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THE CONTRIBUTION OF RENEWABLE ENERGY TECHNOLOGIES TO SUSTAINABLE COMMUNITY DEVELOPMENT IN RUSITU VALLEY, ZIMBABWE

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A minithesis submitted in partial fulfilment of the requirement for to the degree of Magister Artium, Development Studies in the Institute for Social Development, University of the Western Cape.

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Sustainable community development,

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ABSTRACT

THE CONTRIBUTION OF RENEWABLE ENERGY TECHNOLOGIES TO SUSTAINABLE COMMUNITY DEVELOPMENT IN RUSITU VALLEY, ZIMBABWE

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Energy is a catalyst for development and renewable energy sources in particular have gained prominence in empirical literature as a viable alternative to fossil based sources in achieving sustainable development. However, despite implementing renewable energy programmes, many developing countries still do not appear to be on a path towards sustainable development. This research explores the interaction of renewable energy technologies and sustainable development in low income communities. The systems theory is used as a framework to establish the nature of the relationship between renewable energy technologies and the economic, social and environmental dimensions of sustainable development.

This exploratory study is based on the case of the Rusitu Valley, a low income rural community in Zimbabwe. Data was collected using largely qualitative methods and quantitative methods were used to obtain supportive descriptive statistics. Information elicited from focus group discussions conducted with members of the Rusitu Valley community as well as responses obtained from a brief structured questionnaire were used to abstract the Rusitu Valley as a complex adaptive system. Input from in-depth interviews with *government representatives in energy policy, local government and non-governmental organisations as well as a review of secondary sources was used to support the analysis and confirm the contextual validity of the study. This study revealed that there is intimate connection between renewable energy technologies and sustainable community development. A key finding was that the contribution of renewable energy technologies in Rusitu Valley is mostly towards the economic dimensions of the community and is relatively limited with regard to social and environmental dimensions. Therefore, this study concluded that renewable energy technologies have not sufficiently contributed towards sustainable community development in the Rusitu Valley. This study also found that the contribution of renewable energy technologies is constrained not only by internal limitations but also external factors. A conclusion drawn from this study was that effective contribution of renewable energy technologies towards social, economic and environmental facets can be enhanced through mainstreaming of renewable energy in policy and planning, as well strengthening institutions and local capacity which would have the overall effect of sustainable community development in low income communities.*

Date : May, 2012

DECLARATION

I declare that '*The contribution of renewable energy technologies to sustainable community development in Rusitu Valley, Zimbabwe*' is my own work, that it has not been submitted for any degree or examination in any other university, and that all sources I have used or quoted have been indicated and acknowledged by complete references.

Full name ………………………………………… Date ……………………………

Signed ……………………………………………

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LIST OF ACRONYMS AND ABBREVIATIONS

AfBD	African Development Bank
ADF	African Development Fund
CSO	Central Statistical Office (Zimbabwe)
DFID	Department for International Development (UK)
EMA	Environmental Management Agency (Zimbabwe)
GEF	Global Environmental Facility
GoZ	Government of Zimbabwe
GPA	Global Political Agreement
IEA	International Energy Agency
LDC	Least (Economically) Developed Countries
MoEPD	Ministry of Energy and Power Development (Zimbabwe)
NEP	National Energy Policy (Zimbabwe)
OECD	Organisation for Economic Cooperation & Development
REA	Rural Electrification Agency (Zimbabwe)
REN21	Renewable Energy Policy Network for the 21st Century
RET	Renewable Energy Technologies
SCEE	Southern Centre for Energy and Environment
SIRDC	Scientific and Industrial Research and Development Centre
UNDP	United Nations Development Programme
UNEP	United Nations Environmental Programme
WCED	World Commission on Environment and Development
ZERC	Zimbabwe Energy Regulatory Commission
ZESA	Zimbabwe Electricity Supply Authority

1 CHAPTER 1: ENERGY AND DEVELOPMENT

1.1 INTRODUCTION

Energy is a catalyst for development (DFID, 2002) and according to the United Nations Environment Programme access to energy has advanced in developing countries over the last two decades. This achievement is notable for enfranchising over a billion people who previously had no access to electricity and modern fuels (Agbemabiese, 2009). As noted by Kaygusuz (2011) energy development, is both "a driving force and a consequence of such tremendous change", that has had a profound impact on economic, social, and environmental development. Notwithstanding the benefits that have accrued from this expansion, there are still approximately 1.6 billion people who do not have access to electricity and a further 2.5 billion people who continue to rely on traditional biomass fuel to meet their most basic needs such as cooking and heating (REN21, 2005). Rural communities make up approximately 85% of those who do not have access to modern energy services and are thus dependent on traditional biomass fuels to meet their basic household needs and income generating activities (Kaygusuz, 2011). Access to electric power grids in most rural areas in Sub-Saharan Africa ranges mostly between 2% to 5% (Vaccaro *et al*., 2005).

However, considering the current issues around global climate change and the consensus that fossil based energy generation is the main cause of such change, it is thus necessary to ensure that the future energy requirements are met through more sustainable means (Agbemabiese, 2009). Therefore, there is a clear need for a reassessment of the path towards economic, social and environmental development (Barns and Toman, 2004).

Renewable energy technologies as an alternative to conventional energy generation are shifting from the fringe to the mainstream within the context of sustainable development (Martinot *et al.,* 2002). Research has proven that most renewable energy technologies, for instance solar photovoltaic cells, can yield energy savings at or below the cost of supplying electricity through conventional coal powered thermal electricity (Wamukonya, 2003). The same situation exists in virtually every energy application where renewable energy technologies are both economically and environmentally more efficient than traditional energy supply options (ibid). This is significant not only to urban energy consumers but also rural communities as renewable energy technologies opens up new possibilities for delivering energy services cost-effectively to low income communities (Agbemabiese, 2009).

1.1.1 Zimbabwean Context

Since the signing of the Global Political Agreement (GPA) in 2008, Zimbabwe has resumed a positive growth trajectory on the economic front as well. A country brief compiled by the African Development Bank on Zimbabwe confirms that the economic reforms implemented under the GPA have led to positive results with real Gross Domestic Product (GDP) growing by 9% in 2009 and 10% in 2010 (AfDB, 2011). A combination of monetary flexibility in the introduction of the multi-currency system and a cash budget based fiscal policy had brought down inflation to 3% by April 2010 (AfDB, 2011). Further, the expansion of mineral extraction earnings mainly from diamond exports recorded a 47% growth in 2010 helped by stable international mineral and metal prices. Increased agricultural output on the back of improved tobacco, maize, sugar and cotton output has also bolstered Zimbabwe's GDP growth (AfDB, 2011).

Despite the significant economic progress that has been registered since 2009, a significant proportion of the country's productive capacity has not been realised due to the inability to exploit potential energy resources. Renewable energy technologies are not entirely new occurrence in Zimbabwe as major projects such as the GEF/UNDP/GoZ solar photovoltaic scheme having been implemented as early as 1993 (SCEE, 2002). However, the current economic scenario has elevated the emphasis on renewable energy technologies as an alternative to the national grid that has the potential to meet the demand for energy services, particularly in low income communities. However, the challenge that Zimbabwe and many other developing countries in Sub-Saharan Africa face is that; although they are endowed with significant renewable energy sources such as solar, wind and biomass, they are at the same time constrained in harnessing this energy potential due to the lack of financial resources and limited technological options (DFID, 2002).

1.2 STATEMENT OF THE PROBLEM

According to DFID (2002) the poor spend far more time and effort in obtaining energy services than the better off and use up a substantial proportion of their household income in acquiring basic energy services such as cooking, lighting and heating. The need to secure access to "affordable, adequate, and reliable" energy remains a major challenge to many developing countries (REN21, 2005). This constant preoccupation with the demand for energy services presents a challenge for the communities and governments of many Sub-Saharan countries. On one hand, efforts to expand access to grid electric energy have been of limited success, while on the other hand, exploiting the potential of renewable energy sources remains a challenge, despite having an abundant endowment of the renewable energy potential (Karekezi & Kithyoma, 2003). This circumstance is even more critical in the rural areas of developing countries where a significantly larger proportion of the people rely on traditional sources of energy, such as fuel wood. The result is therefore a disproportionate demand for energy services that greatly outweighs the energy resources available to the poor (Kaygusuz, 2011).

The insufficiency and limited diversification of energy resources in rural communities is a critical issue as such shortage has a crippling effect on the development of both households and rural industries at the local level. With this in mind, renewable energy technology alternatives such as small scale solar and biomass energy production have been noted to increased access to energy services for rural communities and in this, also set the platform for more sustainable livelihoods and development (Kaygusuz, 2011). Further support recognizes that renewable energy technologies provide attractive environmentally sound technology options for Africa's electricity industry (Karekezi and Kithyoma, 2003).

However, the successful adoption of renewable energy technologies is complex (Bossel, 1999). And despite the introduction of renewable energy technologies in low income countries[1], most are still not on a path towards sustainable development (REN21, 2005). The success of renewable energy interventions in low income countries is restricted based on the misconception of sustainable development as a linear concept (Bossel, 1999). Therefore, the precise contribution of renewable energy technologies towards sustainable development requires a much broader conception of the different social, economic and environmental dimensions towards such an end. Sathaye *et al.* (2011) stresses that such an understanding should also be mindful of interaction and relationships between the economic, social and

[1] Most notably Burkina Faso, Cameroon, Ghana, Namibia, Niger, Zambia, and Zimbabwe (REN21, 2005)

environmental dimensions if the contribution of renewable energy technologies is to be enhanced.

1.3 AIM AND OBJECTIVES OF THE STUDY

1.3.1 Aim

The aim of this study is to determine the extent to which renewable energy technologies influence sustainable community development in Rusitu Valley.

1.3.2 Objectives

The objectives of this study are;

a) To explore the interaction between sustainable development and renewable energy technologies in low income communities.

b) To establish the nature of the relationship between the different dimensions of sustainable community development and renewable energy technologies.

c) To identify appropriate indicators of sustainable community development in Rusitu Valley, and using these indicators;

d) To ascertain the influence renewable energy technologies have had on sustainable community development in Rusitu Valley.

1.4 SIGNIFICANCE OF THE STUDY

The significance of this study is premised on the realisation that 4 out of 5 people have no access to efficient and effective energy services in the rural areas of the developing world, mainly Sub-Saharan Africa (Agbemabiese, 2009). Energy access is a key element for the economic, social and environmental development of the low income communities (Kaygusuz, 2011:937). The conventional model of central generation and distribution through grid extension has proven too expensive for isolated and haphazard rural settlements, such that the majority of inhabitants in many Sub-Saharan countries are excluded from basic energy services (Agbemabiese, 2009). As a result most households depend on traditional biomass fuels such as fuelwood.

Generally, 83% of rural households in developing countries use biomass for cooking, heating and for other basic household energy services (Kaygusuz, 2011). In Sub-Saharan Africa, this proportion rises to over 90%, indicating that even better off households in rural areas either have no access to, or cannot afford, modern fuels (Kaygusuz, 2011). If the current energy consumption patterns continue, it is expected that the number of people who depend on traditional biomass for energy services will increase from 2.5 billion currently to approximately 2.7 billion by the year 2020 (Kaygusuz, 2012; IEA, 2007). The implication of this scenario would thus be a further worsening of economic, social and environmental status of close to half of the world's population.

This thesis attempts to highlight the contribution of renewable energy technologies in meeting the energy needs of rural communities in the context of sustainable community development. This is particularly important given that attempts to increase access to modern energy services through grid expansion has yielded limited success worldwide, owing particularly to the astronomical costs related to the generation, transmission and distribution of electrical energy (Kaygusuz, 2011). Therefore, this thesis advances the argument for a path towards economic, social and environmental sustainability by highlighting the contribution of renewable energy technologies to low income communities.

1.5 THESIS OUTLINE

This thesis is divided into six chapters as follows;

Chapter 1: This chapter provides an introduction and contextual background to the issues that are contained in this thesis. It draws attention to the relationship between sustainable community development and renewable energy technologies as issues within the development discourse. This chapter highlights the research problem and sets out the aim and objectives of this thesis.

Chapter 2: This chapter discusses sustainable community development within the development discourse. It also provides a reflection on the contribution of renewable energy technologies to sustainable development through a review empirical literature highlighting the experiences of other countries in this regard. From this, a theoretical framework was formulated which was used to frame the analysis and discussion of findings in the study. The chapter ends with a summary of the research design and methodology adopted in this study.

Chapter 3: This chapter gives a detailed description of the Manicaland province and the case study area, Rusitu Valley. It also presents the rationale for the selection of the case study by highlighting the significance of Rusitu Valley as the site of the renewable energy demonstration village project.

Chapter 4: This chapter presents synthesized findings from data collected in Rusitu Valley and other secondary sources as highlighted in the research methodology.

Chapter 5: Presents an analysis of the data presented in Chapter 4. Using the systems theory as the guiding framework, this chapter draw together the specific themes highlighted in this study.

Chapter 6: This chapter presents a summary of the issues that emerged from the study conducted. It also provides conclusions, based on the analysis in Chapter 5, on the aimed at addressing the objectives of this study.

1.6 CONCLUSION

This preliminary chapter has described the context in which this study was conducted. It also gave a brief background on the need for renewable energy technologies and how these are related to sustainable community development. The challenge of securing affordable, efficient and reliable energy services in most developing countries and particularly those in Sub-Saharan Africa remains a major concern. Although, concerted effort has been made with regards to the expansion of grid electricity in predominantly rural areas of many developing countries including Zimbabwe, success has been limited. Renewable energy technologies have been identified as an alternative to conventional energy sources which are capable of meeting the energy needs of low income communities. However, the nature and extent to which renewable energy technologies influence the wider concerns of sustainable community development deserve particular attention.

2 CHAPTER 2: SUSTAINABLE COMMUNITY DEVELOPMENT AND RENEWABLE ENERGY TECHNOLOGIES

2.1 INTRODUCTION

The previous chapter presented the research problem as well as the aim and objectives of the study (*See Chapter 1*). It highlighted the challenge of providing affordable, reliable, effective and efficient energy services in developing countries, noting renewable energy technologies as a means to achieving this end within the wider concerns of sustainable development. This chapter seeks to continue the discussion by focusing on the key concepts of sustainable development and renewable energy technologies. This chapter also provides a discussion based on review of empirical studies relating to introduction of renewable energy technology in developing countries. This discussion provides a basis for theoretical reflections on sustainable development and renewable energy technologies and presents the systems theory as a guiding framework in this study.

This chapter also outlines the research design and provides a discussion of the set of methodological tools that were used to collect data from the field. This section also discusses the sampling techniques that were used to delimit the research population and highlights the data collection instruments used to probe for information on the various themes identified in the review of literature.

2.2 SUSTAINABILITY AND DEVELOPMENT

There has been considerable attention in recent years to the global sustainability agenda[2]. Sustainability as an operational term is derived from the verb 'sustain' which means to "maintain; keep in existence; keep going or prolong" (Webster, 1962:81). In this sense, if sustainability refers to maintenance of a fixed state, then such a concept would have little relevance as human society is not only in a state of constant change but, as some would argue, dependent on such adaptability to thrive (Bossel, 1999). In support of this argument, Gallopin (2003:34) notes that "even pristine ecosystems are in permanent change, involving renewal and destruction of components, adapting to changes in their environment and coevolving with it". However, if the emphasis of sustainability is to "prolong" the viability of human society within the context of an ever changing environment, then such a conception cannot be separated from development (Gallopin, 2003).

Development has been defined variously by authors such as Cypher and Diethz (1997) as an improvement in economic, social and political dimensions of the society as well as a rising income and standard of living. A more intricate definition by Coetzee (2001:120) gives "…the connotation of favourable change moving from worse to better; evolving from simple to complex; advancing away from the inferior (in the form of) social change that will lead to progress... enlarging people's choices acquiring knowledge, and having access to resources for a decent standard of living". A universal definition of 'development' is not forthcoming in the contemporary literature on development. As such, for purpose of this study, the 'development' component of sustainable development can be described as "a social change process for fulfilling human needs, advancing social equity, expanding organizational

[2]Examples include; Rio Declaration on Environment and Development- Agenda 21(1992), United Nations Commission on Sustainable Development- Rio +5 (1997), Johannesburg Declaration on Sustainable Development- Earth Summit (2002).

effectiveness, and building capacity toward sustainability" (Roseland, 2000:87). Of particular note here is social equity which includes both present and intergenerational equity. This aspect of intergenerational equity depends largely upon achieving sustainability through the maintenance of ecological integrity (Roseland, 2000:87). A detailed discussion on the significance of intergenerational equity will be presented in later sections of this chapter.

2.2.1 Sustainable Development

The concept of sustainable development has emerged as a popular solution to the constraint of meeting the material needs of a rapidly growing population while minimizing environmental damage (Bridger and Luloff, 1999). The Brundtland Report, commissioned by the World Commission on Environment and Development defined 'sustainable development' as "development that meets the needs of the present without compromising the ability of future generations to meet their own needs" (Brundtland, 1987:4). Two key concepts emerge from this classic definition; firstly, the concept of "needs" to which priority of the poor should be given, and secondly; the idea of limitations imposed by the state of technology and social organisation on the environment's ability to meet present and future needs [Brundtland, (1987:4) as quoted by Oloyede (2009:57)]. Later sections of this chapter will address the implications of 'appropriate technology' to achieving sustainable development. However, the concept of human needs at this point deserves particular attention.

Much of the debate over the meaning of sustainable development focuses on the tension between the economic necessity for material growth and the reality of ecological limits (Roseland, 2000:95). However, sustainable development according to Gallopin (2003) should rather be "a process of redefining progress" which is concerned with an attempt to guarantee that the changes affecting people are changes for the better. Gallopin (2003) further contends that this attempt at redefining progress is what ought to constitute an understanding of sustainable development. Taking this into account, a more encompassing definition of sustainable development would thus be "a socio-economic change process of fulfilling human needs, advancing social equity, expanding organizational effectiveness, and building capacity within the limits environmental constraints (Roseland, 2000).

2.2.2 Sustainable Community Development

For the most part, definitions of sustainable community development parallel the definitions of sustainable development. The main difference involves the reduction in geographic scope as sustainable community development is local. As such, it is necessary to disaggregate sustainable community development as a composite term, into its two fundamental underpinnings; 'sustainable community' and 'development'. In line with the World Commission on Environment and Development definition, Roseland (2000:99) identifies a sustainable community as "a community that uses its resources to meet current needs while ensuring that adequate resources are available for future generations". More precisely, Estes (1993:2) adds that a sustainable community "seeks a better quality of life for all its residents while maintaining nature's ability to function over time by minimizing waste, preventing pollution, promoting efficiency and developing local resources to revitalize the local economy" (ibid).

The United Nations Educational, Scientific and Cultural Organization (UNESCO) (2001) contends that "there is no single definition of sustainable community development because every community has its own unique characteristics and challenges". However, what can be accepted as a basis, according to Swisher (2009), is that sustainable development among communities is that they share common themes and concerns, that is; "economic security, environmental protection, social justice, and a commitment to the welfare of future generations". A prevailing theme in the literature is that sustainable community development embodies implications on the nature of resources utilisation and assumptions about how these relate to the community (Walker *et al.,* 2009). Two key aspects of sustainable community development that relate these concepts are inter and intra-generational equity.

2.2.3 Intergenerational Equity

Most definitions of sustainable development, and logically the sustainable community development, are based on the principle of "intergenerational equity" or "intergenerational fairness". This concept is well captured by Bridger and Luloff (1999:378) in the idea that the current generation must not compromise the ability of future generations to meet their "material needs and enjoy a healthy environment." Intergenerational equity depends largely upon achieving sustainability through the maintenance of ecological integrity (Roseland, 2000:87). Dasgupta (2007:3) adopts a welfare economics definition of intergenerational equity as an economic equilibrium at which average well-being of present and future generations, taken together, does not decline over time". However, at the core of this concept, regardless of the perspective adopted towards intergenerational equity, the rational for its recognition is a moral obligation to consider the implications on future generations who do not have a say in decisions made by the present generation (Beder, 2000). Intergenerational equity can be realized through two different paths, weak and strong sustainable development.

2.2.4 *Weak* versus *Strong* Sustainability

Within the conceptualization of sustainable development, weak and strong sustainability represent the competing principles behind the pursuance of economic growth or nature conservation (Hediger, 1999). Beder (2000) identifies on the one hand weak sustainability which emphasizes a compensatory effect on future generations for current actions and on the other, strong sustainability which adopts a conservational approach. In detail, weak sustainability as a concept is derived from the neoclassical economic capital theory and embraces the economic value principles (Hediger, 1999). The value principle on which weak sustainability is encored necessitates a condition that there must be a suitably defined value of aggregate capital that is non-decreasing over time (ibid).

In contrast, strong sustainability is defined in terms of the need to maintain environmental quality. This approach is based on physical ecological principles that maintain that a certain properties of the environment must be sustained (Hediger, 1999). Unlike weak sustainability which emphasizes on economic capital, this approach aims to ensure that the stock of natural capital is maintained. In achieving this, Costanza (1991) as cited by Hediger (1999) adapts the ecological value principle to represent a minimum criterion upon which sustainable development should meet in order to uphold strong sustainability. These criteria have been expressed in various protocols and declarations on environmental protection and sustainable development[3].

Weak and strong sustainability represent polarized ontological interpretations of how a sustainable world ought to be. However, of the two approaches to sustainable development and consequently, intergenerational equity, strong sustainability has emerged as the preferable option. Beder (2000) concludes that the current generation should not second

[3] **Protocols on Environmental Protection and Sustainable Development**: Protocol on Environmental Protection of the Antarctic Treaty (1991); Principle 4 (*Environmental Protection*) of the Rio Declaration on Environment and Development (1992); Johannesburg Declaration on Sustainable Development (2002); Millennium Development Goal 7 (*Ensuring Environmental Sustainability*).

guess what future generations will require but rather should allow them the autonomy to determine their own needs by keeping the available options open.

2.2.5 Intragenerational Equity

Anand and Sen (2011) made the case for jointly considering sustainability and equity not only between generations but also within them. They note that "…it would be a gross violation of the universalist principle if (they) were to be obsessed about *inter*generational equity without at the same time seizing the problem of *intra*generational equity" (UNDP, 2011:1). Intragenerational equity is an important aspect of sustainable development in that it addresses inequalities between communities and even nations. The extent to which intragenerational inequity is undesirable is notable in both extremes of the poor and affluent communities or nations. In affluent communities, over consumption often leads to high resource depletion and accumulation of waste (Roseland, 2000). However, of particular significance to this study is the opposite extreme where poorer communities are deprived of choice on whether or not to be environmentally sound about their activities (Beder, 2000). In most cases, poor communities engage in activities that destroy their immediate environment through activities such as tree felling, overgrazing and overuse of marginal land (ibid). Although these activities are conducted out of need, the ultimate effect is that this leads to a depletion of available productive resources which further contributes to the cycle of deprivation (Coetzee, 2001).

When aggregated, it is difficult to suggest whether sustainable community development strategies should favour. However, what is without question is that communities face the choices impacting on sustainable development at the local level and thus attempts to select the prudent alternatives are at the community level as well (Swisher, 2009). Although it is clear what sustainable community development is intended to achieve, it is not entirely agreed as to what the prescription of sustainable community development should constitute. Prevailing themes in the literature are that which connote sustainable community development as embodying implications on both the procedural and substantive considerations.

2.2.6 Procedural and Substantive Sustainable Development

Two main approaches to sustainable development projects can be discerned, namely; substantive and procedural sustainable development (Jaramillo-Nieves and del Río, 2010). Procedural sustainability as given by Scott and Oelofse (2005) is the "ability of people to access and deliberate in decision-making processes that impact on their lives". Since the 1960s, the World Bank and similar development oriented multilateral organisations[4] have supported development initiatives premised on this assertion of procedural sustainable development as a precondition for addressing wider equity concerns (Rifkin and Kangere, 2002). The rationale for this stance reflects the influence of advocacy for participation by its proponents such as Robert Chambers and other supporters of Participatory Rural Appraisal, Rapid Rural Appraisal and other Participatory Learning Approaches (Chambers, 1994; Rifkin and Kangere, 2002). Brohman (1996) as quoted by Roseland (2000: 105) adds that a model for sustainable community development can only be designed with "extensive public participation; seeking to improve society and the environment as well as the economy; and result in increased equity, equality and empowerment across generations".

[4] United Nations (UN), United Nations Development Programme, African Development Bank (AfDB), International Monetary Fund (examples of Multilateral Organizations)

Substantive sustainable development on the other hand is concerned with how a specific project contributes towards the melioration of the economic, social and environmental conditions of a specific geographical space and its inhabitants (Jaramillo-Nieves and del Río, 2010). It is useful to note that the substantive approach to sustainable development is operationalized firstly, as an economic concept that emphasizes the maintenance of a stock of capital (which may be natural, man-made, human and socio-cultural) (ibid). Secondly, the substantive approach can be viewed as an ecological concept in which the material balance is central. However, unlike the stock of capital approach, this perspective recognizes that sustainable development is not achieved by determining a required level of growth and pursuing traditional economic objectives (Harris, 2000). Rather, it is achieved through the realization that protection of natural resources should be an explicit goal that is placed on equal terms with human wants and needs (ibid).

Although these two approaches are dissimilar in their method, their underlying goal is in essence the same, that is, to promote the realisation of human needs in a manner that is both socio-economically prudent and environmentally balanced. Therefore, in practice these approaches are not mutually exclusive, in fact a delicate balance between the procedural and substantive approach has a cumulative effect of enhancing sustainable development (Chambers, 1994).

2.3 APPROPRIATE TECHNOLOGY

Appropriate technology according to Mebratu (1998) is defined as "technology that takes heed of the skill, levels of population, availability of natural resources and pressing social needs (as defined by the people themselves)". This concept was largely considered as the immediate precursor to the concept of sustainable development (Basu and Weil, 1998). The crux of this concept is that technological advances should be aligned to solving specific problems in a given setting. In this case, the threat posed by the consequences of environmental and natural resource depletion and simultaneously the need to ensure sustainable development necessitate the adoption of new technologies.

2.4 RENEWABLE ENERGY TECHNOLOGIES

There are many factors that can contribute to achieving sustainable development. One of the most important, as noted by Dincer (2000), is the requirement for a supply of energy resources that is fully sustainable. A secure supply of energy resources is generally agreed to be necessary for development within a society (DFID, 2002; Karekezi and Kithyma, 2003; Kaygusuz, 2011). However, in the context of sustainable development, Dincer (2000) notes that; although a secure source of energy is necessary, this is not a sufficient requirement. As noted earlier, energy resources are not an end in themselves but provide services which facilitate the fulfilment of basic energy needs. With this in mind, Dincer (2000) contends that sustainable development within a society demands a supply of energy resources that, in the long term, are readily available, at reasonable costs and can be utilized for all required tasks without causing negative social and environmental impacts. Accordingly, Barns and Floor (1996) add that the available evidence suggests that renewable energy technologies assist in closing the gap between community socio-economic needs and resource limitations which has the immediate benefit of significantly reducing poverty in low income communities. In this regard, the intimate connection between renewable energy sources and sustainable development becomes apparent.

However, although the connection between renewable energy technologies and sustainable is clear in principle, the reality of such a relationship is far from what is portrayed in the contemporary literature referred to in the preceding section. A review of empirical literature presented in the subsequent section will highlight specifically the impediments towards the utility of renewable energy technologies in contributing to sustainable development.

2.5 REVIEW OF EMPIRICAL LITERATURE

The underlying theme of the empirical literature presented below is the promotion of sustainable development among the various communities in which renewable energy projects were implemented. The literature presents different dimensions of analysis which highlight the factors in the effective contribution of renewable energy technologies towards sustainable development.

It has been increasingly recognized that social factors can potentially be a powerful impediment to the achievement of renewable energy targets. In attempt to understand the elements required to succeed in meeting global sustainable development objectives through the use of renewable energy technological innovations; Alexandra Mallett looks at the role of social acceptance in the adoption for solar water heaters in rural Brazil. Mallett (2007) discusses the need for more “active” social acceptance within the ‘technology adoption model’ which claims that adoption comes about through a decision-making process occurring in stages; knowledge, persuasion, implementation and confirmation. Using the technology adoption model, these stages could thus be traced to a number of factors such as relative advantage, complexity, and triability. She discusses how this model can be modified using an “active” definition of social acceptance. Mallett (2007) argues that modes of social acceptance need to reflect adequately on the effects of technology cooperation as an integral part of technology adoption. Using mainly qualitative analytical techniques, Mallett (2007) obtained empirical evidence with regard to technology cooperation. Her analysis asserts that the forms of technology cooperation in which “active” participants from various sectors interact continuously throughout the process is most effective in eliciting social acceptance of renewable energy innovations. Mallett’s analysis is inclined towards a substantive conception of sustainable development approaches as it places conscious recognition human wants and needs through the significance of “active” participants to the process of selecting development initiatives.

Gross (2007) approaches this from the perspective of the perceived fairness in the processes leading to the installation of renewable energy technology interventions among communities. She describes a community fairness framework which has potential application in community consultation to increase social acceptance of renewable energy initiative outcomes. This framework was developed based on the findings from a wind farm pilot study in Australia where community perceptions of a consultation process were explored using procedural justice principles to evaluate fairness. A key research finding was that different sections of a community are likely to be influenced by different aspects of perceived justice, namely; outcome fairness, outcome favourability and process fairness (Gross, 2007). The study explains that outcomes that are perceived to be unfair can result in protests, damaged relationships and divided communities particularly when decisions are made which benefit some sections of the community at the perceived expense of others (Gross, 2007). This study is in line with the procedural approach to sustainable development highlighted in previous sections. The centrality of participation through consultation and value of intrinsic motivations based on perceptions of fairness are recurring themes in procedural approaches to sustainable development.

Shah *et al.* (2011) identify the perceived worth of renewable energy technologies within the community as a critical social dimension in existing development scenarios in Pakistan. Shah (2011: 862) suggest a scheme of analysis based on the creation of awareness through the proper functioning of education within science and technology sectors as the pre-requisite for sustainable development through renewable energy. (*See Figure 1*)

Fig 1: A scheme of analysis: Awareness

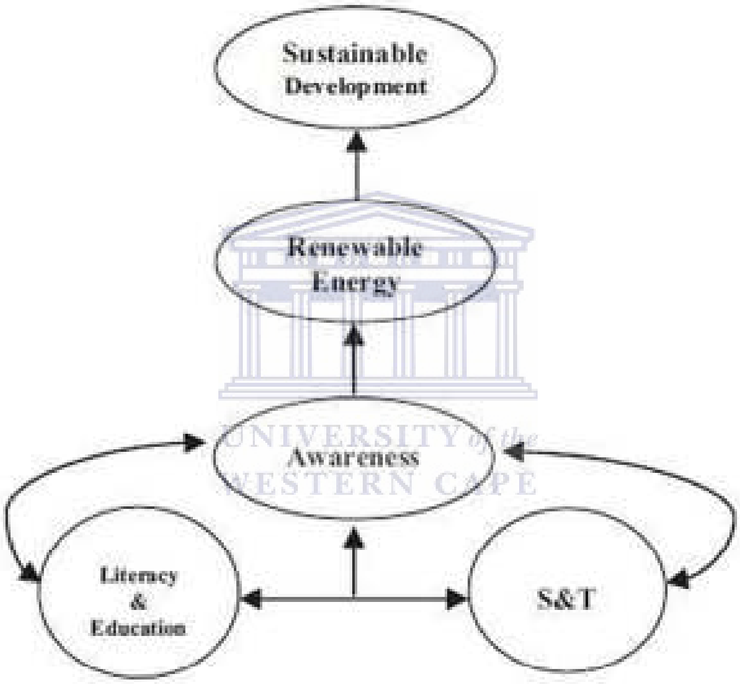


Fig. 1. The scheme of analysis.

Source: Shah *et al.* (2011:862)

To achieve the objective, the scheme determines the current level of awareness regarding simple renewable energy technologies through a survey and then policy integration for techno-economic and socio-political would then be judged through analysis of literacy, educational and science and technology policies in Pakistan. Shah (2011:867) contends that to achieve the aim of sustainable development through renewable energy in any country there must be supportive to national science and technology policies to create awareness regarding sustainable development through renewable energy technologies.

Gosch *et al*. (2002) reviewed a programme of cash based subsidies to promote renewable energy technologies under the theme of sustainable development in India. The renewable energy program was launched primarily as a response to the perceived rural energy crisis in the 1970s. It was initiated with a target oriented supply push approach which primarily sought to develop niche applications, such as unit solar and biomass stoves in rural areas where grid electricity was unavailable. Gosch *et al*., (2002) identify the key mechanism as cash subsidies provided for promoting renewable energy technologies. However, Gosch *et al.* (2002) note that renewable energy technologies were promoted as a panacea to the energy problems, resulting in unrealistic expectations and eventual failure. Limitations were imposed by irrational targets and fixed allocated budgets. This lead to distortions in the prices and non-internalisation of the socio–environmental externalities impeding the progress of renewable energy technologies by adversely affecting their competitiveness compared to conventional energy sources (Ghosh *et al.* 2002). Overall, the programmes failed to develop an orientation towards sustainable development through non-commercialisation of the renewable technologies (ibid). Ghosh *et al.* (2002) conclude that emphasis should have rather shifted to more economically liberal approaches.

Sahir and Qureshi (2008) piloted an assessment of the prospects renewable energy technologies have in support of socio-economic development in Pakistan. The study isolated the limitations in the exploitation of sustainable energy in Pakistan. Sahir and Qureshi (2008) contend that although renewable energy sources cannot serve as alternative for conventional energy resources, these may yet serve to augment the long-term energy needs to a significant level. However, they note that this can only be achieved within a cohesive energy planning approach, emphasizing consistency in government policies and rational policy instruments to deal with the techno-economic and socio-political barriers that are the pre-requisites for long-term sustainable development (Sahir and Qureshi, 2008).

Bugaje (2006) reviews renewable energy use in Africa using South Africa, Egypt, Nigeria and Mali as case studies. In this study, the various national energy policies of these countries were analysed and areas that required attention to achieve sustainability were highlighted. Bugaje (2006) notes a matter of immediate concern in the energy quagmire that most African countries face; as forest resource are gradually declining, the supply of fuel wood becoming more difficult to sustain demand which exceeds the potential supply. However, a key finding in the study was that the failure to advance alternatives for sustainable development was not due to lack of energy resources, but rather the poor state of infrastructural support and appropriate technology to harness these resources, especially ecological resources. Bugaje (2006) therefore suggests the need for African countries to pool resources together in information sharing, and the development of a natural resource base including training and the sharing of skills and particularly with regard to the conservation of ecological systems.

The literature reveals that sustainable development has been framed in the context of a three pillar model that emphasizes the contribution towards economic development, social development and environmental protection (Sathaye *et al.,* 2011). With regard to economic development, this conceptualization is based on natural capital assumptions of economic development which are the essence of the weak sustainability argument. The environmental protection conceptualizations of sustainable development have been premised on the fundamentals of deep ecology theory which in turn forms the basis of the strong sustainability arguments. Social development is realized through the substantive and procedural approaches to sustainable development (Hediger, 1999). However, there still exists a fundamental gap in this fractured analysis which stems from the failure to account for the interconnection of these three pillars within sustainable development.

2.6 THEORETICAL FRAMEWORK

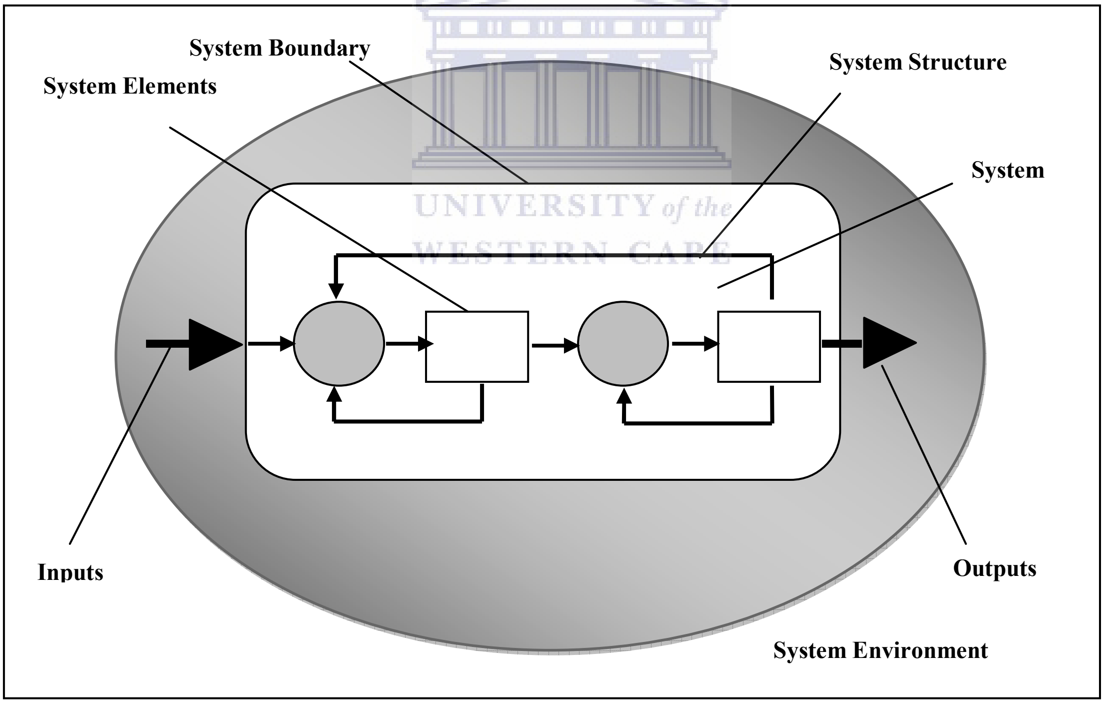
The concept of sustainable development is complex and a thorough comprehension of its intricacies requires an understanding of the interconnection among economic, social and ecological factors (Gallopin, 2003). As such, deciphering the conceptual underpinning requires an encompassing approach to accommodate its spatial and temporal dimensions. Therefore, this study attempts to explorer the contribution of renewable energy technologies within all three dimensions of sustainable development using the systems theory. The systems approach is useful in that it offers an analytical perspective that relates to sustainable development in terms of its interconnectedness, relationships and context (Gallopin, 2003).

2.6.1 The Systems Theory

The systems theory has its foundations rooted in the functionalism as given by Talco Parsons. The functionalist perspective likens human society to biological organisms where different institutions, just as different parts of biological organisms, make a society and "are interrelated and interdependent on each other in a system" (So, 1990). Parsons further asserted that just as each "part of the biological organism performs a specific function for the good of the whole, each of the institutions in societies must also performs a certain function for the stability and growth of the society" (So, 1990).

A 'system' is a set of elements that are interlinked in a characteristic system structure located within a given *system environment* (Bossel, 1999; Gallopin, 2003). The interlinkages between *system elements* manifest in various forms that are determined by the specific *system boundary* which defines the system identity (ibid). The system boundary is permeable; allowing *inputs* from the system environment which through the interaction of system elements allow system generates *outputs* or distinct system functions that reciprocally impinge on the external environment. This is termed an "open system" (Gallopin, 2003). (*See Figure 2).*

Fig 2: A Model of the Open System



Source: (Bossel, 1999: 20).

The rationale for adopting a systems perspective is that this allows for the abstraction of the fundamental elements of sustainable development. Such an abstraction is necessary as human society, being the product of complex economic and social systems, is inseparably entrenched within equally intricate ecological system on which it depends on for support (Bossel, 1999). Thus, within the frame of sustainable development, this relationship of interdependency among the economic, social and ecological systems is not only necessary for the maintenance of each separate sub-system but also the sustenance of all systems on a path towards long term viability which is the goal of the total system (Bossel, 1999). The mechanism of this multifaceted relationship is elaborated through the complex adaptive system.

The complex adaptive system perspective maintains that sustainable development is basically a continuously evolving, open-ended activity with no fixed end state (Agbemabiese, 2009). The fundamental assumption is that the sustainability of the total system depends on the proper functioning of its sub-systems (Bossel, 1999). In achieving this, the sub-systems must continuously adapt to changes in both the internal and external environment in order to survive (Agbemabiese, 2009). The complex adaptive system regards the ability and autonomy of humans to interrelate and learn from interactions between the various sub-systems as important in shaping pragmatic adaptation measures. Furthermore, the context in which humans interact is also important it also changes accordingly influenced by various factors, including the activities of other people within a community (Agbemabiese, 2009). This component of the complex adaptive system is that which this thesis is based. The introduction of renewable energy technologies has implications on the adaption of the total system towards changes in environmental and economic sub-systems.

2.6.2 Application of the Complex Adaptive Systems Theory

The aim of this study is to explore the interaction of sustainable development and renewable energy technologies. To this end, what the application of the complex adaptive systems theory is sought to achieve is to provide a framework within which this interaction can be evaluated. As highlighted earlier, a sustainable system is one that has the ability to proportionally respond to changes in its internal and external sub-systems (Bossel, 1999). Essentially, this thesis attempts to determine the extent to which renewable energy technologies have on the ability of the system to adapt to such changes. Using the established pillars of sustainable development which are premised on the appreciation of social, economic and environmental principles, I attempt to the identify indicators of the rate of adaption in each of these principles and to determine the extent to which renewable energy technologies have on this change. In essence, that is the contribution of renewable energy technologies to sustainable development.

2.7 RESEARCH DESIGN AND METHODOLOGY

The study was exploratory and this approach required that the methods employed to this end be largely qualitative in nature. Kitchin and Tate (2000) support qualitative methods as appropriate to social inquiry in explorative studies and further justify their credibility as methods of data collection. The primary instruments used to collect data were indepth interviews and focus group discussions. Additionally, descriptive statistics collated from a brief structured questionnaire distributed at the end of the focus group discussions were used to support qualitative narratives by tracing existing patterns and making inferences about variable relationships (Rudestam & Newton, 1992).

2.7.1 Case Study Approach

This thesis adopted a case study approach to the research design. The primary justification for the use of this approach was that it allowed the researcher to apply a detailed contextual analysis of complex issues through a real-world representation of his particular interest (Soy, 2006). Further, Yin (1994) identifies the case study approach as a relevant application when the researcher attempts to explore “situations in which the interventions being evaluated have no clear set of outcomes”. Therefore, this approach provided a basis for the application of theory and concepts to real-life phenomena within a particular context through specific methods of inquiry (Soy, 2006; Tellis, 1993).

2.7.2 Sampling and Data Collection Instruments

(i) Primary Data

Case studies are “multi-perspectival” analyses (Tellis, 1997). Thus, in order to be able to give a significantly representative account of the various perspectives from different actors within a particular study, I had to consider multiple techniques appropriate for each group of sampled respondents. This was not only important for the sake of methodological relevance but also methodological pluralism which increases the validity of data collected. In this, I was able to capture an accurate account of the different perspectives offered by respondents and also the interaction between them.

A purposive sampling method was used to select 5 specific representatives from national and local government departments and 5 key informants from non-governmental organisations and research institutions. This method of sampling was used to allow a greater degree of control in selecting key informants who were knowledgeable on specific topics of concern to this research (Barbour, 2001). A total of 10 ‘key’ informants were selected which adds merit to the purposive sampling technique as it is ideal for smaller groups of specific individuals.

This study also made use in-depth interviews as the instrument to collect data from these key informants. In-depth interviews are as Bryman (2008:9) describes “a conversation with a purpose". As such, the decision to use in-depth interviews was primarily influenced by the nature of information sort from these key informants. Using in-depth interviews, I intended to explore the perspectives of national and local government officials on the legal and policy framework related to renewable energy technologies in Zimbabwe as well as the perspectives of project coordinators from non-governmental organizations on sustainable community development. In this, in-depth interviews provided a platform for these key informants to express in detail their "thoughts, experiences and behaviour" (Boyce and Neale, 2006). In-depth interviews were also utilised based on the expectation that the interviewees would be more likely to express their views "spontaneously in a relatively openly designed interview situation" (Bryman, 2008:10).

The selection of community members that participated in focus group discussions was done through a multi-stage sampling technique combining elements of both cluster and random sampling techniques. The main consideration in selecting this method was that it allowed me to include "outliers" or unique groups of respondents through cluster sampling while at the same time using random sampling retain the ability to make a statistical generalization from the data (Tellis, 1997). The unique group of respondents comprised members of the community that were current subscribers to the central solar charging station. A further consideration justifying the need for a multi-stage sampling technique was the need to ensure logistical pragmatism in conducting the actual data collection given the dispersion of respondents. 70 community members were chosen from the total population of ward 21, 22 and 23 using this technique to ensure that the respondents selected were representative of the entire target population.

The 70 community members selected were divided into 4 groups of 12 members and 2 groups of 11 members. I liaised with each group in scheduling convenient times and locations at which focus group discussions could be held. A primary consideration for conducting focus groups discussions was the qualitative nature of data required. I intended to obtain insight into the collective perceptions of renewable energy technologies in relation to the needs of the community as well as the benefits or problems emanating from the use of these technologies. Issues of their beliefs, attitude and personal conceptions of the role renewable energy technology could play in their lives were also explored.

In order to increase the confidence in the interpretation of data collected in focus group discussions, I administered a brief questionnaire to respondents immediately after discussions sessions. Questionnaires were preferred in this triangulation as they provided a rapid and relatively inexpensive means of aggregating the demographic characteristics of the community as well as verifying discussion data. The themes probed using this tool were focused on traditional and renewable energy sources in the community and the contribution of renewable energy technologies to their standard of living. Information sought using questionnaires was aimed at forming a quantifiable impression of the livelihoods in the community and this was achieved by providing a significant number responses to make statistical and analytical generalization based on the data collected (Slocum *et al.*, 1995:94). The questionnaires were relatively uncomplicated to administer and concerns over the inability of respondents to interpret the questions were eliminated as some of the complex terms were explained during the course of the focus group discussions. (*See Table 1*).

Table 1: Summary of Research Design

Category of Respondents	Sampling Techniques	Data Collection Instruments	Sample size
Policy makers from Central Government, Parastatals supporting RE policy.	Purposive (Key ministries involved in policy formulation and development of renewable energy legislation).	In-depth Interviews	(5) Officials from the MoEPD, REA, EMA and Councilor for Ward 21, Rusitu Valley.
Project Coordinators	Purposive (Selection and implementation of RET projects).	In-depth Interviews	(3) SIRDC and Practical Action (Zimbabwe)
Research and Academic Professionals in the area of Renewable Energy Technology and Sustainable Development.	Purposive Sampling (RET and SD issues).	In-depth Interviews and Document Review	(2) Members officials from the SCEE
Community Members from ward 21, 22 and 23, Rusitu Valley.	Random Cluster Sampling (Demographics, experiences and perceived value of RETs)	Focus Group Discussion and Structured Questionnaire,	(70) Community members + Subscribers to the Central Solar Charging Station
			Total (80)

(ii) Secondary Data

A review of secondary data was done with the aim of obtaining the most relevant and current literature in the area of interest. Secondary data on Zimbabwe Energy Policy (draft) was obtained from the Ministry of Energy and Power Development. I was limited to the review of the draft document as the policy still awaits Cabinet approval to come into effect. The Scientific and Industrial Research and Development Centre assisted me with project data on the Rusitu Valley renewable energy demonstration village as well as other community development projects related to renewable energy technologies. Statistical data of renewable energy projects was obtained from Practical Action, Zimbabwe and a Manicaland province baseline report from the Southern Centre for Energy and Environment (SCEE). Other sources included legal instruments from the parliamentary library website and Zimbabwe country data on sustainable development from the United Nations Development Programme (UNDP) website.

2.8 DATA ANALYSIS

The aim of this thesis was to explore the interaction between sustainable development and renewable energy technologies in low income countries. As such, in order to unearth the relationship of these overarching focal areas, a largely qualitative approach was used to analyze the data collected within the framework of the systems theory. Firstly, using both primary and secondary data collected on the social, economic and environmental context of the Rusitu Valley, the analysis was centred on an attempt to abstract the system within which that community is a part of, highlighting the essential components necessary of its viability. Subsequently, using the narratives compiled from the in-depth interviews and focus group discussions, the analysis was focused on identifying key indicators that are invariably influenced by renewable energy technologies and the extent to which these technologies affect the ability of the system in adapting to changes in the social, economic and environmental sub-systems.

2.9 CONCLUSION

This chapter has disaggregated the concept of sustainable community development and provided an understanding of its conceptual underpinnings. The relevance of renewable energy technologies was explored through a discussion on the effects of weak versus strong sustainability, intergenerational versus intragenerational equity within the confines of economic, social and ecological constraints. Based on recognition of the highlighted constraints, a review of empirical literature revealed that most approaches towards sustainable development offer a fragmented conception of the concept. Hence the systems theory as the overarching framework was identified as an appropriate framework in analysing the contribution of renewable energy technologies to sustainable development. Pragmatically, the systems theory allows the incorporation of economic, social and environmental aspects of sustainable development in an encompassing framework.

3 CHAPTER 3: DESCRIPTION OF THE CASE STUDY AREA

3.1 INTRODUCTION

This chapter geographically locates this study by providing a description of the Manicaland Province and its districts. This will give an overall picture of the economic, social and environmental status of the case study area. A detailed description of the Rusitu Valley will identify some of the significant features of the area highlighting the rationale for its selection in the renewable energy demonstration village project implemented by the Scientific and Industrial Research and Development Centre (SIRDC) and the relevance to this study.

3.2 OVERVIEW OF MANICALAND PROVINCE

3.2.1 Geography

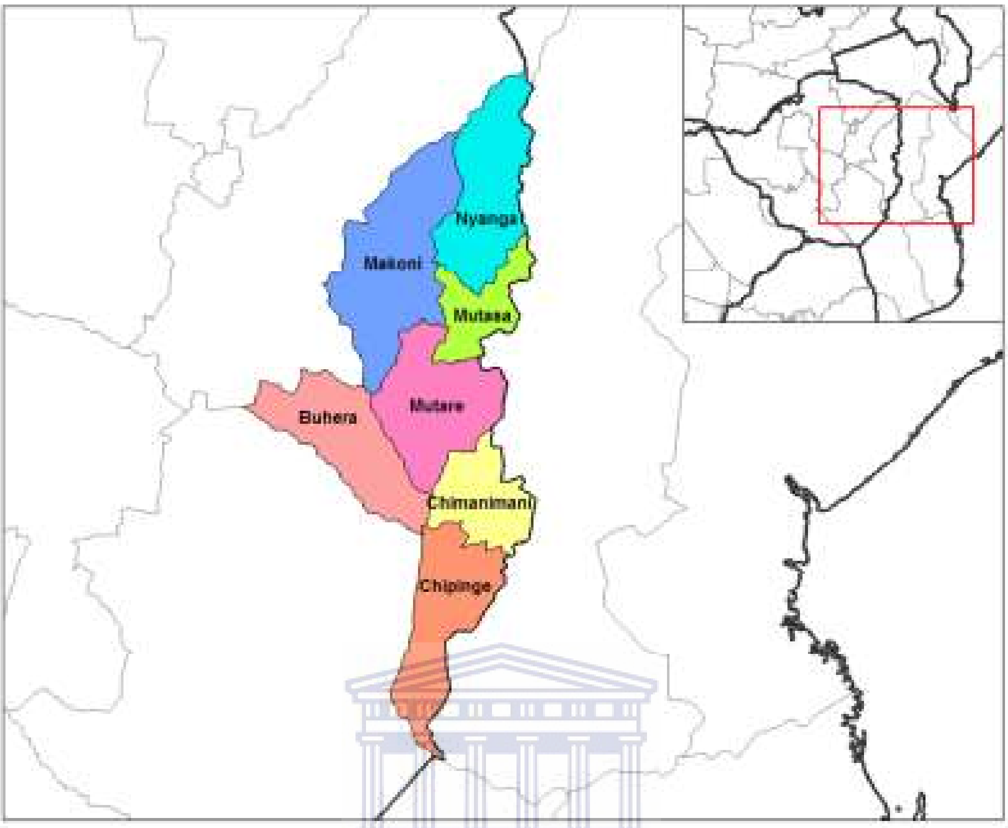
The Manicaland province is one of Zimbabwe's 10 administrative provinces. The province stretches along the eastern border of Zimbabwe neighbouring Mozambique and falls predominantly in the agro-ecological region 1. The climatic conditions of this region are influenced strongly by the mountainous terrain at a range of 1100 to 1600m above sea level (Bailis *et al.,* 2000). The majority of Manicaland province exhibits low to medium temperatures and consistent precipitation throughout the year of more than 1000mm per annum (SCEE, 2002). The most commonly found soil type in the province is the well drained, dark brown clay loam which is ideal for cultivation (Nziramasanga, 2003). The province is mostly prominent for plantation forestry with proceeds from the commercial exploitation of timber constituting over 30% of its gross domestic product (CSO, 2002). At the local level, most agricultural activities in the province are confined to horticulture of cool weather fruit and vegetables and to a lesser extent, cultivation of small grains such as maize and millet due to mountainous slopes of up to 40% (SCEE, 2002). Human settlements are strategically established on high ground for access to water from the perennial streams and to allow for fishing which also contributes to commercial activity in the province (ibid).

3.2.2 Districts of Manicaland Province[5]

Manicaland is comprised of 9 districts, namely; Buhera, Chimanimani, Chipinge, Makoni, Mutare rural, Mutare urban, Mutasa, Nyanga and Rusape. The administrative capital of the province is located in Mutare urban district, specifically in Mutare town and this also serves as the commercial capital of the province. Each of the districts is managed through either an urban or rural district council (RDC). These districts are disaggregated into constituencies proportional to the land size of the district and further into wards which are the lowest administrative structure. Figure 3 below shows the administrative districts of Manicaland province. (*See figure 3).*

[5] Details on the administrative structure of Manicaland Province were provided by Mr. Lovemore Sauramba, a local government officer in the Ministry of Local Government and Urban Development.

Figure 3: Districts of Manicaland Province, Zimbabwe



Source: (SCEE, 2002)

3.2.3 Demography

The distribution of population in Manicaland is skewed towards the rural districts of the province. The majority of the population (83%) in the province resides permanently[6] in rural areas, leaving only 17% in urban areas. The figure below shows the rural urban distribution of population in Manicaland. (*See figure 4*).

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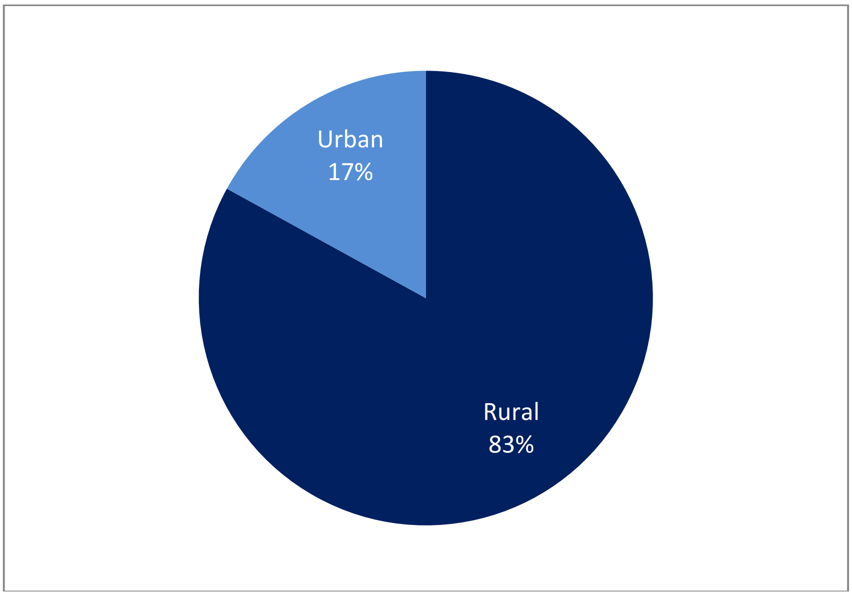
[6] Permanent residence status is defined by the area in which an individual spends more than 183 days of the year.

Figure 4: Rural and Urban Population Distribution for Manicaland Province



3.2.4 Population Distribution by District

The largest district by population is Chipinge with a population of 283,792 and the smallest population is in Rusape district with 25,014 people (Nziramasanga, 2003). This disparity is proportional to the difference in geographical size of the districts as shown in table 2 (*below*). Table 2 shows the detailed distribution of population in Manicaland province.

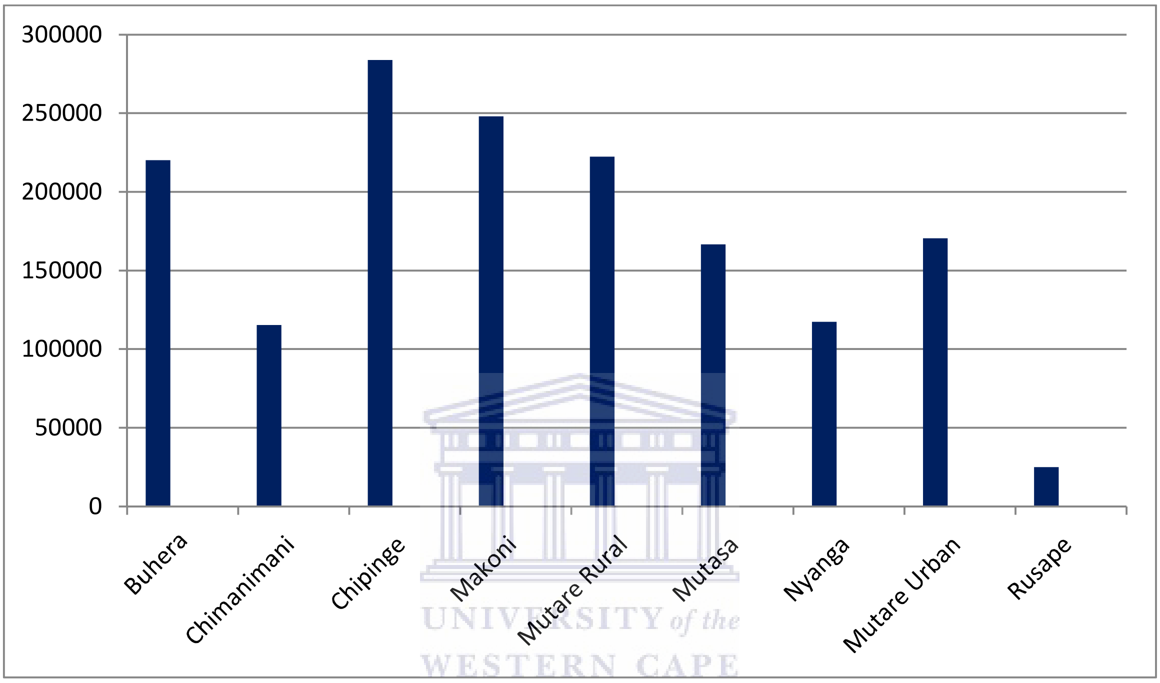
Table 2: Population Distribution in Manicaland Province (By District)

DISTRICT	POPULATION
Buhera	220060
Chimanimani	115297
Chipinge	283792
Makoni	247993
Mutare Rural	222383
Mutasa	166646
Nyanga	117279
Mutare Urban	170466
Rusape	25014
Provincial Total	**1568930**

(Source: Nziramasanga, 2003)

A graphical presentation of the population distribution is shown below. This gives a visual impression of the differences in population among the districts of Manicaland province. (*See figure 5*)

Figure 5: Population Distribution by District: Manicaland Province



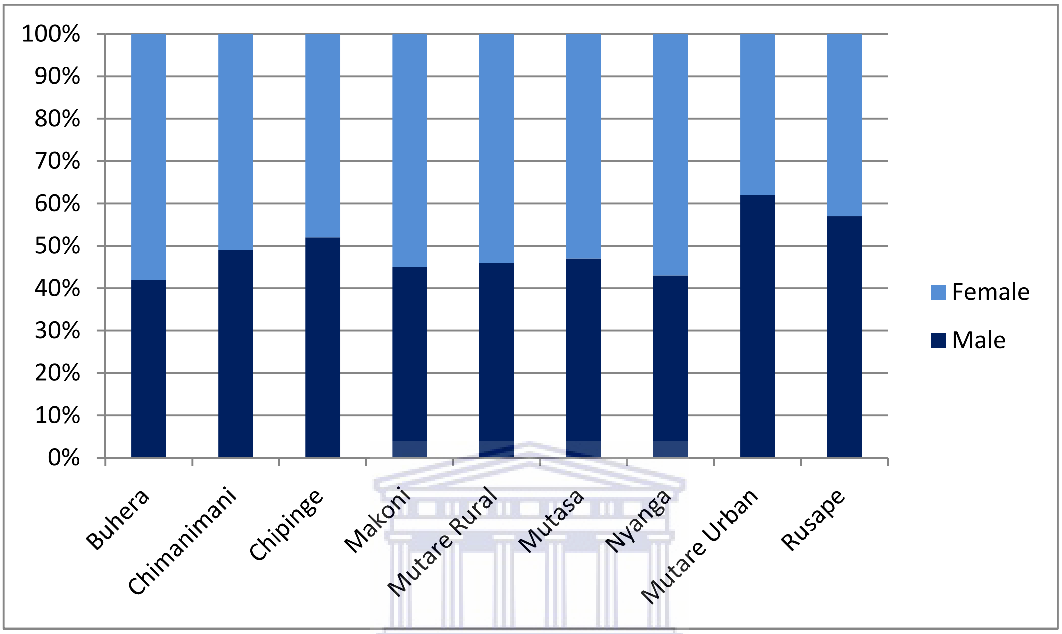
3.2.5 Economically Active Population

The distribution of economically active persons in Manicaland reflects the number of people above the age of 15 but below the age of 65[7]. The graph below (*See figure 6*) shows the distribution of such persons by district (CSO, 2002). With the exception of Rusape, Mutare urban and Chipinge districts, women constitute a higher percentage of the economically active population. It is significant to note that the 3 districts in which men represent a higher proportion of economically active persons are predominantly urban centres. It is typical for

[7] The labour laws in Zimbabwe define the legal age of retirement as 65 years.

women in rural areas to represent a larger proportion of economically persons are most men migrate to urban centres in search of employment opportunities.

Fig 6: Distribution of Economically Active Persons (By District)



Source: CSO (2002)

3.2.6 Social Setting and Livelihoods

The household is the primary unit of production and consumption throughout most of rural Zimbabwe. In some isolated instances, communities engage in pooling of resources such as labour (*mushandira pamwe*) and in more progressive communities, financial resources for bulk purchases of goods and services although these are mostly confined to primary production in agriculture. However, the majority of communal livelihoods are supported by subsistence farming activities at the household level. These are often critically short of financial and productive resources and rely mostly on draft power. These factors limit the probability of individual households in yielding significant success as the focus of development interventions (Nziramasanga, 2003).

3.2.7 Education and Literacy

The high levels of literacy shown in the table below (*See table 3*) are consistent with the high density of educational facilitates in Manicaland province. There are a total of 822 primary and 298 secondary schools in Manicaland province (Manicaland Regional Education Office, 2010). The dispersion of educational facilities in the province shows at least 1 school within every 5km radius (Manicaland Regional Education Office, 2010). Given this, compared to other provinces in Zimbabwe, Manicaland has a higher enrolment rates for both primary and secondary education. The table below shows the percentage of adult literacy[8] rates in the province by sex. These statistics also parallel those of adult numeracy[9] in the province as well.

Table 3: Adult Literacy in Manicaland Province

AGE GROUP	MALES	FEMALES	OVERALL
Buhera	97	94	95
Chimanimani	97	96	96
Chipinge	96	94	95
Makoni	97	95	96
Mutare Rural	97	95	96
Mutasa	97	95	96
Nyanga	97	95	96
Mutare Urban	99	99	99
Rusape	99	98	98
TOTAL	**97**	**95**	**96**

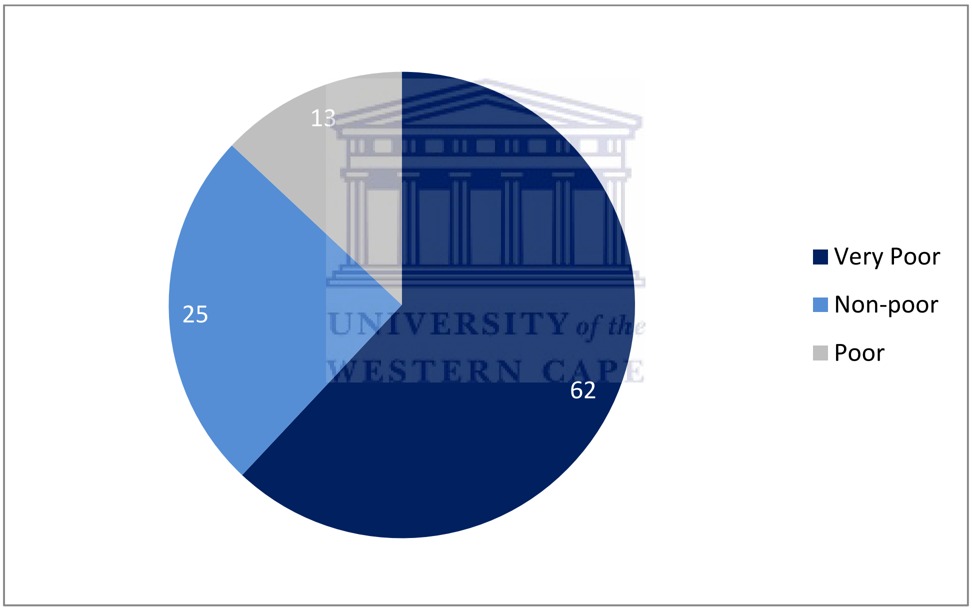
Source: (Manicaland Regional Education Office, 2010)

[8] Adult literacy here refers to the ability to read and write of individuals above the age of 15.
[9] Adult numeracy refers to the “ability to reason and apply basic numerical concepts” (Brooks, 2010).

3.2.8 Poverty and Social Development

Figure 7 below shows the poverty distribution in Manicaland province. 62% of the population are classified as very poor, these are mostly rural populations mostly referred to as chronically poor (Nziramasanga, 2003). The majority of the 13% classified as poor are also predominantly rural and these fall under the category of below USD1.25 per day. 25% are classified as non-poor and a large proportion of these are the urban population.

Fig 7: Poverty Distribution of Manicaland Province



Source: Nziramasanga (2003)

The set of social indicators shown in the table 4 below is given to show a representation of the measures and values used to determine the level of social development in Manicaland province.

Table 4: Social Development Indicators for Manicaland Rural Areas

INDICATOR	MEASURE	VALUE
Type of dwelling unit	Modern	13.00%
	Other	87.00%
Distance to source of water	<500 m	40.00%
	500 - 1000m	30.00%
	>1000m	12.00%
Access to safe water		65.30%
Toilet facilities	Flush	4.00%
	None	39.00%
	Other	57.00%
Main source of energy	Wood	97.00%
	Other	3.00%

Source: Nziramasanga (2003)

3.3 ENERGY ACCESS AND RURAL ELECTRIFICATION IN MANICALAND

The main source of energy in the rural areas of Manicaland province is wood fuel. Over 97% of the population depend on this source of energy to meet most of their household energy requirements such as cooking and heating (Nziramasanga, 2003). The government initiated a national rural electrification scheme in 1993 with the aimed of expanding access to electricity in rural areas (REA, 2007). The primary beneficiaries of this scheme were rural service centres across the country with priority given to 415 institutions such as schools, hospitals, agriculture, government office and business centres across the country. Efforts to expand this scheme were further bolstered in 2002 through the establishment of the Rural Electrification Agency (REA) a quasi-government organisation dedicated to this objective. The agency expanded the programme by identifying 9,906 institutions which would be electrified under a scheme of financing both the connection as well as end-user infrastructure such as irrigation equipment to ensure that electricity contributes towards socio-economic growth and development (REA, 2007).

In Manicaland, some of the projects electrified under this programme included hospitals, schools, and economic growth points or service centres. However, overall electrification in Manicaland is estimated to be 37% and the extent to which this has reduced the dependence on wood fuel in most parts of the province is still limited (REA, 2007). (*See table 5*)

Table 5: Rural Electrification in Manicaland Province

Category	Actual targets	Electrified	Percentage
Primary Schools	779	226	29
Secondary Schools	242	137	56
Health Centres	242	90	37
Business Centres	420	172	40
TOTAL	1683	625	37

Source: REA (2007)

3.4 RENEWABLE ENERGY POTENTIAL

3.4.1 Solar

Manicaland has significant potential for solar-based energy generation. Nziramasanga (2003) notes that the average solar insolation for Manicaland province is between 2080 and 2230 kW/m^2. This is consistent with that of tropical country variations and therefore the region is suitable for the generation of energy through solar photovoltaic applications and solar thermal applications such as solar cookers (Nziramasanga, 2003).

3.4.2 Biomass, Bio-waste, Biofuel and Biogas

The forestry activities in the province produce approximately 70,000 tons of biomass waste per annum which has the potential to be utilized for productive generation of renewable energy (Bailis *et al.,* 2000). However, only 10% of this waste is used as fuel for steam boilers in the industry. The amount of biomass waste produced is set to double by 2015 which would further support the need for biomass energy technology interventions (ibid). There also exist potential for the cultivation of crops for biofuels production. In 2007 the government launched a biodiesel processing plant located in Harare which currently operates at below optimal capacity due to lack inputs among other factors (Themba, 2011). This biofuel plant is currently the only commercial processing plant for biofuel in Zimbabwe and would serve as a ready market for biofuel crops such as Jatropha seed.

3.4.3 Small Scale Hydroelectricity Potential

Feasibility studies carried out by Practical Action (Zimbabwe) have revealed that there exists considerable potential for micro-hydropower generation in the Eastern Highlands (Practical Action, 2007). Over 32 river sites have been identified in Manicaland with significant potential to produce output ranging from 3-750kW throughout the year (Practical Action, 2007). Smaller output schemes could produce pumping and motive power while larger output scheme can feed-in to the national grid (MoEPD, 2007). However, only 8 of these are being exploited leaving a considerable untapped output (Practical Action, 2007).

3.4.4 Wind Energy Potential

Manicaland province has relatively good wind resources. Although there is limited data on the wind map of Manicaland province, there have been reliable surveys that have been conducted in Chipinge (southern part of Manicaland) and Nyanga in the north (Nziramasanga, 2003). Wind speeds averaged 3.7 and 31 meters per second for Chipinge and Chimanimani respectively (ibid). Further, a pilot project of wind generators installed at Chayamiti in Chimanimani district has yielded positive results as it provides electrical energy for a selected facilitates at the business centre (Nziramasanga, 2003).

3.5 DESCRIPTION OF THE CASE STUDY AREA

Rusitu Valley is a small rural community located in Chimanimani district of Zimbabwe. It is situated along the south-eastern border with Mozambique, approximately 45kw away from Chimanimani town which is the district capital and 190km from Mutare, the provincial capital. The Valley constitutes 3 wards, namely; Manyuseni (21), Ngorima (22) and Muchadziya (23) and the current population is estimated to range between 35 000 and 40 000 people. The population density of Rusitu Valley is approximately 70 people per km^2 which is higher than the national average of 29 people per km^2 (www.nationmaster.com/country/zi-zimbabwe/).

The area falls under Zimbabwe's agro-ecological region 1 which is characterized by low to moderate temperature and high rainfall of approximately 1050mm/annum. These conditions are ideally suitable for plantation forestry and tourism which are the largest contributors to the formal economy (Nziramasanga, 2003). However, these account for only 5% of formal employment (ibid). The majority of inhabitants are dependent on small scale horticulture for income as the mountainous terrain is not suitable for subsistence agriculture (Nziramasanga, 2003). Members of the community generate income from the sale of fruits and vegetables such as bananas, pine apples, paw-paws, avocados and peas. Educational facilities are available in Rusitu Valley, with at least one school within a 5km radius[10]. However, other basic services such as healthcare, housing, transport and electricity are generally limited.

3.6 RENEWABLE ENERGY TECHNOLOGIES IN RUSITU VALLEY

3.6.1 Solar Energy Potential in Rusitu Valley

Rusitu valley has an average of 6.5 sunshine hours per day and a solar insolation of 5.7kWh/m^2/day (SCEE, 2002). However, solar energy is not widely used despite the fact that it is inexhaustible and the technology is now relatively inexpensive and simple. Solar electricity is a proven way to meet the energy requirements for agricultural (water pumping), commercial (telecommunications and refrigeration), and other basic household electrical energy requirements such as lighting (Practical Action, 2007).

3.6.2 Biomass Potential in Rusitu Valley

Rusitu valley is located at the southern extreme of Manicaland province in Zimbabwe. This province falls with the agro-ecological region 1 which is characterized by moderate to low temperatures and average rainfall of above 1050mm/annum and with precipitation received in all months (Bailis *et al.,* 2000). This homogenous physiography makes it ideal for plantation forestry which is the largest industry in the region by land use. There is a significant biomass growth and with that enormous potential for biomass based renewable energy technologies (ibid).

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[10] This is in line with the Zimbabwe National Education Policy (Kanyongo, 2005).

3.7 THE RENEWABLE ENERGY DEMONSTRATION VILLAGE[11]

In light of these factors highlighted, the Government of Zimbabwe (GoZ) with the assistance of the United Nations Development Programme and World Bank in 2002 committed to the establishment of a renewable energy pilot scheme. This project initiative was aimed at establishing the feasibility[12] of a sustainable community based energy supply project on a cost-recovery basis. The Scientific and Industrial Research and Development Centre (SIRDC) was selected as the implementing agency through its Energy Technology Institute (ETI).

A primary goal of the renewable energy demonstration village was to increase access to productive and household energy services for individuals and households through the installation of renewable energy technologies. This primary objective was implemented through installation of a central solar battery charging station at Muchadziya clinic in ward 22 and dissemination of solar fruit driers. The intended outputs of this intervention were to promote greater reliance on solar energy for household energy services such as lighting and to promote economic activity through the processing and sale of dried fruit. The project also entailed the dissemination of improved biomass stoves (Tsotso stoves, *See figure 8*) with the intention to reduce the consumption of fuel wood. These interventions were intended to reduce dependence on kerosene (for lighting), and in this reduce the incidence of respiratory problems associated with the use of kerosene particularly among women and children. The renewable energy demonstration village was also intended to strengthen institutional capacity through training of project leadership and local institutions. Institutional capacity would be strengthened through technical and local coordination of the communities by setting up

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[11] Information on the Renewable Energy Demonstration Village in Rusitu Valley was provided by the SIRDC and further details were acquired through an interview with Dr E. Kapuya, Acting Director- ETI, SIRDC.
[12] Feasibility here refers to the acceptability and practicality of a given set of interventions.

community trust. These were intended to promote greater participation of women and to enhance the opportunities for greater social equity.

3.7.1 Biomass-based Renewable Energy Technologies

3.7.1.1 Improved Biomass Stoves

The introduction of improved biomass stoves in Rusitu valley was in response to the increasing shortage of fuel wood experienced in some parts of the community. This project aimed at conserving existing fuel wood resources by improving end-use efficiency, complementing afforestation efforts as well as allowing time for the natural regeneration of indigenous flora. The Energy Technology Institute (ETI) adapted the design of the improved biomass stove to be introduced within the Rusitu community. (*See figure 8*)

Figure 8: Improved Biomass Stove Designs

Images provided by: SIRDC (ETI)

With the assistance of the Chimanimani rural district council, the ETI trained 30 indigenous vocational craftsmen in the construction of the Tsotso stove. The objective of this strategy was to build capacity within the community to construct and maintain these improved biomass stoves. A further objective of the project phase was to educate an influential group of individuals within the community of the eventual demerits of traditional fuel wood exploitation and to demystify negative preconceptions of renewable energy technology as well as intensifying awareness campaigns of their potential benefits.

3.7.2 Solar-based Renewable Energy Technologies

3.7.2.1 Central Solar (PV) Battery Charing Station

The primary intervention in the Rusitu valley community by the Energy Technology Institute was the installation of a central solar battery charging station. The institutional development model adopted by the ETI aimed to identify existing institutions within the community that could be strengthened through enhancing their capacity to deliver community services. The Ministry of Energy and Power Development (MoEPD) assisted the ETI in identifying a local clinic at Muchadziya in ward 22 where the central solar battery charging station was constructed. The rational for locating the station at the clinic was firstly because it was centrally located. Secondly, this was also to provide basic electrification to the clinic's outpatient and maternity wards. Potential beneficiaries of this station where limited to 50 households within the Rusitu valley community. The only requirement from applicants was a commitment to pay a monthly subscription fee of US$5 and thereafter, selection was based on a first-come, first-serve basis.

The basic design of the solar battery charging station was in principle similar to the mini solar grid system. The key distinction was that instead of connecting mounted solar panels to a battery to produce a 12 volt system, the solar charging system connected to an inverter producing a 220 volt system. This augmented output was then used to power a battery charging station where subscribed members were assisted by a technician to charge their 12 volt batteries.

3.7.2.2 Solar Fruit Driers

Community members of Rusitu Valley are predominantly horticulturalists as the area is mountainous leaving little arable land for commercial grain cropping. A significant proportion of the women grow small fruits and vegetables for sale. The ETI introduced solar driers with the aim of enhancing standards of living through mechanised agricultural processing. The solar driers were designed and constructed under the same scheme as the improved biomass stoves. The specific objective of this intervention was to provide a means of improving traditional fruit and vegetable drying techniques and further extending the shelf life of processed commodities. In adopting this technology, beneficiaries would not only save time but also reduce the amount of energy required to complete the same tasks through traditional fruit drying techniques.

3.8 RATIONALE FOR THE CHOICE OF THE CASE STUDY AREA

It is my opinion that the Rusitu Valley is a prime example of an attempt to incorporate renewable energy technologies as a mechanism towards to the achievement sustainable community development. The primary determinant in the selection of Rusitu Valley for the renewable energy demonstration village was the need for energy services in that area given high population density and difficulty in accessing basic services. Secondly, the climatic conditions of prolonged hours of solar insolation and high rainfall suiting the intended solar and biomass renewable energy technology interventions. Therefore an in-depth study based on the renewable energy demonstration village in Rusitu Valley would be most relevant to an attempt to determine the extent to which of renewable energy technologies influence sustainable community development.

3.9 CONCLUSION

This chapter provided a detailed background to the Manicaland province and Rusitu Valley as the case study area. The description of the geography, social setting, local economy and the natural resource potential in Manicaland is necessary in highlighting the main features of the social and economic organization as well as the ecological state in Rusitu Valley. The next chapter will continue this in more detail, abstracting salient features of the various systems in order to be able to apply the systems rationale to the analysis of data on the contribution of renewable energy technologies to sustainable development.

4 CHAPTER 4: PRESENTATION OF FINDINGS

4.1 INTRODUCTION

This chapter presents data collected from Rusitu Valley, the location of the renewable energy demonstration village pilot project implemented by the Scientific and Industrial Research and Development Centre. The findings presented in this chapter are based on data collected from the sample of 70 responses using focus group discussions and a brief structured questionnaire. The findings provide insight into the use and of renewable energy technologies in Rusitu Valley and also the social, economic and environmental dimensions of sustainable development in the community. This chapter provides input that will subsequently be used to analyse the influence renewable energy technologies in Rusitu Valley have on the sustainability of economic, social and environmental systems and the overall sustainable development in the community.

4.2 BASELINE INFORMATION OF RUSITU VALLEY

The baseline data provides an overview of the demographic status of the sample population that forms the major part of the respondents in this research. A breakdown of the social, economic and other aspects of the sample population is relevant to creating a portrayal of the livelihoods of individuals within the Rusitu Valley community.

4.2.1 Age and Sex Distribution of Respondents

The age and sex distribution of the surveyed population shows that the majority of the respondents range in age from 31 to 45 years. (*See table 6*) The sex distribution reveals that 54% of the respondents are male thus the female population make up the difference with a total of 46%.

Table 6. Age-Sex Distribution of Respondents

	Age of the Respondent						
Sex of the Respondent	**26-30**	**31-35**	**36-40**	**41-45**	**46-50**	**51+**	**TOTAL**
Male	5	5	10	9	4	5	38
Female	2	5	7	10	4	4	32
TOTAL	7	10	17	19	8	9	**70**

4.2.2 Education and Literacy Levels

The educational attainment of the respondents corresponds with the high density of primary and secondary education facilities in the Chimanimani district[13]. All respondents in the survey recorded basic literacy and numeracy skills as the lowest level of education was a primary education certificate (19%). Table 7 below shows the distribution of respondents by level of education. The majority of respondents (49%) attained a Zimbabwe junior certificate of education (ZJC), the equivalent of 9 years of formal education. Thirty-three percent (33%) of the respondents had at least an Ordinary level certificate (O'Level) or higher educational attainment in the form of a college diploma or university degree.

[13] There are a total of 822 primary and 298 secondary schools in Manicaland province. The dispersion of educational facilities in the province shows at least 1 school within every 5kn radius (Manicaland Regional Education Office, 2010).

Table 7: **Distribution of Respondents by Level of Education**

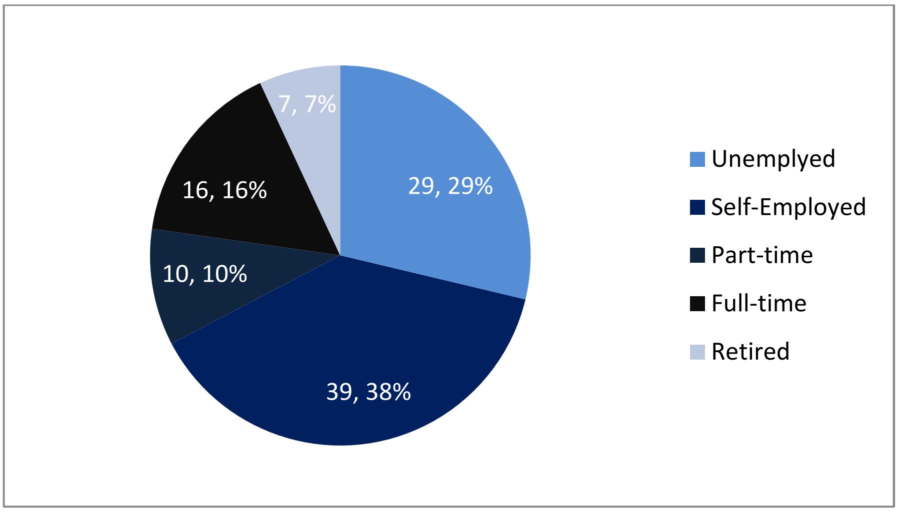
Level of Education	Frequency	Percentage	Cumulative
Primary Cert.	13	18.57	18.57
ZJC	34	48.57	67.14
O' Level	12	17.14	84.29
Diploma	11	15.71	**100.00**
TOTAL	70	**100.00**	

4.2.3 Distribution of Respondents by Employment Status

Figure 9 (*below*) shows the distribution of respondents by employment status. It is significant to note that 64% of the respondents are in either full-time, part-time or self-employment. The distribution reveals that the majority of people are self-employed constituting 39% of the respondents. Women involved in collective vending of horticultural produce such as fruit and vegetables make up the majority of the self-employed group. Unemployment among the respondents is 29% which is significantly lower than the district and national average of 47%[14]. Only 7% of the population are retired from previous employment.

[14] This percentage only accounts for formal employment sectors (CSO, 2002).

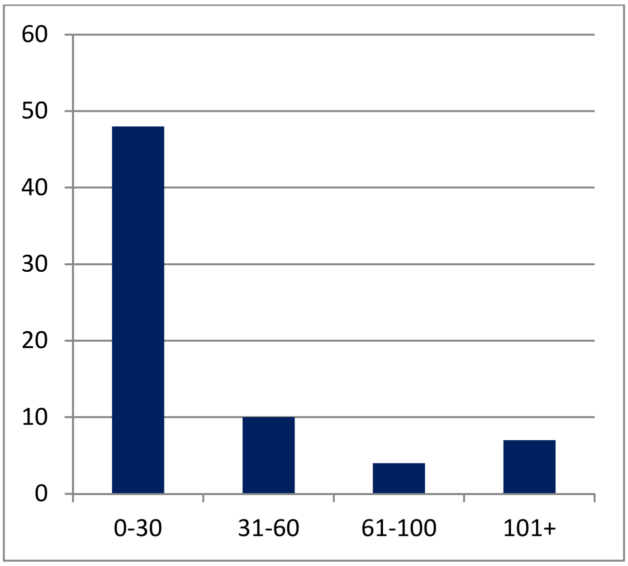
Figure 9: Distribution of Respondents by Employment Status



4.2.4 Income Distribution among Respondents

The graph below presents average income of respondents (*See figure 10*) and it is noticeably shows that 69% of the respondents earn monthly income below 30USD. A further 14% earn between 31 and 60USD indicating that most of the respondents (83%) earn under 2USD per day. This is despite the relatively high employment figures in the community. Only 17% of the respondents earn above 61USD and this mostly by individuals employed in full-time jobs.

Figure 10: Distribution of Respondents by Average Income



4.2.5 Distribution of Household Size

A large proportion of respondents indicated that their household size ranges between 7 and 10 individuals per unit. (*See table 8*). This is significant as it is generally believed that the poor have larger families. Given a fixed income, the per capita consumption of individuals in a particular household is reduced as the number of members increases. This is an important indicator on the standard of living and is further significant to the determination of how and for which purposes different household sizes adopt renewable energy technologies.

Table 8: Distribution of Respondents by Household Size

Size of Household	Frequency	Percent	Cumulative
1-3	8	11.43	11.43
4-6	24	34.29	45.71
7-10	32	45.71	91.43
11-14	6	8.57	100.00
TOTAL	70	100.00	

4.2.6 Community Needs

The table below shows the priority needs of the community from the perspective of respondents who participated in focus groups. (*See table 9*).

Table 9: Most Important Community Needs

	MOST IMPORTANT COMMUNITY NEEDS								
	Water and Sanitation	**Electricity**	**Access to Markets**	**Training and Skills**	**Employment Opportunities**	**Improvement of Transport Networks**	**Improvement of Communications**	**Improvement of Health Services**	**TOTAL**
Male	0	4	3	5	16	4	3	3	38
Female	2	3	11	6	3	3	0	4	32
TOTAL	2	7	14	11	19	7	3	7	70

Among the responses given by participants in focus groups, the most prominently identified community need was employment opportunities, closely followed by the need for access to markets where they could sell horticultural produce. Access to electricity was considered a secondary need, ranking at similar levels with the need for improved health services and improvement of transport networks. The prioritization of economic needs over social needs is typical of low income communities, indicating that motivation to meet basic necessities such as food and shelter is much greater than the perceived benefit of socially valuable services.

4.3 TRADITIONAL ENERGY SOURCES IN RUSITU VALLEY

4.3.1 Fuel wood Consumption

Fuel wood is the most basic form of energy available to low income households in Zimbabwe (Nziramasanga, 2003). Similarly, energy utilisation in Rusitu valley is dominated by fuel wood consumption with 53% of the surveyed population using 41 to 80kg of wood to meet their monthly household energy services. (*See table 10*). These include; cooking, heating and in some cases, lighting. Although there are positive and negative variations, most household fall in this range. Outliers in the positive direction are mostly households that use fuel wood in agricultural and horticultural processing consuming approximately 81 to 160 kilograms per month.

Table 10: Fuel wood Consumption

Fuel wood Use per Month (kg)	Frequency	Percent	Cumulative
10-20	7	10.00	10.00
21-40	10	14.29	24.29
41-80	37	52.86	77.14
81-160	16	22.86	100.00
TOTAL	**70**	**100.00**	

4.3.2 Kerosene Consumption

Kerosene is a commonly used fuel in the predominantly rural areas of Zimbabwe as a fuel for lamps, portable stoves and in more commercially inclined communities as an input to candle manufacturing and basic refrigeration systems. In Rusitu, a similar scenario prevails with all respondents indicating that they use kerosene in their households. (*See table 11*) A significant statistic is that 81% of the respondents use between 1.1 to 2 litres of kerosene a month and this is primarily for lighting utilities as shown in Fig. 8 below.

Table 11: Kerosene Consumption

Kerosene Use per Month (*litres*)	**Frequency**	**Percent**	**Cumulative**
0-1	9	12.86	12.86
1.1-2	57	81.43	94.29
2.1-3	4	5.71	100.00
TOTAL	**70**	**100.00**	

4.3.3 Diesel Consumption

Diesel in Rusitu Valley is mostly used for essential functions such as transportation, mill operation and commercial generators. It also serves as a source for fuel to run small household electricity generators producing below 1000kV although this functionality is less frequent. (*See table 12*) 73% of the respondents indicated that the use on average less than 5 litres of diesel a month. Of the population that use diesel, only 4% of the respondents consume on average 10 to 20 litres of diesel and these are mostly small shop or butchery owner who run vehicles in between Rusitu and Chimanimani rural district centre.

Table 12. Diesel Consumption

Diesel Used per Month (*l*)	Frequency	Percent	Cumulative
0-5	51	72.86	72.86
5.1-10	16	22.86	65.71
10.1-20	3	4.29	100
TOTAL	**70**	**100.00**	

4.3.4 Consumption of Other Non-Renewables

Apart from the major sources of energy highlighted above, the Rusitu Valley community also relies to a lesser extent on other non-renewable sources of energy such as bio-waste, batteries, coal and charcoal. All respondents indicated that they use these occasionally as most reliance is placed on the traditional sources highlighted.

4.3.5 Summary of Baseline Data

Nziramasanga (2003) identifies the development indicators of the typical Zimbabwean rural communities in terms of access to basic facilities and services such as those identified above. In line with this classification, the baseline data of the sample population shows a typical rural livelihood setup with limited access to modern energy sources and low levels of income. This is significant in terms of the relevance of the sampled population as a fair representation for generalization of the analysis in subsequent chapters of this study.

4.4 RENEWABLE ENERGY TECHNOLOGIES IN RUSITU VALLEY

The frequency of renewable energy technology use among community members indicates the extent to which renewable energy technologies are an effective source of energy services. As noted in Chapter 2, renewable energy technologies are not an end in themselves but are desired for the services which they provide. Therefore, it should hold true that if renewable energy technologies are instrumental in uplifting people's standard of living, people should use them more frequently. The data presented below shows frequency tables of renewable energy technology services.

4.4.1 Frequency of Improved Biomass Stove Use in Cooking

Table 13 (*below*) shows the average use of improved biomass stoves in the preparation of meals for households. The data reveals that there is generally low use of improved biomass stoves in this regard, with only 6% of the sampled population use this technology regularly or every day. 24% of the respondents indicated weekly use while a much larger proportion (42%) indicated that they had never used the improved biomass stove at all.

Table 13: Frequency of RET use in Cooking

Frequency of RET (Cooking)	Frequency	Percent	Cumulative
Everyday	4	5.71	5.71
Once a week	24	34.29	40.00
Never	42	60.00	100.00
TOTAL	**70**	**100.00**	

4.4.2 Frequency of Solar Charging Station Use in Lighting

The use of renewable energy technologies in lighting also displayed similar trends as those in the frequency of cooking. The respondents indicated a generally low level of frequent use. (*See table 14*). However, what is notable is that more than half of the respondents (53%) use this form of service on average of once a week. 34% of the respondents indicated that they had not use the technology at all.

Table 14: Frequency of RETs use in Lighting

Frequency of RET (Lighting)	Frequency	Percent	Cumulative
Everyday	9	12.86	12.86
Once a week	37	52.86	65.71
Never	24	34.29	100.00
TOTAL	**70**	**100.00**	

The combined number of respondents who use the technology at least once a week is 48 out of a possible 70 (66%). Therefore, the overall uptake of RETs for lighting is generally higher than that for cooking.

4.4.3 Frequency of RET Use in Household Applications

The use of renewable energy technologies for other households applications such as radios, television sets and cell phones is generally much higher than all other forms of energy services. (*See table 15*). 79% of the respondents indicated that they at least use RETs for household applications once a week. This is an overall much high representation than the improved biomass stove and the lighting. Respondents mostly indicated that they frequently use solar charged 12V batteries to power the charging mobile phones, televisions and radios.

Table 15: Frequency of RETs use in Household Applications

Frequency of RET (Household Applications)	Frequency	Percent	Cumulative
Everyday	13	18.57	18.57
Once a week	42	60.00	78.57
Never	15	21.43	100.00
TOTAL	**70**	**100.00**	

4.4.4 Frequency of RET Use in Community Services

Community services referred to in the table 16 (*below*) represent indirect energy services enjoyed by individuals in the local area. A typical example would be the clinic that now operates for extended hours because of the installation of lighting services provided by the central solar battery charging station. 87% of the respondents indicated that they use the service either directly or indirectly at least once a month.

Table 16: Frequency of RET use in Community Services

Frequency of RET (Community Services)	Frequency	Percent	Cumulative
Once a month	61	87.14	87.14
Once a week	0	0	87.14
Never	9	12.86	100.00
TOTAL	**70**	**100.00**	

This relatively high frequency of renewable energy community services usage gives credence to the institutional development model. The extent to which community members benefit from the healthcare services offered by the clinic impact is not entirely clear because of limited data in this regard. However, the statistical significance of the proportion of users does form an impression on the desirability of such services in the community.

4.4.5 Summary of RET Use in Rusitu Valley

Table 17 below shows a summary of the frequency of renewable energy technology use in Rusitu Valley. Renewable energy technologies are most frequently used in household applications and considerably less for cooking services.

Table 17: Frequency of RET Use in Rusitu Valley

Use of RET	FREQUENCEY OF USE				
	Everyday	Once a week	Once a month	Never	TOTAL
Cooking	4	24	0	42	70
Lighting	9	37	0	24	70
Household Applications	13	42	0	15	70
Community Services	0	0	61	9	70

4.4.6 Auxiliary Support for Renewable Energy Technologies

The type of technical support available to beneficiaries of the renewable energy project is relevant to an assessment of the long term viability of such interventions. The general consensus among all respondents is that the level of support available to them in the form of access to subsidized spares and proximity to repair and maintenance services is insufficient.

4.5 SOCIAL DIMENSIONS OF RENEWABLE ENERGY INTERVENTIONS

4.5.1 Community Participation

Participatory methodologies[15] have significantly influenced sustainable development initiatives that are aimed at alleviating chronic poverty in many developing countries (Jennings, 2000). The SIRDC project was designed to incorporate an aspect of involvement of the local community in the definition of problems, planning and implementation of activities. Table 18 below shows the level of participation by community members in the SIRDC renewable energy demonstration village project.

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[15] A collection of methodological tools emphasizing the centrality of people centered approaches to development, commonly referred to as "participatory development" (Jennings, 2000).

Table 18: Community Participation in SIRDC RET Project

	LEVEL OF PARTICIPATION				
	Always	Sometimes	No	Not Sure	TOTAL
Male	11	27	9	0	47
Female	6	4	13	0	23
TOTAL	**17**	**31**	22	0	70

The table shows that 48 (17 Always, 31 Sometimes) of the respondents acknowledged their participation, at least in part, in the project. This translates to 69% of the respondent and can be deduced to be a fair level of local community participation. However, the mere presence of community members is not a significant barometer of their actual contribution to project interventions implemented within the Rusitu community

4.5.2 Level of Community Participation in Decision-making

The extent to which local community members are able to influence project decisions is significant to the overall relevance of project interventions. Chambers (1994) characterized what he termed 'conventional professionalism' by development practitioners as a practice which views local participation as unprofessional and would rather align interventions with state institutions. Although the motivations for conventional professionalism may be inherently political, the consequences of such practices may have greater implications on the long term viability of the project. With regard to the SIRDC project in Rusitu valley, the table 19 (*below*) shows the level of community decision-making among the community members.

Table 19: Level of Beneficiary Participation in Decision-making

LEVEL OF COMMUNITY DECISION-MAKING						
	Very Much Involved	Involved	Moderately Involved	Slightly Involved	Not Involved	TOTAL
Male	2	2	14	17	3	38
Female	0	1	2	5	2	10
TOTAL	2	3	16	22	5	48

Of the 48 community members that indicated at least some level of involvement in the project, only 5 respondents indicated that they "very much involved" or "involved" in decision-making. The majority of respondents (80%) indicated that they were only either "moderately or slightly" involved. This is a more precise assessment of the level of actual participation in decision-making.

4.5.3 Community Support

An indicator of project relevance to the particular needs of the community is the type of personal contributions beneficiaries are willing to make towards the successful implementation. The project interventions proposed by the SIRDC in Rusitu Valley involved a component of personal contribution in the form of voluntary training in the construction of improved biomass stoves and also solar fruit driers. More importantly, the central solar charging station required a commitment to paying a monthly subscription for use of the facility. Table 20 (*below*) shows the type of community support offered by beneficiaries towards the SIRDC project interventions.

Table 20: Type of Community Support by SIRDC Project Beneficiaries

TYPE OF COMMUNITY SUPPORT IN SIRDC RET PROJECT				
	Cash	Labour	Cash + Labour	TOTAL
Male	11	27	9	47
Female	6	4	13	23
TOTAL	17	31	22	70

The type and level of personal contribution shown in the table provides a more accurate depiction of the general support for the project as generally all respondents indicated that they contributed money, labour or both. The largest proportion of respondents (44%) contributed labour, which is logical given the low incomes highlighted in earlier sections.

4.5.4 Promotion of Gender and Social Equity

Renewable energy technologies have helped enhance the status of women within the Rusitu Valley. The SIRDC project had a specific gender focus that was intended at providing equal opportunities for women and men to participate and benefit. A key observation from the discussions held with community members was that, although women were not proportionally engaged with the project implementation (*See tables 18 and 19*), they have been considerably benefited through the opportunity to earn income from fruit and vegetable sales. The amount of income earned from selling fruit and vegetables is significant in that it allows women greater influence over their household decisions as they contribute towards total earnings.

A similar rationale was for the promotion of social equity among the different individuals in the community. The relatively accessible means to earning an income from solar fruit driers was given as a primary factor. The discussions also revealed that the equal access to enhanced community services, particularly through the clinic located in ward 22 also added to the social dynamic.

4.6 THE ECONOMIC VALUE OF RENEWABLE ENERGY TECHNOLOGIES

4.6.1 Income Generation from Renewable Energy Technologies

It is worth noting from the data that a significant proportion of the community earn income from activities related to the use of renewable energy technologies. Table 21 *below* shows average income earned from commercial activities related to the use of renewable energy technologies.

Table 21: Average Income Generated from Renewable Energy Technologies

Average Income Generated per Month (USD)	Frequency	Percent	Cumulative
0	51	72.86	72.86
1-5	6	8.57	81.43
6-10	9	12.86	94.29
11-15	3	4.29	98.57
16-20	1	1.43	100.00
TOTAL	**70**	**100.00**	

Although the table shows that 73% of the respondents do not earn income from renewable energy technologies, those that do (27%) earn up to USD20 on average.

4.6.2 Savings derived through the use of RETs

Savings realized through the use of renewable energy technologies occur as a result of reduced expenditure that would otherwise have been used to acquire energy services through traditional sources of energy. For example, the use of a rechargeable battery for lighting within the household eliminates the cost of candles and kerosene used to fuel lamps. Table 22 (*below*) shows average household savings derived from the use of various renewable energy technologies.

Table 22: Savings from the Use of RETs

Savings per Month (USD)	Frequency	Percent	Cumulative
0	1	1.43	1.43
1-5	53	75.71	77.14
6-10	10	14.29	91.43
11-15	2	2.86	94.29
16-20	4	5.71	100.00
TOTAL	**70**	**100.00**	

76% of the respondents indicated that they save between 1 and 5USD per month which would have contributed to expense on non-rechargeable batteries, candles and kerosene. A similar trend was observed for larger households as the amount of savings increases (6-15USD per month) proportionally to the household size. Households retaining larger savings were those who utilized more renewable energy technologies. In these cases, solar powered lighting systems contributed most significantly to savings as the cost of conventional grid electricity is a more costly alternative.

4.6.3 Expenses Incurred through RET Use

The expenses incurred as a result from the use of renewable energy technologies are derived from operational costs to ensure effective delivery of energy services. These usually take the form of subscriptions, repair and maintenance. Table 23 (*below*) shows average monthly costs associated with the use of renewable energy technologies.

Table 23: Monthly Expenses from RET Use

Expenses per Month (USD)	Frequency	Percent	Cumulative
0	19	27.14	27.14
1-5	46	65.71	92.86
6-10	4	5.71	98.57
11-15	1	1.43	100.00
16-20	0	0	100.00
TOTAL	**70**	**100.00**	

The table shows a large proportion of the respondents (76%) incur expenses ranging from 1-5USD per month. This is primarily because of the 5USD subscription fee for use of the solar battery charging station. Other expense items that add to this are for purchase of energy saving light bulbs, tubing and repair services. Individuals incurring greater costs (11-20USD per month) are mostly those engaged in commercial activates relying on solar based technologies for refrigeration, lighting and other basic electrical energy needs.

4.6.4 Proportion of Income Spent on Energy

The observation that the poor spend relatively more on acquiring energy services holds true in the case of respondents that participated in focus group discussions. The proportion of income spent in our to provide basic household energy for cooking and heating is more than double that incurred by better-off individuals among the Rusitu Valley community. Table 24 (*below*) shows the inversely proportional distribution of total income and expenditure on energy services. Better-off household earning more than 100USD per month spend approximately 25% of their income on energy services while worse-off member spend as much as 50% of income to acquire the same services.

Table 24: Proportion of Income Spent on Energy (*per month*)

PROPORTION OF INCOME SPENT ON ENERGY			
Total Income Range (Modal Income)		Average Fuel Expenditure (USD)	Proportion of Income (%)
0-30	(15)	8.4	56
31-60	(45)	18.9	42
61-100	(85)	24.65	29
100+	(125)	31.25	25

A possible explanation for this observation would be that; generally, households earning more income are likely to substitute traditional energy sources of 'cheaper' renewable energy technologies such as battery powered lighting. However, this finding is still significant in that it gives weight to the argument that "renewable energies are not for the poorest of the poor" as noted by Ms Mutubuki-Makuyana (*Energy Projects Coordinator, Practical Action Zimbabwe*). In line with this, Nziramasanga (2003) suggests that renewable energy projects are best targeted at the non-poor and poor segments of the community as the very poor are engrossed with the need to emerge from absolute poverty rather than on alternates based on social, economic and environmental concerns.

4.6.5 Non-monetary Costs and Benefits

All the calculations of savings above are based on a monetary costing of the non-renewable alternative from which similar energy services could be derived. Hence, it should be noted that the data provided is limited only to such valuations. A more precise calculation of actual savings should ideally include a valuation of non-monetary expenditure such as that accruing from the destruction of natural environment. For example, the savings derived from the use of improved biomass stoves should consider the alternative costs incurred if fuel wood was used to provide the same energy services.

4.7 ENVIRONMENTAL DIMENSION OF RENEWABLE ENERGY TECHNOLOGIES IN RUSITU VALLEY

4.7.1 Awareness of Natural Environment Constraints

The renewable energy demonstration village project included a complementary initiative to create awareness of the potential negative impact of human activities in the process of acquiring energy services through deforestation. The objective was to promote attitude change in the manner in which the community interacts with the natural environment and develop practices that preserve the biodiversity of the Valley's ecological system.

The focus group discussions revealed that knowledge about the impact of human activates on the natural environment was limited to the effects of deforestation in acquiring fuel wood for household and commercial use. Public awareness campaigns had been conducted throughout the 2 year period of the project implementation in community focal centres such as schools, churches and public meetings and gatherings. The respondents also showed a negligible awareness of the effects of improper disposal of alkaline batteries and the potential harmful greenhouse gas emissions from diesel powered diesel generators and the health hazard of kerosene lamps.

4.7.2 Conservation of Indigenous Ecological Species

As noted in Chapter 3, the Rusitu Valley has a diverse endowment of ecological species in the form of indigenous trees, bushes and flowers. The predominant tree used in the Rusitu Valley community as fuel wood is the '*Mukute*' tree. However, despite the promotion of biomass stoves and the installation of the central solar charging station the natural occurrence of this tree species continues to decline due to felling for the purposes of wood fuel.

4.7.3 Biological Productivity

The installation of solar driers in the Rusitu Valley community was primarily aimed at promoting income generation capacity through the potential to process and sell dried fruit. However, a spill over effect of this intervention was the increase in the number of community members growing of crops and fruits. Although this has an effect of improving the nutrition of a section of the Rusitu Valley community who were previously not engaged in horticultural activities, the overall significance towards the ecological productivity is limited. Further, only small fractions of the community using solar driers to preserve their produce go on to sale their product on the local market. (*See table 21*, *Average Income from RETs*).

4.8 CONCLUSION

As noted in Chapter 3, the renewable energy demonstration village project implemented in the Rusitu Valley area aimed to achieve climate change mitigation by reducing the greenhouse gas emissions and improving the living conditions of communities in Rusitu Valley through the provision of clean and affordable sources of energy. The data presented in this chapter however reveals mixed results in the achievement of such intended end goals. Traditional sources of energy, primarily fuel wood are still the most heavily relied on for the provision of basic energy services. The use of renewable energy technologies in the provision of services such as lighting and other household requirements is generally infrequent with a majority of respondents only making use of such services at least once a week. The most successful renewable energy intervention has been in the enhancement of household applications and community services such as the clinic which a majority of the respondents use frequently.

What can then be drawn from the presented data is that the introduction of renewable energy technologies has intimations on the social, economic and environmental dimensions of the Rusitu Valley. However, whether such interactions have any consequences on the sustainable development of the community is considered in the succeeding chapter.

5 CHAPTER 5: ANALYSIS AND DISCUSSION OF FINDINGS

5.1 INTRODUCTION

Attempts to determine the contribution of renewable energy technologies to sustainable development in empirical literature have adopted a variety of approaches towards this end. However, most attempts confine their analysis to the 3 pillar model of based on economic, social and environmental principles (*See Chapter 2*). While there has been considerable advancement towards the incorporation of these dimensions of sustainable development, most approaches are one dimensional in their perspective of sustainable development (*See Chapter 2*). This chapter will highlight the relationships and dynamics of economic, environmental and social aspects of sustainable development within the systems theoretical framework. In this, I attempt to identify relevant indicators that can be used to analyze the contribution of renewable energy technologies to sustainable community development taking into account the overall viability of the total system.

5.2 THE RUSITU VALLEY SYSTEM

5.2.1 System Environment and System Boundary

The viability of a system is inextricable tied to the environment within which it is embedded (Bossel, 1999). The Manicaland province is the system environment and the administrative demarcation of wards 21, 22 and 23 which make up Rusitu Valley are thus taken to be the system boundary. The properties of the system environment are essential in characterizing the system itself (Bossel, 1999). As noted in Chapter 2, viable systems adapt to their environment and hence such systems are likely to also exhibit similar properties. The Manicaland province is predominantly rural with 83% of the population residing in non-urban settings (*See*

Chapter 3). Similarly, the Rusitu Valley is a rural community displaying typical characteristics of low income communities found in Zimbabwe (*See Chapter 4*).

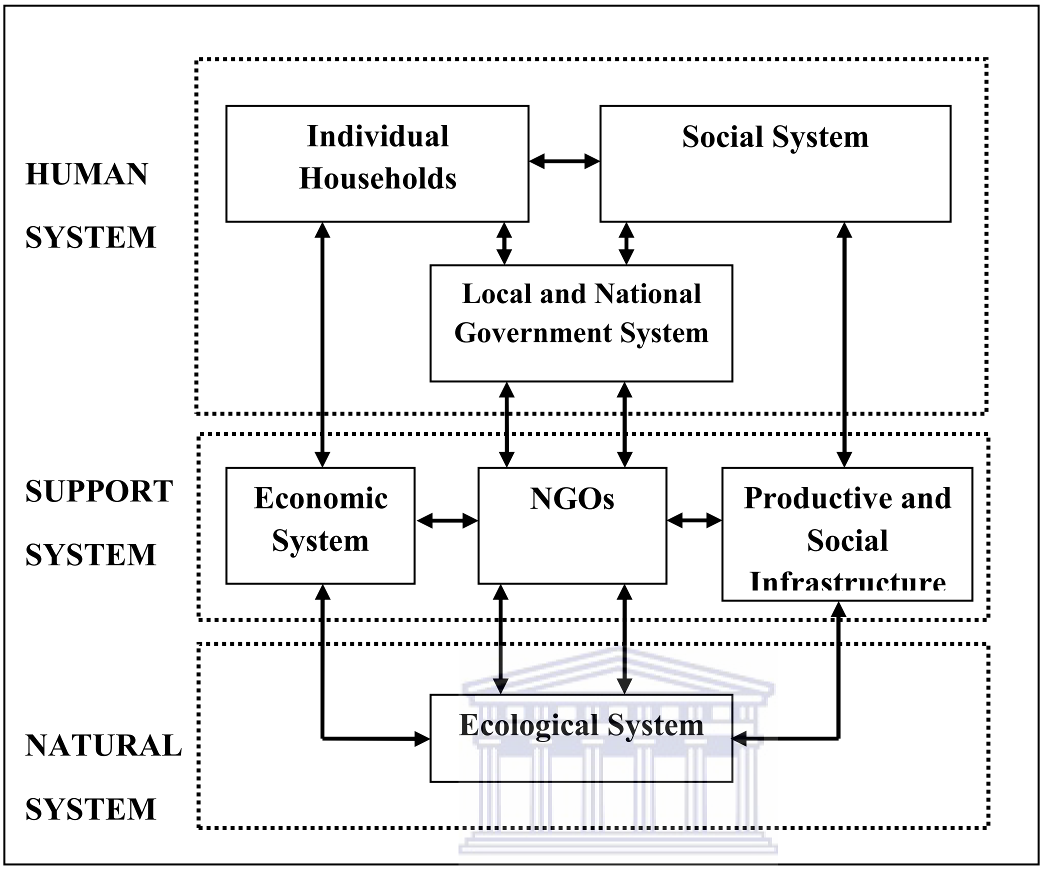
5.2.2 System Elements and Structure

System elements are the components of the system that interact to produce specific functions or outputs (Bossel, 1999). The configuration or organization of the different system element in a functional order is what is referred to as the system structure (ibid). In complex adaptive systems, the internal state of the total system is characterized by sub-systems which in turn are elements of the total system. In Rusitu Valley, system elements include; individuals and households, local and national government, productive and social infrastructure, non-governmental organisations, the social system, economic system and ecological system. In order for the total system to be viable, each of these system elements must be viable (Gladwin *et al.,* 1995).

5.3 OPERATION OF THE RUSITU VALLEY SYSTEM

The interaction of system elements in the Rusitu Valley is structured into three sub-systems; the human system, support system, and natural system. Within the total Rusitu Valley system, individual households interact with the social system and government to form the "human system". Productive and social infrastructure interacts with the economic system and non-governmental organisations within the "support system". The natural environment and resources form the "natural system". *(See figure 11).*

Figure 11: Interrelationships within the Rusitu Valley CAS



Adapted from: (Bossel, 1999)

5.3.1 Indicators of Sustainable Development in Rusitu Valley

Indicators provide comprehensive information on the systems shaping sustainable development. They are quantitative and qualitative measurements of what is important to the system viability (Bossel, 1999). Indicators provide vital information necessary in forming an impression of the current internal state of a system and its viability as well as providing a measure its performance for other systems that depend on it (ibid). Indicators are thus key in determining the course of interventions to correct system behaviour in accordance with the objectives and determining the relative success or failure thereof (Gladwin *et al.,* 1995).

In the case of Rusitu Valley, three main indicators were identified based on responses generated in focus group discussions. Community members were asked to identify what measures they would generally associate with either progress or regression of the community. Summarily, the responses generally focused on the level of monetary incomes (*income levels*), the ability of society to contribute towards their own development (*societal contribution*) and the ability to sustain their livelihoods from their own local natural resources (*resource availability*). In order to determine the internal state of the system, the indicators were assigned output goals or which they should achieve as a measure of positive variation and negative variation derived from the same reference point.

5.3.1.1 Level of Income

The level of incomes was identified as an appropriate indicator of determining the viability of the (economic) support system. The interrelation of the local economic system in Rusitu Valley, support from NGOs and social and productive infrastructure should have an implication on the level of incomes in the community. Measures of the viability of the (economic) support system using the income level, as an indicator, would thus be aligned to the satisfaction of basic needs, enhancement of equity, increase useful goods and services in the community [Barbier, (1987: 103) in Gladwin *et al.* (1995)].

5.3.1.2 Level of Societal Contribution

The level of societal contribution was selected as the appropriate indicator of the human system. The human system as a product on the interaction of local and national government with individual households and the social system, should significantly reflect the contribution of community members themselves. A viable human system would thus be one which reflects participation, social justice and sustainability of social institutions [Barbier, (1987: 103) in Gladwin *et al.* (1995)].

5.3.1.3 Level of Resource Availability

The level of resource availability was selected as the appropriate indicator for the natural system. Adopting this as an indicator of the viability of the natural system would thus require such a system to preserve genetic diversity of ecological species and sustain biological productivity [Barbier, (1987: 103) in Gladwin *et al.* (1995)].

Table 25: Sustainability Indicators in Rusitu Valley

SUB-SYSTEM	INDICATOR	MEASURE *(System Outputs)*
Support System	*Level of Income*	Increase useful goods and services, Satisfaction of basic needs, Enhancement of equity.
Human System	*Societal Contribution*	Participation, Social justice, Sustainability of social institutions.
Natural System	*Resource Availability*	Genetic diversity of ecological species, Sustain biological productivity.

5.3.2 Measuring Sustainable Development in Rusitu Valley[16]

The influence of renewable energy technologies on the viability of the Rusitu Valley system is established through an assessment the effect renewable energy technologies have on the human, economic and societal sub-systems. As highlighted earlier, the sustainability of a

[16] Title adapted from Pearce , D. (1993). *Measuring Sustainable Development*. London: Earthscan Publications Limited.

system is determined by the rate at which it can adequately respond to changes in the internal state and environment (Bossel, 1999). From this perspective, the extent to which renewable technologies have a bearing on the sustainability of the Rusitu Valley system can be credibly determined by their influence on its indicators, that is, the level of income (support systems), societal contribution (human systems) and availability of resources (natural systems).

5.4 THE CONTRIBUTION OF RENEWABLE ENERGY TECHNOLOGIES

5.4.1 Support System- Income Levels

5.4.1.1 Satisfaction of basic needs

It can be noted that renewable energy technologies in Rusitu Valley have generated a wide variety of economic benefits. Job creation is a key part of sustainable development in viable economies (Akella *et al.,* 2009). Community members concurred that the introduction of solar fruit driers had created employment opportunities with the Rusitu Valley. However, there was less support for the usefulness of this technology among other sections of the respondents noting that not all individuals were in the business of selling fruit and hence only a small section of the community has benefited from this tool. (*See table 21*, Average Income Earned through RETs). Only 23% of the respondents earned at least USD5 from through the use of solar fruit driers. However, the benefits on increased employment opportunities extend beyond the income earned from those jobs as people spend part of their income in the local economy. As Akella *et al.* (2009) add that more employment among communities generates spin-off benefits known as the "multiplier effect". The increased spending creates economic activity such as more jobs in other sectors there by enhancing the overall benefit to the community (Akella *et al.,* 2009).

5.4.1.2 Increase useful goods and services

The enhancement of useful goods and services should have the overall effect of increasing rural productivity (Practical Action, 2007). The primary intervention in Rusitu Valley was the installation of solar lighting facilities at Muchadziya clinic in ward 22. This intervention significantly improved access to healthcare services in the Rusitu Valley. (*See table 16, Frequency of RET use in Community Services*). The respondents gave examples of late night maternity deliveries and the refrigeration of medicines and vaccines adding to the overall enhancement of services the received from the clinic.

Community members of the Rusitu Valley generally agreed that renewable energy technologies contributed significantly through the provision of lighting and cooking services. Respondents emphasized that these are services that they require on a daily basis. The introduction of the solar battery charging station enabled the installation of single unit battery powered lighting systems. They said that the introduction of lighting after the regular hours of sunshine had extended their productive hours of the day. (*See table 14, Frequency of RET Use in Lighting*). The community members further indicated that introduction of improved biomass stoves met the basic need for better cooking services in the community. Although, the use of such technologies was generally limited, such an alternative was greatly valued by those utilizing them. The emphasis was on the ease and convenience realized through the use of biomass stoves. The burden of collecting large amounts of fuel wood was significantly reduced as the stove makes more efficient use of limited fuel wood input.

5.4.2 Human System- Societal Contribution

5.4.2.1 Participation

The inadequacies of decision-making processes which exclude meaningful public involvement have been widely recognized (*See Chapter 2*). Public acceptability is increasingly seen as a constraint on the exploitation of renewable energy. In the case of Rusitu Valley, 50% of the respondents (*See table 18, Level of Community Participation*) felt that they were at least slightly involved in decision making processes and this have been a possible explanation of the limited success of some of the proposed interventions particularly, the improved biomass ovens. Despite the high level of general support for renewable energy, attitudes towards specific projects among some parts of the public can be more negative, and conflict can appear particularly within processes of planning (Walker, 1995). This may be a possible explanation for the failure of improved biomass stoves in Rusitu Valley.

A way of addressing both some of the impacts of projects and the lack of local involvement of the local community is to make renewable energy projects smaller and more community based (Walker, 1995). However, in Rusitu Valley, although the opportunity to participate was availed, the ability to influence decisions was generally limited. Participation was primarily valued as community members felt that this would give them an opportunities to engage and access information which would in turn allow them to make informed decisions. (*See table 19, Level of Community Participation*).

5.4.2.2 Enhancement of Social Equity and Social Justice

Renewable energy technologies should be socially equitable. This requires raising issues of gender equity and addressing income disparities between social classes within communities

(Biswas *et al,* 2001). The recognition that all individuals, regardless of their economic or social status, have the same basic right to access energy services advances social justice through the introduction of renewable energy technologies. Community members highlighted that centrality of the solar charging station was important in enhancing equity among subscribers to the scheme from all 3 wards. However, the general concern was that the monthly subscription fee of USD5 would exclude the poorest individuals in the community from benefiting in the scheme. However, it can be noted that the expanded opportunities of additional income from renewable energy related jobs such as fruit drying, this should have a compensatory effect as incomes are raised through the sale of dried fruit, with the overall effect of reducing income disparities, and also having second round effects on social justice.

5.4.2.3 Sustainability of social institutions

The introduction of biomass stoves was particularly ineffective with regard to their contribution towards social institutions. The failure of such systems have yielded limited impact on the household and society in general. For women, in particular, the Rusitu community the burden of collecting fuel wood (a task predominantly carried out by women in rural areas) has not been addressed. As a result, women in the community are still bound by the same societal norms. According to UNDP (2011), poverty reduction, gender and social equity are important objects for sustainable development. Pearce (1993) notes that the most successful efforts in alleviating poverty have made efficient use of labour and have invested in the human capital of labour. Accordingly, the technologies for income generation in Rusitu Valley would be better applied to empower rural poor by investing directly to their indigenous skills and resources to meet their own and local needs (Biswas *et al.*, 2001).

5.4.3 Natural System- Resource Availability

5.4.3.1 Genetic diversity of ecological species

The continued dependence of natural trees and bushes as a source of fuel wood has similarly limited the genetic diversity of ecological species. Only 4% of the respondents indicated that they used renewable energy technologies every day, and a meager 34% use improved biomass stoves once a week. (*See table 13*, *Frequency of RET Use in Cooking*). The resultant ecological imbalance in the community is an important consequence and a contribution towards a spiral of increased poverty as poorer communities depend increasingly on traditional energy sources such as fuel wood for their subsistence. Biswas *et al.* (2001) suggests that appropriate technology elements of a solution need to address energy supply in the prevailing social and economic context in order to be effective.

5.4.3.2 Sustain biological productivity

The general consensus among respondents was that the improved biomass stoves had restricted implications on the natural system of the Rusitu Valley. The limited success of biomass stoves over traditional sources of energy, such as fuel wood, that meant that exploitation indigenous trees continues and the burden on the environment is set to increase given the increasing population. 76% of respondents indicated that despite the introduction of improved biomass stoves, they still use at least 41kg of fuel wood (*See table 10, Fuel wood Consumption*). Therefore, the contribution of improved biomass stoves in sustaining biological productivity in this regard is limited.

A possible explanation for this result is that the limitation of the usefulness of renewable energy technology hampered by the lack of practical applications that the average person can make use of. Somerville (2012) notes that in most cases, using renewable energy technologies requires one to engage in activities they would otherwise not do, which in this case involves the collection of wood chips from the timber mill. Somerville (2012) further adds that although a relative amount effort is necessary to obtain productive energy, what is crucial to note is that greater convenience in the use of renewable energy technologies would have an even larger impact on the utility of such technologies (Somerville, 2012).

For ready acceptance, renewable energy technologies should preferably complement energy sources or technologies currently used as necessities by the Rusitu Valley community. They must be simple but also relatively user friendly, that is, saving resources particularly environmental resources and providing the convenience of shorter time constraints in acquiring energy services. This suggests that if renewable energy technologies are to be held as appropriate technologies, these should not present any unintended side-effects and, in particular, social or environmental disruption [Schumacher (1975) in Biswas *et al.*, (2001)]. Therefore, the most important considerations in proposed renewable energies should note the technical feasibility, affordability, social acceptance and also whether they would be institutionally sustainable.

5.5 SUMMARY OF RENEWABLE ENERGY TECHNOLOGY CONTRIBUTION

The influence of renewable energy technologies towards the improvement of income levels is significant as it contributes towards the satisfaction of basic community needs such as healthcare and basic energy services for cooking and lighting. The increase of useful goods and services within Rusitu Valley through job creation was observed to have a much larger multiplier effects from the increased incomes and spending. Therefore, renewable energy technologies account for a greater intragenerational equity among different classes in the

Rusitu Valley community and as such greater potential for sustainability of the economic system.

The contribution of renewable technologies in Rusitu Valley towards an improvement of societal contribution is also noticeable through considerably less than income levels. Renewable energy technologies have contributed moderately towards the enhancement of participation among members of the Rusitu Valley community and even less towards social equity particularly with regard to women's status and social justice between different classes. There is therefore limited scope for procedural sustainability of the societal system through renewable energy technologies.

The contribution of renewable energy technologies towards a promotion of resource availability was generally restricted. Although significant interventions were introduced to sustain biological productivity and the genetic diversity of ecological species through improved biomass stoves, the degree to which such interventions had an impact was negligible mostly due to the inappropriate technology interventions leading to continued depletion of natural indigenous biodiversity and consequently negative implications on the promotion of intergenerational equity in the Rusitu Valley. Ultimately, the sustainability of the environmental system would be constrained due limited natural resources.

Overall, given the status of the economic, social and environmental systems, it can thus be concluded that the Rusitu Valley system is unsustainable. It has been established that renewable energy technologies have an intimate connection to sustainable development (*See Chapter 2*). Therefore, there is a need to address the internal and external constraints that limit the contribution of renewable energy technologies towards the viability of the different dimensions of sustainable development.

5.6 ENHANCING THE CONTRIBURTION OF RENEWABLE ENERGY TECHNOLOGIES TO SUSTAINABLE DEVELOPMENT

5.6.1 Mainstreaming Renewable Energy Technologies

5.6.1.1 Policy and Structural Gaps

The overall contribution of renewable energy resources to the Zimbabwean scenario has been constrained by a myriad of internal and external factors (MoEPD, 2007). However, the most significant is the lack of a policy framework that coordinates the various stakeholders in the energy industry and promotes renewable energy as well as the associated technologies at the national level. The Ministry of Energy and Power Development is responsible for the implementation of energy development policy. An interview with the Director of Policy and Planning in the ministry, Engineer Munyaradzi, revealed that in the absence of a guiding framework, there is limited synergy (in some cases, conflict) of approaches by various stakeholders towards the development of sustainable renewable energy in Zimbabwe. The MoEPD however indicated that the consultation process and drafting of a National Energy Policy had been completed and awaits Cabinet approval.

A further recommendation offered by Mrs Mutubuki-Makuyana, the Energy Projects Coordinator for Practical Action (Zimbabwe) was that the MoEPD should have energy officers at both provincial and district level that relay energy concerns and advise communities with regard to renewable energy. In Zimbabwe, most rural areas receive advice and services from extension officers, for example; the Ministry of Agriculture and Mechanisation are represented in every ward by Agricultural Extension officers (*Agritex* *officers*). Given the importance of energy particularly to low income communities, Ms Mutubuki-Makuyana suggested that a similar model of extension services for communities should be provided with regard to energy services. This would facilitate the dissemination of information about renewable energy technologies and facilitate the successful implementation of related programmes.

5.6.1.2 Renewable Energy Financing Mechanisms

The Zimbabwean economy has assumed a positive growth trajectory after a prolonged period of economic regression (AfBD, 2011). The consequences of such a downturn were that renewable energy promotion was side-lined in favour of economic revival strategies. Hence limited financial resources were channelled towards development of renewable energy technologies (Practical Action, 2007). Renewable energy is traditionally financed by government and the private sector, stimulated by bilateral and multilateral assistance (Saghir, 2007). However, if the contribution of renewable energy technologies is to be enhanced, this will require increased support from not only traditional sources but also substantial contributions from new financial backers, both domestic and international (Saghir, 2007). Models of financing renewable energy programmes often exclude the non-monetary cost and benefits of renewable energy in communities (Civicus, 2008). However, the valuation of such externalities broadens the overall effect and justification of renewable energy technologies. According to Civicus (2008) renewable energy technologies are already cost competitive compared conventional energy sources when the evaluation of environmental, health and social impacts of potential projects are included in their economic assessment.

5.6.2 Strengthening Institutions and Building Capacity

5.6.2.1 Institutions, Knowledge, Skills and Capacity Building

Renewable energy technologies have had greater impact in Rusitu through social institutions such as healthcare facilities. This highlights that the focus of renewable energy technologies, particularly in low income communities should be on supporting institutions rather than on individual renewable energy technologies (Van Alphena *et al.*, (2008). Further support should be in general education to raise public awareness about renewable energy and the environmental impacts of non-renewable energy sources, especially in developing countries. Capacity building is generally required to support the development of effective programs for raising public awareness, especially with the key stakeholders. Further, funding for research, development and demonstration in the form of grants and loans will aid in the dissemination of renewable technology that would considerably increase the uptake and possibility of successful renewable energy programme implementation.

5.7 CONCLUSION

This chapter used the systems theory to explore the interaction between sustainable development and renewable energy technologies and the nature of this interaction with regards to the different dimensions of sustainable community development. Indicators of sustainable community development in the Rusitu Valley were identified within the 3 pillar model as follows; income levels (economic/support system), societal contribution (social /human system) and resource availability (environmental/natural system). Corresponding measures/outputs of the system were assigned to each of the indicators and used to determine the contribution of renewable energy technology interventions towards each indicator. The analysis revealed that renewable energy technology interventions were biased towards the improvement of income levels and contributed less towards social and environmental components of sustainable community development. The Rusitu Valley system was therefore observed to be ultimately unsustainable due to the limitations on the contribution of renewable energy technologies. However, it was noted that the constraints on the sustainability of the Rusitu Valley also are imposed from external factors. Enhancing the contribution of renewable energy technologies therefore requires mainstreaming renewable energy technologies at the national level as well as strengthening local institutions and capacity.

6 CHAPTER 6: CONCLUSION

6.1 INTRODUCTION

This thesis has attempted to provide answers to the crucial question 'to what extent do renewable energy technologies contribute to sustainable community development?' (*See Chapter 1*, *Aims and Objectives*). The study sought to establish why the introduction of renewable energy technologies in low income communities appears not to be achieving their defined goals of improving the lives of people and their communities. What this study set out to investigate was informed by the observation that despite the introduction of renewable energy technologies in low income rural communities in developing countries, these communities are still not on the path towards sustainable development (*See Chapter 1*, *Problem Statement*). Using the Rusitu Valley as a case study, this study adopted a largely qualitative approach in determining the contribution of renewable energy technologies towards sustainable community development using the systems theory as an overall framework (*See Chapter 2*). Chapter 3 gave a detailed description of Manicaland province and the case study highlighting the factors justifying the selection of Rusitu Valley as a case study for this particular concern. Data collected from Rusitu Valley was presented in Chapter 4 and an analysis based on the framework adapted in Chapter 5. This chapter focuses on the preceding discussions highlighting the main themes of this thesis and attempts to bring these to a close by drawing conclusions on the subject matter.

6.2 RENEWABLE ENEGRY TECHNOLOGIES AS A RESPONSE TO SUSTAINABLE COMMUNITY DEVELOPMENT

Renewable energy technologies have gained prominence as a viable alternative to the conventional model of centralized generation and grid expansion. The major arguments in support of the proliferation of renewable energy technologies have been premised on the notion of sustainable development. Sustainable development, as opposed to the one dimensional concept of economic development, embraces not only economic aspirations but also social and environmental goals.

The Rusitu Valley provided an important basis for the determination of the extent to which renewable energy technologies contribute towards sustainable development in low income communities. A key finding from this case study was that renewable energy technology interventions yielded significantly towards the enhancement of economic dimensions at the expense of social and environmental dimensions of sustainable community development. This scenario thus provided greater opportunity for the promotion of intragenerational equity and less towards intergenerational equity which is one of the fundamental aspects of sustainable development. As such, the overall orientation towards sustainable development of the Rusitu Valley was limited due to social and environmental constraints imposed by a combination of both internal limitations of renewable technologies and external impediments particularly with regard to national policy and development planning.

However, this study has revealed that although the interrelation between sustainable development and renewable energy technologies is apparent, the effective contribution of renewable energy technologies towards such ends is still constrained. A review of empirical literature revealed that the current knowledge base is limited to very narrow interpretations from particular branches of research, whose scope does not comprehensively capture the complexity of sustainable development. Responding to the need for an effective, economically efficient, socially acceptable and environmentally feasible transformation towards greater reliance on renewable energy technologies as an alternative to grid electricity therefore demands a shrewd integration of discernments from social, natural and economic sciences in order to reflect the different dimensions of sustainable development.

What can be drawn from the overall discussion is essentially that renewable energy technologies are essential for sustainable development. More so, renewable energy that is reliable, efficient and effective is a prerequisite for sustainable community development particularly in low income communities However, raising renewable energy services to the level necessary for ensuring economic, social and environmental development is a challenge for most developing countries. Further, financial, technical and institutional barriers impede the effective contribution of renewable energy technologies towards sustainable community development. In order to meet this challenge and ensure sustainable community development, this demands that fundamental changes be made with regard to (among other factors) mainstreaming renewable energy technologies in the policy infrastructure, recognizing the need for "appropriate technologies, procedural and substantive approaches, and most importantly people's behaviour through developing institutional and local capacity building. A delicate balance of these factors is important in enhancing the contribution of renewable energy technologies towards the sustainability of social, economic and environmental systems that ultimately meet the end goal of sustainable community development.

6.3 LIMITATIONS OF THE STUDY

6.3.1 Scope of Case study

This study is restricted to the geographical confines of the case study, Rusitu valley area. As such, the observations of this analysis may also be limited to the areas with similar physiographic and demographic characteristics.

6.3.2 Types of Renewable Energy Technologies

The renewable energy technology interventions introduced in this particular case study are limited to the central solar charging station, improved biomass ovens and solar fruit driers. Although it may be argued that the aims of these interventions were not aimed at achieving sustainable development in its entirety but only components of such grand ambitions. However, this research is still relevant in providing a framework within which an accurate determination of each intervention can be reliably assessed.

6.3.3 Selection of Indicators

Finally, this study I identified 3 only indicators. Although I acknowledge that these may not be exhaustive, I however believe that these 3 indicators are the basic indicators of sustainable development, around which all other indicators are built.

6.3.4 Weighting of indicators

The weight assigned to each of the indicators was derived from measures/output of the sustainable system (sustainable development). The determination of these weights may be contested by those who advocate for internally generated meanings of sustainable development. However, an attempt was made to incorporate goals that were wide enough to encompass most communities' conception of sustainable development while at the same time not being too vague as to what these goals are.

6.4 AREAS FOR FUTURE RESEARCH

The results of this study point towards the limitations of the current approach towards sustainable community development through renewable energy technologies. Therefore, it is my opinion that there exists further opportunities for research into the development of relevant models of renewable energy technology interventions in low income countries and communities that promote greater economic, social and environmental dimensions leading to an orientation towards sustainable community development.

6.5 CONCLUSION

Renewable energy technologies and their utilization are intimately related to sustainable community development. However, in order for low income communities to attain sustainable development, much effort should be devoted to aligning renewable energy technologies towards meeting not only economic systems but also the environmental and social systems. This requires concerted effort on the part of stakeholders such as government, multilateral and non-governmental organisations and the communities themselves in realizing that renewable energy technologies are key to the upliftment of poorer communities and nations. Such realizations should however be based on the wider concerns on sustainable development and the implications of human activities on current and future generations.

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APPENDIX 1

List of Participants in In-depth Interviews

INFORMANT	ORGANISATION	POSITION
Eng. B. Munyaradzi	Ministry of Energy and Power Development	Director, Policy and Planning
Mr. P. Musungate	Ministry of Energy and Power Development	Deputy Director, Policy and Planning
Mr. F. Nyikayaramba	Rural Electrification Agency	Manager, Alternative Energy Technology
Mr. F. Maunganidze	Environmental Management Agency	Energy Officer
Mr. L. Sauramba	Ministry of Local Government and Urban Development	Local Government Officer
Dr. E. T. Kapuya	Scientific and Industrial Research and Development Centre	Acting Director, Energy Technology Institute
Mr. B. Zeyi	Scientific and Industrial Research and Development Centre	Energy Scientist
Ms. R. Mufukare	Southern Centre for Energy and Environment	Energy Scientist
Mrs. C. Mutubuki-Makuyana	Practical Action (Zimbabwe)	Energy Projects Coordinator
Mr. R. Mapfumo	Southern Centre for Energy and Environment	Energy Officer