CHALLENGES AND OPPORTUNITIES IN DEVELOPING OFF-GRID MINI HYDROPOWER PROJECTS IN ZAMBIA

By

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LUSAKA

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DECLARATION

I, **Edmond Mkumba**, do hereby declare that this dissertation is the result of my own research work and that it has not previously been submitted for a degree, diploma or other qualification at this or another University.

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APPROVAL

This dissertation of Edmond Mkumba is approved as fulfilling the partial requirements for the award of the Degree of Master of Engineering in Project Management at the University of Zambia.

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ABSTRACT

Mini hydropower plays a critical role in providing energy access to remote areas through mini-grids. However, the development of mini hydropower sites has lagged in Zambia with the country only witnessing the construction of two off-grid mini hydropower stations namely, Zengamina and Shiwan'gandu Mini Hydropower Stations in Ikeleng'e and Shiwan'gandu Districts respectively in the last 30 years. The research was undertaken to identify the challenges and opportunities including development of a strategy for implementing off-grid mini hydropower projects in Zambia. The research was designed in such a way that both qualitative and quantitative data were captured. The sampling method used was purposive sampling where experts mainly from the energy sector were targeted representing policy makers, developers, implementing agencies, consultants and regulators among others. Critical challenges identified included high initial investment cost, limited funding, long procedures for obtaining the necessary permits and licenses, low electricity tariffs to encourage private sector participation, lack of skills in the local Zambian contractors and limited market for the power generated. Opportunities included Zambia's relatively stable political climate, availability of significant hydropower potential, government's willingness to migrate towards cost reflective tariffs and presence of the required institutional and legal frameworks. High initial investment cost was the most critical challenge in developing off-grid mini hydropower projects in Zambia while the greatest opportunity was the presence of the relatively stable political climate followed by the presence of significant hydropower potential. Following the challenges identified and the opportunities that exist, a strategy for implementing off-grid mini hydropower projects was formulated with integrated planning as the starting point of the strategy. It is also recommended that the government through the institutions overseeing mini hydropower development embraces integrated planning and develop a mini hydropower framework and master plan to guide the actual development of such projects in Zambia. Development of off-grid mini hydropower projects would contribute to increasing the electricity access rate in rural areas which stands at 4.4% as at 2015.

Keywords: *rural area; electricity; access; strategy; funding*

DEDICATION

This dissertation is dedicated to my lovely son Edmond Bukata Mkumba and my lovely daughter, Emmanuella Chikonjiwe Mkumba as an encouragement for them to excel in their studies and achieve more than I have done.

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ACRONYMS

BOO	Build Own Operate
BOT	Build Operate Transfer
CAPEX	Capital Expenditure
CoSS	Cost of Service Study
CSO	Central Statistical Office
DOE	Department of Energy
E&M	Electro and Mechanical
EPC	Engineering, Procurement and Construction
ERB	Energy Regulation Board
ESIA	Environmental and Social Impact Assessment
FS	Feasibility Study
HFO	Heavy Fuel Oils
HPP	Hydro Power Plant
IEA	International Energy Agency
ICOLD	International Commission on Large Dams
ICSHP	International Centre for Small Hydro Power
IRENA	International Renewable Energy Agency
IRR	Internal Rate of Return
kW	Kilo Watts
LHPC	Lunsemfwa Hydropower Company
MEWD	Ministry of Energy and Water Development
MW	Mega Watts
NPV	Net Present Value
OECD	Organisation for Economic Co-operation and Development
O&M	Operation and Maintenance
OPEX	Operational Expenditure
OPPPI	Office for Promoting Private Power Investment
PFS	Pre- Feasibility Study
PPP	Public Private Partnership
PV	Photovoltaic
RGC	Rural Growth Centre

REA	Rural Electrification Authority
REEL	Renewable Energy and Energy Efficiency Law
REMP	Rural Electrification Master Plan
SADC	Southern African Development Community
SHP	Small Hydro Power
UNDP	United Nations Development Programme
UNIDO	United Nations Industrial Development Organisation
USACE	United States Army Corps of Engineers
ZDA	Zambia Development Agency
ZPCL	Zengamina Power Company Limited

CHAPTER 1: INTRODUCTION

1.1 Background

Access to electricity is key to rural development. Mini hydropower plays a critical role in providing energy access to remote areas through mini-grids (Klunne, 2013). Yah et al., (2017) argues that 2.4 billion people worldwide still rely on traditional biomass for cooking and 1.6 billion people do not have access to electricity. Further, it is stated that around 550 million people in the world will remain without any access to electricity in 2040 with most of them mainly residing in Sub-Saharan Africa (OECD/IEA, 2015). In Zambia, electricity access rate is at 31.2%, with urban access rate at 67.7% while rural electricity access rate is at 4.4% and 7.4% for grid and solar photovoltaic systems respectively (CSO, 2015).

Considering that over 58.2% (CSO, 2015) of the population in Zambia is estimated to be rural based, the provision of modern energy services in rural areas will play a pivotal role in improving the living standards of the people residing in rural areas. One technological option for electrifying the rural areas that are far from the national electricity grid is the development of mini hydropower stations where hydropower potential exists.

It is argued that small and large hydropower projects are the most important renewable energy projects for electrical power production worldwide as they provide 19% of the planet's electricity (Sachdev et al., 2015). Further, it is argued that small hydropower is best in terms of its suitability for off-grid and remotely located sites having negligible impact on local environment, smaller investment, short gestation period, grid isolated power solution and less conflict with social issues (Kumar, 2007). Most countries in the world have made hydropower development a priority in the quest to expand their energy sectors as a result of the ever-increasing demand for energy and global climate change (UNIDO and ICSHP, 2016). It is estimated that globally, around 19% of the hydropower potential has been developed and countries which have actively developed hydropower use around 60% of their potential (OECD/IEA, 2010).

Zambia is endowed with significant renewable energy potential, with approximately 6,000 MW hydropower potential, of which only 2,388.3MW represents total installed capacity as at 2016 (ERB, 2017). The total installed capacity of small hydropower in Zambia was estimated at 31 MW (Liu et al., 2013).

Despite mini hydropower plants being the most preferred option for electrifying rural areas far from the grid, little is known about the actual challenges and opportunities in developing off-grid mini hydropower projects in Zambia. It was therefore the aim of this study to assess the challenges and opportunities in developing off-grid mini hydropower projects in Zambia and develop an appropriate strategy for project development.

The classification of hydro power plants depends on the country in question as there was no internationally adopted standard. In India for example, hydropower projects are classified based on their generation capacity as per Table 1.1 below (Ullah, 2015):

Table 1.1: Classification of hydropower projects in India

SN	CLASSIFICATION	GENERATION CAPACITY
1	Pico	5kW and below
2	Micro	100kW and below
3	Mini	1000kW and below
4	Small	25,000kW and below
5	Medium	100,000kW and below
6	Large	Above 100,000kW

Source: Ullah, (2015)

According to the International Hydropower Association, the upper limit for a small hydropower plant in China is 50MW. In Zambia and the world at large, there is no internationally agreed classification of hydropower projects and as such for this study, mini hydropower will be used interchangeably with small hydropower to represent capacities between 101kW and 10MW. The upper limit value of 10MW is becoming more generally accepted for mini hydropower projects, especially in the European countries (Jaber, 2012).

The development of hydropower projects involves seven phases with the following project development activities from a developer’s perspective which include site identification, pre-feasibility study, feasibility study, financing/contracts, detailed design, construction and commissioning (Fichtner Management Consulting AG, 2015) as per Figure 1.1.

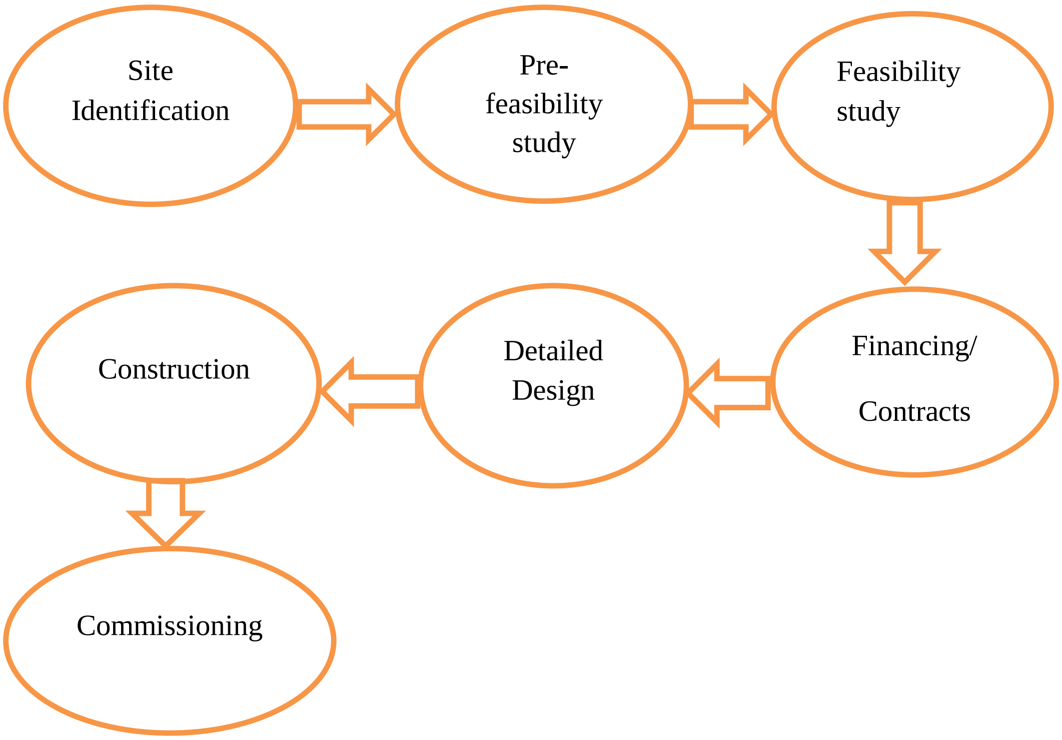

Figure 1.1: Flow chart showing hydropower development stages

1.2 Overview of the energy sector in Zambia

According to the National Energy Policy of 2008, Zambia has a wide range of energy resources, particularly woodlands and forests, hydropower, coal and renewable sources of energy. Petroleum is the only source of energy which is wholly imported in Zambia, while the country is basically self-sufficient in all the other energy resources, as it has substantial unexploited reserves of these forms of energy (ZDA, 2014).

The electricity generation mix in Zambia is dominated by hydropower generation which accounts for approximately 84.5 % (ERB, 2017). The hydropower generation mix is composed of large and mini hydropower stations. Zambia's national electricity utility company, ZESCO Limited owns most of the generation stations while the rest are owned by Independent Power Producers (IPPs). As of 2014, there were only two operational private IPPs under hydropower category, namely Lunsemfwa Hydro Power Company (LHPC) and Zengamina Power Company Limited (ZPCL) (ERB, 2015). According to the Energy Sector Report for 2016 by the Energy Regulation Board, the installed capacity from ZESCO Limited and the IPPs was

2,827 MW of which hydropower accounted for 84.5 percent (2,388.3 MW) of the total national installed capacity. Power generation from coal was at 10.6 percent (300 MW), followed by thermal (diesel) at 3.1 percent (88.6 MW), while Heavy Fuel Oil (HFO) accounted for 1.8 percent (50 MW) and solar photovoltaic (PV) was less than 0.1 percent (0.06 MW) (ERB, 2017).

1.2.1 Legal framework

There are three main statutes related to rural electrification namely; Electricity Act (enacted in April 1995 and amended in December 2003), Energy Regulation Act (enacted in April 1995), and Rural Electrification Act (enacted in December 2003).

The Electricity Act was enacted to regulate the generation, transmission, distribution, and supply of electricity. The Energy Regulation Act was enacted to establish the Energy Regulation Board and to define its functions and responsibilities, and to manage the licensing of undertaking for the production of energy or production or handling of certain fuels. The Rural Electrification Act was enacted to establish Rural Electrification Authority and to define its functions and to provide for matters connected with or incidents to the foregoing.

The National Energy Policy of 2008 encompasses a wide range of energy options, including hydropower. Among the policy measures relevant to small hydropower development adopted in the National Energy Policy include the following (Liu et al., 2013):

i. encourage the development of identified potential hydro sites;
ii. move towards cost reflective tariffs;
iii. adopting an open access transmission regime and;
iv. application of smart subsidy mechanisms.

1.2.2 Institutional framework

The following institutions are key in the electricity subsector:

i. Ministry of Energy

The overall responsibility for energy administration and policy formulation lies with the Ministry of Energy. The Department of Energy (DOE) under the Ministry is a key player in facilitating the development and implementation of energy policy and programmes. The Department was established in 1982 by a Cabinet decision and commenced its operations in early 1983 (MEWD, 2018).

ii. Office for Promoting Private Power Investment

The Office for Promoting Private Power Investment (OPPPI) is a unit under the Ministry of Energy whose role is to promote private sector involvement in the development of power projects in Zambia. OPPPI identifies projects; undertakes feasibility studies; develops an appropriate solicitation strategy and documents for developers; procures developers and facilitates negotiations for Implementation Agreements on behalf of the Government of the Republic of Zambia (OPPPI, 2017).

iii. Energy Regulation Board

The Energy Regulation Board (ERB) formed through an Act of Parliament of 1995, among other functions, ensures that all energy utilities in the energy sector are licensed, monitors levels and structures of competition, investigates and remedies consumer complaints (ERB, 2018).

iv. ZESCO Limited

ZESCO Limited is a vertically integrated public power utility company, which generates, transmits, distributes and supplies electricity in Zambia (ZESCO, 2018). ZESCO Limited owns most of the power stations, transmission lines, and distribution facilities in Zambia, including small hydro and diesel power plants.

v. Rural Electrification Authority

The Rural Electrification Authority (REA) is statutory body established under the Rural Electrification Act No. 20 of 2003 with the mandate of promoting the rural electrification development agenda of the Government of the Republic of Zambia (REA, 2014). REA uses the Rural Electrification Master Plan (REMP) for systematic electrification of the identified 1,217 Rural Growth Centres (RGCs) throughout Zambia (Government of the Republic of Zambia, 2008).

1.3 Problem statement

Access to electricity is basically one of the key drivers for rural development as it provides light, heat and power for productive uses of electricity which in turn leads to improved social and economic standards of the rural communities. Access to electricity acts as a catalyst in the provision of other social services such as telecommunication, reliable health care, water supply, irrigation and local manufacturing which goes a long way in eradicating poverty.

Various efforts have been made by the Government of the Republic of Zambia to accelerate rural electrification rate which currently stands at 4.4% (CSO, 2015). One of the efforts includes the creation of the Rural Electrification Authority (REA), through the Rural Electrification Act No. 20 of 2003. REA electrifies the rural areas of Zambia using grid extension and for areas far from the grid, development of mini hydropower plants and solar home/mini grid systems are considered among other renewable energy technological options.

Despite Government initiatives, development of mini hydro sites has still lagged in Zambia. In the last 30 years, the country has only witnessed the construction of two off-grid mini hydropower stations namely, Zengamina and Shiwan'gandu Mini Hydropower Stations in Ikeleng'e and Shiwan'gandu Districts respectively (Liu et al., 2013). With the current energy crisis, there is urgent need to fast track the development of mini hydro sites so as to add on to the country's generation capacity. The national utility's large hydropower stations and the distribution lines were under pressure hence the need to complement them with the development of small hydropower stations which would mainly be off-grid schemes to service areas far from the grid.

Increased power supply and reliable renewable energy services in the rural areas will promote income generation activities, which is a key element in the Zambian Government's efforts to reduce poverty. The problem statement for this research can be summarized thus:

Despite mini hydropower plants being the most preferred option for electrifying the rural areas far from the grid, little was known about the actual challenges and opportunities in developing off-grid mini hydropower projects in Zambia.

Therefore, this research sought to assess the challenges and opportunities in developing off-grid mini hydropower projects in Zambia and develop an appropriate strategy for project development. The strategy would help overcome the identified challenges and take advantage of the opportunities that exist in the development of off-grid mini hydropower projects in Zambia.

1.4 Research objectives

The research was guided by the following objectives:

1.4.1 Main objective

The main objective of the research was to identify the challenges and opportunities in developing off-grid mini hydropower projects in Zambia and develop an appropriate strategy for project development.

1.4.2 Specific objectives

In order to achieve the main objective of the study, the following were the specific objectives:

i. to identify the current challenges in developing off-grid mini hydropower projects in Zambia;
ii. to identify the current opportunities in developing off-grid mini hydropower projects in Zambia; and
iii. to formulate an appropriate strategy for developing off-grid mini hydropower projects in Zambia.

1.5 Research questions

To achieve the above research objectives, the research was guided by the following questions:

i. What challenges exist in developing off-grid mini hydropower projects in Zambia?
ii. What opportunities and incentives exist to both a public and private developer to encourage the development of off-grid mini hydropower projects in Zambia?
iii. What strategy can be developed to overcome the identified challenges and take advantage of the opportunities in the development of off-grid mini hydropower projects in Zambia?

1.6 Significance of the research

Considering that not all rural areas in Zambia could be connected to the national electricity grid, it was therefore imperative that the isolated areas where hydropower potential exists were developed using mini hydropower technology through local mini grids. However, the development of these off-grid mini hydropower projects had not progressed at the desired levels contributing to the low electricity access rate of 4.4% in the rural areas. Rural electricity access rate has remained low despite the country having ambitious target in the REMP of reaching rural electricity access rate of 51% by the year 2030.

Therefore, the identification of challenges and opportunities that exist in the development of the off-grid mini hydropower projects in Zambia and the formulation of an appropriate strategy would provide relevant information towards policy formulation for the energy sector regarding the development of the off-grid mini hydropower sites across the country. Further, the proposed strategy would be cardinal to the policy and decision makers in the country to accelerate the electricity access rate in the rural areas of Zambia.

The study employed both qualitative and quantitative data. The data was collected using structured questionnaires and semi-structured interviews. The sampling method used was purposive where experts mainly from the energy sector were targeted representing policy makers, developers, implementing agencies, consultants and regulators among others.

1.7 Dissertation layout

This dissertation comprises of six chapters: introduction; literature review, research methodology; results and discussions; strategy for development of off-grid mini hydropower projects; conclusion and recommendations.

Chapter 1 highlights the background to the study reported in the dissertation. It further outlines the statement of the problem, the aim of the study and the objectives. In addition, the chapter brings out the research questions used and the significance of the study.

Chapter 2 provides an insight of what mini hydropower is and the various development stages. Further, the chapter highlights what others have found out on challenges and opportunities in developing mini hydropower projects around the world. In addition, a critique of the literature reviewed is provided.

Chapter 3 outlines the methodology adopted for the study in order to answer the research questions. The chapter further highlights the research instruments used with corresponding justification of their choice.

Chapter 4 provides the results of the inquiry including a discussion of the same results arrived at using semi-structured interviews and self-administered questionnaires.

Chapter 5 provides the proposed strategy for developing off-grid mini hydropower projects in Zambia.

Chapter 6 provides a conclusion of the study and outlines the recommendations of the study with limitations to the study also highlighted.

1.8 Summary

The chapter provided a background to the study reported in the dissertation. It further outlined the statement of the problem, the aim of the study and the objectives. In addition, the chapter brought out the research questions used and the significance of the study. The next chapter provides literature review in detail to bring out the gaps to be filled in.

CHAPTER 2: LITERATURE REVIEW

2.1 Introduction

The literature relevant to the development of off-grid mini hydropower projects is reviewed including the challenges and opportunities in developing such projects around the world. The basic understanding of hydropower including its classification is highlighted. Further, the project management processes in relation to the five process groups is also highlighted including the seven development stages of a hydropower project. A critique of the literature reviewed is provided in this chapter.

2.2 Access to electricity

Electricity is the set of physical phenomena associated with the presence and flow of electric charge (Technical Leaning College, 2001-2018). It is a secondary energy source which means that we get it from the conversion of other sources of energy, like coal, natural gas, oil, nuclear power and other natural sources like water.

Access to electricity plays a pivotal role in the global socio-economic development. The demand for energy has increased significantly because of many industrial, domestic and agricultural activities that have grown rapidly to fulfill the user needs. However, Yah et.al, (2017) argues that there are still 2.4 billion people worldwide who still rely on traditional biomass for cooking and 1.6 billion people who still do not have access to electricity. Around 550 million people in the world will remain without any access to electricity in 2040 with most of them in sub-Saharan Africa (OECD/IEA, 2015).

In Zambia and the world at large, access to electricity is one of the key drivers for rural development as it provides light, heat and power for productive uses which in turn leads to improved social and economic standards of the rural communities. Access to electricity acts as a catalyst in the provision of other social services such as telecommunication, reliable health care, water supply, irrigation and local manufacturing which goes a long way in eradicating poverty.

Zambia has not been spared with the challenge of low electricity access rate. As at 2015, electricity access rate in Zambia stood at 31.2%, with urban access at 67.7% and rural electricity access rate at 4.4% and 7.4% for grid and solar photovoltaic (PV) systems respectively (CSO, 2015). The Living Conditions Monitoring Survey for 2015 by the Central Statistical Office estimates that over 58.2% of the population in Zambia is estimated to be rural. Therefore, the provision of modern energy services in rural areas will play a critical role in improving the living standards of the people. The Zambian New Energy Policy of 2008 sets out government's intentions that are aimed at ensuring that the energy sector's potential to drive the economic growth and reduce poverty is fully harnessed (Government of the Republic of Zambia, 2008). This will therefore lead to the actualizing of the Vision 2030 which aspires that the nation lives as a strong and dynamic middle-income industrial nation by the year 2030 (Government of the Republic of Zambia, 2008). Achieving these economic trends will require significant access to energy services in rural areas.

One technological option for electrifying the rural areas far from the national electricity grid is the development of mini hydropower stations where potential exists. For the purpose of this dissertation, only hydropower development under the renewable energy resources will be discussed in sufficient detail.

2.3 Classification of hydropower plants

Hydropower is the generation of power by harnessing energy from moving water (World Energy Council, 2016). According to Fichtner Management Consulting AG (2015), a hydropower plant (HPP) is site -specific, but plants can generally be classified according to the following parameters:

i. size or installed capacity;
ii. head availability;
iii. operation regime; and
iv. purpose of plant structures

2.3.1 Classification by size

HPPs are commonly classified based on installed capacity P (MW). There is no internationally agreed threshold that separates individual classes. HPPs are also classified based on dam head, as shall be noted in the next section. The classification that follows is approximate but widely accepted criteria vary among countries.

The bigger the height difference between the upstream and downstream water level, the greater the amount of electricity generated. Below is one classification that holds as much as there is no internationally agreed classification:

i. Micro $P < 0.1$ MW;
ii. Small 0.1 MW $< P <$ 10 MW (some countries go up to 30-35 MW);
iii. Medium10 MW $< P <$ 100 MW; and
iv. Large $P >$ 100 MW

Micro hydropower projects can supply electricity for an isolated industry, or small remote community. Usually, micro HPPs are stand-alone, i.e., they are not connected to the grid, and they are always run-of-river type. Small water storage tanks are sometimes constructed so that hydropower generation is guaranteed for minimum period per day, even during low-water flow conditions. Micro hydropower schemes are commonly encountered in rural areas of developing countries where they provide an economical energy source without fuel dependency.

Small HPPs are dimensioned considerably smaller than medium and large HPPs because small HPPs usually exploit low discharges. Most small HPPs are run-of-river types that are connected to the power grid.

Medium hydropower schemes are either of the run-of-river or storage type and in most cases always feed into a grid. Their layout may include a dam to create a head pond. The electro and mechanical (E & M) equipment is similar to that of large hydropower schemes.

Large hydropower schemes are always connected to a large grid and can be run-of-river or storage type. Each layout is site-specific, and each plant's E & M equipment is designed for local needs and conditions.

2.3.2 Classification by head size

Depending on the head, H being exploited for electricity production, HPP schemes are divided into the following categories:

i. High head: $H > 100$ m
ii. Medium head: 30 m $< H <$ 100 m
iii. Low head: $H < 30$ m

However, like classifications based on power output, definitions can vary by country and organization. The International Commission on Large Dams (ICOLD) defines a 'large dam' as one greater than 15 m in height (Fichtner Management Consulting AG , 2015). Also, classifying HPPs according to head may be inconsistent with classification based on power capacity. Power capacity is proportional to the product of available flow and head as per Equation 2.1.

$$P = \gamma * Q * H * \eta \ (kW) \qquad \text{Eqn. 2.1}$$

Where **γ** is the specific weight of water, **Q** is the discharge, **H** is the effective/net head and lastly but not the least **η** is the combined efficiency of the turbine and generator.

Hence, even high-head installations might be characterized as micro or small HPPs. Typically, mountainous terrain provides conditions necessary for implementing high-head or medium-head HPP schemes, often storage-type. Lowland areas with wide river valleys provide locations feasible for installing low-head schemes, mostly run-of-river types.

2.3.3 Classification by operation

According to the International Hydropower Association, (2017), there are four broad hydropower types categorized according to the type of operation as follows:

i. Run-of-river hydropower

Run-of-river hydropower is a facility that channels flowing water from a river through a canal or penstock to spin a turbine. Typically, run-of-river schemes have no storage capacity, or limited storage, which limits peak power operation to a few hours. Run-of-river provides a continuous supply of electricity (base load), with some flexibility of operation for daily fluctuations in demand through water flow that is regulated by the facility. As a result, run-of-river HPPs are subject to weather and seasonal variations resulting in variable power generation.

ii. Storage hydropower

Storage hydropower is basically a large system that uses a dam to store water in a reservoir. The schemes are characterized by water impoundment upstream of a dam structure to create a reservoir in which water is predominantly stored during high-flow periods and consumed for energy production during low-flow periods. Electricity is produced by releasing water from the reservoir through a turbine, which activates a generator. Using stored water for the inflow to generate energy creates some security against natural fluctuations in water availability caused by weather and seasonal variations. Reservoir size determines the level of flow regulation. Storage hydropower provides base load as well as the ability to be shut down and started up at short notice according to the demands of the system (peak load). It can offer enough storage capacity to operate independently of the hydrological inflow for many weeks or even months.

iii. Pumped storage hydropower

Pumped storage hydropower is a facility that provides peak-load supply, harnessing water which is cycled between a lower and upper reservoir by pumps which use surplus energy from the system at times of low demand. When electricity demand is high, water is released back to the lower reservoir through turbines to produce electricity.

iv. Offshore hydropower

Offshore hydropower is a less established but growing group of technologies that use tidal currents or the power of waves to generate electricity from seawater.

The above four types of hydropower can often overlap. For example, storage projects can often involve an element of pumping to supplement the water that flows into the reservoir naturally and run-of-river projects may provide some storage capability (International Hydropower Association, 2017)

2.3.4 Classification by purpose

Multi-purpose schemes provide water for other uses for human subsistence and development. About one-third of existing hydropower projects serve other functions in addition to energy generation (Fichtner Management Consulting AG, 2015).

The additional functions of HPP schemes may include the following:

i. flood protection where water storage reduces the impact of floods.
ii. drought mitigation by supplementing irrigation and community water supplies during dry periods;

iii. irrigation by providing water for agriculture;
iv. water supply where the reservoir provides community water supply; and
v. improved conditions where raising the water level in a reservoir improves conditions for navigation, fishing, tourism and recreation.

2.4 Development of hydropower projects

China is leading in global installed capacity of hydropower with 26% followed by Brazil, United States, and Canada with 8.6%, 7.8%, and 7.6% respectively (UNIDO and ICSHP, 2016). The United Nation Industrial Development Organisation and the International Centre on Small Hydropower (2016) state that the globally installed small hydropower (SHP) capacity is estimated at 78 GW and approximately 36 per cent of the total global SHP potential had been developed by 2016. The World Small Hydropower Development Report for 2016 states that SHP represents approximately 1.9 per cent of the world's total power capacity, 7 per cent of the total renewable energy capacity and 6.5 per cent (< 10 MW) of the total hydropower capacity (including pumped storage). The report further highlights that one of the world's most important renewable energy sources, SHP is fifth in development, with large hydropower having the highest installed capacity to date, followed by wind and solar power. China continues to dominate the SHP landscape. Fifty-one per cent of the world's total installed capacity (definition of below 10 MW) and approximately 29 per cent of the world's total SHP potential are in China (UNIDO and ICSHP, 2016).

Zambia's installed capacity of small hydropower is 31 MW (Liu et al., 2013).

According Fichtner Management Consulting AG (2015), the development of hydropower involves seven phases with the following project development activities from a developer's perspective:

i) site identification/concept;
ii) pre-feasibility study;
iii) feasibility study;
iv) financing/contracts;
v) detailed design;
vi) construction; and
vii) commissioning

For this study, only challenges and opportunities from a developer's perspective are looked at.

i. Site identification

Site selection is the first step. In developing countries, information on potential hydropower plant (HPP) sites, especially for small HPPs, may be unavailable or unreliable and out of date, unlike developed countries where most potential sites for medium and large hydropower plants are already well known (Fichtner Management Consulting AG , 2015). Conditions surrounding HPPs are subject to changes, not only the power tariffs or the power market structure, but also the social and environmental characteristics, all of which can affect the attractiveness of potential sites. As such, sites that were unattractive in the past may become attractive in the future and vice versa.

Two main components of an HPP are the headworks, including an intake structure/dam, and a powerhouse. Since these structures are positioned some distance from each other and connected by waterways, site selection requires two suitable locations that is for the intake and for the powerhouse. In general, site selection must consider potential energy generation (water power capacity), which depends on the head and the usable discharge, and potential constraints related to construction costs, plant operation and the environmental and social risks and impacts of the location. The following constraints must be considered: water resources, topography, geotechnical characteristics, site access, energy demand, interaction with other HPPs, construction constraints, grid connection, environmental issues, social issues, and financial incentives. Therefore, site selection involves (a) identifying a location with a high-water power capacity and (b) finding the most suitable sites for the HPP structures at the identified location. Good hydrological data are essential to select an HPP site and develop the optimum plant design. Typically, hydrological data for at least 15 years are required and should include not only the amount of water (flow rate) but also annual distribution (Fichtner Management Consulting AG, 2015).

ii. The pre-feasibility study

Pre-feasibility study (PFS) undertakes further project assessment to answer the following questions. To answer the first question, the project developer needs to assess its financial attractiveness (expected return on investment) and identify potential deal-breakers.

a. Is the project financially viable?
b. If so, which technical option/concept is most attractive?

During the PFS, the design concept is elaborated. Technical variants and options are explored, and a preferred technical concept is selected usually one that will maximize financial returns.

The PFS must also evaluate environmental and social aspects of the project. A preliminary assessment is undertaken to identify boundary conditions under which the project must be developed further, and to examine potential barriers.

The PFS phase requires acute attention to hydrological data, which is the decisive factor for plant design and resulting energy yield. Full clarity on this issue is required before the next phase can be triggered. The PFS may determine that additional hydrology data may be needed.

iii. The feasibility study

The feasibility study (FS) is at the core of the project development process (Fichtner Management Consulting AG , 2015). Through extensive investigation, the FS assesses project viability, determines optimum project layout and all other requirements to further the project development process. When the FS is completed for a viable project, the information should be sufficient to support a decision about whether to proceed to project financing (appraisal and due diligence by financial institutions).

The FS structure is similar to that of a PFS, except FS detail is built up by collecting and analyzing additional data such as soil investigations/drillings, hydrological investigations, environmental/social research, and including a detailed elaboration of the design.

The FS is built on PFS findings, which examined several potential technical concepts and selected the most viable. The selected concept is optimized during the feasibility study, which includes the following core elements:

a. Technical concept: Specification and description of the most suitable layout and design for civil works, mechanical equipment, hydraulic steel structures, electrical equipment and grid connection, and optimization of the main power plant parameters such as head water level, installed flow, and so forth.
b. Hydrology/energy production: Expected annual energy generation and impact of dry years on power output.

c. Geology: Results of geological investigations, particularly for large civil constructions such as dams.
d. Cost estimates: Detailed estimates of anticipated CAPEX (ideally based on budget offers), including range of contingencies and OPEX estimates.
e. Power market: Identification of the off-taker of the generated electricity, preliminary price and duration of the power purchase agreement.
f. Financial viability: Detailed financial (and if required, economic) analysis estimating the key financial parameters (IRR, NPV, etc.), which determine project attractiveness.
g. Financing options: Available equity, debt requirements, and other resources (e.g., subsidies and grants).
h. Commercial arrangements: Identify the type of project [build-operate-own (BOO) or build-operate-transfer (BOT)] and start developing the procurement strategy including the number of contracts to be let and the operation and maintenance (O&M) contract.
i. Environmental and social: Results of environmental and social impact assessments (ESIA) and management plans, such as resettlement plans and contingency plans for issues identified.
j. Permitting: Status of the process, overview of outstanding permits/licenses.
k. Risk assessment: Summary of key project risks and mitigation options.
l. Recommendations: For undertaking remaining project activities.

The FS includes drawings for general project layout, topography, dam site, waterways, powerhouse and other infrastructure. The FS is the base document for project follow-up activities such as preparing tender design and negotiating with potential financing institutions. The FS is also the basis on which lenders prepare their due diligence. Typically, the general design developed in the FS is considered final, but the level of detail is elaborated later during tender and construction.

The FS is the basis for investors' final decision about whether to proceed. At this stage, the project is already quite developed but negative FS results, such as inadequate financial performance or environmental and social constraints still have the potential to dampen investor willingness to proceed.

Small HPPs: Although many developers use a simplified approach for small HPPs including standardized equipment, this may be often shortsighted and costlier (Fichtner Management Consulting AG , 2015). In fact, some developers merge the PFS and FS into one document, or prepare the design based on PFS results, an approach that may appear to save time and money but is often the reverse. General studies without a detailed analysis of the plant concept can produce a sub-optimal plant design or other project pitfalls, such as overestimating hydrology, underestimating CAPEX, sub-optimal turbine design, among others.

iv. Financing and contractual arrangements

The development phase closes with financing and contractual arrangements. In addition, the developer finalizes permitting and licensing. During contracting, plant construction contractors are selected based on the following selection principles, and depending on procurement strategy:

a. Prime contractor or turnkey EPC (engineering, procurement and construction) contractor: One contractor has overall responsibility for all lots including civil works, E & M equipment, grid connection, and so forth. Under the prime contractor option, one EPC contract is signed, and the contractor is responsible for overall management of construction, especially interfaces among civil works, E & M equipment and grid connection. Risk is transferred to the prime contractor, which raises the overall contract price compared to a lot-by-lot contracting. Most financial institutions prefer turnkey EPC contracts. Typically, the developer will engage an owner's engineer to supervise the prime contractor.
b. Separate contractors for each lot: For typical lots - civil works, E & M equipment, grid connection, and penstock - separate EPC contractors are engaged. The developer assumes overall responsibility for plant construction and is likely to engage an owner's engineer, if its own engineering capacity is limited.

   The engineer will assume responsibility for contractor coordination, for managing the interfaces among them. For larger HPPs, this is a demanding and crucial activity that requires highly experienced engineering expertise. For the procurement process, the so-called 'tender design' must be prepared. Tender design specifies detailed responsibilities for EPC contractors; and for lot-by-lot procurement, interfaces among the lots.

Fichtner Management Consulting AG (2015) argues that to minimize construction risks, the developer must ensure the following:

a. The EPC contractor has sufficient expertise and experience to supply and construct specified equipment.

b. The proposed contract price, scope of delivery and schedule conforms to overall project documentation (cost estimates, time schedule, etc.).
c. Potential risks, especially cost overruns and delays are balanced between contractor and project developer. Any non-fulfillment of contract obligations by the EPC contractor should be penalized. During the financing and contractual phase of project development, before the start of the construction, the project must achieve financial closure. Most HPPs are financed through project or corporate finance. At this stage, lenders are conducting intensive technical, environmental and social, financial and legal due diligence of the project using a team of independent advisors to review details of the feasibility study and draft contract agreements (e.g., power purchase agreement, EPC contracts, etc.). If the result is a positive assessment, agreement is reached on the financing package. Financial closure occurs when all required conditions have been met and all project and financing agreements have been signed. Financial closure might be achieved during this phase or in the detailed design phase.

The development phase could vary significantly, depending on the individual project. Small HPP can be developed faster, especially since financing is easier, but it can still take up to six months. In many cases, developers begin design and even construction before financial closure is achieved. To compensate for the risk if no loan agreement is signed, a higher equity contribution is required. For medium and large HPPs, achieving financial closure takes much longer. Preparing adequate tender documents and procuring EPC contractors can take up to 18 months (Fichtner Management Consulting AG , 2015). For a build-operate-own (BOO) concept for project finance, the tender process can take up to two years.

v. Detailed design

After the EPC contracts are signed, the contractor will begin preparing the detailed design, which is the basis for plant construction. Detailed designs are prepared for each plant component including intake/weir, desander, waterways, penstock, powerhouse, tailrace, substation, transmission line, and so forth. The detailed design includes all specifications for quantities and materials. For lot-by-lot procurement, the owner’s engineer must ensure that the interfaces among the lots are specified. The design must conform to national standards, but since national standards do not cover all aspects of hydropower plants, in particular medium and large HPPs, project designers can use standards and guidelines from the United States Army Corps of Engineers (USACE) or International Commission on Large Dams (ICOLD).

Developing a detailed design for a small HPP takes a few months and for a large HPP, more than a year.

vi. Construction

Hydropower plant construction is a long process, in part because plants are often built in remote areas where access is difficult, and weather conditions can impede progress during cold or rainy seasons. Access roads and other infrastructure such as offices and worker accommodations must be built prior to beginning work on the HPP scheme. Construction time for smaller HPPs is usually 9 to18 months, and for medium and larger HPPs, up to four years (Fichtner Management Consulting AG , 2015). During construction, most lenders engage an engineering firm to monitor the process, and reviews are undertaken quarterly. Construction progress is monitored using contractor and engineering firm progress reports and site visits; an independent party reports to lenders.

vii. Commissioning

The commissioning phase of HPP development requires civil, mechanical, and electrical engineering expertise to cover the broad spectrum of hydropower development. Lenders may also hire an independent engineer for the commissioning phase. Before commissioning tests begin, all required documents - quality certificates, test procedures, test results from equipment installation and all other tests shall be made available to the lead commissioning engineer.

Commissioning testing includes the following:

a. Dry tests: After installation, equipment is tested in dry conditions to verify basic functionality.
b. Wet and load tests: This can occur a long time after dry tests if reservoirs must be impounded, coffer dams removed, and so forth.
c. Performance testing: Turbine hydraulic efficiency and generator electrical efficiency are verified.
d. Trial operation and reliability run: This requires 3-10 days for smaller HPPs and about 30 days for large HPPs.

At the end of the commissioning phase, the project developer provides the contractor with a certificate and prepares detailed documentation of test procedures and results. The certificate declares acceptance of the HPP by the developer and usually it is linked to the release of the EPC from its obligations; also, the developer makes the final payment to the EPC.

The commissioning phase is shorter than earlier phases. Normally, each test takes about one month, and less time for small HPPs. The longest period might be between dry and wet testing; in large storage projects, the first reservoir fill might require more than two years.

From a project management point of view, the development stages highlighted above are related to the project management cycle. Project management is the application of knowledge, skills, tools, and techniques to project activities to meet the project requirements (Project Management Institute, 2013). The project management cycle involves appropriate application and integration of the project management processes, which are categorized into five process groups. These five process groups include:

a. initiating,
b. planning,
c. executing,
d. monitoring and controlling, and
e. closing

The above captioned cycle or processes also apply to hydropower projects.

2.4.1 Challenges to the development of small hydropower

The challenges involved in the development of mini hydropower vary across regions. Some challenges might be specific to developing countries while others might be generic, affecting both developed and developing countries. Consequently, studies which have attempted to highlight the challenges in the development of hydropower projects bring out different challenges depending on the region where the study focused. Some of the challenges can be categorized as follows:

i. Financial barriers

The UNDP (2014) identified financial challenges in the development of renewable energy projects in rural areas of Zambia to include high cost of capital, lack of economies of scale due to dispersed markets and the rural electrification fund being ineffective. Shi et al., (2016) argue that rural electrification and off-grid renewable energy (OGRE) projects face challenging financial obstacles which cannot be addressed by current market mechanisms such as high initial costs, limited local financial resources and low return rates. The report by Shi et al., (2016) also states that OGRE projects can hardly be attractive to private investors, and the existing lending terms set by lenders (or funders) are often unsuitable for OGRE projects. The findings by Shi et al., (2016) are not representative of all off-grid projects like mini hydropower projects because in Zambia, Zengamina Power Company (a private company) operates an off-grid mini hydropower project of 750kW capacity.

In the same way as the cost of capital was a challenge in Zambia, Jaber (2012) also studied the challenges in the development of mini hydropower projects in Jordan and finds high investment cost which led to low profits generated by the developers as a major challenge. These results support Shi et al., (2016) who argue that rural electrification and off-grid renewable energy projects, of which small hydropower is part of, face challenging financial obstacles such as high initial costs, limited local financial resources and low return rates. Further Meier et al., (2011) argue that access to long-term financing for small hydropower projects was a challenge for companies without strong balance sheets in Peru, especially considering the limited interest of commercial banks in project finance and/ or small-scale projects.

Another major challenge which relates to financials is size of the markets in rural areas and the ability of the end users of electricity to pay for it. The relatively small size of the off-grid market and low income of end-users do not make of-grid mini hydropower development substantially attractive to foreign investors, which is why the Zambian Energy Sector has mainly involved local private operators with the support of donors and development partners (IRENA, 2013). These findings are consistent with findings of the study done by Kabaka and Gwang'ombe (2007) in Tanzania. Indeed, most rural areas in Zambia are characterized by small market size to demand the generated power. High poverty levels also make it challenging for people to pay for electricity or demand enough electricity for the investor to recoup their investments. Therefore, it can be deduced that rural electrification often faces a poverty–affordability deadlock that cannot be tackled without external interventions as argued by Shi et al., (2016).

Mostly, people in rural areas demand power for lighting and this leads to very low energy demand. This makes these areas unattractive for the investors to commit their funds to development of off grid energy projects to serve rural areas. Kaunda (2013) finds low levels of disposable income for users to pay for the electricity and their services in many rural areas of Malawi where most of SHP potential sites as a discouraging factor for energy service companies to invest in such areas. He therefore argues that the promotion of the technology would rely on Government and NGOs to install the SHP systems as part of the campaign to provide electricity to rural communities. It can hence be argued that the economic success of the SHP system depends largely on achieving a high load factor which could be obtained by using the scheme for income-generating activities in rural areas. However, the presence of electricity can help to open up business opportunities in the un-electrified communities which can induce further demand for electricity (Kaunda, 2013).

Apart from high cost of capital and the small size of the markets as challenges to development of off-grid energy systems, some studies have found low tariffs to be responsible for private investors shunning investing in off-grid energy projects. A study was conducted in Peru where it was found that the most fundamental constraint to developing Peru's hydro potential was the low tariff faced by generators, which was a consequence of the low domestic price of natural gas. The argument was that almost all new power generation installed in Peru during the last decade had been based on low priced natural gas from the Camisea Field (Meier et al., 2011). Liu et al., (2013) also argues that the development of small hydropower plants in Zambia was hampered by low electricity tariffs which were as a result of heavy subsidies. However, the Government had decided to promote a gradual migration towards cost-reflective tariffs.

The challenges discussed above are generic to all off grid energy systems and do not give a specific view of the challenges of mini hydropower development, especially in Zambia. Hence there is a gap as these challenges have not been studied in the context of Zambia.

ii. Technical barriers

Challenges in the development of renewable energy projects pertaining to technical can be categorised as limited technical capacity to design, install, operate, manage and maintain renewable energy systems; limited or non-existent standards for energy performance, manufacture, installation and maintenance and lack of local manufacturing and/or assembly of renewable energy technology components according to UNDP (2014).

Other studies have revealed that lack of access to technology and lack of appropriate infrastructure to manufacture components needed in the development of SHP were among the challenges. For example, Klunne (2007) argues that 'large-scale development of small hydropower is hindered by lack of access to appropriate technologies, lack of infrastructure for manufacturing, installation and operation, and lack of local capacity to design and develop small hydropower schemes for areas sometimes considered too remote'. These findings are in line with what was found by Taele et al., (2012) and Kaunda (2013) on the Lesotho and Malawi experience with small hydropower development respectively.

According to a review on small-scale hydropower as a source of renewable energy in Malaysia by Yah et al., (2017), despite renewable energy technologies, particularly hydropower being preferable choices for energy generation in Malaysia, they had not been fully exploited yet due to technical, economic, and institutional challenges. However, the review did not categorically bring out the challenges in developing off-grid mini hydropower projects.

iii. Policy and regulatory barriers

Documentation by UNDP (2014) identified some challenges relating to policy and regulation in the development of renewable energy systems. These challenges included, inadequate incentives for renewable energy development, lack of standardized power purchase agreements which deters potential investors in power generation, lack of fair competition in the energy sector to attract independent power producers in the energy sector and complete implementation of Zambia's policy/legal and institutional framework to promote renewable energy production and diffusion. However, these challenges were more biased towards energy systems which had the potential to be connected to the national grid at some point.

Studies by Klunne (2007) and (Kabaka and Gwang'ombe, 2007) find the challenges facing small hydropower exploitation to be as a result of lack of clear-cut policies on renewable energy, administrative delays, the absence of low-cost, long-term financing models, topographical, geological and environmental challenges. These findings are consistent with the findings of the study by Sharma and Thakur (2015) in Jammu and Kashmir States of India where it was revealed that the procedures adopted by the state government in granting no objection certificate from various quarters were very lengthy and time-consuming hence causing delays in the start of work.

Further, Kaunda (2013) argued that despite the presence of a liberalised energy policy and the accompanying energy laws in Malawi, there was no stand-alone renewable energy policy or strategy in the country to guide development and popularization of SHP as the case with other countries such as Nepal and India.

In summary, the findings of the various scholars do not bring out challenges specific to off-grid mini hydropower projects. However, the literature shows that policy, technical, economic/financial, institutional and local capacity to undertake such projects are the main issues to be considered. For example, the report by UNDP (2014) is general and does not really zero in on the actual challenges faced in the development of off-grid mini hydropower projects in Zambia. Further, a key challenge for mini-grids is that, apart from the possible presence of a main 'anchor customer', they need to serve very low-income customers, so system design must centre on affordability (PwC global power & utilities, 2016). Sustainability of mini grids was a challenge as mini-grids have struggled to grow beyond pilot projects (ENEA and Practical Action, 2016).

2.4.2 Opportunities in the development of small hydropower

Despite various challenges affecting the development of off-grid mini hydropower development, opportunities are also available which could encourage investments in these projects.

According to the study by (SNV Netherlands Development Organisation, 2014) in Vietnam, the presence of diverse natural resources, that are potential energy sources, coupled up with research and development presented an opportunity for development of renewable energy projects of which small hydro is part of. Further, the report states that policy frameworks have a great influence on the development and implementation of the off-grid rural electrification program. For example, the Vietnamese Government built a clear policy framework with a set of principles, long-term goals, and national commitments to the program which are basically opportunities in the development of small hydropower. The claim by SNV shows that even in the Zambian scenario, the presence of the significant potential of hydropower presents an opportunity for developing the small hydropower projects which could serve communities far from the national electricity grid.

Meier et al. (2011) observe that the keys to unlocking the small hydro potential would include an adequate and predictable tariff, as well as an efficient and transparent auction system for tariff premium allocation in Peru. Other opportunities identified included incorporation of power plants in existing hydraulic infrastructure projects. Small hydropower developments of this type involve incorporation of power-generating facilities in hydraulic structures already constructed for purposes of irrigation, mining, or power production.

A study on mini hydropower in Malawi by Kaunda (2013) revealed that, despite the challenges, there were some opportunities available for development of SHP systems. These opportunities included acute shortage of electricity supply in Malawi, presence of infrastructure for manufacturing basic SHP components, presence of the liberalised energy policy and the accompanying legal and regulatory frameworks in the energy sector, government's promotion of development of clean and renewable energy technologies and the inclusion of hydropower projects in its Rural Electrification Master Plan. These opportunities if well exploited would surely increase the number of mini hydropower plants which would ultimately add to the energy stock of the country.

Another study by Jaber (2012) observes that the presence of the Renewable Energy and Energy Efficiency Law (REEL) released in early 2010 to define Jordan's plans to introduce renewable energy generation to the local sector was an opportunity in the development of small hydropower.

According to the Zambia Development Agency (ZDA) (2014), following the amendment to the second schedule of the ZDA Act, power generation has now been declared a priority sector. This amendment was in recognition of the need to reduce the cost of developing power plants and attract independent power producers to increase generation capacity in Zambia and meet the growing demand for power for the productive sectors especially mining. With this amendment, building of power plants to generate power from various sources of energy including hydro, will now qualify for tax concessions under Zambia Development Agency (ZDA) Act.

The content analysis of the literature reviewed is summarized in Table 2.1.

Table 2.1: Content analysis of reviewed literature

Author	Country/region	Objective(s)	Method	Conclusions	Comments/Critique
Meier et al., (2011)	Peru	Assessing the challenges of hydropower development specifically in the Peruvian economic and energy context, as of mid-2008.	Survey	Fundamental constraint to developing Peru's hydro potential has been the low tariff	The low tariff was based on the lowly priced natural gas from the Camisea Field. The tariff was not cost reflective. The study did not provide specifically an off-grid scenario. The study only employed a survey where only quantitative data was collected.
Jaber (2012)	Jordan	To assess the prospects and challenges of small hydropower development in Jordan.	Desk reviews and surveys	The high investment cost was a major barrier to development of small hydropower. The development of renewable energy projects including small hydro would lower the costs of providing electricity as well as	The opportunities have been highlighted which include the presence of the Renewable Energy and Energy Efficiency Law (REEL) released in early 2010 to define Jordan's plans to introduce renewable energy generation to the local sector. Given their high investment costs, the

Author	Country/region	Objective(s)	Method	Conclusions	Comments/Critique
				increasing security of supplies due to reduced imports of oil and gas.	profitability of small hydropower plant projects is a general issue and follows the situation in the local market.
Liu et al., (2013)	Zambia	To provide the status of the world small hydropower development	Interviews and literature review	Low electricity tariffs, poor accessibility of the potential sites and limited market for the power generated	The report on World Small Hydropower Development of 2013 by the United Nations Industrial Development Organisation and the International Centre on Small Hydro Power does not segregate the challenges of small hydropower development in to off-grid and on-grid.
Taele et al., (2012)	Lesotho	To provide an overview of the setbacks that inhibit the smooth operation of small hydropower plants in Lesotho.	Case study	The absence of targeted incentives for private development of small hydropower is a major barrier to development of	As much as the study brought out that some of the main challenges to the development of both large and small hydropower

Author	Country/region	Objective(s)	Method	Conclusions	Comments/Critique
				mini hydropower plants in Lesotho.	projects are high capital investment costs on projects of this nature and heavy siltation of small reservoirs due to extensive soil erosion, the study did not provide specific challenges for off-grid and on-grid projects.
Klunne (2007)	Africa	To provide status of small hydropower development in Africa	Desk review and case study	Challenges to large scale implementation of small hydropower projects is due to (i) lack of access to appropriate technologies, (ii) lack of infrastructure for manufacturing, installation and operation including (iii) lack of local capacity to design and develop small	The challenges were too generic as individual countries in Africa had their own challenges.

Author	Country/region	Objective(s)	Method	Conclusions	Comments/Critique
				hydropower schemes for areas sometimes considered too remote.	
SNV Netherlands Development Organisation (2014)	Vietnam	To screen off-grid communities and to evaluate renewable energy resources, technologies, and potential funding for their electrification	Desk study, expert interviews and questionnaire survey	There was a strong need for an improved enabling environment, developed policy framework that supports the development of access to renewable energy. Renewable energy projects implemented were mainly driven by donor funds and grants. Commercial investment was limited to larger scale hydropower. Vietnam's abundant natural resource (water) was an opportunity for	The opportunities were country specific though the availability of appropriate policy framework and availability of natural resources were cardinal for the development of small hydropower. The report was on renewable energy and off-grid hydropower was dealt with in sufficient detail in terms of its specific challenges.

Author	Country/region	Objective(s)	Method	Conclusions	Comments/Critique
				development of small hydropower	
Kabaka and Gwang'ombe (2007)	Tanzania	To present the existing information on small hydro power (SHP) resources in Tanzania and highlighting challenges associated with SHP development, in the context of rural electrification.	Desk review of available literature	The natural topographic features of Tanzania provided the country with ample opportunity for hydropower Development. Challenges to small hydropower development could be grouped in to (i) rural electrification policy, (ii) financing of small hydropower, (iii) characteristics of rural electricity load market, (iv) institutional set up, and (v) human resources development for small hydropower development.	The report was agreeing with Taele et al., (2012) findings in Lesotho. However, the paper does not come out clearly on challenges specific to off-grid small hydropower projects. The study relied on desk review of available literature which is usually dependent on already published data. Hence the conclusions drawn from such data may not be dependable.

Author	Country/region	Objective(s)	Method	Conclusions	Comments/Critique
Yah et al., (2017)	Malaysia	To provide information for further investigations on the application of small-scale hydropower for rural electrification in Malaysia.	Desk reviews	Despite renewable energy technologies, particularly hydro-power being preferable choices for energy generation in Malaysia, they have not been fully exploited yet due to technical, economical, and institutional challenges.	The study does not categorically bring out the challenges in developing off-grid mini hydropower projects The study relied on desk review of available literature which is usually dependent on already published data. Hence the conclusions drawn from such data may not be dependable.
UNIDO and ICSHP (2016)	Eastern Africa	To provide development information about small hydropower	Desk reviews	Barriers to SHP development include the costs of infrastructure development, including transmission lines and roads to SHP sites; lack of long-term financial solutions from local banks; and a need for capacity building with	The report does not really show how the experts obtain information about each country in the Eastern African region. The small hydropower referred to does not specify whether it is off or on-grid. The study relied on desk review of available literature which is usually

Author	Country/region	Objective(s)	Method	Conclusions	Comments/Critique
				regard to maintenance and operation of SHP plants.	dependent on already published data. Hence the conclusions drawn from such data may not be dependable.
Kaunda (2013)	Malawi	To review and document energy situation and small-scale hydropower potential and application status in Malawi including identifying challenges and opportunities towards popularisation of the technology.	Desk reviews and key informant interviews	The challenges to the development of small hydropower include limitations in economic, technical and awareness of the technology.	The challenges are generic, and the paper did not bring which challenges were for off and on-grid schemes. However, the study brought out rich information by combining desk review with Key Informant Interviews.
Sharma and Thakur (2015)	India	To assess the challenges in developing hydropower projects in Jammu and Kashmir States of India.	Case study	The most critical factors were administrative, social and financial.	The method used for the study does not incorporate issues of construct validity, reliability and replicability. The results may not be generalised.

Author	Country/region	Objective(s)	Method	Conclusions	Comments/Critique
Shi et al., (2016)	Singapore	To assesses the effectiveness of supporting instruments that facilitate off-grid renewable energy investment	Literature review, survey and case study	Rural electrification and off-grid renewable energy projects face challenging financial obstacles which cannot be addressed by current market mechanisms such as high initial costs, limited local financial resources and low return rates.	Financing of off-grid projects was crucial. The Delphi technique used in the survey is commendable as consensus is built.

Source: Author’s compilation

2.5 Summary

The literature review has established that challenges in the development of off-grid small hydropower include financial (funding), legal, institutional capacity (local skills), technological (know how) and political (tariffs and other incentives). The other challenges include poor accessibility of the sites and the sparse distribution of the rural population within the vicinity of the hydropower plant who may not consume all the electricity generated from an off-grid plant. The opportunities have been identified as the availability of the natural resources which include viable small hydropower sites, the presence of an enabling policy framework.

This research sought to identify challenges and opportunities in developing off-grid mini hydropower projects in Zambia. Further, the research sought to come up with the appropriate strategy for implementing off-grid mini hydropower projects in Zambia. The next chapter provides the methodology adopted for the study in order to answer the research questions. The chapter further highlights the research instruments used with corresponding justification of their choice.

CHAPTER 3: METHODOLOGY

3.1 Introduction

The previous chapter looked at reviewed literature on challenges and opportunities in developing small hydropower projects in various parts of the world. The general stages of project development were highlighted with their basic description. The critique of the literature reviewed was also presented. In this chapter, the methodology used in carrying out this research is outlined. The research instruments used in this inquiry have also been highlighted including the justification of their choice. Research methodology in this study is defined as a way to systematically solve the research problem and may be understood as a science of studying how research is done scientifically (Kothari, 2004).

3.2 Research Design

The research was designed in such a way that both qualitative and quantitative data were captured so as to give good insight of the challenges and opportunities involved in the development of off-grid mini hydropower projects in Zambia. Qualitative data was collected first through semi-structured interviews and helped to structure the questionnaires for the survey. Ten key informants were interviewed who were experts representing policy makers, implementing agencies, private developers, consultants and cooperating partners. The interview guide is as per Appendix 1.

The choice of the mixed research methodology was arrived at considering that it minimises the shortcomings of qualitative and quantitative research. This is in line with Dawson (2007), who argues that neither qualitative nor quantitative research is better as both approaches are just different, and they have their strengths and weaknesses. Further, according to Creswell (2014), the combination of qualitative and quantitative approaches provides a more complete understanding of a research problem than either approach alone.

3.3 Sampling

Before coming up with the sample for the inquiry, a population for a study was defined. According to Kasonde (2013), a study population is that group (usually people) about whom we want to be able to draw conclusions. In this study, the population was taken as experts in hydropower from institutions in the Zambian energy sector dealing with hydropower development in one way or the other.

There are two types of sampling techniques used namely probability and non-probability. The research study adopted the non-probability sampling technique and the method used was purposive sampling. Purposive sampling is a sampling method where the researcher purposively targets a group of people believed to be reliable for the study. The power of purposive sampling lies in selecting cases with rich information for in-depth analysis related to the focal issue being studied (Kasonde, 2013).

In this research, expert purposive sampling was used with key informants coming from both public and private institutions within the energy sector. Preliminary investigations were carried out using semi-structured interviews to identify the key experts in the sector who were relevant to the study. The exact number could not be established as some experts had retired and could not be traced. However, the investigation established 36 experts who were selected to take part in the questionnaire survey. However, out of the 36 experts, 30 responded to the questionnaires which were used for data collection. Before structuring the questionnaires, semi-structured interviews were conducted with 10 key experts who were also respondents for the questionnaire survey. The results of the interviews helped to structure the questionnaires accordingly.

3.4 Data collection techniques

Two data collection techniques were employed namely primary and secondary techniques.

3.4.1 Primary techniques

With this technique, primary data was collected using interviews and questionnaires. The interviews were done with key personnel from government and quasi-government institutions, private sector institutions mainly comprising independent power producers, consultants in the energy sector and the cooperating partners. Questionnaires were also administered to the same institutions.

Four types of interviews were available namely structured, semi-structured, open-ended and focus group discussions (Siverman, 2006). Further, the survey was designed to be cross-sectional in nature due to limitations in terms of finances and time. Sample questionnaire has been provided in Appendix 2.

The Delphi Technique was not used to build consensus on the challenges and opportunities in the development of off-grid mini hydropower projects in Zambia due to limited time and financial constraints.

3.4.2 Secondary techniques

This technique was used to collect secondary data from a range of documents which included published books and peer reviewed journals on energy and related issues. This technique provided the basis for research background and literature review.

3.5 Choice of study area

The institutions interviewed were all from within Zambia and that helped to bring out the experiences from both the private and public perspective in the development of off-grid mini hydropower projects in Zambia.

3.6 Pilot study

The semi-structured interviews and the self-administered questionnaires were piloted on a policy maker, private developer, public developer, consultant, regulator and cooperating partner (financier) to determine whether the questions were clear without any ambiguity and appropriate to the respondents. As for the initial questionnaire, minor modifications were made to the questions following the feedback from the respondents. A total of six questionnaires were administered for the same purpose.

3.7 Ethical considerations

According to Creswell (2014), ethical issues in research command a lot of attention today and ethical considerations that need to be anticipated are extensive and reflected through the research process. Attention needs to be directed towards ethical issues prior to conducting the study; beginning a study; during data collection and data analysis and in reporting, sharing and storing the data (Creswell, 2014). All the individuals that took part in the survey had an opportunity to be briefed on what the study was all about through the introductory letter of the questionnaire. Assurance of anonymity was given as the questionnaire had no provision for name of respondent which motivated voluntary participation of the respondents. The data was collected by making visits to the individuals involved while questionnaires were delivered by hand and in many cases through email. The responses were also submitted in a similar manner to that for the delivery of questionnaires.

3.8 Method of analysis

The data was coded and analysis was done using Microsoft Excel 2016 and Stata 11.2 Software. Stata Software was used as it provided a better platform for data encoding and validation. Excel was used to produce graphs considering its versatility in terms of graphics. Quantitative data analysis was performed where basic descriptive statistics both numerical and graphical were produced.

After proposing the strategy, the process of validation of the strategy was conducted. A sample of five respondents who earlier participated in the questionnaire survey and interviews was selected. The validity criteria of credibility, transferability, dependability and confirmability of the proposed strategy were achieved by circulating the proposed strategy to the five members and recording their comments. The comments were analysed and compared for incorporation in the proposed strategy.

3.9 Summary

The chapter presented the methodology adopted in the study. The study adopted a mixed research design where both qualitative and quantitative data were captured. Qualitative data was collected first through face to face interviews and helped to structure the questionnaires for the survey.

The choice of the mixed research methodology was arrived at considering that it minimises the shortcomings of qualitative and quantitative research. This is in line with Dawson (2007), who argues that neither qualitative nor quantitative research is better as both approaches are just different, and they have their strengths and weaknesses.

The research instruments employed in the study included key informant interviews and structured questionnaire. Expert purposive sampling was used with key informants coming mainly from both public and private institutions within the energy sector. Out of the 36 experts, 30 responded to the questionnaires which were used for data collection. Ten experts were interviewed.

The data was coded and analysis was done using Microsoft Excel 2016 and Stata 11.2 Software. Quantitative data analysis was performed where basic descriptive statistics both numerical and graphical were produced.

The next chapter presents the results and discussion of the findings gathered from both the interviews and the questionnaire survey.

CHAPTER 4: FINDINGS AND DISCUSSION

4.1 Introduction

The previous chapter presented the methodology adopted in the study and this chapter presents the findings of the inquiry. The study adopted a mixed research design where both qualitative and quantitative data were captured so as to give good insight of the challenges and opportunities involved in developing off-grid mini hydropower projects in Zambia. Qualitative data was collected first through face to face interviews and helped to structure the questionnaires for the survey. This chapter presents the results of the findings gathered from both the interviews and the questionnaire survey.

4.2 Demographic information

The demographic information of the respondents was as presented below.

4.2.1 Sector to which the Respondents belonged

Data was collected on the sector to which the respondents belonged. The results showed that 25 out of 30 respondents were working in the energy sector while the rest were working in other sectors which supported energy projects. The fact that most respondents came from the energy sector justifies the robustness of the results as the same respondents were better placed to highlight the challenges and opportunities in off-grid mini hydropower development and in the energy sector in general.

4.2.2 Role of organization in mini hydropower development

Results of the role of organisation from which the respondents were drawn showed that most of them came from the implementing agencies. The least came from financiers as indicated in Table 4.1. The results accurately reflect the diversity of respondents in terms of their role in the development of mini hydropower projects.

Table 4.1: Role of organization in mini hydropower development

Role of respondent's organization in mini hydropower development	Frequency
Consultant	8
Developer	4
Financier	1
Policy Maker	5
Regulator	2
Implementing Agency	10
Total	**30**

4.2.3 Experience of Respondents in the energy sector

The results indicate that none of the respondents had experience of less than 3 years in the energy sector. The majority had experience of more than 13 years as per Table 4.2. The results imply that the study targeted respondents with vast experience in the energy sector and capable of providing reliable responses on the subject at hand.

Table 4.2: Experience of Respondents in the energy sector

Number of years worked in the Energy Sector	Frequency
1 to 3 years	1
4 to 7 years	8
8 to 10 years	5
11 to 13 years	4
Over 13 years	12
Total	**30**

4.2.4 Level of education of the Respondents

Majority of the respondents (15) had a master's Degree, 11 had Undergraduate Degree, 2 had PhD and 2 had Post Graduate Diploma as per Figure 4.1. The results imply that the study targeted well qualified respondents and capable of providing reliable responses on the subject.

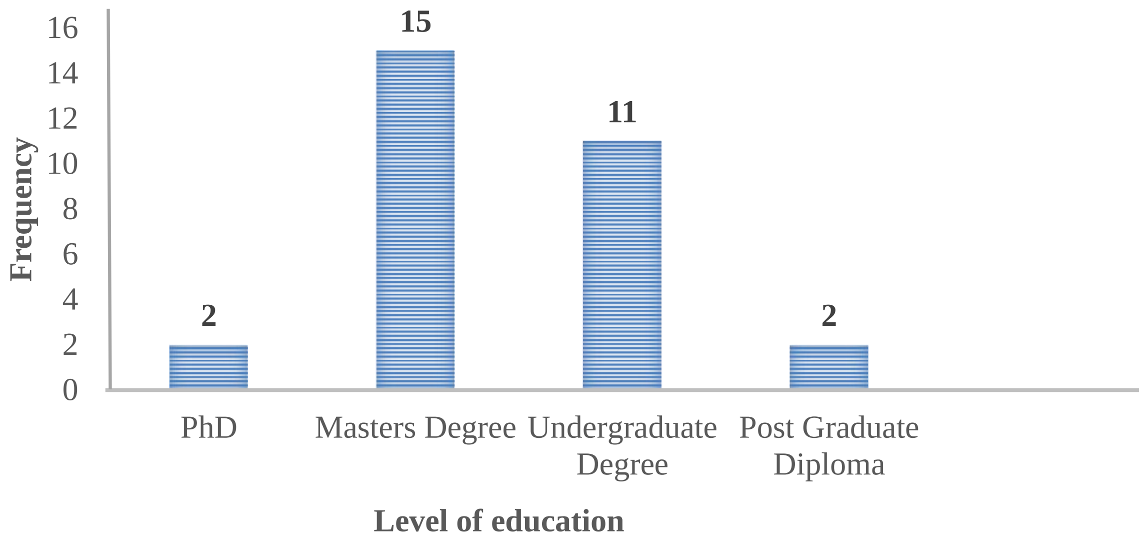

Figure 4.1: Level of education of the Respondents

4.2.5 Gender of the Respondents

Two out of the 30 respondents were female while 28 were male. While the sample indicate some level of gender biasness, this did not affect the results as gender was not a key variable in the study. However, it was clear that most energy experts in Zambia were male.

4.2.6. Level of involvement in the project development stages for off-grid mini hydropower projects

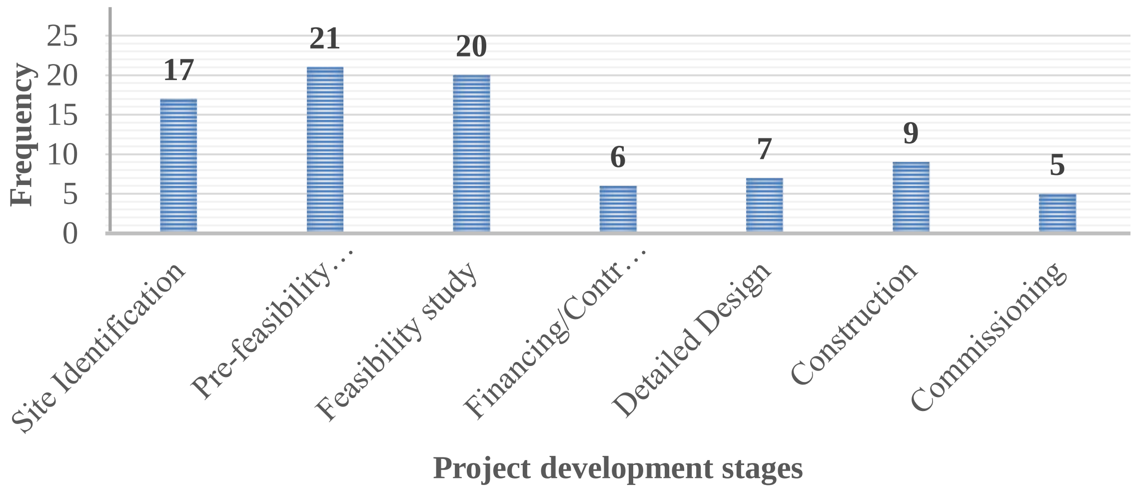

Figure 4.2: Level of Respondent's involvement in the project development stages for off-grid mini hydropower projects

From the results obtained, it is clear that the respondents had experience in the development of mini hydropower projects as all stages of hydropower development had representation. Further, the majority had been involved in pre-feasibility studies followed by feasibility studies of mini hydropower projects. Generally, the involvement of respondents in the project development stages varied. Only one person had been involved in all the seven stages of project development.

4.3 Challenges in developing off-grid mini hydropower projects in Zambia

The challenges in developing off-grid mini hydropower projects in Zambia were as presented in this section. They included high initial investment costs, limited funding, procedures for obtaining necessary permits and licenses being too long, limited market for the power generated, low tariff to attract private sector investment, lack of skills in the Zambian contractors, lack of appropriate incentives to attract private sector participation, lack of well laid down procedures in the development of mini hydropower projects and lack of proper inventory of all available mini hydropower sites in Zambia.

4.3.1 High initial investment cost

Figure 4.3 shows that out of 30 respondents, 97% agreed that high initial investment cost was a challenge in the development of off-grid mini hydropower projects in Zambia. Only 3% of the respondents disagreed. The initial investment cost was usually high for off-grid mini hydropower projects like was the case for most of the renewable energy projects.

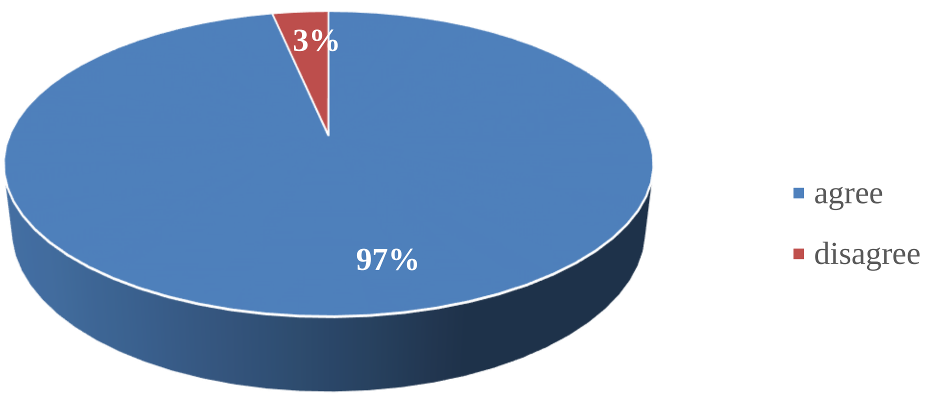

Figure 4.3: Responses to high initial investment costs

In the development of mini hydropower projects, initial investment costs do not only include construction costs of the power plant but also construction costs of supporting infrastructure like the access road among others. The same additional costs lead to high initial investment cost which leads to low rate of return on investment and would not attract private investment in mini hydropower development. High initial investment cost had a negative impact on the return on investment which was a major decision parameter considered by investors. Another source of high investment costs in the mini hydropower development in Zambia could be attributed to the fact that most of the components needed to develop these projects like the turbine generator sets and protection and control panels were imported. The finding was consistent with literature where Jaber (2012) also studied the challenges in the development of mini hydropower projects in Jordan and found that high investment cost which led to low profits generated by the developers was a major challenge.

4.3.2 Limited Funding

Out of 30 respondents, 24 agreed that limited funding for off-grid mini hydropower projects was a challenge in the development of off-grid mini hydropower projects in Zambia. Only 3 respondents were neutral and another 3 disagreed as per Figure 4.4.

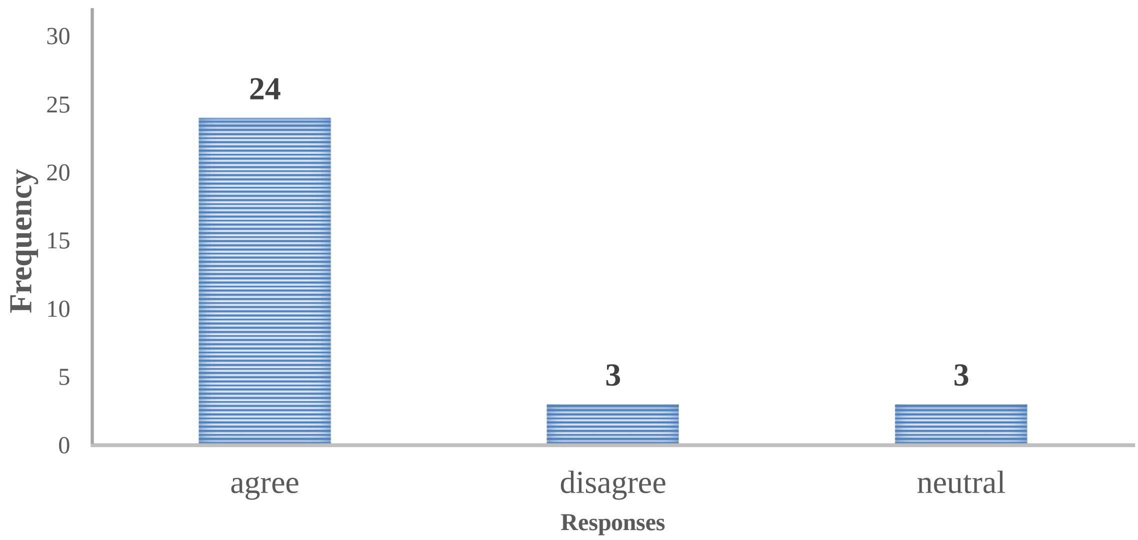

Figure 4.4: Responses to limited funding for off-grid mini hydropower projects

The finding of limited funding applied to both the private and public-sector institutions. As for the private sector institutions willing to invest in off-grid mini hydropower projects, the challenge was usually access to the required funding from financial institutions and obtaining the required level of subsidy. Like in project finance, any lender of money would have to examine the nature of the business and assess the ability of the business to pay back within a reasonable period. However, the majority of the off-grid mini hydropower projects served isolated communities that were in the rural areas where poverty levels were also high and the ability to pay was low. Many lenders were usually unwilling to sponsor projects where the financial and economic analysis of a project revealed non-viability. Funding was critical to the implementation of any project hence adequate financial support to both private and public initiatives in the development of off-grid mini hydropower projects needed to be prioritized. The findings were basically consistent with reviewed literature like Taele et.al, (2012) who echoes the same challenge. From the interviews conducted and the questionnaire survey, it was very clear that funding was the major challenge.

4.3.3 Procedures for obtaining necessary permits and licenses

As seen from Figure 4.5, out of 30 respondents, 80% agreed that procedures for obtaining the necessary permits and licenses were too long and, in some cases, not well documented. While 13% disagreed and 7% remained neutral on the subject. This challenge was identified as one of the critical ones in the development of off-grid mini hydropower projects in Zambia.

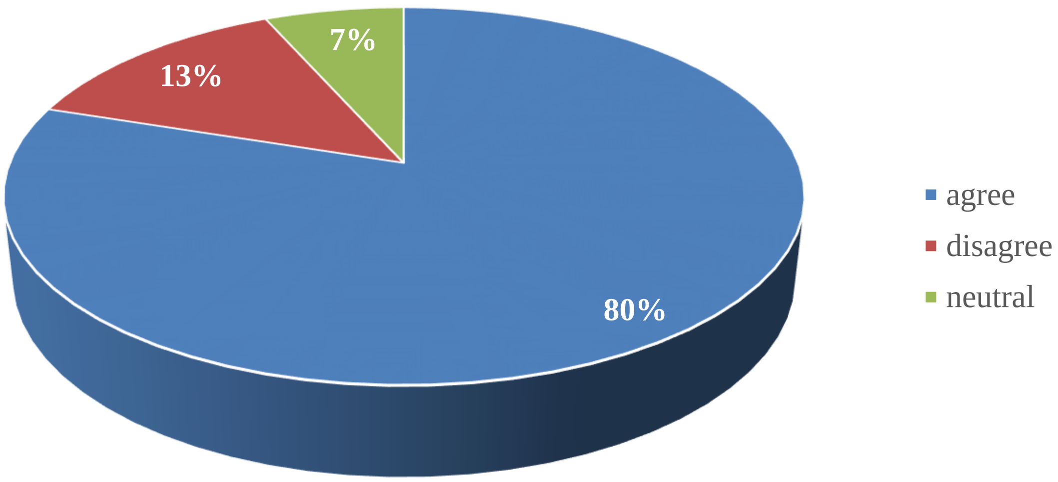

Figure 4.5: Responses to procedures for obtaining the necessary permits and licenses being too long

The study further revealed that obtaining environmental clearance, water permit, generation, transmission and distribution licenses took a long time in reality. However, on paper, the processes were relatively short taking approximately 90 days for each permit or license. The bureaucracy associated with the processes was usually what made them long. In addition, there was duplication of requirements like public hearing at environmental clearance stage and at generation license stage. Both stages required that public hearing was allowed for, when in fact the generation license stage needed to rely on the results of the public hearing at environmental clearance stage. In some cases, these procedures were not well documented and communicated to the public.

4.3.4 Limited market for the power generated

Out of 30 respondents, 24 agreed that limited market for the power generated was a challenge in the development of off-grid mini hydropower projects in Zambia. Only 3 respondents were neutral and 3 disagreed as shown in Figure 4.6.

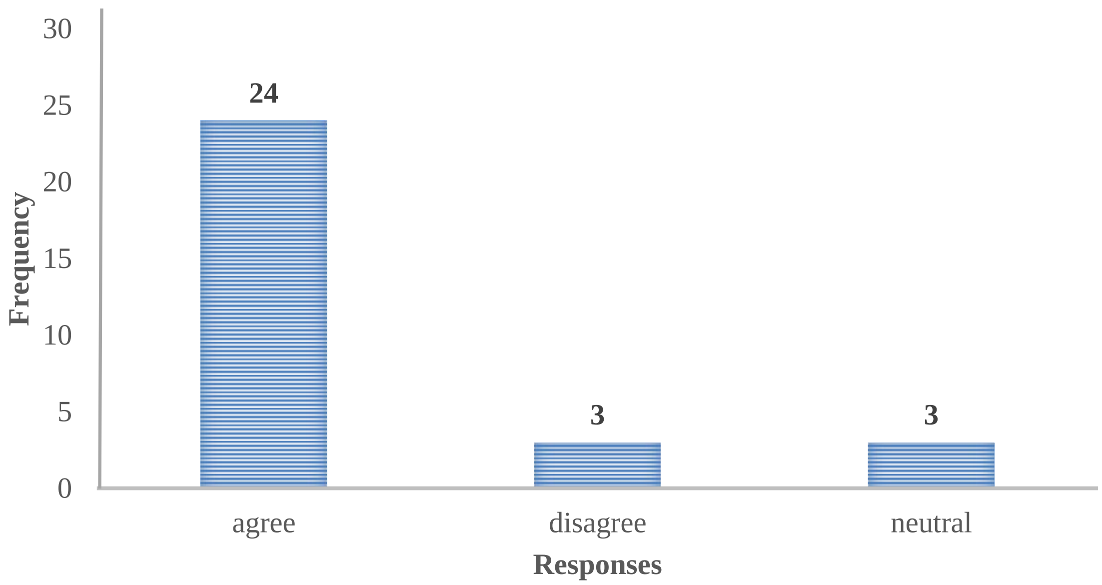

Figure 4.6: Responses to limited market for the power generated

Indeed, the market was usually limited in the rural areas for the power that would be generated by the power plant. However, the limitation of the market was site specific as some sites could generate for example 300kW which could all be consumed within the vicinity of the hydropower project. However, the nature of the settlement pattern in Zambia was that the rural areas were sparsely distributed with limited concentrated loads. Guaranteed off taker of the power generated was critical to the development of any power project. As already presented earlier, the majority of the off-grid mini hydropower projects serve isolated communities that were in the rural areas where poverty levels are also high and the ability to pay was low. The settlement patterns contributed to the limited market in question. The finding was consistent with the findings of Shi et al. (2016) and Kabaka & Gwang'ombe (2007) among others.

4.3.5 Low tariff to attract private sector investment

Out of 30 respondents, 80% agreed that Zambia had a relatively low tariff to attract private sector investment which was a challenge in the development of off-grid mini hydropower projects in Zambia. Only 17% of the respondents disagreed while 3% was neutral on the subject as highlighted in Figure 4.7.

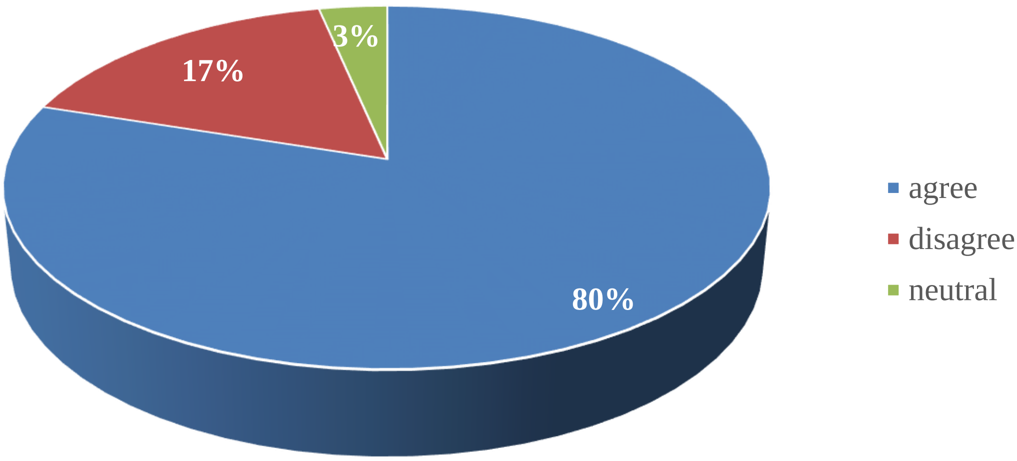

Figure 4.7: Responses to Zambia having a relatively low tariff

As seen from the results and consistent with literature, the issue of tariff was cardinal to attract private sector investment. Electricity tariffs in Zambia remained very low at an average of US$0.06/kWh as compared to the Southern African Development Community (SADC) regional average of US$0.093/kWh (ESI AFRICA, 2016). These low tariffs were responsible for low investments in mini hydropower development due to their negative impact on the rate of return on investment. Although Zambia had implemented a 75% tariff increment in a quest to migrate towards cost reflective tariff, the fruits of the increment were yet to be seen. However, the move was expected to attract many players in the electricity subsector in form of developers of power generation projects. Most developers were interested in mini hydropower projects with a well-defined and sustainable market. In addition, the tariff for an off-grid mini hydropower project was usually higher than the uniform tariff currently charged by ZESCO Limited and the same was a source of concern by the affected communities in rural areas.

4.3.6 Lack of skills in the local Zambian Contractors

Out of 30 respondents, 77% agreed that Zambian contractors lacked skills in the development of mini hydropower projects as most of the contractors on such projects were foreign contractors. Only 23% of the respondents disagreed with the subject as per Figure 4.8.

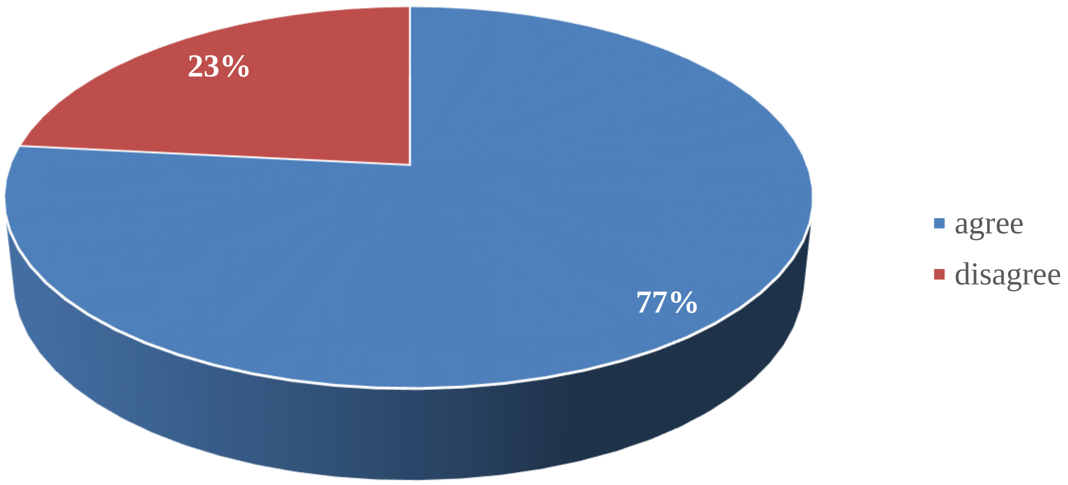

Figure 4.8: Response to lack of skills in the local Zambian contractors

As can be deduced from the results, lack of skills in the local Zambian contractors was a challenge. Due to lack of skills by local contractors, there was limited participation by the local contractors in the development of mini hydropower development. That left most of the contracts in the hands of foreign contractors who did not usually transfer the skills to local contractors. However, the skills could be there but what could be lacking would be the actual exposure for the contractors to exhibit and showcase their capabilities. As already mentioned earlier, the initial investment cost for off-grid mini hydropower projects was high meaning that even the contractors to undertake such projects needed to have a sound financial background to favourably compete for award of such jobs. It was basically for the same reasons highlighted that most contractors for hydropower projects in Zambia were foreign firms.

However, technical expertise to conduct feasibility studies and design such projects was available in the country.

4.3.7 Lack of appropriate incentives to attract private sector participation

Out of 30 respondents, 21 agreed that Zambia lacked appropriate incentives that could attract private sector participation which was a challenge in the development of off-grid mini hydropower projects in Zambia. Only 6 of the respondents disagreed while 3 were neutral on the subject as per Figure 4.9.

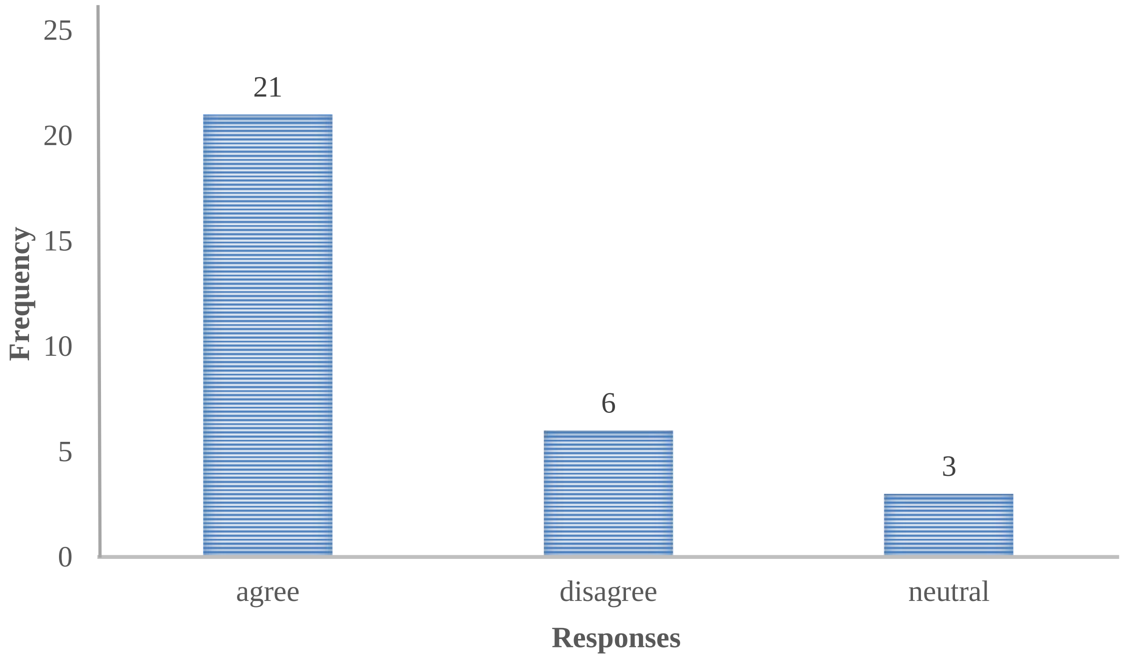

Figure 4.9: Responses to lack of appropriate incentives that can attract private sector participation

Incentives in this context were broad and mainly bordered on government policies and strategies. Despite the country having the National Energy Policy of 2008, there were no specific policies developed for renewable energies, specifically off-grid electricity projects. There was also lack of guidelines on the pricing of electricity from off-grid systems such as mini hydropower plants. Absence of such guidelines created uncertainty on the part of the private investors. There was also lack of guidelines on what would happen when the national grid was extended to the areas where the private investor would have developed an off-grid mini hydropower project. Another barrier to increased private sector participation in the development of mini hydropower projects was that, the government had not removed taxes like import duty on all hydropower equipment which made it expensive to import such equipment. However, the move to migrate towards cost reflective tariff was an incentive in its own right to encourage private sector participation.

4.3.8 Lack of well laid down procedures in the development of mini hydropower projects

Out of 30 respondents, 67% agreed that Zambia lacked a well laid down procedure for developing hydropower projects which was a challenge in the development of off-grid mini hydropower projects in Zambia. Only 30% of the respondents disagreed while 3% was neutral on the subject as per Figure 4.10.

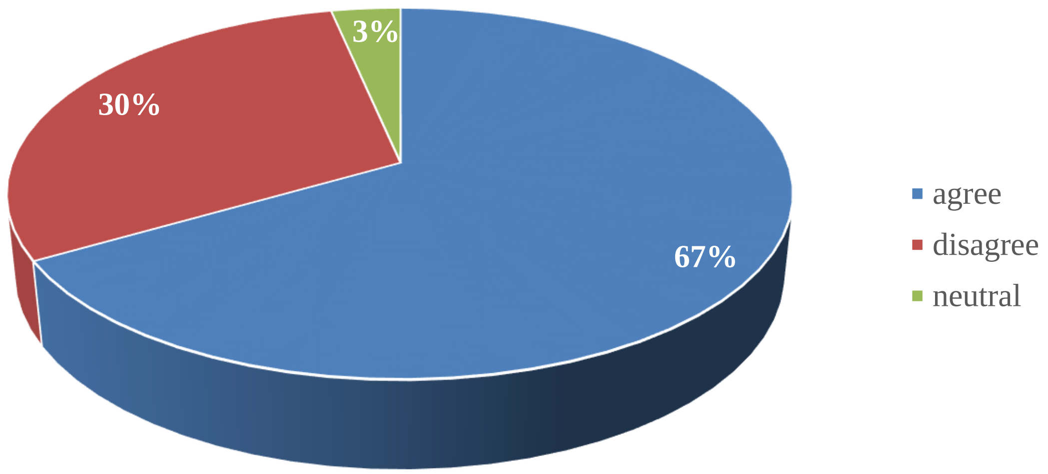

Figure 4.10: Responses to lack of well laid down procedure for developing mini hydropower projects

A well laid down procedure would make it easy for anyone intending to develop an off-grid hydropower project whether through public or private arrangement. However, the findings clearly show that it was not easy for any investor to develop a hydropower project as the lack of well laid down procedure would be discouraging. Lack of procedures for mini hydropower development was related to lack of guidelines in the development of these projects. For example, there were no clear guidelines on ownership of the hydropower sites as most of these sites were under traditional land.

4.3.9 Lack of proper inventory of all available mini hydropower sites in Zambia

Out of 30 respondents, 19 agreed that there was lack of proper inventory of all available mini hydropower sites in Zambia which was a challenge in the development of off-grid mini hydropower projects in Zambia. Only 8 of the respondents disagreed while 3 were neutral on the subject as per Figure 4.11.

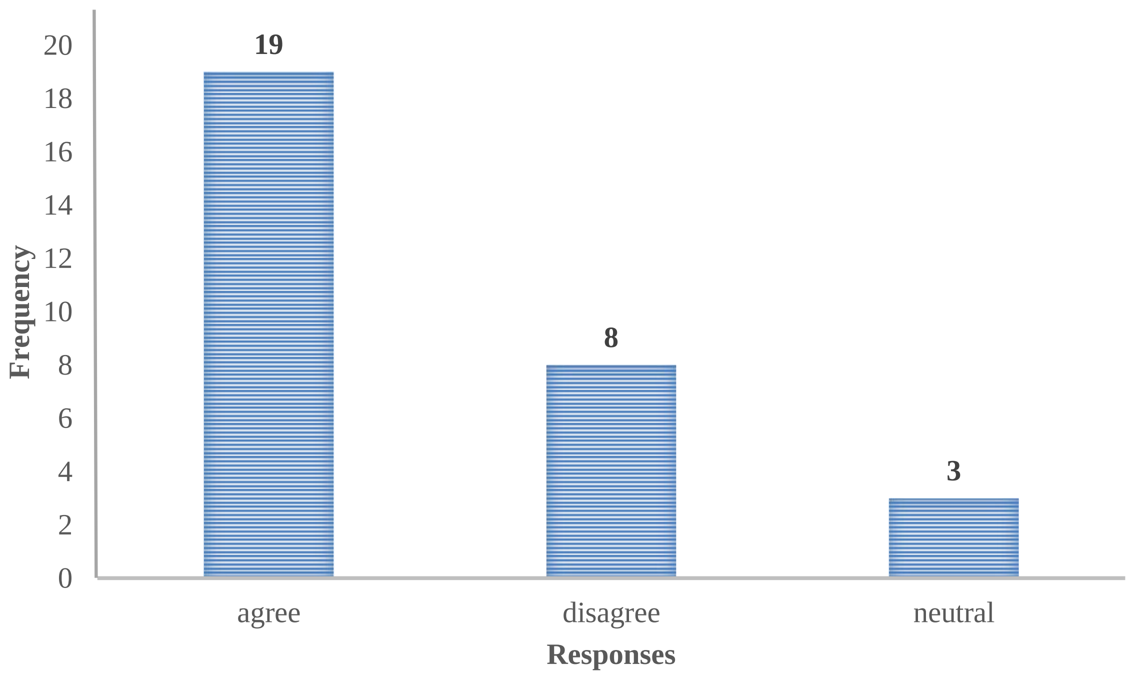

Figure 4.11: Responses to lack of proper inventory of all available mini hydropower sites in Zambia

Despite the REMP identifying 29 micro/mini hydro sites, these sites were not comprehensive as some of them were not accessible at that time. Lack of inventory of the sites in the country was one challenge in the development of off-grid mini hydropower projects as potential developers had no reference point in their quest to develop such projects. Therefore, there would be need to commission a comprehensive study that would map out all potential sites in the country on all rivers and streams and followed by pre-feasibility studies to identify which sites would need to be taken to full feasibility study stage. This information was critical in decision making hence the need to invest in the establishment of a comprehensive inventory for all the sites. However, such a study would cost a lot of money hence the need to strategize in the allocation of the scarce resources for the country and the energy sector in particular.

4.3.10 Lack of technical capacity to conduct feasibility studies of identified mini hydropower projects

Out of the 30 respondents, 63% disagreed that there was lack of technical capacity to conduct feasibility studies of identified mini hydropower projects in Zambia while 30% agreed and 7% remained neutral on the subject as per Figure 4.12.

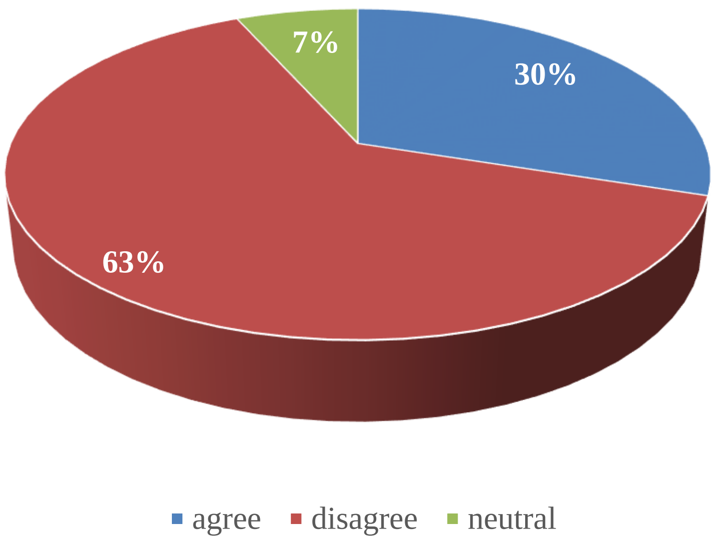

Figure 4.12: Response to lack of technical capacity to conduct feasibility studies of identified mini hydropower projects

From the results of Figure 4.11, it could be deduced that the identified challenge was non-critical as the majority of the respondents disagreed that there was lack of technical capacity to conduct feasibility studies of identified mini hydropower projects in Zambia. It could further be deduced that there was technical capacity to conduct feasibility studies of identified mini hydropower projects as evidenced by the respondent's involvement in the hydropower development stages as per Figure 4.2.6. The result disagrees with the generic challenge where lack of local capacity to design and develop small hydropower schemes for areas sometimes considered too remote was identified by Kaunda (2013) in Malawi as one of the major challenges in the development of small hydropower.

4.3.11 Government and other cooperating partners preferring to fund large hydropower projects as compared to mini hydropower projects

Out of 30 respondents, 60% agreed that government and other cooperating partners prefer to fund large hydropower projects as compared to mini hydropower projects which was a challenge in the development of off-grid mini hydropower projects in Zambia. Only 33% of the respondents disagreed while 7% were neutral on the subject as per Figure 4.13.

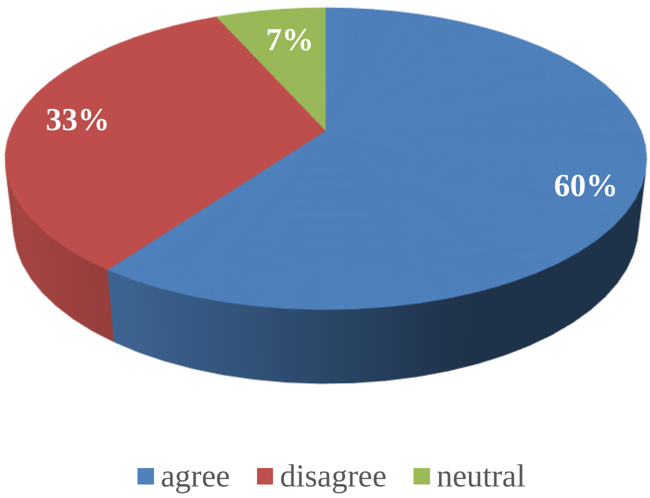

Figure 4.13: Response to government and other cooperating partners preferring to fund large hydropower projects as compared to mini hydropower projects

From the results in Figure 4.13, it is clear that there was some level of biasness by government and other cooperating partners in terms of funding as large hydropower projects were preferred as compared to mini hydropower projects. The result was consistent with the finding by Taele et. al., (2012) where the same biasness was identified as a major barrier to the development of small hydropower projects in Lesotho.

4.3.12 Lack of political will to develop off-grid mini hydropower projects in Zambia

Out of 30 respondents, 36% agreed that there was no political will to develop off-grid mini hydropower projects in Zambia which was a challenge in the development of off-grid mini hydropower projects in Zambia. 37% of the respondents disagreed while 27% were neutral on the subject as per Figure 4.14.

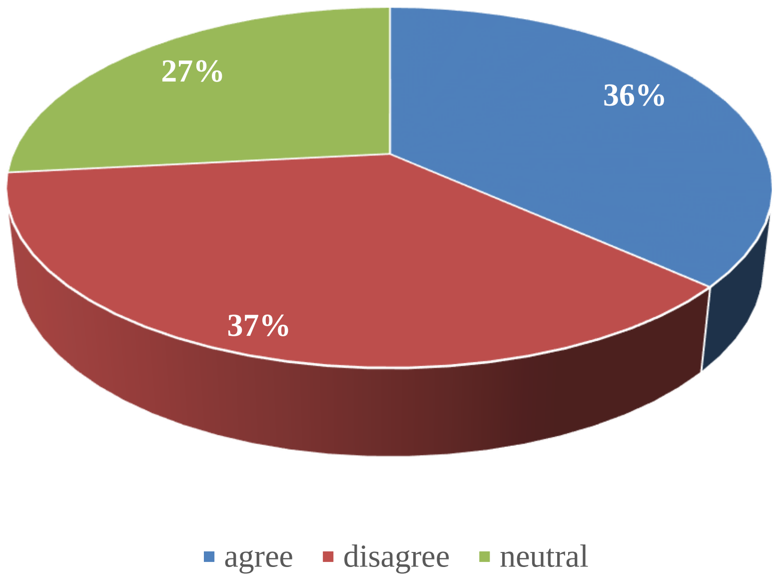

Figure 4.14: Response to lack of political will to develop off-grid mini hydropower projects in Zambia

From the results obtained, the challenge of lack of political will to develop off-grid mini hydropower projects in Zambia was non-critical despite being identified as a challenge. From the interview and questionnaire survey, the respondents mainly from government institutions preferred to remain neutral on the subject of political will despite assurance of anonymity as per the questionnaire in Appendix 2. The generic challenge of lack of political will was country specific depending on the level of adherence to the legal and regulatory framework among others.

4.3.13 Lack of coordination among sector institutions in the development of mini hydropower projects

Out of 30 respondents, 57% agreed that there was lack of coordination among sector institutions in the development of mini hydropower projects in Zambia which was a challenge in the development of off-grid mini hydropower projects in Zambia. 23% of the respondents disagreed while 20% were neutral on the subject as per Figure 4.15.

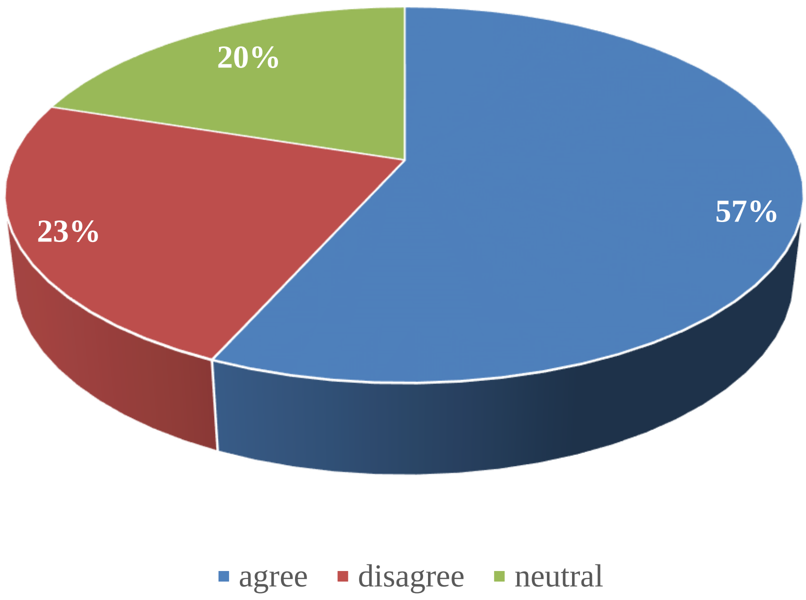

Figure 4.15: Response to lack of coordination among sector institutions in the development of mini hydropower projects in Zambia

From the results obtained, it is clear that there was lack of coordination among sector institutions in the development of mini hydropower projects in Zambia which was a challenge to the development of off-grid mini hydropower projects in Zambia. The lack of coordination led to duplication of efforts in the energy sector despite the scarce resources which need to be optimally allocated. The challenge of lack of coordination was consistent with literature reviewed.

4.4 Ranking of the challenges in terms of their severity

The challenges were ranked in order of severity following the responses according to the Likert Scale. Since the Likert Scale was ranking responses on a scale of 1 to 5, with 1 representing strongly disagree and 5 representing strongly agree and 3 representing neutral responses, another scale was established between 0% and 100%. The ranking was categorised as follows: 0% to 25% strongly disagree, 25% to 50% moderate disagree, 50% to 75% moderately agree and 75% to 100% strongly agree.

To rank the challenges according to severity, two categories (agree and disagree) were created by collapsing the five categories of the Likert scale and removing the neutral scale. A percentage of responses for each category was then established. A rule was established that if a challenge received less than 50% of the responses, then that challenges was non-critical. If the challenge received between 50% and 75% of the responses, then that challenge was moderately critical. If a challenge received more than 75% of the responses, then that challenge was considered to be critical.

The results show that six of the challenges were critical as they received responses to the agreed category of more than 75%. The critical challenges included the high initial investment cost, limited funding, limited market for the power generated, long procedures for obtaining the necessary permits and licenses, low tariff to attract private sector participation and lack of skill in the local Zambian contractors in development of mini hydropower projects. Of all the challenges identified, the most critical challenge was high initial investment costs required for development of mini hydropower projects while the least critical was lack of coordination among sector institutions in the development of mini hydropower projects. Five challenges were established to be moderate while two challenges were deemed non-critical. The two non-critical challenges were, lack of technical capacity to conduct feasibility studies for identified mini hydro power sites and lack of political will to develop off-grid mini hydropower projects in Zambia.

4.5 Opportunities in developing off-grid mini hydropower projects in Zambia

Results highlighting the opportunities in developing off-grid mini hydropower projects in Zambia were as presented below. These opportunities included the presence of a relatively stable political climate, the significant hydropower potential, government's willingness to migrate towards cost reflective tariff, institutional framework and legal framework.

4.5.1 Relatively stable political climate

Out of 30 respondents, 83% agreed that Zambia had a relatively stable political climate which was an opportunity in the development of off-grid mini hydropower projects in Zambia. Only 10% of the respondents disagreed while 7% were neutral on the subject as per Figure 4.16.

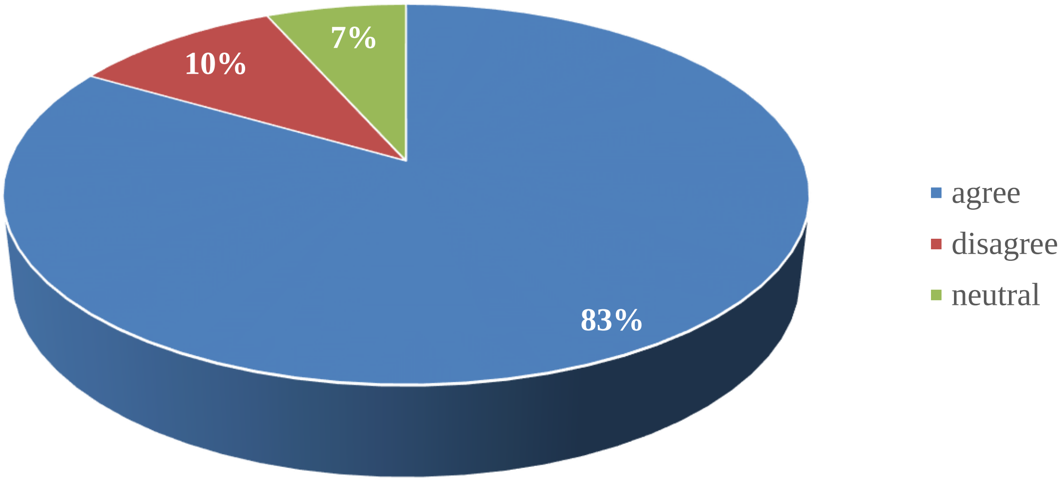

Figure 4.16: Responses to Zambia having a relatively stable political climate

A stable political climate was recipe for any business to flourish. Investors/developers were willing to do their business in an environment which was peaceful and relatively stable in terms of financial and economic policies of a country. Zambia's stable political climate could have been attributed to its democratic nature where leaders were democratically elected and no major conflicts had been recorded since independence in 1964. That makes Zambia a haven for investment by both local and foreign companies. The finding therefore concludes that Zambia was relatively stable in terms of the political climate which presents an opportunity for the development of off-grid mini hydropower and developmental projects.

4.5.2 Significant hydropower potential in Zambia

Out of 30 respondents, 80% agreed that there was significant hydropower potential in Zambia which was an opportunity in the development of off-grid mini hydropower projects in Zambia.

Only 13% of the respondents disagreed while 7% were neutral on the subject as shown in Figure 4.17.

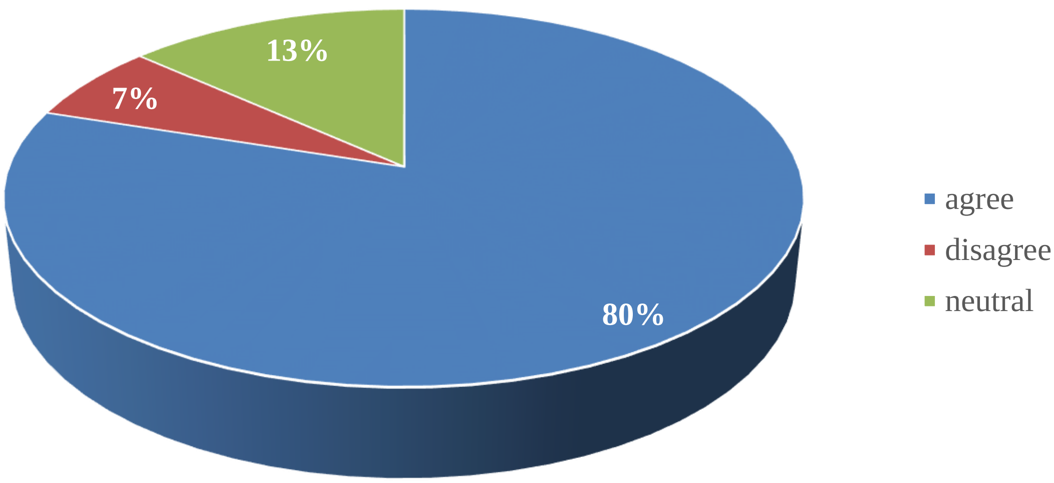

Figure 4.17: Responses to availability of significant hydropower potential in Zambia

The study revealed that availability of abundant natural resources like water from streams and rivers mainly in the northern parts of the country presented an opportunity for mini hydro development in the country. The same was in line with the findings by SNV Netherlands Development Organisation (2014) where the availability of natural resources was identified as an opportunity in the development of off-grid renewable energy projects. However, the availability of water for power generation was dependent on climatic conditions which were favourable in Zambia. As already highlighted by the Energy Regulation Board (ERB) in their 2014 Energy Sector Report, the hydropower potential for the country was at approximately 6,000MW which was significant. Further, according to the 2016 Energy Sector Report for Zambia by ERB, the installed capacity from hydropower was approximately 39.8% of the estimated hydropower potential. From the statistics given, it could be seen that there was still 60% of the untapped potential to be exploited which presented an opportunity for any public or private developer in Zambia.

4.5.3 Government's willingness to migrate towards cost reflective tariff

Out of 30 respondents, 80% agreed that there was government's willingness to migrate towards cost reflective tariff which was an opportunity in the development of off-grid mini hydropower projects in Zambia. Only 10% of the respondents disagreed while 10% were neutral on the subject as highlighted in Figure 4.18.

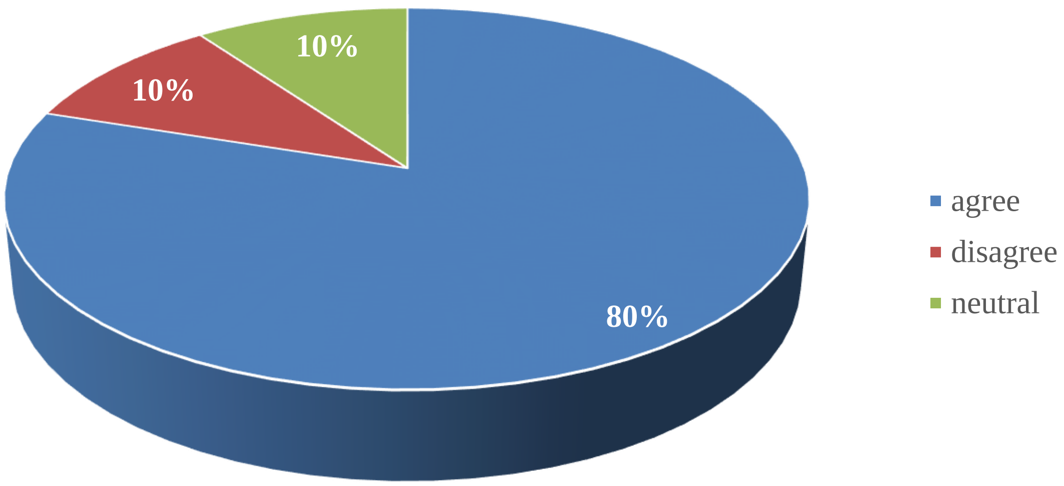

Figure 4.18: Responses to government's willingness to migrate towards cost reflective tariff

Electricity tariffs in Zambia remained very low at an average of US$0.06/kWh as compared to the Southern African Development Community (SADC) regional average of US$0.093/kWh (ESI AFRICA, 2016). These tariffs had not reflected the cost of generating, transmitting, distributing and supplying power to various customer categories. This meant that Zambia lagged in terms of attracting private investors in the power sector who could not recover their costs at those subsidized tariffs. However, government realized that it couldn't perpetually subsidize electricity and hence instituted measures towards moving to cost reflective tariffs. Some of the measures included increasing the electricity tariffs by 75% in 2017 by the national utility company, ZESCO Limited. However, cost reflective tariffs had not yet been established pending the results of the Cost of Service Study (CoSS).

4.5.4 Availability of the required institutional framework

Out of 30 respondents, 60% agreed that Zambia had the required institutional framework which was an opportunity in the development of off-grid mini hydropower projects in Zambia. Only 20% of the respondents disagreed while 20% were neutral on the subject as shown in Figure 4.19.

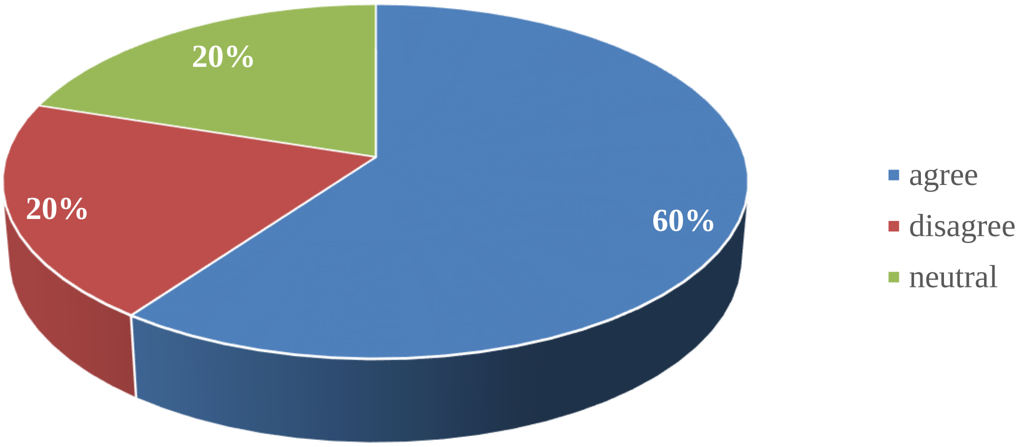

Figure 4.19: Responses to the presence of the required institutional framework in Zambia

Zambia had the required institutional framework as evidenced by various institutions in the energy sector stemming from policy level, regulatory, implementing agencies and consultants. However, there was lack of coordination among the institutions leading to duplication of efforts. Therefore, there would be need for the Department of Energy which was charged with policy guidance to take a leading role in coordinating various institutions.

4.5.5 Availability of the required legal framework

Out of 30 respondents, 57% agreed that Zambia had the required legal framework which was an opportunity in the development of off-grid mini hydropower projects in Zambia. Only 20% of the respondents disagreed while 23% were neutral on the subject as per Figure 4.20.

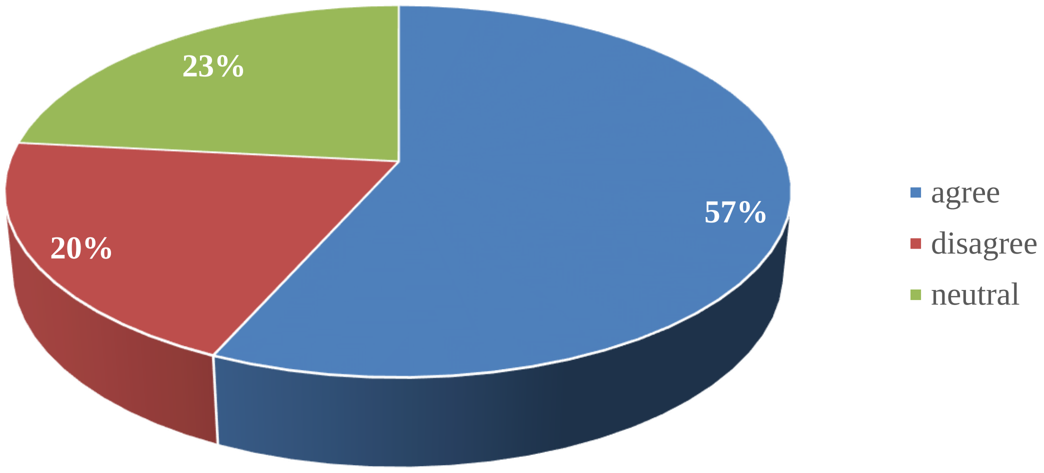

Figure 4.20: Responses to the presence of the required legal framework in Zambia

Zambia had in place a required legal framework to guide the development of electricity generation projects as presented in Chapter 1. However, specific legal framework for development of off-grid mini hydropower projects was non-existent including the Renewable Energy Policy. Notwithstanding, government had developed the Renewable Energy Feed-in-Tariff (REFiT) Strategy to complement the existing frameworks and strategies aimed at impacting specific development of the energy sector such as increased private sector participation. The National Energy Policy of 2008 was in place though it needed revising to match the current trends in the energy sector.

4.6 Summary

The chapter presented the results of the survey and interviews including discussion of the findings. The next chapter presents the proposed strategy for developing off-grid mini hydropower projects in Zambia.

CHAPTER 5: STRATEGY FOR DEVELOPING OFF-GRID MINI HYDROPOWER PROJECTS IN ZAMBIA

5.1. Introduction

The previous chapter presented the results and discussion on the findings. This chapter presents a way forward in form of the strategy for developing off grid mini hydropower projects in Zambia.

5.2. Proposed strategy

The proposed strategy for development of off-grid mini hydropower projects in Zambia is summarized in Figure 5.1. The proposed strategy was arrived at after assessing the challenges in developing the off-grid mini hydropower projects in Zambia and coming up with measures to overcome them. The opportunities have also been optimized in the strategy.

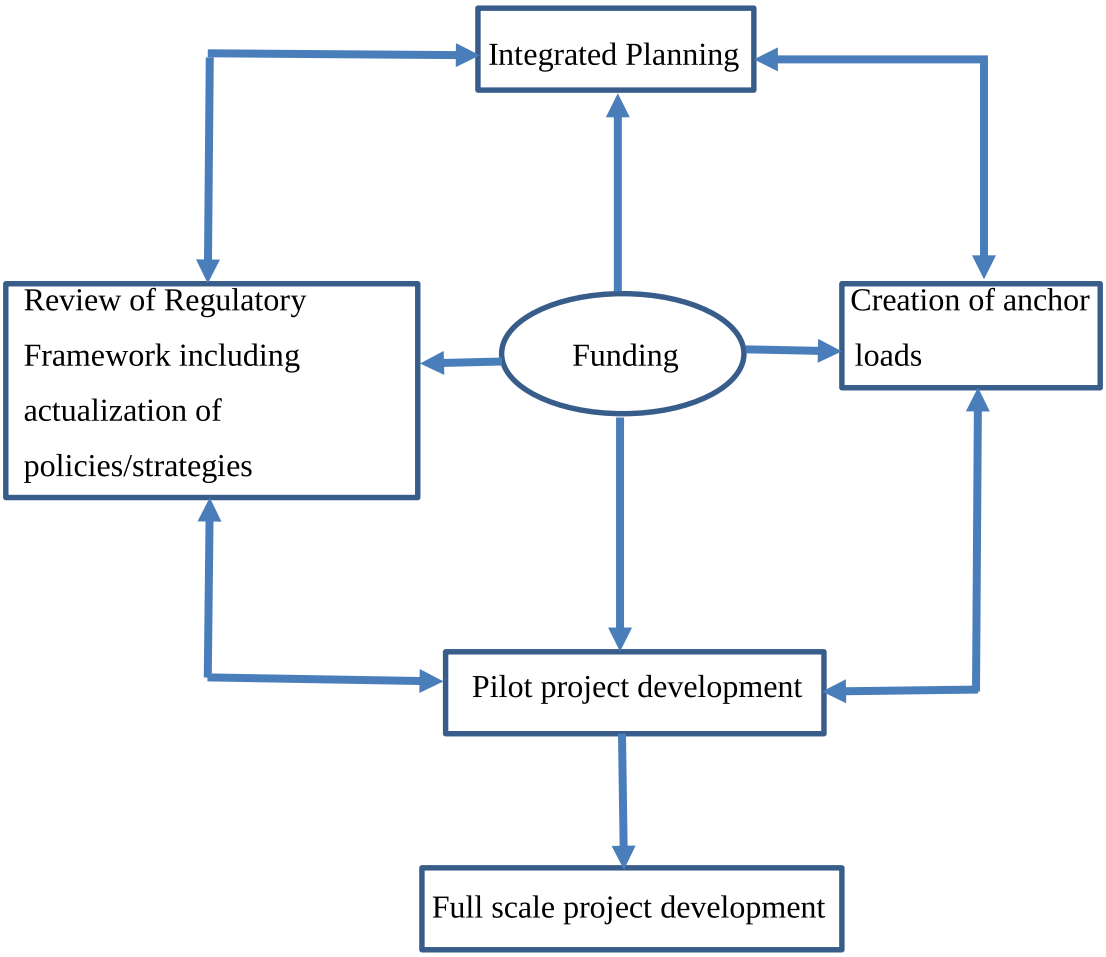

Figure 5.1: Proposed strategy for developing off-grid mini hydropower projects in Zambia

The strategy mainly focuses on the public sector which forms the basis for engaging the private sector. The private sector would mainly come in at full scale project development stage with a few coming in using their own funding.

After proposing the strategy, the process of validation of the strategy was conducted. A sample of five respondents who earlier participated in the questionnaire survey and interviews was selected. The validity criteria of credibility, transferability, dependability and confirmability of the proposed strategy were achieved by circulating the proposed strategy to the five members and recording their comments. The comments were analysed and compared for incorporation in the proposed strategy.

5.2.1 Integrated planning

Planning is very cardinal in any endeavor. In the project management cycle, project planning is the second stage after project initiation. However, planning needed to be well executed to make implementation easy as the plan would also act as a reference point for subsequent project activities. In the case of off-grid mini hydropower projects, integrated planning would be ideal as it would involve a number of stakeholders coming together and plan accordingly on which projects to embark on. For example, the Ministry of Energy through the Department of Energy would spearhead the planning component by bringing a number of stakeholders like implementing agencies, ministries in charge of education, health, agriculture, telecommunication and transport among others and traditional leaders from project areas.

Such an approach would ensure that other ministries contribute in one way or the other to the development of the mini hydropower sites at different stages. For example, the Ministry of Health would have a rural health centre in a locality far from the grid and relying mainly on diesel generator sets or solar power may be interested in the development of a hydropower project in the same area to provide reliable power to the health facility. In the same way, the ministry in charge of agriculture would want to put up an irrigation scheme in the rural area which was far from the grid and development of an off-grid mini hydropower project with a multipurpose reservoir would be ideal. Like in Lesotho as reported by Taele et al., (2012), donors were more interested in multipurpose projects.

As already seen from the challenges identified, there was need for close collaboration among the stakeholder institutions to come up with well laid down procedure for developing the projects in question. Therefore, integrated planning was critical to avoid duplication of efforts and save the scarce resources which are challenging in terms of allocation. The planning phase would also include conducting feasibility studies and packaging projects for implementation subject to availability of funds. The packaging of the projects would overcome the challenge of lack of a proper inventory of all available mini hydropower sites in the country. The planning phase would also be informed by the fact that the country had significant hydropower potential which was considered as an opportunity in the development of off-grid mini hydropower projects.

Integrated planning would take care of the challenges identified like high investment cost and limited funding as it would allow for cost sharing among stakeholders as earlier highlighted. The Ministry of Energy would take advantage of the opportunity of relatively stable political climate by mobilizing resources from within the treasury and through cooperating partners to enhance the funding challenge. In addition, integrated planning would allow stakeholder consultation on how to shorten the procedure for acquiring the necessary permits and licenses in addition to coming up with a well laid down procedure for developing the off-grid mini hydropower projects in Zambia.

5.2.2 Review of the regulatory framework including actualization of policies/strategies

There was urgent need to review the procedure for the current development process for hydropower projects in Zambia. As already highlighted that Zambia lacked a well laid down procedure for the development of mini hydropower projects, there would be need to finalise any draft guidelines in place. Ownership of the sites was one issue which was not clear hence the need to be clarified. The processes for obtaining the necessary permits and licenses in Zambia were deemed to be too long and, in some cases, not well documented. From the interviews conducted with experts, it was highlighted that there was duplication of stages in the environmental clearance and generation license applications as both stages had the need for public hearing to obtain public opinion on the project. Therefore, the review would be mainly on the internal processes and not the Energy Regulation Act or Zambia Environmental Management Act. In addition, the bureaucracy involved in the approval processes was also seen as a hinderance to effective delivery of mini hydropower projects. For example, the absence of a board for an institution like the Water Resources Management Authority could lead to delayed issuance of water permits which would be required in the application for the generation license. Such a challenge could cause projects to fail where funding was tied to a particular time frame.

The Renewable Energy Strategy for Zambia was not in place as the document had remained in draft form since 2010. The finalization of such a document was cardinal to the provision of the overall direction on how renewable energy projects including off-grid schemes would be developed. The Renewable Energy Policy was non-existent and would also provide guidance on how an operator or developer of a mini grid would be compensated or treated in an event that the electricity national grid reached their project area. The Renewable Energy Policy would take care of the challenge of low tariff by clearing providing direction in terms of incentives that would encourage private sector participation in the development of off-grid mini hydropower projects in Zambia. Formulation and actualisation of such documents required a strong political will.

The review of the regulatory framework would ride on the fact that there was some existing legal and institutional frameworks which were identified as opportunities in the development of the hydropower projects in question.

5.2.3 Creation of anchor loads

As already highlighted under the previous chapter, lack of anchor loads or limited market for the power generated was a challenge in the development of off-grid mini hydropower projects in Zambia. Generally, the settlement pattern in the rural areas of Zambia was such that the population was sparsely distributed making it impossible for people within the vicinity of the hydropower plant to consume all the power generated. It was again through integrated planning that the creation of anchor loads could be achieved. For example, having a deliberate government policy on establishing irrigation schemes and setting up of agro-processing industries in the project areas to encourage uptake of the power generated. Further, sensitizing the communities to engage in productive uses of electricity by setting up small business would increase uptake of electricity. The creation of anchor loads would be encouraged by the fact that the country had a relatively stable political climate which was among the pre-requisites for investment to flourish. Integrated planning would also encourage the establishment of the anchor loads through consultations with the relevant stakeholders in order to foster development of the rural areas.

5.2.4 Pilot project development

With the planning done, which could also include creation of anchor loads and the procedures well laid down, there would be need to pilot the off-grid mini hydropower projects. One challenge identified was lack of skills in the local contractors hence the need to use local contractors together with experienced foreign firms as Supervising Engineers commonly referred to as the Owner's Engineer on such projects. That move would ensure that capacity is built within the local contractors. In addition, to ensure that the projects go beyond pilot stage, lessons learnt would need to be well documented and presented to relevant institutions as the country moved to full scale development of off-grid mini hydropower projects. This entails having to follow through the project management cycle and updating the project management manual or document accordingly. In addition, the availability of institution framework to encourage development of off-grid mini hydropower project was already identified as an opportunity which would be taken advantage of during the piloting phase.

5.2.5 Full scale development of off-grid mini hydropower projects

Following the successful pilot stage, the next stage would be to roll out the development of the off-grid mini hydropower projects on a larger scale throughout the country with guidance from the master plan to be developed. Full scale development would start with site identification up to commissioning as presented by Fichtner Management Consulting AG (2015). With all being in place, the off-grid mini hydropower projects may be developed purely by the private sector, public sector or through Public Private Partnerships (PPP) as encouraged in the revised National Energy Policy of 2008.

5.2.6 Funding

As presented in Figure 5.1 above, funding was at the centre of the strategy with linkage to every component of the schematic illustration of the strategy. Funding was identified as one of the critical challenges to the development of off-grid mini hydropower projects in Zambia. Despite funding being one of the critical issues to consider, all other components of the strategy were interdependent. Funding with no proper planning would be a waste of resources. However, even the same integrated planning would require some funding for it to be effectively carried out hence the interdependency. Further, funding would entail having a clear subsidy programme by the government through its implementing agencies to encourage private sector participation in the development of off-grid mini hydropower projects. Therefore, there would be need to increase public funding to the energy sector in order for the private sector to also benefit in form of attractive subsidy levels. Increasing public funding to the energy sector was one thing while the actual allocation of the institutional budgets to the development of off-grid mini hydropower projects was another. One way to increase funding for the institutions charged with the responsibility of overseeing development of off-grid mini hydropower projects was for the government to come up with resource mobilization strategies which would entail engaging the cooperating partners among other initiatives.

5.3. Summary

This chapter provided the proposed strategy for developing off-grid mini hydropower projects in Zambia. The next chapter provides the conclusions and recommendations including suggestions for further work.

CHAPTER 6: CONCLUSIONS AND RECOMMENDATIONS

6.1 Introduction

This chapter gives the conclusion to the study as well as recommendations and limitations.

6.2 Conclusions

The study sought to identify the challenges and opportunities in developing off-grid mini hydropower projects in Zambia. The research was designed in such a way that both qualitative and quantitative data were captured using interviews and structured questionnaires respectively. Critical challenges identified included high initial investment cost, limited funding, long procedures for obtaining the necessary permits, low electricity tariffs to encourage private sector participation, lack of skills in the local contractors and limited market for power generated.

The study further, identified opportunities in the development of off-grid mini hydropower projects. These opportunities included the presence of a relatively stable political climate, the significant hydropower potential, government's willingness to migrate towards cost reflective tariff, availability of institutional framework and legal framework. A strategy to overcome the challenges and take advantage of the opportunities was presented with integrated planning being the starting point of the schematic presentation of the strategy. Integrated planning was required by all relevant government ministries and all stakeholders concerned with rural development.

Despite the challenges identified being more than the identified opportunities, the future for the development of off-grid mini hydropower projects in Zambia was bright with concerted effort from all stakeholders as already highlighted in the strategy. Development of off-grid mini hydropower projects would contribute to increasing the electricity access rate in rural areas which stood at 4.4% as at 2015. The development of such projects would bring out other benefits like job creation among others which would be part of the opportunities.

6.3 Recommendations

Following the results of the study, the following recommendations were made:

i. Government needed to increase its funding allocation to the institutions overseeing mini hydropower development and further market the sites to potential cooperating partners.

ii. There was need for the Department of Energy, through consultation with the relevant stakeholder institutions, to come up with a standardised process flow in the development of mini hydropower projects from both the public and private sector perspective.

iii. There was need to review the regulatory framework in terms of simplifying and shortening the procedure for obtaining the necessary permits and licenses in Zambia.

iv. There was need to provide incentives that would attract private sector participation especially in form of pre-determined subsidy levels.

v. There was need to pilot projects where local contractors/consultants would be given an opportunity to develop such projects under the supervision of experienced foreign firms.

vi. There was need for the development of a master plan for all mini hydropower sites in form of a comprehensive database accessible by all relevant institutions.

vii. Above all, integrated planning was required by all government ministries and all stakeholders concerned with rural development.

viii. There was need to finalise the Renewable Energy Policy which would also address the legal issues related to off-grid mini hydropower projects.

6.4 Limitations and suggestions for further work

The study examined challenges of developing off-grid mini hydropower projects up to commissioning stage. However, the study could be extended to further look at the sustainability aspects of the off-grid mini hydropower projects in Zambia using case studies by focusing on the operation and maintenance phases of the projects.

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APPENDICES

APPENDIX 1: Interview guide

INTERVIEW GUIDE

Introduction and explanation of the purpose of the interview

I am currently pursuing my Master of Engineering Degree in Project Management at University of Zambia Great East Road Campus. As part of the requirements for award of the master's Degree, I am conducting a research on the challenges and opportunities in implementing off-grid mini hydropower projects in Zambia. I would be very grateful if you could please spare a few minutes of your time to interact with me on issues related to mini hydropower development in Zambia. The purpose of the interview is to obtain data for the for my research which would also contribute to the development of mini hydropower projects in Zambia. Any information given shall be held in confidence and not used for any other objective contrary to the stated purpose.

(A) GENERAL INFORMATION

1. What is the name of your organisation?

   …………………………………………………

2. What is the role of your organization with regards mini hydropower development?

   ………………………………………………………………………………………………

3. For how long have you been working in the Energy Sector?

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

4. What project stage(s) have you been involved in with regards the development of off-grid mini hydropower projects in Zambia?

(B) CHALLENGES OF IMPLEMENTING OFF-GRID MINI HYDROPOWER PROJECTS IN ZAMBIA

Kindly state and explain what challenges exist in the development of off-grid mini hydropower projects in Zambia.

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…………………….

(C) OPPORTUNITIES IN IMPLEMENTING OFF-GRID MINI HYDROPOWER PROJECTS IN ZAMBIA

Kindly state and explain what opportunities exist in the development of off-grid mini hydropower projects in Zambia.

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……
……

(D) WAYFORWARD

Based on the identified challenges and opportunities that exist in the development of off-grid mini hydropower projects in Zambia, what should the country do to accelerate the development of mini hydropower projects in the country.

……
……
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……
……

Thank the interviewee for their participation

APPENDIX 2: Sample questionnaire

THE UNIVERSITY OF ZAMBIA

SCHOOL OF ENGINEERING

DEPARTMENT OF CIVIL AND ENVIRONMENTAL ENGINEERING

Dear Sir/ Madam,

I am currently pursuing my Master of Engineering Degree in Project Management at University of Zambia Great East Road Campus. As part of the requirements for award of the master's degree, I am conducting a research on the challenges and opportunities in implementing off-grid mini hydropower projects in Zambia. I would be very grateful if you could please help with filling in the attached questionnaire by responding to the questions to the best of your ability. The questionnaire is administered for the purpose of collecting data for academic purpose and also to contribute to the development of hydropower projects in Zambia. Any information given shall be held in confidence and not used for any other objective contrary to the stated purpose.

The questionnaire will only take approximately 10 minutes of your time and I wish to thank in advance for your participation.

Yours faithfully,

Edmond Mkumba

QUESTIONNAIRE – PUBLIC AND PRIVATE INSTITUTIONS IN ZAMBIA DEALING WITH MINI HYDROPOWER RELATED MATTERS

(E) GENERAL INFORMATION

Kindly tick your option where choice has been provided.

5. Please indicate the name of your organization……………………………………………….
6. Please indicate which sector of the economy your organization belongs to………………………………………………………………………………………….
7. How long has your organization been in existence?

   1 to 3years [ ] 4 to 7years [ ] 8 to 10years [ ] 11 to 13years [ ] Over 13 years [ ]

8. What is the role of your organization with regards mini hydropower development?

   Policy maker [ ] Implementing Agency [ ] Consultant [ ] Financier [ ]

   Transaction Advisor [ ] Others [ ]

   If your answer is '*Others*', kindly specify…………………………………………………

9. For how long have you been working in the Energy Sector?

   1 to 3years [ ] 4 to 7years [ ] 8 to 10years [ ] 11 to 13years [ ] Over 13 years [ ]

10. What is your highest level of education?

    Master's Degree [ ] Undergraduate Degree [ ] Diploma [ ] Certificate [ ]

    Any other (specify)…………………………………………………………………

11. Sex

    Female [ ] Male [ ]

12. What project stage(s) have you been involved in with regards the development of off-grid mini hydropower projects in Zambia? Kindly tick the applicable project stage(s).

    Site identification [ ] Pre-feasibility study [ ] Feasibility Study [ ] Financing/Contracts [ ]

    Detailed Design [ ] Construction [ ] Commissioning [ ]

(F) CHALLENGES OF IMPLEMENTING OFF-GRID MINI HYDROPOWER PROJECTS IN ZAMBIA

Kindly indicate (by ticking) your level of agreement with the following statements, on a scale of 1 - 5, with the following meaning:

1 - strongly disagree; 2 – disagree; 3 – neutral; 4 - agree and; 5 - strongly agree.

STATEMENT	**1**	**2**	**3**	**4**	**5**
Zambia lacks the technical capacity to conduct feasibility studies of identified mini hydropower sites					
There is no well laid down procedure for the development of mini hydropower sites from a private developer's perspective					
There is limited funding for off-grid mini hydropower projects					
Government and other cooperating partners prefer to fund large hydropower projects as compared to mini hydropower projects					
Zambia has relatively low tariff levels to attractive private sector investment					
Zambia lacks appropriate incentives to attract private sector participation in the development of mini hydropower projects					
Development of off-grid mini hydropower projects requires high initial investments considering that most of the equipment required is manufactured abroad					
There is limited market for the power generated within the vicinity of hydropower plants in rural areas due to the sparsely distributed population in the same areas					
Zambia lacks local skills in the development of mini hydropower projects as most of the contractors on such projects are foreign contractors					
There is no political will to develop off-grid mini hydropower projects in Zambia					
There is lack of coordination among sector institutions in the development of mini hydropower projects					
There is lack of proper inventory of all available mini hydropower sites in the country					
Procedures in obtaining the necessary permits and licenses are too long and not well documented					

For any other challenges, kindly state them in the spaces provided below

……

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(G) OPPORTUNITIES IN IMPLEMENTING OFF-GRID MINI HYDROPOWER PROJECTS IN ZAMBIA

Kindly indicate (by ticking) your level of agreement with the following statements, on a scale of 1 - 5, with the following meaning:

1 - strongly disagree; 2 – disagree; 3 – neutral; 4 - agree and; 5 - strongly agree.

STATEMENT	**1**	**2**	**3**	**4**	**5**
Zambia has the required institutional framework to facilitate the development of off-grid mini hydropower projects					
Zambia has the required legal framework to facilitate the development of off-grid mini hydropower projects					
Though Zambia's electricity tariff was not cost reflective, there was willingness to migrate towards cost reflectivity					
Zambia has huge mini hydropower potential					
Zambia has a relatively stable political climate to attractive private sector investment					

For any other opportunities, kindly state them in the spaces provided below

……

……

……

Thank you for your participation