic appraisal is thus to determine the economic feasibility of the project, i.e. whether the implementation of the project results in a net benefit for the entire population.

Economic benefits are split into the benefits that can be quantified and valued (these are included in the quantitative analysis and directly compared to quantitative costs) and the benefits that cannot practically be quantified or valued in monetary terms (these are discussed in the qualitative analysis). The economic feasibility of the project is determined by consideration of both the quantitative and qualitative analysis.

Figure 22 Overview of quantifiable economic benefits

Health benefits	• Improved WSS and training will decrease water-related illnesses. Diversified diets and additional food security is expected to also enhance the health of the beneficiaries
Time savings	• Closer water points with more efficient supply than shallow wells. Time savings are also associated with a decrease in the need to source wild foods
Economic value of crops	• Additional crops grown due to additional draught power but not sold due to market constraints. Additional crops grown through assured water supplies
Economic value of livestock	• The value of milk and manure produced by additional livestock, assumed to be consumed/used by the household rather than sold
Lower livestock losses	• The economic value of livestock that was previously lost due to wildlife conflict/transmission of disease

10.5.1 Quantitative analysis

Economic costs

Shadow pricing should be applied where possible to account for market distortions. A conversion factor lower than one suggests that the market price is higher than the true value of that input. A labour surplus, for example, would lead to a conversion factor lower than one, indicating that the opportunity cost of labour may be informal wages or even unemployment. Conversely, if the conversion factor is higher than one, then the observed price is lower than the shadow price, meaning that the opportunity cost of that good is higher than that captured by the market (European Commission, 2014). Excess demand for foreign exchange in the economy would indicate a conversion factor larger than one and would indicate that the true value of tradable goods is higher than their financial prices.

In this quantitative economic appraisal, the financial capital costs were retained as the economic project costs without shadow pricing due to a lack of data on conversion factors in Zambia. In the absence of further information, it is best to retain financial costs as a proxy for economic costs.

Economic benefits

As shown in the figure above, the economic benefits included in the quantitative analysis of the infrastructure project are health benefits, time savings, the economic value of crops and livestock and the impacts of lower HWC on livestock.

Health benefits

Sanitation in the Mulobezi GMA is poor. Most houses use unimproved pit latrines or practise open defecation. Additionally, water supplies are often shared with livestock or wildlife.[22] The GMA currently has one clinic that services over 700 households. This facility is located in Moomba Central near the Chief's palace, more than 20 km from some of the project sites (Lyoni is located 15km from the Chief's palace, while Munengo is 25km from the Chief's palace). Current health challenges include inadequate health care providers, and poor quality of health care services. Improving access to and quality of health care was identified as a priority by the Conservation Action Plan Workshop held by TNC in 2012 (TNC, 2012).

The most prevalent diseases in Kazungula District are malaria; diarrhoea and dysentery; bilharzia; upper tract infection; malnutrition; skin diseases; and ear, nose and mouth infections. National statistics find diarrhoea prevalence in children under five of 17.3% in the Southern Province of Zambia, and it is found to be a major cause of morbidity. Rural water supply and sanitation coverage are estimated at 37% and 13% respectively (WaterAid, 2009).

The World Bank Water and Sanitation Programme (WSP) has calculated the economic costs of poor sanitation in Zambia; it found that Zambia loses approximately GBP 134 million annually – or GBP 11 - per person annually – due to poor sanitation (WSP, 2012). These figures comprise the following costs:

- The cost of time lost by people practising open defecation – which falls disproportionately on women – in finding a private location to defecate.

[22] KII, site visit December 2015

- The cost of premature death due to illness attributed to poor water, sanitation, and hygiene (predominantly diarrhoea). As indicated above, diarrhoea is a prevalent challenge already in the Mulobezi GMA.
- The cost of productivity losses while sick or accessing health care. This again relates to further opportunity costs of time.
- The cost of health care treatment for related diseases. This burden can fall directly on households, or places a significant burden on the state in the case of public care.

The economic cost estimate of poor sanitation is used as a basis to estimate the health benefits (or avoided cost) of the project on the resident population. Some of these costs are borne by the state in terms of the fiscal cost related to health care treatment, and some of these costs fall on individuals either in the form of direct treatment costs and/or a loss of productive days.

Exposure to diarrhoea-causing agents is frequently related to the use of contaminated water and to unhygienic practices in the preparation of food and disposal of excreta (Central Statistics Office *et al*., 2009), and the World Health Organisation (WHO) and Stockholm International Water Institute (SIWI) find that improved water supply can decrease diarrhoea morbidity by up to 25%; and hygiene interventions and drinking water quality can reduce the number of diarrhoeal cases by up to 45% and 39% respectively (WHO and SIWI, 2004). Population growth in these water-stressed areas will further exacerbate the poor sanitation and hygiene situation in the absence of any water supply improvements. It is assumed that the project decreases the incidence of water-related costs by 45% in the target population in line with the above.

Table 25 below provides a summary of the estimated health benefits of the project for selected years.

Table 25 **Annual estimated health benefits (GBP)**

Site	Year 1	Year 5	Year 10	Year 15	Year 20
Lyoni	1,249	1,448	1,672	1,937	2,172
Silangi	658	765	892	1,040	1,173
Munengo	1,840	2,131	2,462	2,840	3,181
Chinyama	1,106	1,285	1,489	1,723	1,937
Kamwi	1,703	1,968	2,274	2,621	2,937
Mudobo	969	1,122	1,300	1,509	1,698
Total	**7,525**	**8,718**	**10,089**	**11,670**	**13,097**

It is important to note that WSP argues that the estimate of GBP 134 million is very likely an underestimation of the true cost of the current sanitation situation, as some costs have been excluded from the analysis due to the difficulty associated with their estimation. These costs, which are also relevant in the Mulobezi GMA, include:

- the cost of epidemic outbreaks. The economic implications of a cholera outbreak go far beyond the immediate health system response to include productivity losses, premature death, diversion of expenditure, and losses in trade and tourism. This risk in the Mulobezi GMA is particularly acute given its significance as a transboundary tourism area;
- the cost of reduced long-term cognitive development which is a result of early childhood diarrhoea and associated under-nutrition, stunting and wasting;
- the cost of funerals, which is borne directly by households and is particularly significant in African culture;
- the cost of water pollution and the adverse impact of excreta disposal on water resources. WSP found that such figures are not available for Africa specifically; however, as there are no large rivers near the project sites, this cost is not assumed to be important in the area;
- the cost of the negative impact of inadequate sanitation on tourism. The sanitation status of a country is one of the key factors that contribute to travel and tourism competitiveness. This is particularly relevant in the case of the Mulobezi GMA given the surrounding lodges. As such, the potential positive impact of the project on the tourism sector is considered in the qualitative section below.

This quantification of health benefits excludes the positive impact on the community associated with diversified diets and a larger, more stable supply of food. Health benefits as a result of improved diets are difficult to quantity, being long run in nature, but include positive impacts on child development, as well as cognitive and physical improvements.

Domestic time savings

At present, the majority of households interviewed collect water from streams (or from shallow wells dug into river beds). KIIs with women's groups suggested that women can spend up to an hour collecting water, especially in the dry season when they must wait for water to seep into their hand-dug wells. Chemonics (2011) suggest that women and children can spend two hours per day fetching and preparing water.

Households are an average of 5.4 people in size, with a number of these being children. It is assumed that households will make three trips to fetch water per day, where women are able to collect a 20 litre bucket of water per trip.[23]

In order to calculate the time savings per household, it is assumed that households previously spent half an hour per trip to fetch water, but that the time will be reduced by 80% due to the proposed infrastructure. Time savings will be from a combination of shorter walking distances, as well as less waiting time at the water source.

[23] Adults are assumed to use approximately 20 litres of water. This figure is therefore relatively conservative, but accounts for the fact that children are assumed to require much less water than this. The number of daily trips to fetch water could be higher as 5.4 if all household members are adults

Using the conservative minimum wage of GBP 2.5[24] per day, multiplied by the labour conversion factor of 64% (Asian Development Bank, 1999), the real value (opportunity cost) of time savings was estimated. This labour conversion factor reduces the value of labour below the minimum wage in the area due to the fact that there is a surplus of labour in the community. It is unrealistic to assume that the opportunity cost of fetching water is equivalent to the formal market wage. Table 26 below provides a summary of the estimated domestic time savings accruing from the project for selected years.

Table 26 **Annual estimated annual domestic time savings (GBP)**

Site	Year 1	Year 5	Year 10	Year 15	Year 20
Lyoni	4,070	4,718	5,449	6,312	7,077
Silangi	2,143	2,492	2,907	3,389	3,821
Munengo	5,997	6,944	8,024	9,253	10,366
Chinyama	3,605	4,186	4,851	5,615	6,312
Kamwi	5,548	6,412	7,409	8,538	9,568
Mudobo	3,156	3,655	4,236	4,917	5,532
Total	**24,519**	**28,406**	**32,875**	**38,024**	**42,676**

It is important to note that these time savings do not include expected time savings for livestock watering – assumed to be substantial, especially in the dry season. Estimating these time savings is challenging due to the fact that children are often the ones who herd cattle to watering points and the value of a child's time is more difficult to quantify. The opportunity cost of cattle herding is most likely to be a decrease in employability due to a lack of school attendance. Additional time savings that are omitted from the above quantification are those of gathering wild foods (as an increase in irrigated agriculture is expected to reduce the need for these activities for the households partaking in the scheme).

It is also important to note that the economic benefits that are derived from improved health and time savings are largely concentrated toward women and children, as these are the members in the community responsible for fetching water. The project will thus directly impact the lives of women and children in the project sites and thus aid in improved living standards for both women and children who reside within the project sites.

[24] Statutory minimum wages for the lowest band of wage (domestic workers) were used as a proxy for agricultural wages. See http://www.mywage.org/zambia/main/decent-work/workers-compensation

Economic value of crop benefits

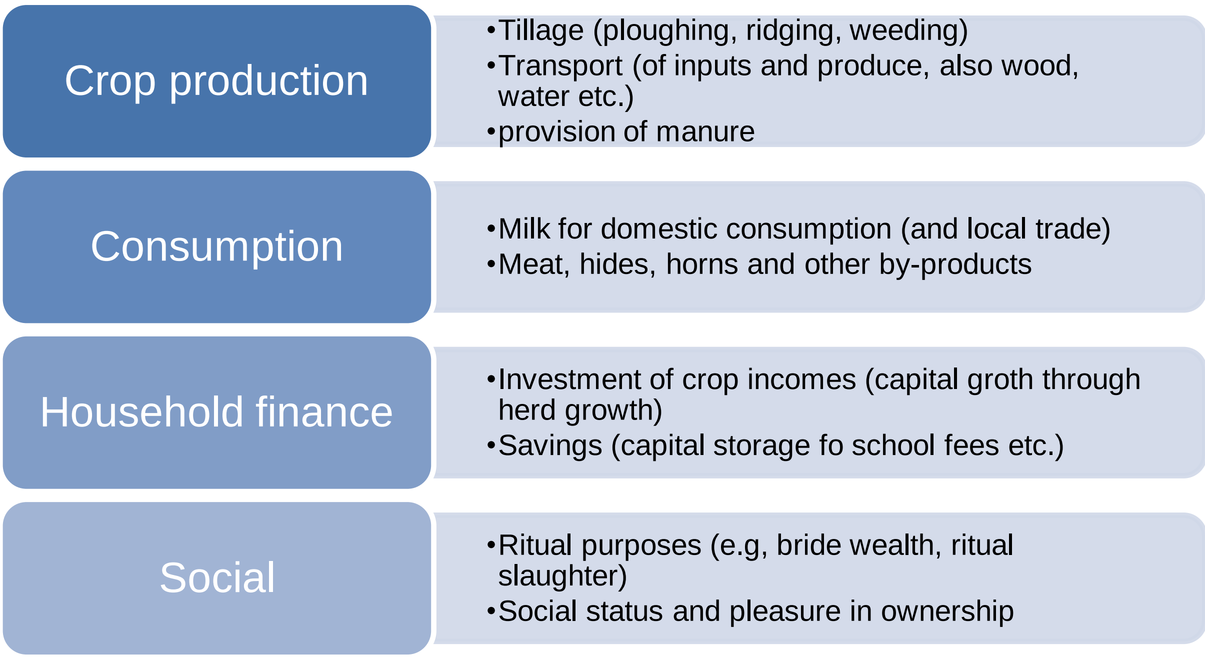
Food security for residents of the Mulobezi GMA is a major socio-economic challenge. Poor soils and relatively low rainfall make crop production risky and difficult (TNC, 2012). Over the past 50 years, there has been a noted decline in rainfall, with significant impacts on the food security of households (TNC, 2012). This has knock-on effects on the area, such as unsustainable harvesting of natural resource products (e.g., fuel wood, meat, fish, honey) to support livelihoods (TNC, 2012).

The market value of crops only captures the monetary value of the resource at local prices. However, due to limited marketing opportunities and supply chains, it is likely that the true value of the crops is significantly higher than what they are currently sold for. While it may be possible to calculate the conversion factors needed to convert the financial prices into economic prices, financial prices were used as a proxy for these prices as a conservative estimate of their true value.

Economic value of livestock benefits

Although commercial off-take in the Mulobezi GMA is low, farmers get a multitude of additional benefits from their livestock. The economic rationale for cattle ownership is firstly to provide draught power and manure for cultivation and secondly to provide milk and meat for local consumption for households who own the cattle (Barrett, 1991). Only a few cattle are actually sold in the market, often in times of crisis or when large sums of money are required by a homestead (e.g. for school fees, medical bills or crop inputs). In this way, cattle represent a store of value for their owners – an important benefit and source of financial security to remote rural communities with limited access to formal financial institutions such as banks. Investment of crop income in cattle ownership leads to capital growth as the herd grows through reproduction (Barrett, 1991). In principle, all of the above values can be quantified and included within the economic valuation of livestock.

Figure 23 Full spectrum of community benefits derived from livestock



Source: Adapted from Barrett (1991).

In the financial appraisal, additional livestock benefits flowed in the form of sales of additional livestock (although limited to 5% of additional livestock produced due to the infrastructure), as well as additional rainfed crops grown on land that was cultivated due to the presence of additional livestock. It was assumed that only 50% of these additional rainfed crops grown would be sold due to marketing constraints. The other 50% of the crops would be consumed locally by the household. While these crops would not generate financial revenues to the household, they would have an economic value, and this is included in the economic benefits of the project.

Additional non-market benefits captured in this appraisal include the value of milk and manure. Milk is an important protein-providing nutrient in diets that largely consist of maize (Barrett, 1991). The value of manure produced by the additional livestock is also quantified and included in the appraisal. Quantifying the economic value of livestock presents substantial problems in that many of these benefits are not final outputs (as is the case with manure and draught power), while consumption of milk and meat from local slaughter also takes place largely within the household (Barrett, 1991). There are no observed market prices for these inputs. In line with Barrett's (1991) methodology, it is assumed that the monetary value of draught power accounts for 63% of the true value of a herd of communal cattle, and that the value of milk and manure accounts for roughly 14 and 9% respectively. Since we have quantified the value of draught power in the financial appraisal, using these proportions allows us to value milk and manure.

Thus the full value of the livestock improvements attributed to the implementation of the project is four times more than the potential market revenues of the herd. However, in order to avoid double counting, the financial values associated with an increase in the number of livestock over time, the quality of the meat of the herd and lower livestock losses due to wildlife, are removed from this estimation.

Table 27 **Annual economic benefits derived from improved livestock (GBP)**

Site	Year 1	Year 5	Year 10	Year 15	Year 20
Lyoni	**1 306**	**3 435**	**5 785**	**8 650**	**11 146**
Draught power	206	1 404	2 724	4 334	5 738
Offtake	89	605	1 174	1 867	2 471
Milk	44	300	583	928	1 228
Manure	28	188	366	582	771
Silangi	**722**	**1 897**	**3 219**	**4 835**	**6 230**
Draught power	124	784	1 527	2 436	3 220
Offtake	53	338	658	1 049	1 387
Milk	27	168	327	521	689

Site	Year 1	Year 5	Year 10	Year 15	Year 20
Manure	17	105	205	327	432
Munengo	**1 980**	**5 065**	**8 590**	**12 629**	**16 301**
Draught power	330	2 064	4 045	6 316	8 380
Offtake	142	889	1 742	2 720	3 609
Milk	71	442	866	1 352	1 794
Manure	44	277	543	848	1 125
Chinyama	**1 140**	**3 049**	**5 253**	**7 750**	**10 026**
Draught power	165	1 238	2 477	3 880	5 160
Offtake	71	533	1 067	1 671	2 223
Milk	35	265	530	831	1 104
Manure	22	166	333	521	693
Kamwi	**1 870**	**4 661**	**7 966**	**11 638**	**15 016**
Draught power	330	1 899	3 756	5 820	7 719
Offtake	142	818	1 618	2 507	3 325
Milk	71	406	804	1 246	1 652
Manure	44	255	504	782	1 037
Mudobo	**1 030**	**2 646**	**4 555**	**6 832**	**8 815**
Draught power	165	1 073	2 147	3 426	4 541
Offtake	71	462	925	1 476	1 956
Milk	35	230	459	733	972
Manure	22	144	288	460	610
Total	**8,048**	**20,753**	**35,368**	**52,332**	**67,534**

Lower human-wildlife conflict

As discussed in the financial appraisal, livestock that that are no longer lost are, in effect, additional cattle made available by the project to be used for farming and to be sold. These additional cattle are included in the economic benefit of the project at their market prices in the absence of economic conversion factors.

Quantitative results

The results of the quantitative economic appraisal, as summarised in Table 28 below, indicate that the project is economically desirable at both a 3.5% and 10% discount rate, with positive ENPVs.

The economic rate of return (ERR) for the overall project is 24%.

At a 10% social discount rate, the project has an ENPV of GBP 355,571 and BCR of 2.15. At a 3.5% discount rate, the ENPV amounts to GBP 876,907 and the economic BCR 3.55. These results show a very 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. 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.

Table 28 **Economic appraisal results summary (GBP)**

Indicator	3.5 % discount rate	10 % discount rate
ENPV	876,907	355,517
ERR (%)	24%	24%
EBCR	3.55	2.15

The above analysis does not capture the non-quantifiable benefits to the project, as will be discussed below, which would make these results even stronger.

Sensitivity analysis

Two important factors in the estimation of economic benefits are the length of time taken to fetch water as well as the impact of the intervention on water-related illnesses (i.e. the proportion of water-related illnesses that the infrastructure avoids). The impact of these assumptions is investigated in Table 29 below. The base case scenario (at a 10% social discount rate) has an ENPV of 355,517, a BCR of 2.15 and an N/K ratio of 3.21.

Table 29 **Economic Sensitivity Analysis**

Parameter	Change	ENPV after change GBP	ERR after change	BCR after change	N/K[25] after change
Increase in time taken to collect water (10% SDR)	+10%	381,101	24%	2.24	3.34
Decrease time taken to collect water (10% SDR)	-10%	329,934	23%	2.07	3.09
Increase in health-related illness reduction (10% SDR)	+10%	363,369	24%	2.18	3.25
Decrease in health-related illness reduction (10% SDR)	-10%	347,665	23%	2.13	3.17

While changing the parameters of time saved and the incidence of water-related sickness avoided due to the intervention, the BCR changes from 2.15 to 2.07 and 2.13 respectively, which are only marginal changes. A change in magnitude of 10% in either direction thus does not pose a major change in the economic outcomes of the appraisal. The outcome of the proposed intervention is thus relatively robust to changes in these two important parameters, suggesting that the project provides a positive net benefit to society.

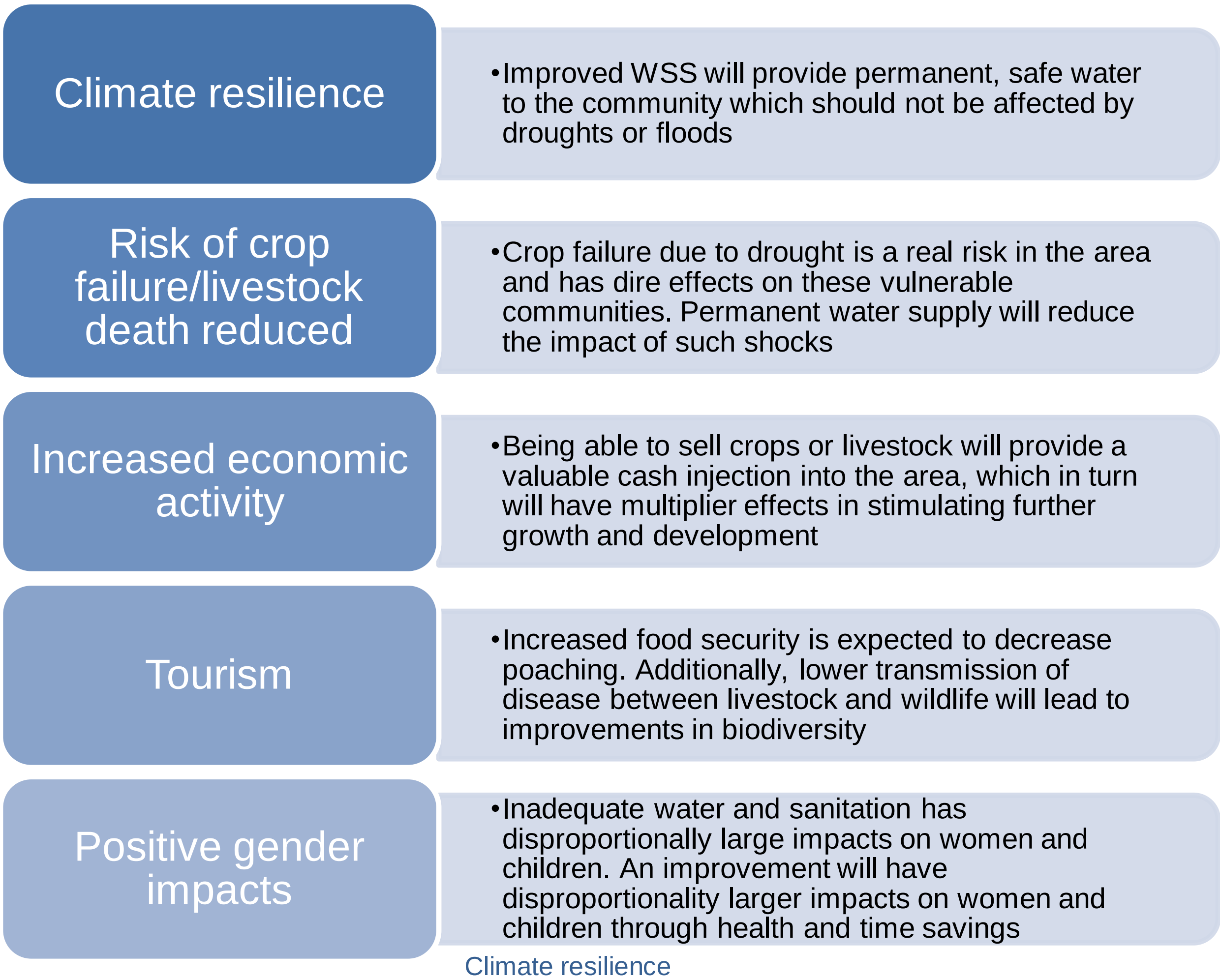
10.5.2 Qualitative project benefits

A project of this nature, which includes welfare impacts such as time savings along with enterprise benefits such as irrigated vegetable production, is associated with a wide range of fundamentally important impacts for the local communities as well as further afield, given the transboundary nature of the KAZA area. This section aims to give a description of some of the most important of these qualitative benefits that are excluded from the

[25] N/K refers to the net present value of the benefit stream divided by the upfront capital expenditure cost

quantitative appraisal due to challenges associated with their objective and robust monetisation. While these benefits are not valued in monetary terms, they provide very real and meaningful enhancement to the local communities.

Figure 24 Overview of qualitative economic benefits (difficult to measure objectively)



Climate resilience

At present the population of the Mulobezi GMA has limited resilience to climate shocks such as floods or droughts. Surface water is extremely limited, and communities rely on shallow wells dug into riverbeds in the dry season. Additionally, a significant portion of the population uses traditional pit latrines (section 3 above). Open defecation is practiced by some of the local community. In the case of a flood, these ablution practices are severely detrimental to the health of the population through their contamination of the water supply.

The compounding pressures of growing populations and climate change, which sees a decrease in the average rainfall to the area while simultaneously more variable rainfall (CEEPA, 2006), suggests the urgent need for better water infrastructure.

The infrastructure is, by nature, climate resilient in that it provides permanent water supply to six vulnerable communities. Its design is also ‘climate-proof’ in that solar energy is suggested as the most appropriate form of energy for the pumps.

Risk of crop failure/livestock death

The Mulobezi GMA is particularly prone to drought. The droughts of 1991 and 2002 were particularly acute, with widespread crop failure and livestock loss (Chemonics, 2011). The majority of households face high levels of food insecurity and rely on the harvesting of resources such as wildlife. Food insecurity also directly affects the ability of children to attend school. Additionally, many of the governance and resource abuse issues stem from food insecurity.

A permanent water supply that will not be affected by droughts will reduce the risk of a total crop failure in the beneficiary communities due to the fact that there will always be some water available for crop irrigation and livestock watering.

Increased economic activity and multiplier effects

The economic benefits of improved access to safe water are both immediate and long term. Immediate benefits include averted health-related costs and time savings associated with having closer water facilities with shorter waiting times. In the longer term however, these benefits compound each other: sufficient supply of treated water will translate into long-run health benefits, which in turn will relate into more productive populations. In terms of educational outcomes, a lower incidence of illness due to improved water supply is expected to result in less absenteeism and a higher propensity to learn.

Additionally, increased revenue in the communities through the sale of crops and livestock is anticipated to have significant multiplier impacts in the local community, as other small trades can be supported.

Tourism

The process of establishing this TFCA was initiated in recognition of the area's significance as a centre for tourism. Tourism is, however, directly and indirectly affected by the health of the local communities. Healthy local communities with improved sanitation and water supplies will have less impact on the natural resources that they relied on in the absence of irrigated agriculture and designated livestock water. In turn, tourism will benefit from improved environmental management. Additionally, lower seasonal movement of livestock in search of water is expected to decrease the transmission of sickness between livestock and wildlife, thus avoiding tourism losses due to losses in wildlife.

The area was affected by rampant poaching that occurred during the restructuring of the National Parks and Wildlife Services (NPWS) into the Zambia Wildlife Authority (ZAWA), now changed again to the Department of National Parks and Wildlife. A significant factor is that law enforcement in the area has been poorly maintained, with only 16 village scouts and seven game scouts patrolling a vast landscape. According to a 2003 CONASA/USAID study on the bush meat trade, Mulobezi is a major source of bush meat sold to urban markets such as Livingstone, Lusaka, and even the Copper belt province. The study showed that 77.8% of those interviewed obtained their bush meat from the Mulobezi GMA, while 2.4% hunted it from the Kafue National Park (KNP). The study further showed that local illegal hunters were largely responsible for the game found on the market. Decline in wildlife populations has also been attributed to habitat fragmentation, excessive burning and competition with people around the dry season water points.

Gender

Inadequate water and sanitation has disproportionally large impacts on women in communities through health and time savings impacts. Time savings will result in additional productivity in the communities, felt especially by women and children who are usually tasked with fetching water. While it is difficult to quantify the value of one hour spent fetching water by children due to the fact that there is no obvious (monetary) opportunity cost to this time, increased productive time for children can be spent playing or studying for school, both with important long-run positive impacts on the labour force.

10.6 Risk analysis

There are a number of key risks to the successful implementation and operation of the scheme. These are outlined below.

10.6.1 Ability to pay

Communities currently have significantly limited ability to pay for infrastructure, although they demonstrate strong commitment to contributing to ongoing costs of the project. However, if they are able to convert the gains from the infrastructure into cash, then their ability to pay will increase dramatically. Marketing constraints are a challenge for most of the villages, as the villages are remote and sometimes a six hour walk to the nearest market. Thus, the infrastructure design should endeavour to keep ongoing costs of operating and maintaining the infrastructure low. Additionally, marketing opportunities should be investigated and supply chains strengthened in order to facilitate cash generation in the communities.

The affordability analysis demonstrated that even if enterprises take eight years to establish, or market access is significantly limited, communities should still be able to meet the ongoing costs of the scheme.

10.6.2 Site location and community buy-in

Community buy-in is an integral part of the success of a project of this nature, where successful utilisation and maintenance of the infrastructure depends on community collaboration (at least in terms of funding its ongoing costs). This is only possible if community members take ownership of the infrastructure. Four out of the six locations visited showed clear community buy-in for the location of the project site, while two of them had some outstanding issues.

1) There is some disagreement in the community as to whether to put the borehole and associated infrastructure at Kamwi village or at Mpengu village.
2) Mudobo is the proposed site for the sixth borehole, which was initially planned to be located at the site of a school. While it is suggested at this time that the site is put in Mudobo village, this decision must be made with full institutional buy-in.

10.6.3 Migration and natural resource damage

The Mulobezi GMA is a sensitive ecosystem – bordering the Kafue National Park, the area has pristine natural beauty, including wetlands and forests. However, these attributes are already attracting migration into the area, which is accompanied by land clearing, deforestation and poaching. While the local communities are in desperate need of improved water supply and a means of improving their livelihoods, there is the real risk that these improvements will encourage faster migration into the area. Until now, migration has been limited by water shortages, the hot climate and disease; however, investments may signal a means of overcoming these difficulties. Without adequate management of this ecosystem, the effect would be devastating.

10.6.4 Institutional arrangements

The successful implementation of the scheme involves the establishment of a water committee to oversee operation and maintenance of the infrastructure. Additionally, the communities must decide who is allocated land within the irrigated garden and how this should operate (as individual plots or collaboratively). There must also be land set aside for the project, which should be done without causing displacement in the communities.

These and other risks are presented in Table 30 below.

Table 30 **Key risks and proposed mitigation measures**

Risk	Mitigation
Acceptance of user fees in the community Risk level: High	Given that no user fees are currently levied for accessing water from the hand-pumps, it may be difficult to enforce the discipline of payment for water usage. CRIDF should work with the communities in establishing a water committee early on in the project who can take responsibility for sensitising the community to the idea. The council must ensure that user fees are affordable for community members, and sensitise the community on the need for regular payment for water usage, particularly for the O&M of the water infrastructure.
Financial sustainability during the O&M phase Risk level: Medium	Currently the communities have significantly limited ability to pay for the ongoing costs of the infrastructure. CRIDF must ensure that the technical design accounts for this and that market opportunities are explored. Additionally, water committees, who will be responsible for determining user fees and collecting them, should receive sufficient training in the institutional arrangements necessary for the successful operation of such a scheme (including how to deal with a household who will not or cannot pay). Fees are expected to meet expected O&M requirements at a minimum, as well as be affordable for the community. There may be potential to institute a differentiated tariff for the different consumer segments, such as those who use the irrigation, livestock or domestic components of the infrastructure.
Replacements of parts and skills required Risk level: Medium	There is a high risk that the skills or parts required to fix any part of the infrastructure are not available in the community. This is evidenced by the fact that there are a number of non-functioning boreholes in the area that have not been fixed since they broke. In order to mitigate these risks, it is necessary that the project design account for parts that are easy to access from Mulobezi, while ensuring that community members are taught how to fix the infrastructure themselves.

CRIDF

Risk	Mitigation
Migration and unsustainable use of natural resources in area Risk level: Medium	The Mulobezi GMA is a sensitive ecosystem – bordering the Kafue National Park, the area has pristine natural beauty, forests and virgin land. However, these attributes are already attracting migration into the area, which is accompanied by land clearing, deforestation and poaching. While the local communities are in desperate need of improved water supply and a means of improving their livelihoods, there is the real risk that these improvements will encourage even faster migration into the area. Until now, migration has been limited by water shortages, the hot climate and disease. However, investments into improving these services may signal additional support for such migration. Without adequate management of this ecosystem, the effect would be devastating. If the project goes to implementation phase, discussions must be held with TNC and ZAWA in the region to discuss this risk and to find sustainable ways to mitigate it.
Water availability to meet demand Risk: Medium	Detailed geotechnical studies should be conducted prior to procurement and implementation to confirm that there is sufficient water availability to meet demand. Additionally, pump tests to measure the yield of each proposed borehole should be done to make sure that monthly abstraction does not rise above the recommended level. Continual monitoring of groundwater yield from each proposed borehole should also be encouraged. Embark on a public awareness campaign if residents are using more water than the system is designed to cater for in order to control demand side pressures.
Conflict in site locations Risk: Low	During the site visit, Kamwi village was identified as a location that needs further discussion with community members to finalise the site location. Additionally, formal stakeholder buy-in for placing the site at Mudobo is necessary.
Project procurement strategy Risk: Low	Timely discussions with the District Council, KAZA and CRIDF to determine a modality of infrastructure delivery that meets procurement procedures and due diligence required to unlock grant funding is needed to maintain community support for the project.

10.7 Conclusions and recommendations

The KAZA area provides a valuable opportunity to demonstrate that livelihoods and wildlife can co-exist. However, challenges facing the area such as water scarcity have resulted in highly vulnerable communities and high HWC. The proposed design includes the implementation of permanent water supplies to six vulnerable communities and is associated with financial gains in the form of agricultural and livestock improvements.

Overall, the project is economically viable at both the 10% and 3.5% social discount rate. 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, it is concluded that there is sufficient socio-economic justification for the implementation of the project.

The 20-year financial CBA appraisal indicates that the financial returns from the project infrastructure are inadequate to cover the capital costs – that is, without any financial support the project is not financially viable. However, the project demonstrates strong operational sustainability – the additional revenue generated from the enhanced economic activity is sufficient to cover on-going annual O&M costs. With a minimum grant of GBP 94,484, the project therefore achieves financial viability, however given the immediate financial vulnerability of the communities, it is also recommended that the full capital expenditure of GBP 206,726 is funded by CRIDF, along with the sanitation and agricultural extension training programme (GBP 58,411). **It is therefore recommended that a total grant of GBP 265,137 be sourced and committed in order to successfully implement the project.**

11 Climate vulnerability and risk assessment

11.1 Introduction

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?

11.2 Scope of Review

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

Climate risk screening on the following project components (to be provided to six sites):

- Borehole, pump and tank with reticulation for potable water
- Water supply (from the boreholes) to develop small-scale irrigated gardens
- Fencing of garden(s)
- Small-scale irrigation equipment (hoses, sprinklers)
- 1 ha gardening plot
- Livestock watering trough (with reticulation from tank)

Identification of resilience benefits of the following project outcomes:

- Assured, quality water supply for potable water
- Assured water for small-scale irrigated gardens
- Fencing of garden(s)
- Livestock watering trough (with reticulation from tank)
- Extension sanitation support
- Extension inputs on gardening, conservation agriculture
- Extension of water infrastructure O&M

11.3 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.[26] The tool has been applied to this Project's six sites. Detailed findings from this application are outlined in Annex 6.

11.3.1 Climate Vulnerability Tool Indicators

Table 31 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 7.

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 31 **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	3.0 people per km^2
Household and community resilience	0.57 Moderately less resilient
Groundwater stress	Low (<1)
Upstream storage	Extremely low (<0.12)
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

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

The above indicators show that the Project is located in area where both *water risk under climate change* and *climate change pressures* are indicated as high. The results also indicate that the area suffers from medium to high *drought risks*, and extremely high *seasonal variability*, and the lack of accessible upstream storage exacerbates these problems.

The Project contributes to reducing drought risks by making effective use of groundwater resources for the local population.

11.4 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 Track 1 review makes use of CRIDF's regional projections and impact table to understand how the future climate change might impact the project.

Figure 25 Climatic Zones in SADC

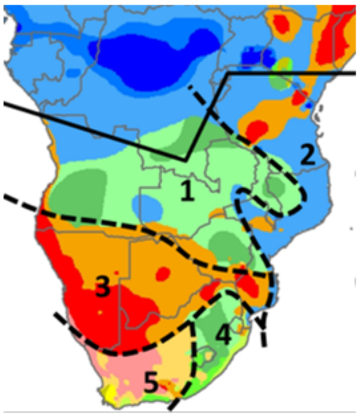


Figure 1: Climatic Zones in SADC

- **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.

11.5 Climate Trends Overview

The project falls under the boundaries between regions 1 and 3. If the ICTZ moves further north then it will most closely represent the conditions found in Region 3. The following impacts presented in **Table 32** have been identified.

Table 32 **Climate projections for project area (Region 3)**

Parameter	Impact by 2025	Impact by 2055
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°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°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.

Parameter	Impact by 2025	Impact by 2055
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. Lack of WASH is likely to lead to increased incidences of diarrhoea due to the lack of clean water.	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.

11.6 Review results

Following the review of the vulnerability indicators for the area and the climate trends, the Project Director lead an assessment to identify, at a high level, climate risks and resilience benefits of the project. This assessment was informed by findings from the work carried out by the Activity Lead, Economist and Sociologist – detailed earlier on in this report. The key individuals that were involved and informed this process and its outcomes are presented in the Table below.

Details on the results of this process are provided in the following two sections.

11.6.1 Climate Risks

The Project comprises of a number of physical 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 33 **Project components and climate threats**

Project component	Climatic threats
• Borehole, pump and tank with reticulation for potable water • Water supply (from the boreholes) to develop small-scale irrigated gardens • Fencing of garden(s) • Small-scale irrigation equipment (hoses, sprinklers) • 1 ha gardening plot • Livestock watering trough (with reticulation from tank)	• **Flood**: There is small flood risk in the area, likely to intensify with climate change • **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

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

Table 34 **Climate Risk Matrix**

Project component	Flood	Drought	Fire	Risk mitigation options
Borehole, pump and tank with reticulation	**Low**: Low exposure / not much flooding in the area	**High: Prolonged drought can reduce recharge rate of groundwater reservoirs and levels of sustainable yield**	**Low**: Some fires in the area but unlikely to impact infrastructure as area is clear	**Drought**: Explore what sustainable yields could look like depending on precipitation levels at the area under future climate change scenarios
Fencing of garden(s)	**Low**: Low exposure / not much flooding in the area	**Low**: Low sensitivity	**Medium**: Fire is prevalent in the area and wooden fencing materials could be damaged	**Fire**: Ensure that maintenance involves clearing vegetation a few meters each side of the fence
Small-scale irrigation equipment (hoses, sprinklers)	**Low**: Low exposure / not much flooding in the area	**Low**: Amount withdrawn from reservoir is very small compared to water available	**Low**: Some fires in the area but unlikely to impact infrastructure as area is clear	
1ha gardening plot	**Low**: Low exposure / not much flooding in the area	**High: Prolonged drought can reduce recharge rate of groundwater reservoirs and levels of sustainable yield**	**Low**: Some fires in the area but unlikely to impact infrastructure as area is clear	**Drought**: Explore what sustainable yields could look like depending on precipitation levels at the area under future climate change scenarios
Livestock watering trough (with reticulation from tank)	**Low**: Low exposure / not much flooding in the area	**Low**: Low sensitivity	**Low**: Some fires in the area but unlikely to impact infrastructure as area is clear	

11.6.2 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 35 **Project outcomes and resilience benefits**

Project outcomes	Resilience benefits
• Assured, quality water supply for potable water • Assured water for small-scale irrigated gardens • Fencing of garden(s) • Livestock watering trough (with reticulation from tank) • Extension sanitation support • Extension inputs on gardening, conservation agriculture • Extension of water infrastructure O&M	• Livelihoods • Safety • Health • Governance • Gender • Education

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

Table 36 **Climate Resilience Benefits Matrix**

Project component	Livelihoods	Safety	Health & nutrition	Governance	Gender	Education	Environment
Assured, quality water supply	**Medium:** Improved opportunities to generate livelihoods as a result of decreased time required to collect water	**High**: Less likely to have significant encounters with wildlife	**High**: Enables access to sufficient quantity and quality water, lower incidences of diarrhoea and water related diseases	**Medium**: Some level of community ownership and management in place for the programme	**High**: It will reduce burden of women to fetch water. Also water supply supports sanitation needs of women during menstruation	**High**: It will save time for children to go to school instead of fetching water	Not applicable
Irrigation	**Medium**: It enables a small amount of cash crop production / reduces need for alternative seasonal employment and increase of local social capital	Not applicable	**High**: increases the availability of more nutritious foods e.g. vegetables	**Medium:** The management of the water resources will be improved through developing a water users association	**Medium:** Most of the cultivation of the small garden plots will be undertaken by women	Not applicable	**Medium:** reduces reliance on rain-fed cropping, hence clearing large areas of land for crops, with associated erosion and soil loss.
Fencing of garden(s)	**High**: Increased production due to lower losses from wild animal damages	**High**: Less likely to have significant encounters with wildlife	**Medium**: side benefits of nutrition due to decreased production losses	Not applicable	Not applicable	Not applicable	Not applicable

Project component	Livelihoods	Safety	Health & nutrition	Governance	Gender	Education	Environment
Livestock watering trough (with reticulation from tank)	**Medium**: Increases livestock production and avoids losses due to climate shocks	**High**: Decreases likelihood of death of livestock due to wildlife encounters	**High**: Decreases likelihood of contamination of water supply / tap stands. Health impacts from lower wildlife/livestock disease transmission (contact)	Not applicable	Not applicable	Not applicable	**High:** manage livestock and grazing more effectively thereby reducing degradation in riverine areas and around natural water bodies.
1 yr. extension sanitation support	Not applicable	**Low**: Less likely to have significant encounters with wildlife from defecating in the bush	**High**: Lower incidence of diseases	**Low**: Community health clubs have been established	**Medium**: Women, who are usually tasked with hygiene and sanitation, are better equipped to manage issues	**Medium**: Less incidences of diseases mean children (especially girls) are more likely to attend school	Not applicable
1 yr. extension inputs on gardening, conservation agriculture	**Medium**: Increased production	Not applicable	**Medium**: Increased yields translate to higher nutritional value	Not applicable	Not applicable	Not applicable	**Medium:** Conservation agriculture comes with environmental benefits

11.7 Recommendations and Next Steps

The Track 1 CCRA identified a number of risks in relation to the associated infrastructure and risk mitigating actions to be taken by the project team. The Project Director is responsible for ensuring that the actions below are implemented.

11.7.1 Drought

Drought is a known and recurrent issue in the area and is likely to intensify with climate change which gives rise to the following risks:

- Prolonged drought can reduce recharge rate of groundwater reservoirs and levels of sustainable yield

11.7.1.1 Actions and Next Steps

- Explore what sustainable yields could look like depending on precipitation levels at the area under future climate change scenarios

11.7.1.2 Fire

Fire is a known and recurrent issue in the area and is likely to intensify with climate change (increased temperatures and drought) which gives rise to the following risks:

- Wooden fencing materials could be damaged from fires

11.7.1.3 Actions and Next Steps

- Ensure that maintenance involves clearing vegetation a few meters each side of the fence

12 Procurement Options

The scope of the KAZA Zambia project is very similar in nature and scale to those in Namibia and Zimbabwe; the experiences of procurement in these projects will inform the procurement strategy for KAZA Zambia, however the procurement strategy will be tailored to the situation in Zambia.

To move forward then, an acceptable project owner with a mandate in Zambia must first be identified. Secondly, an assessment must be undertaken to determine the finance route for the project. Since CRIDF is not proposing to provide capital for the KAZA Zambia projects an external funder must be identified to take the project forward to implementation. The chosen finance route will have a strong bearing on how a suitable in-country partner or contractor is selected to carry out the works.

On the first point, the KAZA Secretariat is already mandated to work across the five KAZA TFCA partner countries to facilitate project implementation and is the obvious body with whom to engage on this project. It should be noted that the KAZA Secretariat are not yet legally constituted and cannot therefore enter into legal contracts. However, the Peace Parks Foundation (PPF) have been mandated by the partner countries to act as a nominee signatory and custodial employer on behalf of the KAZA Secretariat. Under KAZA Phase 1, CRIDF entered into an Agreement with PPF and the KAZA Secretariat for provision of administrative support of CRIDF interventions in the KAZA TFCA in Namibia, thus providing a mandated entity through which CRIDF projects can be delivered. This Agreement thus provides the framework for engagement going forward and a potential financing route once a suitable funder has been identified.

At this stage it is too early to confirm the project finance route. Detailed discussions will be required with KAZA Secretariat, potential funders and others before this can be fully assessed and decided upon. This having been said it is likely that the procurement approach selected by an external funder will be used.

Initial engagements have been held with a number of potential funders for the CRIDF KAZA projects. Those which have expressed an interest following initial engagement include WWF, Global Environment and Technology Foundation (GETF) – a Coca Cola foundation, Coca-Cola South Africa and KfW. Further discussions will need to be held with these potential funders during the financial closure stage. In addition, and based on CRIDF experience, the CRIDF KAZA interventions in Zambia could be suitable for climate funding and especially the Green Climate Fund (GCF).

For Zambian Government procurement, from the time a procuring entity makes a decision to proceed to procurement until a contract is signed, it can generally take anything between one to two years. The process generally starts with a requisition for procurement from the user department and ends with contract signing following review and no-objection by the Ministry of Justice. The length of this process may not necessarily fit with CRIDF timelines. Parastatals and other State owned 'companies' may offer alternative and speedier routes that need to be explored. For KAZA, depending on the financier, ZAWA may be a preferred ultimate receipient of funding and ultimate owner of the infrastructure. This may allow CRIDF or other procurement process to be followed, with concomitant savings on time and integrity of the process.

A CRIDF team led by the Chief Engineer Leonard Magara will visit Zambia in early April to discuss procurement issues; it is planned to incorporate the outcomes of these discussions into the final bankability report for KAZA Zambia.

Annex 1: Climate data

Table 37 **Livingstone weather station data**

Month	Min Temp	Max Temp	Humidity	Wind	Sun	Rad	ETo	Rain	Eff rain
	°C	°C	%	km/day	hours	MJ/m²/day	mm/day	mm	mm
January	18.6	29	73	112	6	19.9	4.36	184	123.2
February	18.5	28.8	79	95	6	19.5	4.09	162	105.6
March	17.2	29.6	68	121	8	21.3	4.56	98	54.4
April	15	29.7	66	104	9	20.4	4.18	24	4.4
May	10.1	27.7	62	104	10	19.2	3.60	4	0
June	6.8	25	57	112	10	17.9	3.12	0	0
July	6.5	25	54	121	10	18.5	3.23	0	0
August	9.2	28.2	45	121	10	20.7	4.02	0	0
September	14.2	31.8	39	131	10	23.3	5.18	2	0
October	18.3	34.5	40	147	9	23.7	6.07	19	1.4
November	18.8	31.5	61	130	7	21.3	5.12	80	40
December	18.6	29.5	68	173	6	20	4.78	176	116.8
Average	14.3	29.2	59	123	8.4	20.5	4.36	749	445.8

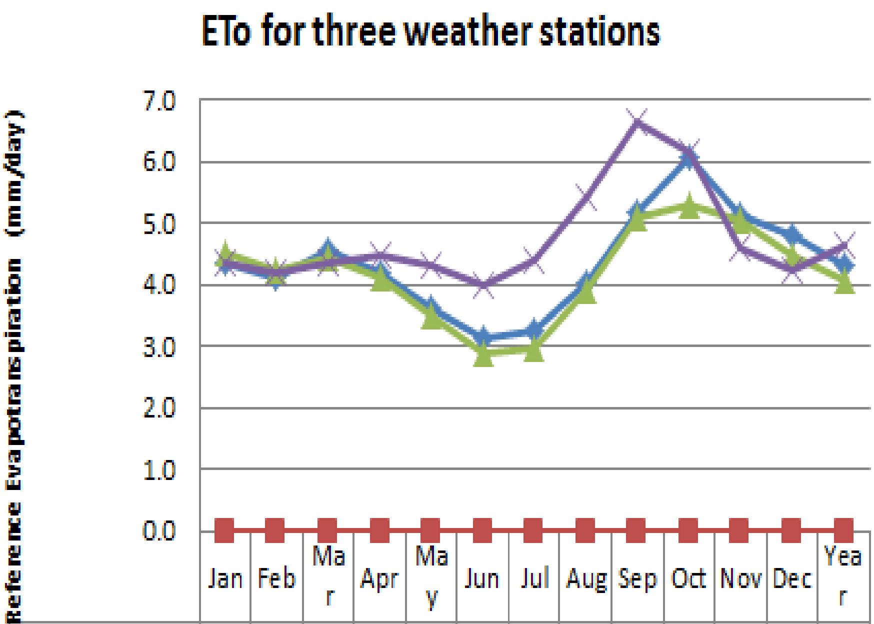
Table 38 **Sesheke weather station data**

Month	Min Temp	Max Temp	Humidity	Wind	Sun	Rad	ETo	Rain	Eff rain
	°C	°C	%	km/day	hours	MJ/m²/day	mm/day	mm	mm
January	18.1	30	79	95	7	21.5	4.52	170	112
February	18	30	74	95	6	19.5	4.24	172	113.6
March	16.6	29.7	74	112	8	21.4	4.44	99	55.2
April	13.8	29.8	70	95	9	20.5	4.10	25	5
May	7.7	28	70	95	10	19.3	3.50	1	0
June	3.8	25.3	67	86	10	18.0	2.88	3	0
July	3.5	25.8	63	86	10	18.6	2.95	0	0
August	5.8	29.1	53	112	10	20.8	3.92	0	0
September	10.8	32.8	42	121	10	23.4	5.07	3	0
October	16.6	35	46	86	9	23.7	5.30	26	5.6
November	18	31.8	63	130	7	21.3	5.06	61	26.6
December	18.3	30.3	73	112	6	19.9	4.46	166	108.8
Average	12.6	29.8	65	102	8.5	20.7	4.20	726	426.8

Table 39 **Mongu weather station data**

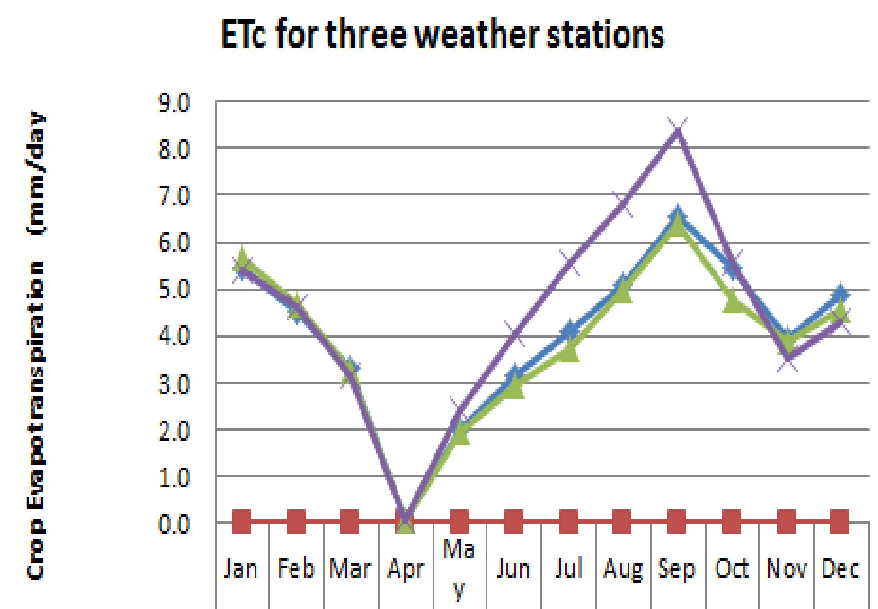
Month	Min Temp	Max Temp	Humidity	Wind	Sun	Rad	ETo	Rain	Eff rain
	°C	°C	%	km/day	hours	MJ/m²/day	mm/day	mm	mm
January	18.3	28.3	75	147	6	19.8	4.33	223	154.4
February	18.5	27.8	76	147	6	19.5	4.19	218	150.4
March	18	28.5	72	156	7	20	4.36	147	93.6
April	16	29.5	72	173	9	20.9	4.48	46	17.6
May	11.5	28.1	65	207	10	19.9	4.31	2	0
June	8.5	26.1	56	199	10	18.6	3.97	1	0
July	8.5	26.5	48	225	10	19.2	4.41	0	0
August	11.7	29.5	42	233	10	21.3	5.4	0	0
September	15.2	33	39	259	9	22.2	6.63	1	0
October	17.1	33.8	46	190	8	22.2	6.14	28	6.8
November	17.6	30.5	66	121	6	19.6	4.59	122	73.6
December	18.2	28.7	75	95	6	19.8	4.22	213	146.4
Average	14.9	29.2	61	179	8.1	20.3	4.75	1001	642.8

Figure 26 Sioma irrigation feasibility study: ETo for three weather stations



	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

Figure 27 Sioma irrigation feasibility study: ETc for three weather stations



	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

CRIDF

Annex 2: Gender equality and social inclusion

GENDER EQUALITY SOCIAL INCLUSION RATING OPERATIONS TABLE					
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	✓[27]		
		• Report findings of country/regional gender diagnostics (gender assessment, poverty assessment, etc.) relevant to project development objectives of components.	✓		
		• 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?	✓		
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**

[27] Financial and Economic Appraisal adequately covers poverty, social and economic impacts.

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	✓[28]		
		• 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	✕[29]		
If at least one check above (yes)				**YES**	**2**
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?	✓[30]		
		• 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)					**4**
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)				**10/12**

[28] Project has potential to strengthen women-specific activities such as gardening, which is an occupation for women.
[29] There are no distinct gender disparities. The Project will alleviate the burden of all members of the community.
[30] During hand over a Project monitoring and evaluation framework shall be developed and assign the responsibility of monitoring and collecting gender disaggregated data to the TNC, KDC and community representatives.

Annex 3: Ministry of Local Government and Housing – RWSS Community Application Form

MINISTRY OF LOCAL GOVERNMENT AND HOUSING
CHIPATA MUNICIPAL COUNCIL

COMMUNITY APPLICATION FORM

NATIONAL RURAL WATER SUPPLY AND SANITATION PROGRAMME
(For Communities /Institutions)

After filling in this form, send it to the Council either through the Area Development Committee or direct. (Please remember to retain one copy for the community/Institution).

SECTION A: GENERAL PROPOSAL DETAILS

1 Name of Community or Institution...

2 Date of Proposal: ……………………………………………………………………

3 Name and Position of Contact Person: ....

4. Address:………………………………………………………………………………
……………………………………………………………………………………..
……………………………………………………………………………………...

5 Tel …………………………….. ……. E-mail if any………………………………...

6. Date the Community Based Organisation or Institution was formed………………

7. Target Population / Number of Households:………………………………………

8. Province:……………………….…………District……………….……………………….
Ward………………………………………Constituency…………………………………
Chiefdom…………………………………..

9. Project Description:…………………………………………………………………

…………………………………………………………………………………………………
…………………………………………………………………………………………………
……………………………………………………………………………………………………
…………………………………………………………………………………………………..

SECTION B: SITUATION ANALAYASIS ON WATER SUPPLY

10. Describe the existing situation (tick as appropriate)

Source of water	Condition			Water Quality			Distance from the furthest Point
	Good	Fair	Poor	Good	Fair	Poor	
Borehole							

2

Protected well							
Shallow well							
River/Stream							
Dam							
Traditional wells							

Describe below in your own words the existing water situation in the community/institution:

____
____
____

SECTION C: PROJECT JUSTIFICATION

11. List the problems that have arisen in the community as a result of poor or inadequate water supply

____
____
____
____

12. What measures have been put in place to solve the problems?

____
____
____

13. List the prevalence rate of waterborne, water washed and water related diseases the last two years (obtain the rates from the nearest health centre)

____
____
____
____
____

SECTION D: PROJECT PROPOSAL PLANNING

14. Has the community held meeting(s) at which it was agreed that the project proposal should be done?

Yes ☐ No ☐

If yes, indicate in the table below the people that attended the meeting(s) and attach Minutes and attendance list(s):

Date	Participants				
	Adults		Youth (below 18 years)		Total
	Male	Female	Male	Female	
Any other follow-up meetings					
Total					

4

SECTION E: COMMUNITY ORGANISATIONS

15. Existing Community Groups and skills in relation to water supply

Community Group	Membership		Skills
	Male	Female	
Village Water Committees			
Area Development Committees			
Neighbourhood Health Committees			
Village Natural Resources Committees			
Village Environmental Groups			

SECTION F: COMMUNITY CONTRIBUTION/COMMITMENT

16. Has the community implemented and completed any project(s) in the past?
Yes ☐ No ☐

If yes explain when the project(s) was started, completed, total project cost and what was your contribution?

____
____
____
____

17. Are the community able and willing to meet the 5% (or prescribed unit rate for) community cash contribution?

Yes ☐

If Yes explain when the community is going to raise the expected contribution?

SECTION G: PROJECT SUSTAINABILITY

18. How is the community going to ensure that the facility will continue providing the services over its lifetime (10 - 20 years)?

____
____
____
____
____
____
____

SECTION H: ENVIRONMENTAL SCREENING

19. Indicate in the boxes below, whether the following areas of concern will (a) be negatively affected, (b) in which way and (c) how the effects will be reduced:

Area of concern	(a) YES or NO	(b)Possible ways in which area of concern will be affected	(c)Actions to be taken to reduce effect(s)
Schools			
Health centre			
Market and other shopping centres			
Farming fields			
Roads and streets			
Health of young people			
Health of the elderly			
Health of wild life			
Health of tamed animals			
Safety of water sources including rivers and lakes			
Forests			

CRIDF

HIV/AIDS			

SECTION I: FULL NAMES AND SIGNATURES OF ELECTED PROJECT COMMITTEE MEMBERS

20. Members representing the community or organisation applying for the Project should write their names, positions and signature in the table below:

Position	NAMES	Tick whether male (M) Or female (F)				SIGNATURE
		ADULT		YOUTH		
		M	F	M	F	
Chairperson						
Vice Chairperson						
Secretary						
Vice Secretary						
Treasurer						
Vice Treasurer						
Committee Member						
Committee Member						
Committee Member						
Committee Member						

Date:

____

Name of Chairman / Applicant

____

Signatory

____

Name of Secretary (if any)

____

Signatory

Completed application is to be delivered to the Area Development Committee or to be sent to Chipata Municipal Council, P.O. Box 510020 attention RWSS Coordinator

(For ADC use only) - Not to be filled by the community

SECTION J: VERIFICATION AND APPROVAL BY THE AREA DVELOPMENT COMMITTEE

Application received date: ……………………………………………………….

Discussed by ADC date: ………………………………………………………..

Members present in ADC pre-appraisal and resolution meeting:

Name	Position	Signature
____________	____________	____________
____________	____________	____________
____________	____________	____________
____________	____________	____________
____________	____________	____________
____________	____________	____________

Resolution:

____
____
____
____

Project recommended: Yes No

If No;

State the reasons that the project is not recommended:

____
____
____
____
____

____________________ ____________________
Chairman Secretary

Complete application to be sent to Chipata Municipal Council, P.O. Box 510020 attention RWSS Coordinator

(For D-WASHE use only) - Not to be filled by the community

SECTION K: APPROVAL BY THE D-WASHE COMMITTEE

Application received by Dir of Works date:…………………………………………

Discussed by D-WASHE date: ………………………………………………………..

Members present in D-WASHE resolution meeting:

Name	Position	Signature
___________________	___________________	___________________
___________________	___________________	___________________
___________________	___________________	___________________
___________________	___________________	___________________
___________________	___________________	___________________
___________________	___________________	___________________

Resolution:

____
____
____
____

Project recommended: Yes No

If No;

State the reasons that the project is not recommended:

____
____
____
____
____

____________________ ____________________
Council Secretary Secretary

(For Council use only) - Not to be filled by the community

SECTION L: APPROVAL BY THE PLANNING, WORKS AND DEVELOPMENT COMMITTEE

Presented for approval to PWDC date……..:………………………………………….

Project approved: Yes No (tick as appropriate)

If No;

State the reasons that the project is not recommended:

____

____

____

____

____

Council Secretary   Secretary to PWDC

SECTION M: APPROVAL BY FULL COUNCIL

Presented as part of a WSS development plan for full council approval

date……..:………………………………………….

Project approved: Yes No (tick as appropriate)

If No;

State the reasons that the project was excluded from the development plan:

____

____

____

____

____

Town Clerk   D-WASHE Secretary

Annex 4: Livestock

Table 40 **Estimated number of cattle in the project area**

	2016		2036	
Project site	No. households	No. cattle	No. households	No. cattle
Lyoni	44	176	79	316
Silangi	23	92	43	171
Munengo	65	260	116	463
Chinyama	39	156	70	282
Kamwi	60	240	107	427
Mudobo	34	136	62	247
Total	265	1,060	476	2,638

Annex 5: Financial and economic results

Table 41 **Summary results from appraisal**

GBP		Lyoni	Silangi	Munengo	Chinyama	Kamwi	Mudobo	OVERALL
FINANCIAL								
	F-NPV	-14 265	-22 257	-5856	-16 272	-7 620	-18 469	-84 739
	F-IRR	6.9%	3%	10%	6%	9%	5%	7%
	F-B/C	0.72	0.55	0.89	0.68	0.85	0.63	0.72
	F-N/K	0.82	0.63	1.01	0.78	0.97	0.73	0.83
ECONOMIC								
(10%)	E-NPV	58 629	17 287	100 995	48 801	91 174	38 638	355 517
	E-IRR	23.4%	15%	31%	21%	29%	19%	24%
	E-B/C	2.14	1.3	2.93	1.95	2.75	1.75	2.15
	E-N/K	2.49	1.6	3.39	2.27	3.20	2.04	3.21
(3.5%)	E-NPV	144 911	66 977	224 903	126 595	205 980	107 552	876 907
	E-IRR	23.4%	15%	31%	21%	29%	19%	24%
	E-B/C	3.53	2.2	4.9	3.21	4.56	2.88	3.55
	E-N/K	4.59	2.9	6.3	4.17	5.90	3.74	5.91

CRIDF

Table 42 **Snapshot of financial and economic appraisal**

Year		0	1	2	3	4	5	6	7	8	9	10
COSTS												
Capital Expenditure		206 726										
Recurrent costs arising		-	-	-	6 397	6 397	6 397	6 397	6 397	6 397	6 397	6 397
Agricultural extension		29 791										
Sanitation		28 620										
TOTAL COSTS		**265 137**	-	-	**6 397**	**6 397**	**6 397**	**6 397**	**6 397**	**6 397**	**6 397**	**6 397**
BENEFITS												
Irrigated agriculture		-	**12 559**	**12 559**	**12 559**	**12 559**	**12 559**	**12 559**	**12 559**	**12 559**	**12 559**	**12 559**
Lyoni		-	2 093	2 093	2 093	2 093	2 093	2 093	2 093	2 093	2 093	2 093
Silangi		-	2 093	2 093	2 093	2 093	2 093	2 093	2 093	2 093	2 093	2 093
Munengo		-	2 093	2 093	2 093	2 093	2 093	2 093	2 093	2 093	2 093	2 093
Chinyama		-	2 093	2 093	2 093	2 093	2 093	2 093	2 093	2 093	2 093	2 093
Kamwi		-	2 093	2 093	2 093	2 093	2 093	2 093	2 093	2 093	2 093	2 093
Mudobo		-	2 093	2 093	2 093	2 093	2 093	2 093	2 093	2 093	2 093	2 093
Livestock production (milk, animals, and better quality animals)		-	**6 928**	**8 196**	**9 540**	**10 847**	**12 191**	**13 575**	**15 073**	**16 571**	**18 108**	**19 645**
Lyoni		-	1 130	1 323	1 553	1 784	2 014	2 245	2 475	2 706	2 975	3 244
Silangi		-	617	732	848	963	1 078	1 232	1 347	1 501	1 654	1 770
Munengo		-	1 700	2 007	2 315	2 622	2 968	3 314	3 659	4 044	4 389	4 774
Chinyama		-	1 000	1 192	1 423	1 615	1 807	1 999	2 229	2 460	2 690	2 921
Kamwi		-	1 590	1 859	2 166	2 435	2 743	3 050	3 396	3 703	4 049	4 395
Mudobo		-	890	1 082	1 236	1 428	1 582	1 735	1 966	2 158	2 350	2 542
TOTAL BENEFITS		-	**19 487**	**20 755**	**22 099**	**23 406**	**24 750**	**26 133**	**27 632**	**29 130**	**30 667**	**32 204**
Net revenues		**-265 137**	**19 487**	**20 755**	**15 703**	**17 009**	**18 354**	**19 737**	**21 235**	**22 733**	**24 270**	**25 807**
NPV	**-84 739**											
IRR	**7%**											
BCR	**0.72**											
N/K ratio	**0.83**											

ECONOMIC COSTS												
COSTS												
Capital Expenditure		206 726										
Recurrent costs arising		-	-	-	6 397	6 397	6 397	6 397	6 397	6 397	6 397	6 397
Agricultural extension		29 791										
Sanitation		28 620										
TOTAL EXPENDITURE		**265 137**	**-**	**-**	**6 397**	**6 397**	**6 397**	**6 397**	**6 397**	**6 397**	**6 397**	**6 397**
ECONOMIC BENEFITS												
BENEFITS												
Agriculture												
Irrigation gains		-	**12 558**	**12 558**	**12 558**	**12 558**	**12 558**	**12 558**	**12 558**	**12 558**	**12 558**	**12 558**
Lyoni		-	2 093	2 093	2 093	2 093	2 093	2 093	2 093	2 093	2 093	2 093
Silangi		-	2 093	2 093	2 093	2 093	2 093	2 093	2 093	2 093	2 093	2 093
Munengo		-	2 093	2 093	2 093	2 093	2 093	2 093	2 093	2 093	2 093	2 093
Chinyama		-	2 093	2 093	2 093	2 093	2 093	2 093	2 093	2 093	2 093	2 093
Kamwi		-	2 093	2 093	2 093	2 093	2 093	2 093	2 093	2 093	2 093	2 093
Mudobo		-	2 093	2 093	2 093	2 093	2 093	2 093	2 093	2 093	2 093	2 093
Livestock production (milk, animals, and better quality animals)		-	**8 048**	**10 472**	**13 042**	**15 539**	**18 110**	**20 753**	**23 618**	**26 482**	**29 419**	**32 357**
Lyoni		-	1 306	1 673	2 113	2 554	2 995	3 435	3 876	4 317	4 831	5 345
Silangi		-	722	942	1 163	1 383	1 603	1 897	2 117	2 411	2 705	2 925
Munengo		-	1 980	2 568	3 155	3 743	4 404	5 065	5 726	6 460	7 121	7 855
Chinyama		-	1 140	1 507	1 948	2 315	2 682	3 049	3 490	3 931	4 371	4 812
Kamwi		-	1 870	2 384	2 972	3 486	4 074	4 661	5 322	5 910	6 570	7 231
Mudobo		-	1 030	1 397	1 691	2 058	2 352	2 646	3 086	3 454	3 821	4 188
Time savings		-	**24 519**	**25 267**	**26 031**	**26 795**	**27 592**	**28 406**	**29 253**	**30 150**	**31 047**	**31 944**
Lyoni		-	4 070	4 186	4 319	4 452	4 585	4 718	4 851	5 000	5 150	5 299
Silangi		-	2 143	2 209	2 276	2 342	2 409	2 492	2 575	2 658	2 741	2 824
Munengo		-	5 997	6 180	6 362	6 545	6 744	6 944	7 143	7 359	7 575	7 791
Chinyama		-	3 605	3 721	3 837	3 954	4 070	4 186	4 319	4 452	4 585	4 718
Kamwi		-	5 548	5 714	5 881	6 047	6 229	6 412	6 595	6 794	6 994	7 193
Mudobo		-	3 156	3 256	3 356	3 455	3 555	3 655	3 771	3 887	4 003	4 120
Health savings		-	**7 525**	**7 754**	**7 989**	**8 223**	**8 468**	**8 718**	**8 978**	**9 253**	**9 529**	**9 804**
Lyoni		-	1 249	1 285	1 326	1 366	1 407	1 448	1 489	1 535	1 580	1 626
Silangi		-	658	678	698	719	739	765	790	816	841	867
Munengo		-	1 840	1 897	1 953	2 009	2 070	2 131	2 192	2 259	2 325	2 391
Chinyama		-	1 106	1 142	1 178	1 213	1 249	1 285	1 326	1 366	1 407	1 448
Kamwi		-	1 703	1 754	1 805	1 856	1 912	1 968	2 024	2 085	2 146	2 208
Mudobo		-	969	999	1 030	1 060	1 091	1 122	1 157	1 193	1 229	1 264
Total economic benefits		-	**52 650**	**56 051**	**59 620**	**63 116**	**66 728**	**70 436**	**74 407**	**78 443**	**82 553**	**86 663**
10% Net revenues		-265 137	52 650	56 051	53 223	56 719	60 331	64 039	68 010	72 047	76 157	80 267
NPV	355 517											
IRR	0.24											
BCR	2.15											
N/K ratio	3.21											
3.5% Net revenues		-265 137	52 650	56 051	53 223	56 719	60 331	64 039	68 010	72 047	76 157	80 267
NPV	876 907											
IRR	0.24											
BCR	3.55											
N/K ratio	5.91											

Annex 6: Climate Vulnerability Mapping Tool Analysis

CRIDF Climate Resilience Strategy

According the CRIDF Climate Resilience Strategy (Activity, formerly 1985):

"All infrastructure supported through the Facility will build 'climate resilience', [while] ensuring that it remains viable for its intended purposes both in extreme events such as extended droughts (or longer dry seasons) as well as being able to cope with potentially higher floods, and as a result of longer term climate trends. To practically deliver on this a coherent approach is needed to integrate climate resilience into CRIDF."

CRIDF aims to mainstream climate resilience into its infrastructure planning and the development. This is part of the wider CRIDF programme which is grounded in the water situation in SADC, summarised in the CRIDF's "Projects to Peace" document. Principles 7 and 8 (based on the IPCC definition of climate vulnerability) relate directly to climate resilience and provide the basis to integrate climate resilience into CRIDF at the activity, project and programme level. To select and deliver projects and technical assistance to achieve such objectives, CRIDF has developed a Water Security and Climate Resilience Framework.

CRIDF has developed a climate vulnerability assessment tool to identify the vulnerability to climate change at project sites and to crosscheck that all elements of proposed infrastructure projects and their implementation, in address climate change. If the project is not adequately responding to the assessed climate vulnerability, the tools helps the project propose practical low cost options to address this.

The nature of CRIDF's interventions are such that they take place at a particular location and that means the vulnerability assessment requires a tool that is able to capture as close as possible what is happening at that location. Furthermore the tool needs to say something more than just the level of vulnerability (Low/Medium/High), the assessment tool needs to identify the pertinent vulnerability indicators in terms of scale and location. For example, what is the point of having Coastal elevation weighted at 20% as one of your vulnerability indicators when you are assessing a project site in a landlocked country?

The CRIDF Climate Vulnerability Assessment Tool is an innovative, cost effective and user friendly, aid to the strategic planning of climate change resilient infrastructure developments in southern Africa andis available on-line at: http://geoservergisweb2.hrwallingford.co.uk/CRIDF/CCVmap.htm

The tool however, is restricted in a number of ways:

- It is based on limited data that often is not nuanced enough
- The tool does not inform on extreme events and longer-term variability in the climate (i.e. climate hazards), nor vulnerabilities at each site, nor Project infrastructure's exposure to the identified hazards.
- The tool draws on a derived proxy indicator that is a combination of two Representative Concentration Pathways (RCPs), when a range of scenarios ideally is needed to order to plan for extremes.

Objective of the Assessment

An assessment must be undertaken to establish how and to what extent the project builds resilience amongst those most vulnerable to the impacts of climate change. The following details must be recorded:

- Demographic or social trends and/or projections that are likely mitigate or exacerbate the identified vulnerability;
- The adaptive capacity of the population considered vulnerable, including their socio-economic status; and
- The way in which the project Activities will reduce the identified vulnerability and increase the resilience of the beneficiaries.

Project Rationale

The primary objective of the project is to establish permanent water provision for communities whose livelihoods are stressed by unreliable, inadequate water supplies and by HWC, which is exacerbated by the need to move livestock long distances to water. In addition to this, the project will also improve the livelihood of members of the community through a range of benefits which include health improvements, crop and livestock gains, climate resilience and time savings. Time savings and health impacts have a concentrated impact on the livelihoods of women and children, thus having a strong impact on gender equality in these vulnerable communities. To this end, water infrastructure for seven communities in the area has been suggested.

Specifically, the project scope entails the following activities:

- drilling of new boreholes to a depth of at least 50 meters and fitting them with solar pumps;
- provision of limited water reticulation infrastructure from the water source to delivery points for domestic use, livestock watering and irrigated gardens;
- provision of small (1 ha) fenced community vegetable gardens that will derive water from the developed water sources;
- promotion of appropriate latrines to improve the sanitation of the communities;
- promotion of and improving the understanding of the need for improved hygiene; and
- support services to improve agricultural production from the irrigated plots and to improve the communities understanding and use of sanitation and hygiene.

Climate resilience vulnerability assessment

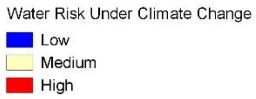
The CRIDF vulnerability assessment tool is made up of an explicit set of spatial data that represent the key components of climate risk for CRIDF. Data layers included in the assessment tool are Baseline water stress; Inter-annual variability; Seasonal variability; Flood occurrence; Drought severity; Upstream storage; Groundwater stress; Future risk to people; Water risk under climate change; climate change pressure; Baseline risk to people; Resilient population; Population density; and Household and community resilience.

Table 43 below shows the results of the vulnerability assessment for KAZA according to each defined indicator:

Table 43 **Climate resilience indicators**

Indicator	Legend	Outcome
Baseline Water Stress	Baseline Water Stress 1. Low (<10%) 2. Low to medium (10-20%) 3. Medium to high (20-40%) 4. High (40-80%) 5. Extremely high (>80%) Arid & low water use No data	Low (<10%)
Inter-annual variability	Interannual Variability 1. Low (<0.25) 2. Low to medium (0.25-0.5) 3. Medium to high (0.5-0.75) 4. High (0.75-1.0) 5. Extremely high (>1.0) No data	Low to medium (0.25-0.5)
Seasonal variability	Seasonal Variability 1. Low (<0.33) 2. Low to medium (0.33-0.66) 3. Medium to high (0.66-1.0) 4. High (1.0-1.33) 5. Extremely high (>1.33) No data	Extremely High (>1.33)
Flood Occurrence		No Data
Drought Severity	Drought Severity 1. Low (<20) 2. Low to medium (20-30) 3. Medium to high (30-40) 4. High (40-50) 5. Extremely high (>50) No data	Medium to high (30-40)
Upstream Storage	Upstream Storage 1. High (>1) 2. High to medium (1-0.5) 3. Medium to low (0.5-0.25) 4. Low (0.25-0.12) 5. Extremely low (<0.12) No data No major reservoirs	Extremely low (<0.12)

Groundwater Stress	Groundwater Stress 1. Low (<1) 2. Low to medium (1-5) 3. Medium to high (5-10) 4. High (10-20) 5. Extremely high (>20) No data	Low (<1)
Household and community resilience	Household & Community Resilience Least resilient Less resilient Moderately less resilient Moderately more resilient More resilient Most resilient	0.57 Moderately less resilient
Population density	Population density (people per sq km) 1 - 2 3 - 4 5 - 7 8 - 12 13 - 22 23 - 47 48 - 100	3.0 (people per km^2)
Resilient Population	Resilient Population Low Medium High	Medium
Baseline Risk to People	Baseline Risk to People Very low Low Medium High Very High	Medium
Climate Change Pressure	Climate Change Pressure Very low Low Medium High Very High	High

Water Risks Under Climate Change		High
Future Risks to People		Moderately high

KAZA Development of Water Infrastructure: Zambia

Below the results of the assessment are discussed by each indicator.

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/m^2 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.

What this means for the 6 project sites is that for the amount of available blue water and the water withdrawals, there is **Low** stress. There is enough available blue water, and it is a matter of getting it out. Nonetheless, this intervention will improve the water security and climate resilience for the villages in question by making more water available to the 6 villages, and decreasing the amount of water withdrawals.

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. What this means for the Kaza project area - 6 project sites in question - is that there is a huge variation in terms of total available water supply annually, hence the **Low to Medium** result. Which indicates that historically, year in year out the amount of available water supply has been varies considerably.

Seasonal variability

This indicator is the 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.

The seasonal variability in terms total blue water for the 6 project sites is **Extremely High** – which means plenty of water during the rainy season followed by little or no water during the dry season. That means water resources have to be used carefully during times of plenty in order to make them last the entire year. That means careful management of storage facilities – which in this case broadly mean making sure that the aquifer is managed properly. Furthermore, that means catchment management becomes important in order to mitigate against the estimates variances between the mean monthly values.

Flood Occurrence

This indicator refers to the number of flood occurrences (1985-2011). Flood counts are calculated by intersecting hydrological units with estimated flood extent polygons.

For the project area there was no data available.

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.

Tied to inter-annual severity – which is **Medium to high** – the drought severity indicator means that there are times of water stress – that requires careful planning and well executed interventions.

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.

There are no significant storage facilities upstream from the 6 project sites, in this case the indicator is **Extremely low** – except for a few tanks. Any variation in the water supply due to floods, droughts, etc. means that they are exposed to even more vulnerability.

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.

The project area has **Low** groundwater stress – the value is less than 1. That means that the aquifer is recharged adequately during the rainy season and that the amount of water withdrawals are sustainable.

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.

In the event of a natural hazard event, people and communities that are already sick or undernourished, that lack access to water and health care, and that have low levels of education are more likely to experience problems than those that are healthy and well-fed, with adequate access to water, health services, and education.The households/community in the 6 project sites are **Moderately less resilient**, which means that any intervention that improves their access to water and sanitation will improve their vulnerability.

Population density

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

The vulnerability assessment includes population density as one of the key sources of vulnerability. When natural hazard events occur in densely populated areas, the impact is likely to be more severe than it would be in areas with fewer people. The population density for the 6 project sites is **3.0** (people per km^2), which means that any climate change risks are likely to be less acute than in a densely populated area. Nonetheless, any increase in population density, the sudden population shift may put further strain on local systems.

Resilient Population

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

Whether or not individuals experience the worst effects of climate related hazards will partially depend on the quality of governance in the country in which they live. Government support can enable communities to prepare for and adapt to the expected impacts of climate change and can help them respond when climate related disasters do occur. The resilient population vulnerability indicator for the 6 project sites is **Medium**. This indicator aims to capture this dimension by including a variety of measures, including government responsiveness, government response capacity, openness to external assistance, and political stability. This intervention, which is partly through external assistance means that this indicator is likely to stay the same or even improve.

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. The baseline risk to people for the 3 project sites is **Medium** – this is mainly because of the low population density for the project area.

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.

The climate change pressure for the 6 villages is **High**. By investing in water infrastructure in order to improve resource use, availability, this intervention is likely to mitigate against the climate change pressures due to changes in average rainfall and temperature.

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.

The water risk under climate change for the 6 project sites is **High**. What this means is that with the anticipated climate change pressure together with the amount of physical water available, the 6 project sites will face water risks in the future. This intervention, by improving the amount of physical water available has the potential to push this vulnerability indicator even lower.

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.

The future risks to people indicator for the 6 project sites is **Moderate -** this intervention has the potential to push that even lower through decreasing the baseline risk to people, and increasing the amount of physical water available.

Conclusion

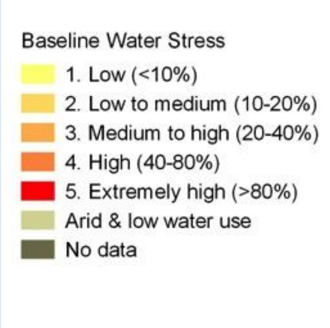
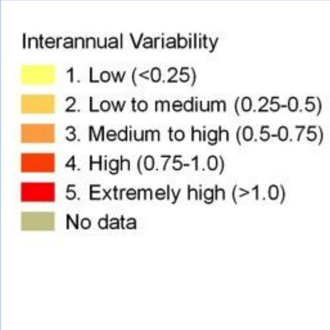
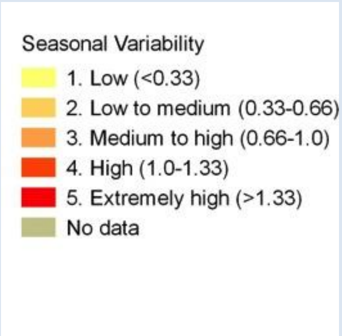
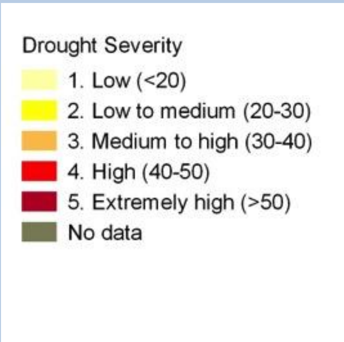
As mentioned earlier these are the main interventions for this project, aimed to improve livelihoods through the provision of domestic and livestock water supply, as well as small garden irrigation facilities in the following village locations in Moomba community, Mulobezi GMA, Southern Province, Zambia.

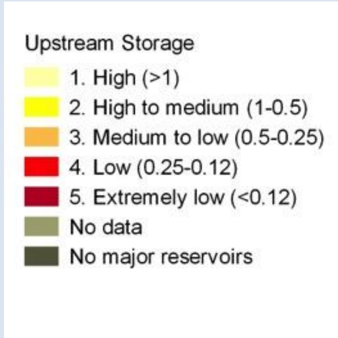
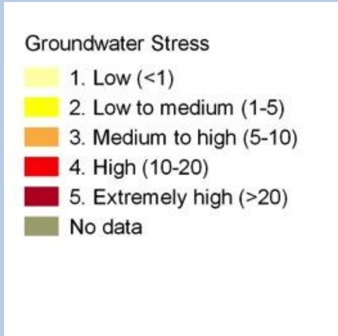
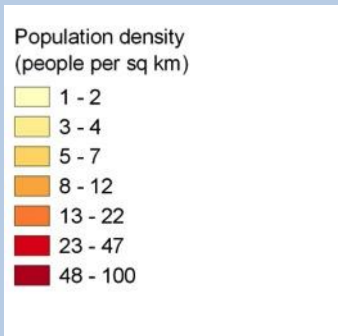
- drilling of new boreholes to a depth of at least 50 meters and fitting them with solar pumps;
- provision of limited water reticulation infrastructure from the water source to delivery points for domestic use, livestock watering and irrigated gardens;
- provision of small (1 ha) fenced community vegetable gardens that will derive water from the developed water sources;
- promotion of appropriate latrines to improve the sanitation of the communities;
- promotion of and improving the understanding of the need for improved hygiene; and
- support services to improve agricultural production from the irrigated plots and to improve the communities understanding and use of sanitation and hygiene.

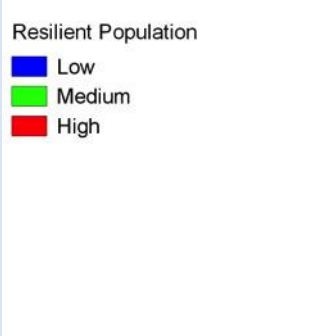
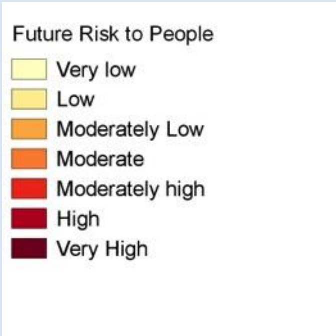
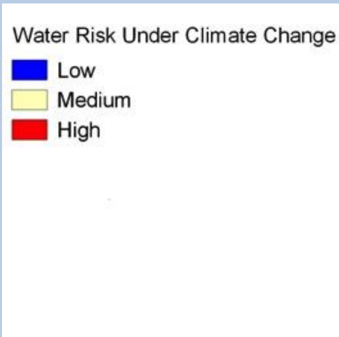
The overarching result of the assessment is that the planned interventions – broadly water supply and storage together with sanitation improvements and agricultural extension work - for the 6 project sites directly address climate change vulnerabilities, and improve the livelihood of members of the community. The planned interventions to the 6 project sites villages directly address the following vulnerabilities:

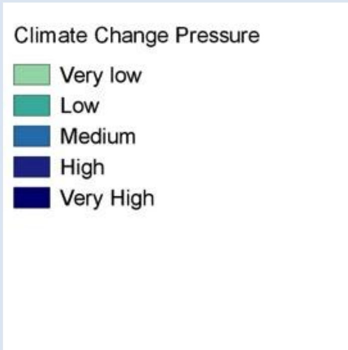
- Seasonal and Inter-annual variability;
- Extremely low upstream storage
- Drought severity;
- Future risk to people;
- Water risk under climate change;
- Climate change pressure.

Annex 7: CRIDF Climate Vulnerability Tool Risk Indicators

Risk indicator	Comments	
Baseline Water Stress	This indicator is based on WRI's Aqueduct 2.0 dataset and 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. It provides an overview of the water stress situation at a country or area in cases where the dataset underpinning the stress level has enough granularity.	
Inter-annual variability	This indicator is based on WRI's Aqueduct 2.0 dataset and measures the variation in water supply between years. This indicator is useful for understanding risks particularly to agriculture. High inter-annual variability creates difficulties in managing water resources in low water availability periods and can create stresses to ecosystems.	
Seasonal variability	This indicator is based on WRI's Aqueduct 2.0 dataset and measures variation in water supply between months of the year. The higher this indicator the less reliable water supply can be expected during any given a year. High seasonal variability can have negative implications for steady water supply for households and year round agriculture particularly when rain-fed. This indicator can be helpful to characterise drought risks for rain-fed agriculture.	
Drought severity	This indicator is based on WRI's Aqueduct 2.0 dataset and measures drought severity calculated as the average length of droughts times the dryness of the droughts. It includes data from 1901 to 2008. This indicator can be taken into account to characterise drought risk in an area.	

Upstream storage	This indicator is based on WRI's Aqueduct 2.0 dataset and 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	This indicator is based on WRI's Aqueduct 2.0 dataset and measures the ratio of groundwater withdrawal relative to its recharge rate over a given aquifer. Higher values indicate areas where unsustainable groundwater consumption could affect groundwater availability and groundwater-dependent ecosystems. This indicator can be taken into account to characterise water availability risk at an area that is mainly dependent for groundwater for its water supply needs.	
Household and community resilience	This indicator is based on the Climate security vulnerability model by the Robert S. Strauss Centre and combines data on physical, socio-economic, demographic, and political insecurities to provide an indication on household and community vulnerability to climate change. It can be taken into account when characterising impacts to local communities. The lower the resiliency the higher the consequence can be expected for any given impact. Most resilient communities can withstand a 20% crop loss, however this can be catastrophic for the least resilient.	
Population density	This Population density index is based on the Climate security vulnerability model by the Robert S. Strauss Centre. This indicator can be taken into account when trying to understand H&S impacts to local communities from extreme weather events.	

Resilient population	HR Wallingford has developed this indicator by combining population density, the CCAPS governance layer and the CCAPS household and community resilience layer. It can be taken into account when characterising impacts to local communities. The lower the resiliency the higher the consequence can be expected for any given impact. Highly resilient communities can withstand a 20% crop loss, however this can be catastrophic for the least resilient.	
Baseline risks to people	HR Wallingford has developed this indicator by combining the resilient population layer and the AQUEDUCT physical water quantity risk.	
Future risks to people	HR Wallingford has developed this indicator by combining the baseline risks to people layer, the climate change pressure layer and the physical water risk layer.	
Water risk under climate change	HR Wallingford has developed this indicator by combining the climate change pressure layer and the physical water risk layer.	

Climate change pressure	HR Wallingford has developed this indicator by 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.	

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