The Potential Contribution of Non-Electrical Renewable Energy Technologies (RETs) to Poverty Reduction in East Africa

By
Stephen Karekezi
John Kimani
Ayago Wambille
Patrick Balla
Finias Magessa
Waeni Kithyoma
Xavier Ochieng

AFREPREN/FWD
P.O. Box 30979, 00100 GPO, Elgeyo Marakwet Close,
Nairobi, Kenya

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EXECUTIVE SUMMARY

High poverty levels especially in rural areas are a significant challenge that faces East Africa. Based on the national poverty threshold, the number of people living in poverty in Kenya is estimated to have risen from 11 million (48% of the population) in 1990 to 17 million (56% of the population) in 2001. Most poor households (87%) live in rural areas. Of these, subsistence farmers account for over 50% in Kenya. Efforts to reverse poverty trends have been inadequate, as poverty levels continue to rise. In Tanzania, surveys indicate that poverty is more prevalent in rural areas relative to urban areas. About 60% of rural population is poor compared to about 39% of the urban population (TaTEDO, 2004).

Despite the role of energy in poverty reduction being widely recognized, energy services for productive purposes in agricultural, small-scale agro-processing and small and medium enterprises (SME) are yet to be adequately addressed. The limited access that rural people have to adequate, affordable and convenient energy sources possibly ranks amongst the greatest impediments to their social and economic well being and development.

Rural electrification levels in both Kenya and Tanzania are woefully low. In cases where electricity is provided in rural areas, it is often unaffordable to the poor, who therefore cannot access it. With the bulk of the region's poor resident in dispersed rural settlements, conventional grid electrification is, in the near term, considered too costly. As a result, the use of modern and improved energy options is very limited in rural areas. Traditional biomass energy dominates major consumption sectors, namely, household, agriculture and small enterprises. This state of affairs significantly contributes to the poverty levels in rural areas of the region.

Renewable energy technologies (RETs) can play an important role in poverty reduction in rural areas in the region. This is especially true for RETs that operate on the basis of solar, thermal, mechanical and animate power, i.e. non-electrical RETs. These energy options are not only affordable to the poor, but can also play a major role in national development in terms of job creation and income generation, as well as providing environmentally sound energy services. A growing number of energy analysts perceive non-electrical renewable energy options as important for productive uses and poverty reduction.

This study seeks to assess the potential role of non-electrical renewable energy options on poverty reduction, by presenting case studies of water pumping and irrigation technologies. The study has five specific objectives:

- Review the current status of RETs in East Africa.
- Review the agricultural sector in rural areas and identify the current irrigation practices in Kenya and Tanzania.
- Assess the potential role of renewable powered mechanical water pumps for irrigation and their impact on poverty reduction.
- Highlight successful case studies for possible replication in the region.
- Identify factors necessary for the development and dissemination of renewable powered mechanical water pumps.
- Propose policy options and strategies of introducing them in ongoing and future policy dialogue processes.

In addressing these objectives, a broad review of RETs and the agricultural sector in Kenya and Tanzania was done. In addition, a review of non-electrical water pumping and irrigation technologies and their impact on poverty was also done. Organizations involved in research, design, manufacture and installation of pumping systems were visited for additional information on these technologies. The organizations visited also provided monitoring information on their activities and end users of the technologies. The study focussed on wind pumps, treadle pumps and ram pumps. Preliminary findings were subjected to a stakeholders' forum for review and deliberation. The stakeholder forum also identified the factors necessary for the development and dissemination of mechanical water pumps in East Africa. The main limitations of the study include lack of data in some circumstances, limited

time and not being able to visit and interview end-users of these technologies due to remoteness of their locations.

The findings of the study indicate that small-scale irrigation systems such as treadle pumps have continued to gain popularity and are making significant impacts on rural communities in Kenya. The pumps, costing between US$ 39-69, have ensured improved food security, diversification of crop production, income generation and creation of employment to end-users. Only 10% of the estimated market of 360,000 units has been reached and this is attributable to many factors such as rampant poverty; lack of information; capital; inadequate promotional strategies; limited research and adaptation of new pumps; lack of clear policies on irrigation; land tenure and inadequate quantity; and quality of water. However, there is an upward trend in the adoption of these pumps.

Wind pumps, on the other hand, are cost competitive where average speed is greater than 3m/s (e.g. over 50% of Kenya experiences such a wind regime) and can be more attractive than other options such as diesel and solar driven pumps. Wind pumps are in use to lift water for domestic uses, irrigation and livestock. The pumps can be used to meet water needs in rural areas of Kenya and Tanzania where more than half of the population has no access to safe water. Most wind pumps on the market are manufactured locally, with the bulk of the components sourced from local stores and workshops.

Ram pumps are a mature technology that has been widely disseminated in Tanzania. Most of the ram pumps reported in Tanzania were locally manufactured by a local company, Jandu Plumbers and have been in operation for more than 10 years hence can be said to be reliable. Ram pumps are mostly intended for domestic and livestock supplies in hilly and mountainous areas, requiring small flow rates delivered to high heads. However, although not originally designed for direct irrigation purposes, ram pumps are already used for this purpose, requiring significant investment in drive and delivery pipes to ensure the requisite high flow rates for irrigation purposes.

Other barriers hindering development and adoption of non-electrical RETs have been identified as: lack of ideal institutional coordination models since these technologies fall within a number of sectors (e.g. water, agriculture, etc) with no specific allocation of mandates and responsibilities. Furthermore, past project failures in water pumping and irrigation technologies pose one of the main challenges in the development and adoption of these technologies. Identifying and documenting reasons for the failure of these technologies will go a long way in overcoming the barriers to adoption in future.

Likewise, there are good case studies on the use of small scale mechanical water pumping and irrigation technologies that go unnoticed due to lack of awareness. Best practices exhibited by small informal artisans have not been documented for wider dissemination, a challenge that needs to be addressed. While lack finances inhibit development and adoption of technology, the study acknowledges that the few available financing mechanisms have not been fully utilised, since the institutions involved have not packaged their portfolios to accommodate the needs of small-scale farmers and acquisition of renewable energy systems.

The study also indicates that the role of informal technicians and artisans who have been innovative in the fabrication and maintenance of such technologies has not been recognised. Curricula development at universities and colleges has not addressed needs of personnel and artisans for such technologies at local levels.

The available data, case studies and analysis is not sufficient to make a conclusive assessment of the potential of the small-scale non-electrical RETs examined in this report, but preliminary findings indicate that the small-scale non-electrical RETs covered in this report have the technical potential for irrigation and water supply. Specifically, the technologies have the potential for enhancing food security through increased food production. In addition, they have the potential to meet other priority needs of the rural poor such as income and health.

Secondly, all the three selected technologies are fully locally manufactured and distributed and installed by the private sector indicating a high potential for local job generation. The technologies require limited owner/operator maintenance hence they are ideal for the rural poor as well as for operation in remote rural areas. Thirdly, available data indicates high cost of some of the technologies, notably, wind pumps and ram pumps. These are, therefore, unlikely to be affordable to individual poor farmers. However, these pumps could benefit the poor if installed through self-help groups organised specifically to pool the requisite capital.

Recognising the potential and devising mechanisms to address the above mentioned barriers would help rejuvenate these technologies to meet the needs of the poor in rural areas of Kenya and Tanzania. The study recommends the need for urgent creation of an enabling environment for the uptake of these small-scale technologies. Aggressive and targeted lobbying of policy makers, aimed at ensuring non-electrical renewables are given higher priority should be done in each of the countries. Another key recommendation is the establishment of a rural energy fund to finance the acquisition of non-electrical RETs. Such a fund will enable the poor to access these technologies, which can play an important role in improving their incomes and food security.

TABLE OF CONTENTS

LISTS OF TABLES

LIST OF FIGURES

LIST OF BOXES

LIST OF ACRONYMS AND ABBREVIATIONS

ADB	African Development Bank
AFREPREN/FWD	African Energy Policy Research Network
ApproTEC	Appropriate Technology for Enterprise Creation
ASALs	Arid and Semi arid Lands
BHEL	Bob Harries Engineering Limited
CAMARTEC	Centre for Agricultural Mechanization and Rural Technology
CITC	Christian Industrial Training Institute
CWD	Consultancy services in Wind energy for Developing countries
DFID	Department for International Development
FAO	Food and Agriculture Organization of the United Nations
GDG	Gatongoria Development Group
GDP	Gross Domestic Product
GEF	Global Environment Facility
GNESD	Global Network on Energy for Sustainable Development
GNI	Gross National Income
GOK	Government of Kenya
GTZ	German Technical Cooperation
Ha	Hectares
ICIPE	International Centre for Insect Physiology and Ecology
IDB	Irrigation and Drainage Branch
IEA	International Energy Agency
IPAR	Institute of Policy Analysis and Research
IPRTID	International Programme for Technology and Research in Irrigation Development
IRA	Institute of Resource Assessment
ITDG	Intermediate Technology Development Group
IWMI	International Water Management Institute
JICA	Japanese International Co-operation Agency
LVIA	Lay Volunteer for International Association
MDGs	Millennium Development Goals
MoE	Ministry of Energy
MoWD	Ministry of Water Development
NGO	Non Governmental Organization
NIB	National Irrigation Board
NIDP	National Irrigation Development Programme
PRSP	Poverty Reduction Strategy Paper
PV	Photovoltaic
R&D	Research and Development
RET	Renewable Energy Technology
SGP	Small Grant Programme
SME	Small and Medium Enterprises
TaTEDO	Tanzania Traditional Energy Development and Environment Organisation
TDTC	Technology Development and Transfer Centre
TDV	Tanzania Development Vision
TEMDO	Tanzania Engineering Machines and Development Organization
TIRDO	Tanzania Industries Research and Development Organization
TV	Television
UDSM	University of Dar es Salaam
ULI	Ujuzi Leo Industries
UNDP	United Nations Development Program
UNIDO	United Nations Industrial Development Organization
URT	United Republic of Tanzania
USA	United States of America
VAT	Value Added Tax

WEC	World Energy Council
WMS	Welfare Monitoring Survey
ZERO	Zimbabwe Environmental Research Organisation

LIST OF UNITS

%	percent
"	inches
ft	feet
GWh	Gigawatt hour
ha	hectare
hr	hour
kg	kilogrammes
kgoe	kilogrammes of oil equivalent
km	kilometres
km^2	square kilometres
Ksh	Kenya shilling
kW	kilowatt
kWh	kilowatt hour
kWp	kilowatt peak
l	litres
l/s	litres per second
m	metres
m/s	metres per second
m^3	cubic metres
min	minutes
mm	millimetres
MW	megawatt
TJ	tera joules
toe	tonnes of oil equivalent
TSh	Tanzania shilling
US$	United States dollar
W	watts
Wp	watts peak
yr	year

1.0 BACKGROUND OF THE STUDY

This study is part of a wider study of the RETs Working Group of the Global Network on Energy for Sustainable Development (GNESD). The key objective of the Working Group is to assess the potential of renewables in meeting the energy requirements of the poor. This study focuses on the East African countries of Kenya and Tanzania. Due to limited available time and resources, the study mainly focuses on the impact of non-electrical renewables on the rural agricultural sector[1] with special emphasis on selected non-electrical RETs for irrigation and to a limited extent rural water supply for residential/social/community purposes. The rationale for focussing on non-electrical renewables is elaborated in latter sections of this report.

This section provides an overview of East Africa by highlighting key poverty patterns as well as the status of the energy sector, RETs and agriculture in the region.

1.1 Poverty in East Africa

In both Kenya and Tanzania, the rural population represents nearly 70% of the total population (AFREPREN/FWD, 2004a). In both countries, the rural population is defined as those people living in the areas outside administrative boundaries of urban local authorities (i.e. county councils, municipalities and city councils).

Compared to its urban counterpart, the rural population is characterized by high poverty levels partly due to low and intermittent incomes mainly from agriculture. In Tanzania, surveys indicate that poverty is more prevalent in rural areas relative to urban areas in the country. About 60% of rural population is poor compared to about 39% of the urban population (TaTEDO, 2004).

In Kenya, virtually the entire (100%)[2] rural population falls under the US$ 2 per capita per day. In urban areas (using the US$ 2 figure) about 80% of the population is poor. When the US$ 1 measure is used, the proportion of the poor remains significantly high at 80% in rural areas (World Bank, 2003) compared to only 40% for urban areas. It is estimated that 87% of the poor households in Kenya live in rural areas, while subsistence farmers' account for over 50% of the total poor in Kenya (IPAR, 2002a; GOK, 2003).

In Kenya, efforts to reverse rural poverty trends have been inadequate, as poverty levels continue to rise. There is large regional variation in poverty levels, particularly so in the area of food poverty. For example, poverty levels have been decreasing in Central province, but increasing in Nyanza and Coast provinces (IPAR, 2002a; IPAR, 2002b; GOK, 2003). Some households, especially in the rural arid and semi-arid lands almost wholly depend on relief food.

The rural population is also faced with high mortality rates partly due to high levels of indoor air pollution, few and poorly equipped health facilities as well as inadequate access to sanitation and clean water. In addition, rural households have very low access to modern energy such as electricity and petroleum.

The majority of the rural poor depend on subsistence agriculture for provision of their food requirements, as well as generation of supplementary income (Blair Commission Report on Africa,

[1] The key rationale for focusing on the rural areas is that, in the absence of income-differentiated energy consumption data, the rural population serves as the proxy for the poor due to its relative lower economic status compared to its urban counterpart (see section 1.1).

[2] Stated as 100%, as the few individuals with incomes higher than US$ 2/day constitute a tiny total that adds up to a fraction of a decimal point (effectively, a rounding error).

2004)[3]. Research findings indicate that the bulk of income generating activities undertaken by the rural poor are agro-based (Karekezi and Kithyoma, 2002; Mapako and Mbewe (eds), 2004[4]). Agriculture is also a central source of food and livelihood for most rural families in East Africa. To a large extent, the state of the agricultural sector can often determine the survival of the rural poor.

1.2 Status of Energy in Rural Areas

As shown in the following table (Table 1), modern energy consumption in Kenya and Tanzania is very low. In the case of Kenya, it is less than 10% of that of South Africa while Tanzania's modern energy consumption is less than 2% of South Africa's consumption.

Table 1: Modern Energy Consumption per Capita (kgoe)

	1992	1993	1994	1995	1997	1998
South Africa	1,110.0	1,071.0	1,068.0	1,138.0	1,165.0	1,166.0
Kenya	88.4	86.7	88.9	88.8	86.5	84.0
Tanzania	24.0	22.0	21.0	21.0	20.0	20.0

Source: Karekezi et al (eds), 2002

Most low-income households that form majority of the rural population in East Africa have limited access to affordable and reliable modern energy services. Recent data indicates that the average level of modern energy services for rural households is far below desired levels (AFREPREN/FWD, 2004a). Consequently, rural households tend to use non-commercial forms of energy such as traditional biomass and to limited extent kerosene, which collectively account for about 90% of the energy supply of the vast majority of East African rural households.

The low levels of modern energy consumption in Kenya and Tanzania can partially be attributed to these countries being among the least electrified in sub-Saharan Africa (see table 2). Rural electrification levels in Kenya and Tanzania are about 0.8% and 1%, respectively. In cases where electricity is provided in rural areas, it is often unaffordable to the poor, who therefore cannot access it[5]. With the bulk of the region's poor resident in dispersed rural settlements, conventional grid electrification is, in the near term, considered too costly in East Africa, which has very low electrification levels. The cost of rural electrification is significantly higher in East Africa where in contrast to the village settlement patterns of West Africa and Central Africa, the majority of the rural population resides in dispersed homesteads.

[3] "A driver of poverty trends is agricultural performance, on which sub-Saharan Africa is heavily reliant. Over 70% of the people are involved in agriculture in some way and it represents half of exports and over one third of GNI. Most farmers are women. They produce most of the food consumed in sub-Saharan Africa and the income earned by them is more likely to be used productively, for children's food, clothing and education" (Blair Commission Report, 2004).

[4] Some of the rural income-generating activities that rely on agriculture include: beer brewing, fish smoking, baking, tobacco curing, dairy processing, grain milling, edible oil processing and honey processing (Karekezi and Kithyoma, 2002; Mapako and Mbewe(eds), 2004).

[5] Provision of electricity is largely confined to the privileged urban middle and upper income groups as well as the formal commercial and industrial sub-sector (Karekezi and Kimani, 2002; Clancy and Skutsch, 2003). The poor, however, do benefit in an indirect fashion through the use of institutional services such as dispensaries and schools that use electricity as well as through employment in rural commercial and industrial establishments that use electricity.

Table 2: Electrification Levels in Selected African Countries

Country	Rural electrification levels % (2001)
Mauritius	100.00
South Africa	50.00
Zimbabwe	19.00
Namibia	15.00
Botswana	8.00
Senegal	7.50
Cameroon	6.00
Swaziland	5.00
Eritrea	2.00
Zambia	2.00
Mali	1.00
Uganda	1.00
Tanzania	**1.00**
Kenya	**0.80**
Mozambique	0.70
Ethiopia	0.20
Malawi	0.05

Sources: AFREPREN/FWD, 2004a

Available estimates of energy consumption in the rural agricultural sector in East Africa indicate limited use of modern energy resources in the agricultural sector (FAO/ADB, 1996). Limited use of modern and improved energy services means that human labour continues to be an important source of power for agricultural activities in the continent. The continued low consumption of modern energy is a source of concern, given the importance of agriculture to food security and economic development in the region (Karekezi and Kithyoma, 2004).

Biomass consumption is still dominant in many small and micro rural enterprises, most of which are reliant on the agricultural sector. Examples of enterprises that largely rely on biomass include beer brewing, fish smoking, baking and tobacco curing. For example, tobacco curing uses 23% of total fuelwood consumption in Malawi (Kgathi and Mlotshwa, 1997), while beer brewing consumes 25% of total fuelwood annually in Zambia (ZERO, 1998). Most agro-based small and micro rural enterprises require thermal, motive and shaft power, which can be provided by non electrical options such as pico/micro hydro, wind pumps, treadle pumps, solar dryers and solar water heaters.

1.3 Status of Renewable Energy Technologies in East Africa

1.3.1 Biomass Energy

The rural energy sector in East Africa is dominated by traditional and inefficient biomass energy[6] in terms of both the supply and demand. In the two countries of focus of the study - Kenya and Tanzania - biomass accounts for 65% and 82%, respectively, of primary energy supply (see figure 1) and in 2001 accounted for up to 77.8% and 91.6%, respectively, of total energy consumption (AFREPREN/FWD, 2004a; Karekezi and Kithyoma, 2002; IEA, 2002).

In Tanzania, fuelwood and charcoal consumption for the households is by far the largest single demand on forests and woodlands. On the other hand, tobacco production, brick making, tea drying and fish smoking are the main biomass using agents. So far, biomass energy technology development is in its infancy and this includes briquetting, charcoal production, charcoal stoves, and biogas technology (Sheya et al, 2000).

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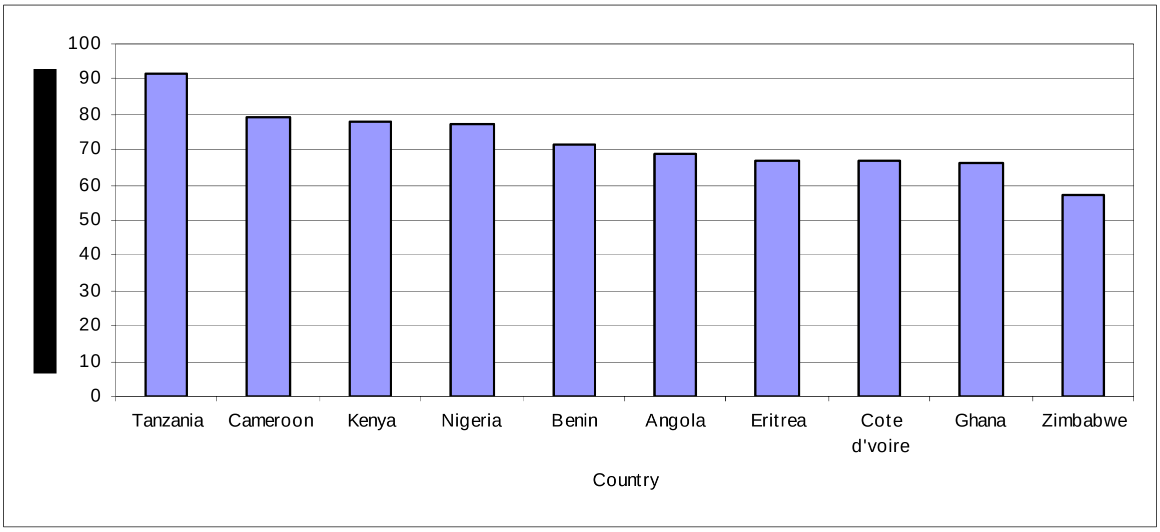
[6] The term 'biomass energy' refers to a wide range of natural organic fuels such as wood, charcoal, agricultural residues and animal waste.

Figure 1: **Biomass Energy as a Percentage of Total Energy Supply for Selected Sub-Saharan Africa Countries (2001)**



Source: AFREPREN/FWD, 2002; IEA, 2003

Kenya's biomass resource base is estimated by Ministry of Energy at a standing stock of 35 million cubic metres grown mainly on farms through agro-forestry, which currently produces 84% of the total consumption while gazetted forests and trust land provide 8% each. The current demand for woodfuel is estimated at 35 million metric tonnes relative to a sustainable supply of 15 million metric tonnes. This translates into a deficit of some 20 million tonnes.

Traditional biomass energy use has serious environmental drawbacks. Air pollution from unvented biofuel cooking stoves is a major contributor to respiratory illnesses in rural areas of East Africa where cooking is mainly done indoors (Ezzati and Kammen, 2002). In addition, heavy reliance on biomass, especially charcoal, can lead to land degradation. This is especially true around major urban centres like Dar-es-Salaam (Tanzania), and Nairobi (Kenya), where charcoal demand may have contributed to degradation of the surrounding woodlands and forests (Karekezi, 2002a; Kantai, 2002; Hibajane, et al, 1993; Hosier et al, 1993; Zheng, 2000).

In the last 20 years, substantial effort has been directed towards the modernization of small-scale biomass energy systems. Two of the most sustained efforts have been the development of an energy efficient charcoal kiln and an environmentally sound improved cookstoves for rural and urban households in sub-Saharan Africa. Both these initiatives have delivered significant benefits to both the urban and rural poor.

Modern biomass (in form of bagasse and wood waste) is used in the sugar and saw milling industries as fuel for cogeneration. The sugar industry in Kenya produces bagasse that can be used for co-generation. Between 1996 and year 2000, seven sugar companies produced and average of 1.6 million tonnes of bagasse annually. Out of this quantity, 56% was used in co-generation and the balance disposed. During the power crisis of 1999/2000, some 2 MW of surplus power were injected into the grid. The sugar factories have a combined potential of producing over 50 MW as excess supply from bagasse (Yuko, 2004).

The estimated co-generation potential in Tanzania is more than 315 GWh/per year. This is 10.5 % of the national electricity generation. The table below shows some details of the existing biomass fuelled power plants in Tanzania. The current energy generation potential from excess bagasse in sugar mills is about 99 GWh/year, which is 3.5% of the national electricity generation.

Table 3: Existing Biomass Fuelled Power Plants in Tanzania

Name of plant	Region	Power (MW)	Fuel
Kilombero Sugar Company K1	Morogoro	2 x 3 steam turbine	Bagasse
Kilombero Sugar Company K2	Morogoro	1.3+1.5 x 0.8 steam turbine	Bagasse
Mtibwa Sugar Estate	Morogoro	2.5 + 1.5 + 9.0 steam turbine	Bagasse
Tanganyika Planting Company	Kilimanjaro	2.5 + 3.0 steam turbine	Bagasse
Kagera Sugar Company	Kagera	2 x 2.5 steam turbine	Bagasse
Sao Hill Saw Mill	Iringa	1.025 steam turbine	Sawmill Waste
Tanganyika Wattle Company	Iringa	2.5 steam turbine	Wood Logs

Source: Gwang'ombe, 2004

Biogas technology is a viable supplementary source of rural energy for cooking and lighting. In Kenya, adoption of the technology peaked in mid-1980s, but the rate of further diffusion has been declining since. It is estimated that about 1,100 units have been installed, of which approximately 30% have fallen into disuse. The main problems are poor management, high initial capital cost, high maintenance cost, limited water supply and weak technical support. The major constraint against faster diffusion of biogas technology is the high up-front cost besides the lack of adequate public awareness.

1.3.2 Solar Energy

Kenya receives an estimated 4 to 6 kWh per square meter per day of solar isolation equivalent to about 300 million tonnes of oil equivalent (Toe) per day. This has not been effectively harnessed for commercial and domestic use. Applications of solar energy include solar thermal for heating and drying and solar PV for lighting, water pumping, refrigeration and telecommunications.

Solar PV is widely used for the provision of electricity in off-grid rural and urban areas. The Ministry of energy estimates indicates that up to 4 MW of PV power is currently installed in Kenya Solar PVs are also widely disseminated in the region with Kenya taking a significant lead in the number of PVs installations which are mainly used for household lighting and powering TV sets and radios. Solar home systems are popular among the educated and relatively well to do rural households and other consumers who are far from the grid. It is estimated that 200,000 PV solar home systems mostly rated between 10 – 20W_e installed at estimated cost of Ksh. 1,000/W_e are currently in use in Kenya. Over the last three years, the number of solar home systems installed has grown at an average of 20,000 units per annum. This growth is attributed to aggressive marketing by the private sector with limited support in form of low taxes on panels (MOE, 2004). The Ministry also estimates (2003 figures) that a total of 140,000 square metres of solar heat collectors for domestic water heating were in use, mostly installed in hotels, hospitals and institutions.

In Tanzania, there is little application of solar energy through solar heating, and solar photovoltaic. The estimated current installed PV capacity in Tanzania is to the tune of 550 kW_e with an annual growth rate of about 20% (Gwang'ombe, 2004).

PV technology has proven very successful in high-tech applications of communication. It is also an ideal alternative for powering vaccine refrigeration in rural remote clinics. Vaccines can dramatically improve the health of the rural poor and in this respect. PV can play a role in delivering benefits to Africa's rural poor. There is growing evidence that PV does not benefit the rural poor because of prohibitive cost and high import content. A number of African energy analysts believe that PV should be confined to the few niches where it has proven to be cost-competitive and not be perceived as an important option for meeting the modern energy needs of Africa's rural poor.

Solar thermal technologies that have been disseminated in east Africa include solar water heaters, solar cookers, solar stills and solar dryers. With increased efficiency and reduced cost of solar water heaters, small-scale solar water heaters now have a payback period of 3 - 5 years (Karekezi and Ranja, 1997). However, the diffusion of these systems has in recent years been slower than anticipated. The bulk of the solar water heaters in use in Kenya are owned by high-income households, institutions and large commercial establishments such as hotels and game lodges. The urban and rural poor have not enjoyed significant benefits from solar water heating technologies.

Solar pasteurisation is one of solar water heating technology that could yield major benefits to the poor. Exposure of water in a clear plastic bag to sunlight for a few hours can substantially reduce harmful micro-organisms. Slightly more sophisticated solar waters pasteurizers incorporating some form of distillation can provide potable water.

Although solar cookers have not proven particularly popular with end-users (because of several cultural and socio-economic barriers), the extensive work and field tests of solar cookers have provided valuable technological insights, field experience and dissemination that could be effectively deployed in the dissemination of low-cost solar pasteurisation technologies to the rural poor of Africa.

Extensive research has been carried out to develop reliable solar dryers. Research projects have developed suitable solar crop dryers in Ghana, Kenya, Mauritius, Nigeria, Uganda, Zambia and Zimbabwe among other countries (Karekezi and Ranja, 1997). Solar dryers for drying agricultural products such as grain, tea leaves and other crops, fish, and also timber (called solar kilns) are available. In general, research has shown that solar dryers perform well and produce better results than the traditional method of drying crops in the open sun (Wereko-Brobby and Breeze, 1986; Bassey and Schmidt, 1987; Karekezi and Ranja, 1997). Solar dryers can assist in reducing post-harvest losses because dried produce is less susceptible to natural deterioration and insect infestation (Garg, 1990). More work on the development of low-cost solar dryers could potentially deliver significant benefits to Africa's rural poor.

1.3.3 Wind Energy

Wind is a significant resource, but has hitherto remained largely unexploited in East Africa. It is largely used to pump water for irrigation and to meet domestic and livestock water needs and to some extent, power generation.

In Kenya, only 550 kW of wind power generation capacity is currently installed and less than 500 water pumps are in operation mainly in the arid and remote parts of the country. In Tanzania, about 129 windmills were installed by 1996 and 40% of them were out of order. A very limited number of attempts have been made to install wind turbines for electricity generation. The known wind turbine installations amount to a mere 8.5 kW_e. The existing installations have been privately imported

The constraints facing dissemination of wind energy technology in East Africa include: high capital costs, which make it less attractive relative to diesel fired alternatives, lack of appropriate credit schemes and financing mechanism, lack of awareness about the economic opportunities offered by the technology, inadequate wind regime data, limited after sales service and lack of systems standards and poorly designed or expensive prototypes (details have been covered in section five)

1.3.4 Small Scale Hydropower Energy Systems

There is a potential of more than 1,500 MW from isolated mini/micro hydro sites. Despite small-scale hydropower being a very promising energy technology for rural electrification, the numbers of schemes installed in Kenya are limited, with 28 MW installed capacity for Mini-hydro owned by the Kenya Electricity Generating Company, and less than 1 MW for schemes owned by community and private enterprises. Over 150 potential sites for hydropower development have been discovered, while others are yet to be discovered (Balla, 2003).

Tanzania's hydropower potential is estimated at 4,500 MW of which only around 563 MW is currently developed. It is estimated that 100 GWh/yr could be produced from micro/mini systems. Currently only around 32 GWh/yr is produced from these smaller systems, many of which are private schemes run by religious institutions.

Pico and micro hydropower systems are useful for providing motive and shaft power. Unlike other sources of energy, pico and micro hydropower systems have the great advantage of multiple uses: energy generation, irrigation and water supply. In addition, the technology is very reliable and has a solid track record. It is ideal for rural areas where grid connections do not reach, and has demonstrated important contributions to rural industrial growth in many countries (Karekezi and Ranja, 1997).

While this technology seems promising, the results of many of the initiatives in the region have been disappointing largely because of the unexpected complexity of developing, selecting and implementing these options (Karekezi and Ranja, 1997).

Tables 4 and 5 provide a summary of renewable energy potential as well as its current and future exploitation for Kenya and Tanzania.

Table 4: Energy Potential and Current Exploitation in Kenya

Renewable Energy	Potential	Current Exploitation (2002/03)
Biomass consumption (tonnes)	n.a	34,280,490
Cogeneration Installed Capacity (MW)	134*	36.5
Small Hydro (MW)	3,000	14
Solar PV Installations (units)	n.a	150,000
Solar Water Heaters Installations (units)	n.a	50,000
Geothermal Installed Capacity (MW)	2,000	121
Wind Turbines Installed Capacity (kW)	n.a	550

Note: n.a - Data not available; * - Estimated potential based on utilisation of boilers rated at 82 bars.
Source: Republic of Kenya, 2004; Karekezi and Kimani, 2002; Yuko, 2004; Mbuthi and Andambi, 2004

Table 5: Renewable Energy Potential and Current Exploitation in Tanzania

Renewable Energy	Potential	Current Exploitation (2001)
Biomass consumption (‘000 toe)		114,060 .0
Cogeneration Installed Capacity (MW)	77.2	35.8
Small Hydro (MW)	35*	4.0
Solar PV Installations (kWp)	n.a	300
Solar Water Heaters Installations (units)	n.a	100**
Geothermal Installed Capacity (MW)	> 100	0.0
Wind Pumps (units)	n.a	58.0

* Refers to data available as per 1990
** Refers to data available as per 1996
Sources: AFREPREN/FWD, 2004a; Mwihava, et al, 2004; Gwang’ombe, 2004; Kjellstrom et al, 1992.

From the data provided in Tables 4 and 5, it is clearly evident that only a small proportion of the potential of renewable energy in the two countries has been harnessed. The lack of penetration of modern energy in rural areas in East Africa provides opportunities for the dissemination of renewables. A number of initiatives to disseminate RETs in the region have been put in place over the years. For example, numerous improved stove programmes have been introduced in the region with positive results. Wind pumps for water pumping have been disseminated for areas with sufficient wind potential (3m/s), while pico and micro hydropower options have shown potential (Karekezi and Ranja, 1997; Fraenkel et al, 1993; Karekezi and Kithyoma, 2002). Table 6 presents the status of dissemination of selected renewables in Kenya and Tanzania. There is still significant work that remains to be done, especially in disseminating non-electrical RETs.

Table 6: Renewable Energy Technologies Dissemination in Kenya and Tanzania

	Tanzania	Kenya
Improved household Stoves	54,000	3,136,739
Biogas Units	1,000	1,100
Estimated PV units	n.a	200,000
Estimated PV installed capacity (kWp)	300	3,600
Wind pumps disseminated	58	360
Treadle Pumps disseminated	>200	36,000

n.a - data not available

Sources: AFREPREN/FWD, 2004a; Republic of Kenya, 2004; Balla, 2004; TaTEDO, 2004

1.4 Status of Agriculture in East Africa

In all sectors, industry, agriculture, transport, household and commercial, a lack of minimum energy inputs has lead to continued low productivity and impaired economic growth (FAO, 1995). It is also clear that in all sectors, energy is but one of the many important inputs for production, conversion, processing and commercialisation. However, and especially in the agricultural sector, increased yields and production due to energy and other inputs, can lead to important benefits such as improved incomes, new employment opportunities and agro-industrial growth, which will in themselves tend to increase energy requirements. In this context, energy can be viewed as a "motor" for development (FAO, 1995). The following table (table 7) compares sectoral energy consumption in Kenya and Tanzania.

Table 7: Sectoral Energy Consumption in Kenya and Tanzania

Sector	Kenya		Tanzania	
	(%)	(TJ)	(%)	(TJ)
Agriculture	22.60	28,494.53	18.30	27,969.72
Industry	32.90	41,480.98	53.65	81,998.66
Transport	35.10	44,254.78	8.80	13,449.92
Commercial & Others	9.40	11,851.71	19.25	29,421.70
Total	***100.00***	***126,082.00***	***100.00***	***152,840.00***

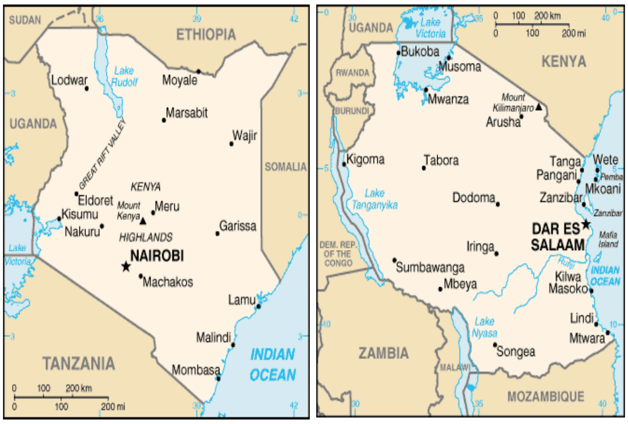
Source: FAO, undated

Agriculture is the dominant economic activity in rural areas and a significant income earner in Eastern Africa, and thus the focus on agriculture. In Kenya, for example, the sector contributes approximately 25% of the gross domestic product (GDP) and accounts for about 52% of exports. Agriculture also accounts for about 90% of rural incomes and provides about 62% of the employment (GOK, 2002; CBS, 2004; FAO, 2004). The agricultural sector also provides raw material to the manufacturing sector and thus has a large indirect impact on non-farm incomes and employment. According to Kenya's National Development Plan 2002 – 2008, growth in agriculture and improved rural incomes has a significant and direct impact on reducing overall poverty.

In Tanzania, agriculture currently contributes to nearly 50% of the GDP (Government Printer, 2002) and supports livelihoods of more than 80% of Tanzanians living in rural areas, and provides nearly all the food consumed in the country. As such, the sector is the largest contributor to the economy, the largest foreign exchange earner and also provides employment to about 80% of the population in rural areas (TaTEDO, 2004).

Table 8 compares selected Kenya and Tanzania socio-economic and agricultural indicators.

Table 8: **Performance Comparison of Kenya and Tanzania Agricultural Based Economies**



	Kenya	**Tanzania**
Population (million)	31.9 (2002)	36.8 (2002)
Total Land Area (km^2)	582,646	945,000
% of Land that is Arable	20	*
Access to Safe Water (% of population)	57 (2000)	68 (2000)
GDP (US$)	11.5 billion (2002)	9.4 billion (2002)
External Debt (US$)	5.6 billion (2002)	6.9 billion (2002)
GDP per Capita (US$)	361 (2002)	250 (2002)
Overall 12 Month Inflation (%)	16.0 (April 2005)	4.8 (March 2005)
Labour force employed in agriculture sector (%)	62 (2002)	80 (2002)
Labour force employed in industries and services (%)	38 (2002)	20 (2002)
Contribution to GDP (%)	25 (2002)	50 (2002)

* at the time of undertaking the research, the data on percentage of land that is arable for Tanzania was unavailable for the referred literature.

Source: Country Reports, 2002; GOK, 2002; Government Printer, 2002

Agriculture in these two countries relies heavily on rain-fed cultivation and this has, in times of drought, led to frequent crop failures and food shortages. In addition, the realization of the full potential of agriculture in rural areas of the two countries has been hampered by a number of factors, which include:

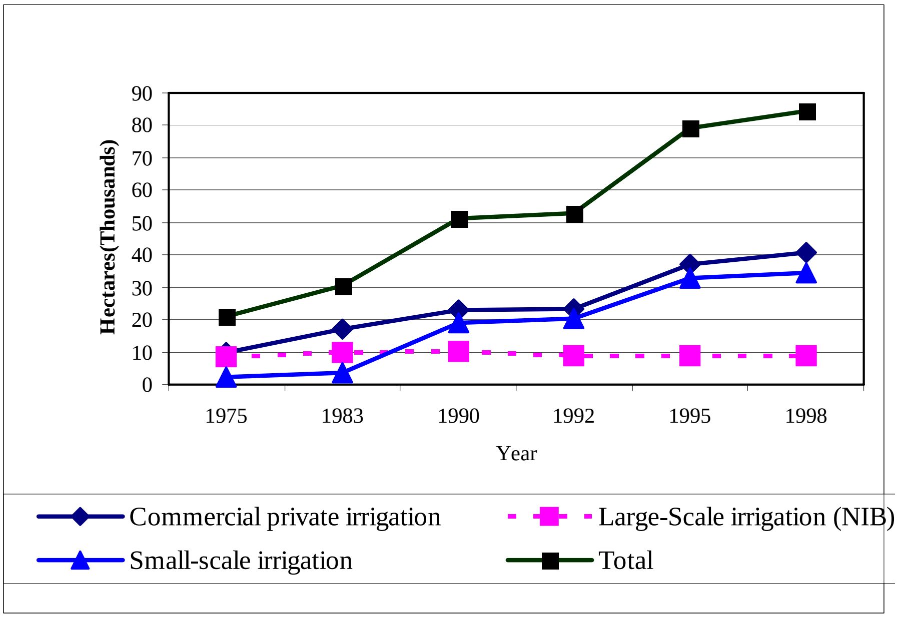
- Decreasing farm sizes;
- Inadequate use of appropriate technologies;
- Poor marketing infrastructure;
- Limited access to credit;
- High costs of farm inputs including agricultural machinery;
- Inadequate early warning systems; and,
- Lack of an appropriate land use policy.

The majority of the rural population practice mixed farming where they plant subsistence crops to feed their families and rear livestock to supplement food requirements and as a source of income. Typical farm sizes are about 2-3 acres in rural areas in the case of Kenya and 0.2 to 2.0 hectares in Tanzania. Productive land is becoming scarce and thus a more valuable resource due to rapid population growth (Balla, 2004; TaTEDO, 2004). Subsistence farming is increasingly no longer a viable means of livelihood, as a growing rural population needs to produce more food and generate more income from the shrinking landholding. This has led to a gradual shift in farming practices from rain-fed agriculture to the adoption of irrigation technologies that supply water throughout the year (Balla, 2004).

Kenya's Ministry of Water Development (MoWD) estimates the country's irrigation potential as 539,500 ha, while the Japan International Cooperation Agency estimates it at 471,860 ha. The country is unable to exploit its large irrigation potential mainly due to its inability to tap surface water. Only 5.4% of the potential (14 x 10^9 m^3/year) surface water resources is exploited (Blank et al, 2002). The ground water exploitation is also meagre and only 9.4% (57.2 x 10^6 m^3/year) of it is exploited.

The aforementioned inadequate exploitation of irrigation potential in Kenya is partly due to the limited tradition of irrigation. The few large-scale irrigation schemes in existence were developed by the Government between 1960 and 1980. Since then, the rate of Government supported large-scale irrigation development has stagnated. On the other hand, private individuals and NGO supported small-scale irrigation development activities have progressively increased (Balla, 2004). Figure 2 shows the trends in irrigation development in Kenya, with small-scale technologies recording the highest rate of growth.

Figure 2: Trends in Irrigation Development in Kenya



Source: Balla, 2004

The high growth rate of small-scale irrigation development is partially attributed to a number of promising small-scale irrigation technologies with high water use efficiency being promoted in the rural areas. These include, but not limited to, low head drip irrigation systems, treadle pumps, wind pumps and low head sprinklers. A number of these technologies are gaining attention and popularity. However, the increase in irrigated acreage resulting from these technologies appears not to be captured in the national statistics.

In Tanzania, the potential area for irrigation has been estimated at 850,000 ha. Modern, large-scale schemes occupy only 25,000 ha, and most of these are state-owned farms producing rice and sugar. In addition to the large state irrigation schemes, there are several smallholder irrigation schemes developed by the Government, and a few private farms in the northern part of the country, which produce flowers and vegetables for export (Maganga, 1998). Only about 150,000 hectares (or 4%) of cultivated area by smallholders is currently under irrigation.

2.0 RATIONALE AND MOTIVATION OF THE STUDY

As mentioned earlier, this study is part of a wider study of the RETs Working Group of the Global Network on Energy for Sustainable Development (GNESD). The key objective of the Working Group is to assess the potential of renewables in meeting the energy requirements of the poor. This study focuses on the East African countries of Kenya and Tanzania. Due to limited available time and resources, the study mainly focuses on agriculture in rural areas[7] with special emphasis on selected non-electrical[8] RETs for irrigation and to a limited extent rural water supply for residential/social/community purposes.

The rationale for the study's focus on agriculture is two fold. First, the agricultural sector is the backbone of the rural economy in East Africa. As mentioned earlier, majority of the poor rely on agriculture for provision of basic food requirements as well as income generation. The importance of the agricultural sector to the survival of the rural poor can, therefore, not be overemphasised. Secondly, agriculture is a major contributor to the Gross Domestic Product (GDP) of both Kenya and Tanzania, estimated at 25% and 50% respectively (Government Printer, 2002; GOK, 2002; CBS, 2004; FAO, 2004). The limited use of mechanised energy technologies in agriculture is an indication that the sector is not getting the required attention at policy level, despite its importance to the economy. The agricultural sector is, therefore, an ideal entry point for poverty reduction initiatives in the region.

Recent World Bank studies on incidence of drought indicate that, since 1991, both Kenya and Tanzania have been experiencing significant rainfall shortages in areas of high agricultural potential (see Table 9). In fact, for the last 7 consecutive years, both Kenya and Tanzania had rainfall shortage with the exception of 2001 when rainfall was adequate in Tanzania.

Table 9: Years of Significant Rain Shortages in Agriculturally Productive Areas

Country	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
Ethiopia	D	D		D			D		D	D	D	D	D
Kenya		D	D				D	D	D	D	D	D	D
Tanzania		D					D	D	D	D		D	D
Uganda							D		D	D	D	D	D
Rwanda					D	D		D	D	D			

D = Year in which there was a significant rain shortage in agriculturally productive areas
Source: World Bank, 2004

The prolonged rainfall shortage depicted above has eventually led to famine in Kenya and, at the time of drafting this report; the country is facing famine that has led to the starvation of an estimated 3 million people (approximately 10% of the entire population), the majority being the rural poor.

There is a growing consensus, regionally and internationally, on the important role that small-scale renewables can play in enhancing food security and poverty reduction in terms of job creation and income generation as well as providing environmentally sound energy services. For example, at the recently concluded international conference on Renewable Energies (Bonn, Germany June 1 - 4, 2004), the role of renewables in meeting the energy needs of the poor were emphasized. The following excerpt from the political statement of the conference underscores this:

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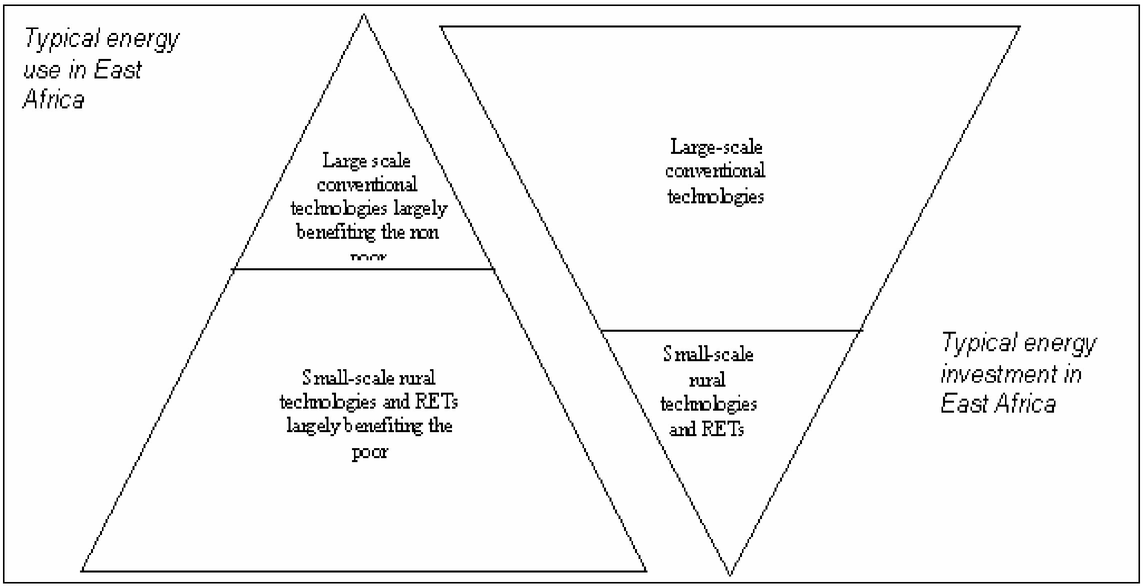
[7] The key rationale for focusing on the rural areas is that, in the absence of income-differentiated energy consumption data, the rural population serves as the proxy for the poor due to its relative lower economic status compared to its urban counterpart (see section 1.1).

[8] The study recognises the importance of electrical renewable energy technologies and the complementing role of the non-electrical RETs in poverty alleviation. However, non-electrical RETs form the focus of this paper.

"Ministers and Government Representatives from 154 countries gathered in Bonn, Germany, for the International Conference for Renewable Energies acknowledge that renewable energies combined with enhanced energy efficiency can significantly contribute to sustainable development, to providing access to energy, especially for the poor…"

It is also imperative to study small-scale RETs as energy investment patterns and energy use in the region indicate that large-scale conventional energy sector serves a smaller proportion of the population (primarily the non-poor), but receives the lion's share of energy investments in East African countries. Conversely, small-scale technologies such as non-electrical RETs that meet the energy needs of the majority of the population (mainly in rural areas) receive very little investment. The aforementioned energy investment and energy use patterns in the region are shown in figure 3. A number of analysts in the region argue that this pattern of investment needs to be reversed if the poor are to benefit from the region's investments in the energy sector.

Figure 3: Typical Energy Use Vs Energy Investment in Africa



Renewables and in particular small-scale non-electrical renewable energy technologies can also play a role in achieving the Millennium Development Goals (MDGs). Table 10 correlates the contribution of small-scale non-electrical renewables with the MDGs.

Table 10: Contribution of Small Scale Non-Renewable RETs to Achieving MDGs

	Millennium Development Goals (MDGs)				
Energy Technology	**Halve poverty**	**Reduce hunger**	**Ensure environmental sustainability**	**Increase gender equality and empowerment**	**Reduce child mortality**
Mechanical water pumping and irrigation technologies	√	√	√	√	√
Low cost efficient hand tools and animal drawn implements	√	√	√	√	√
Solar dryers	√	√	√	√	√
Improved biomass cookstoves	√	√	√	√	√
Pico and micro hydro	√		√	√	√
Solar water pasteurises			√	√	√

Another reason for undertaking the study on selected non-electrical RETs for water pumping and irrigation (wind, ram and treadle pumps), is that these technologies have a significant potential for enhancing food security among the poor. Of significance to this study is that these technologies are already serving the rural poor in parts of Kenya and Tanzania making it possible to undertake an assessment of their potential in poverty reduction.

Another justification for focusing on small-scale non-electrical RETs is that there is plenty of research work that has already been undertaken on other RETs and conventional rural energy investments such as rural electrification. The role of small and micro-scale non-electrical RETs in meeting the needs of the poor has not been extensively covered in existing literature (UNDP, 2004; World Bank, 2004; The Economist Newspaper Ltd., 2004). DFID has ongoing projects on non-electrical energy options. However, the coverage of the DFID projects is mainly in Asia and Latin America. Limited coverage has been given to non-electrical energy options for productive uses among the poor in East Africa (www.dfid.gov.uk). ITDG has also undertaken some research work on renewables, which mainly focuses on improved biofuel technologies and electrification of the poor. Limited studies have also been undertaken on non-electric uses of pico and micro hydro as the bulk of ITDG projects on pico and micro hydro are for electricity production (www.itdg.org). The limited attention given to the study of non-electrical energy options in rural areas is an important rationale for this study.

Lastly, although some of the technologies to be studied, such as treadle pumps, are simple technologies operated by animate (human) energy, end-user experience indicates that they have significant potential for transforming the living conditions of the rural poor. For example, the economic lifespan of treadle pumps is, on average, about 5 crop seasons (about 2 years). However, depending on the irrigated acreage, the type of crops cultivated and their market prices, during their economic lifespan, treadle pumps could generate sufficient income for poor farmers to enable them to procure more advanced pumps such as petrol pump sets or electrically-driven pumps which are not only more effective but also have the potential to generate higher levels of income for these farmers.

3.0 NEEDS ASSESSMENT AND ENERGY REQUIREMENTS FOR AGRICULTURE

3.1 Energy Requirements for Agriculture

The energy needs for agricultural production in rural areas range from intensive power use in transport, water lifting and pumping, land preparation, primary and seedbed cultivation, to weed control, planting, transplanting and harvesting. The total energy consumption for agriculture in Kenya and Tanzania is a very small proportion of the national energy consumption accounting for less than 1% and about 5%, respectively, (MoE, 2002; IEA, 2003) of the total energy consumption - an indication that animate energy (human) is the predominant form of energy input in agriculture but not accounted for in the national statistics.

Reliance on human power using mainly hand tools for cultivation has generally been the norm in both Kenya and Tanzania. There is limited use of semi-mechanised hand tools and animal drawn tools (Karekezi and Kithyoma, 2002). Human power, however, has limited output when compared to mechanised power sources. Humans are nevertheless flexible, skilled and can make sophisticated judgements and adjustments as they work. Table 11 estimates animate power requirements for various agricultural activities.

Table 11: Human Power Consumption of Various Farming Activities

Activity	Gross Power Needed (Watts)	Gross Power in kWh (Assume 7 hour Working Day)
Clearing bush and scrub	400-600	2.8-4.2
Felling trees	600	4.2
Hoeing	300-500	2.1-3.5
Ridging, deep digging	400-1000	2.8-7.0
Planting	200-300	1.4-2.1
Ploughing with animals	350-550	2.45-3.850

Average daily dietary energy supply for humans is equivalent to 2.55kWh.
Source: WEC/FAO, 1999; National Energy Foundation, 1995; 2004; Karekezi and Kithyoma, 2002

An important view to consider when estimating the amount of human energy available for agricultural activities in rural areas is the amount of calories contained in food intake. In many sub-Saharan African countries, daily per capita calorie supply is below 2,000 calories (2.32 kWh) as compared to the recommended daily average calorie intake of 2,200 calories (2.55 kWh) (National Energy Foundation, 1995). For rural inhabitants, the typical daily calorie intake is significantly less than 2,000 calories[9]. It would therefore appear that the daily per capita calorie intake in rural areas is insufficient for a full day's agricultural work (Table 11). If one factors in the debilitating impacts of frequent food shortages, famine, disease drought and floods, it is most likely that few rural inhabitants have access to an adequate calorie intake.

Many small-scale non-electrical renewables are ideal for meeting rural energy needs for agriculture (see table 12). Small-scale non-electrical RETs especially for irrigation offer more attractive opportunities for income generation and job creation for the majority of the rural population. The following table presents the applications of selected non-electrical renewables that have been disseminated in rural areas of Eastern Africa for agricultural production.

[9] The daily per capita calorie intake needs to be used with caution because it includes allocations for children, who may not be fully involved in agricultural activities, and is partly based on an average per capita calorie intake figure that includes urban and higher income groups.

Table 12: Small-Scale Non-electrical Renewables for Agriculture

Renewable Energy	Agricultural Process
Solar Drying	Crop drying, fish and meat drying, fruit drying
Solar water heaters	Dairy processing and heat energy for poultry
Wind pumps, Treadle pumps, and Ram pumps	Irrigation, Water lifting
Animal driven vehicles	Transport
Pico- and Micro-Hydro	Crop processing, irrigation
Biogas plants	Production of fertiliser
Bio-fuel cookstoves	Milk pasteurisation, heat energy for poultry, crop drying, crop processing

Source: AFREPREN/FWD, 1999; Karekezi and Kithyoma, 2002; Bhagavan and Karekezi (eds), 1992

3.2 Energy Requirements for Irrigation

As mentioned earlier, small scale non-electrical RETs for irrigation could have considerable impact in the region's agricultural sector and, therefore, the rural poor. For example, there has been a rapidly growing uptake among the rural and peri-urban poor of affordable and effective small-scale treadle pumps and to a lesser extent ram pumps. The potential for wider use of wind pumping is significant as the average wind speeds (about 3 m/s) in Kenya and Tanzania are sufficient for water pumping. This potential has not been fully exploited mainly due to the high initial cost of the pumps. Solar PV water pumping for irrigation has also been disseminated in the two countries. This technology has also not registered widespread success mainly due to the high cost of installation. The cost of solar PV water pumps is approximately average US$ 21/Wp (McNeil's, et al, 1992).

To assess the irrigation and water supply requirements for rural areas as well as the potential of the selected small-scale RETs to meet these requirements, the following series of tables were developed. Table 13 provides an assessment of rural requirements for irrigation and water supply while identifying matching renewable and non-renewable energy technologies.

Table 13: Energy Technologies and Requirements

Category	Requirements	Renewable Technologies	Compatibility with users	Competing non-renewable
Residential/ Social/Community Services	Portable water	- Wind pump - Ram pump	Very high	- Diesel/electric pumps - Portable petrol pumps
Productive (Agriculture)	- Crop irrigation - Watering livestock	- Wind pump - Ram pump - Treadle pump	Very high	

The following table (Table 14) assesses the energy requirements of the selected technologies and also highlights the potential impact of these technologies on the respective target groups.

Table 14: Energy Requirements

Category	Type of Requirements	Energy requirements	Target group	Impact	Priority
Residential/ Social/Community Services	Portable water	• Wind energy - 3 m/s (wind pump) • Hydropower (ram pump)	Rural households/communities	• Clean drinking water • Reduced water borne diseases • Improved health standards	Very High
Productive (Agriculture)	• Crop irrigation • Watering livestock	• Wind energy - 3 m/s (wind pump) • Hydropower (ram pump) • Animate power (treadle pump)	Rural peasant farmers Rural cattle ranches	• Increased food production • Increased income • Improved livestock health	Very High

Table 14 shows that the selected small-scale non-electrical RETs have significant impact on the poor, notably on food security and other key priorities such as health and income.

The following table (Table 15) identifies potential case studies where the subject renewable energy technologies have been used for rural water supply and irrigation. More in-depth analysis of these case studies has been provided in section 5 of this report.

Table 15: RETs Selection Matrix

Category	Requirement	Energy req.	Technology	% covered with RETs	Target group	Case study context
Residential/ Social/Community Services	Portable water	Wind energy (3 m/s)	Wind pump	100%	Rural households/ communities	• Gatongora Development Group (Kenya) • Mwiyoyo Community Water Project (Kenya) • Maji Moto Community Water Project (Kenya) • Kisigisa Village Community Water Project (Tanzania)
		Hydropower	Ram pump	100%		• Boimanda Hydram Scheme (Tanzania) • Ikhoho Hydram Scheme (Tanzania)
Productive (Agriculture)	- Crop irrigation - Watering livestock	Wind energy (3 m/s)	Wind pump	100%	Rural cattle ranches	• Mugie Cattle Ranch (Kenya)
		Hydropower	Ram pump	100%	Rural peasant farmers	• Coffee farmer, Arusha (Tanzania)
		Animate power	Treadle pump	100%*	Rural peasant farmers	• ApproTEC treadle pump (Kenya)

* It is important to note that the performance of the pump highly depends on animate power (human), which largely relies on the calorific intake of the operator.

Existing motorized pumping and irrigation technologies are not the best options for rural areas and poor urban since they are expensive (costing between Ksh. 25,000 –30,000), and the costs are above an average disposable income of most farmers. The cost of servicing and maintaining motorized pumps is way above the affordability of majority of farmers in both rural and urban areas. Fuel and storage costs range between Ksh. 30, 000 –40,000 annually and have a large irrigating capacity (at least 5 acres). This makes it uneconomical to small farms for average Kenyans (ApproTEC annual report 2001-2002). To address these problems, the right technologies need to be identified and adapted to suit small-scale farmers. These technologies need to be appropriate, simple and made from local materials and skills, affordable and have the potential to earn high returns on the investment.

The following section analyses key features, characteristics, costs and potential of wind, treadle and hydraulic ram pumps in water supply for small-scale irrigation and its role in poverty alleviation amongst poor farmers, citing case studies from in Kenya and Tanzania.

4.0 KEY FEATURES, CHARACTERISTICS, COSTS AND POTENTIAL OF SELECTED NON-ELECTRICAL RETS FOR IRRIGATION AND WATER SUPPLY

This section highlights the key features of selected non-electrical RETs as well as assessing their costs and potential for irrigation and water supply. The technologies to be assessed include wind pumps, treadle pumps and ram pumps. As explained earlier, the selection of these 3 technologies was largely driven by the availability of required data and case study information as well as the limited resources available to the research team

4.1 Wind Pumping Technology

4.1.1 Key Features and Characteristics of wind pumps

The basic components of the wind pump include the rotor, the tail, tower, pump rods, the transmission, the rising main, the pump and borehole as source of water (Fraenkel, 1993). Most wind pumps are connected to a tank for water storage. Figure 4 shows a wind pump installation in Kenya.

Figure 4: A Wind Pump for Water Supply in Lokiriama, Turkana, Kenya

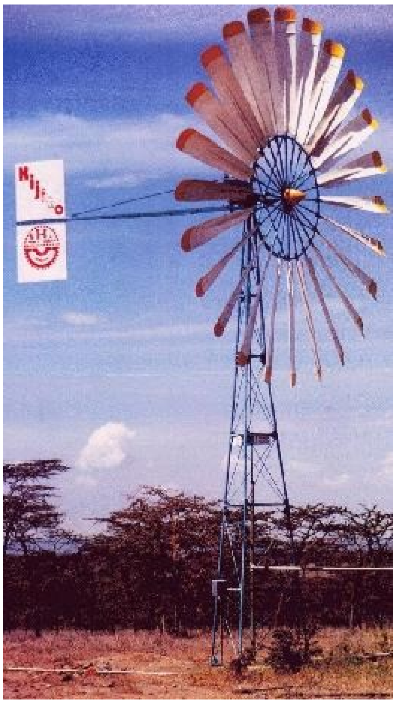
Photo by Patrick Balla

A borehole is by far the most common water source from which the pump will draw water. A classical multi-blade farm wind pump has a piston pump pumping to an elevated storage tank. There are many other configurations possible, depending on the nature of water source and demand. These machines have a rotor diameter of between 2.5 and 8 meters but seldom exceed 4 or 5 metres (Balla, 2004).

The power is transmitted from the rotor to the pump rods via a gearing system or via direct drive mechanism. The movements of pump rods cause the pump to lift water to the tank. Water can then be fed into the distribution network from the tank. The function of the tail vane is to keep the rotor oriented into wind. Most wind pumps have a tail vane that is designed for automatic furling (turning of the machine out of the wind) at high speed to prevent damage (ITDG, 2004).

The most commonly used wind pumps in East Africa region are of the Kijito type (see figure 5), manufactured by Bob Harries Engineering Ltd (BHEL) in Thika and come in a range 8 – 26 feet of rotor diameters. More recently, BHEL has been involved in the development of a range of small wind pumps called Kijito 2000 series. The concept behind these designs is to provide much simpler and lower cost designs that would be suitable for small holder farmers, with water sources of about 20m below ground and who need a limited amount of water for livestock and domestic needs. This series of wind pumps come with a rotor of either 6 or 8 ft diameter (Harries, 2002).

Figure 5: Kijito Windpump



Source: Gasch and Twele, 2002

Other pumps employed in East Africa include the Pwani pumps installed along the coastal part of Kenya, the classical multi-bladed wind pumps such as Southern Cross, Dempster, Climax and Comet etc in Tanzania (TaTEDO, 2004).

4.1.2 Water Pumping and Irrigation Potential of Wind Pumps

The amount of water discharged (or pumped) depends on the head and wind pump rotor size, assuming uniform wind speeds. At wind speeds of 2-5m/s, a pump of 12ft rotor will yield approximately 10 – 59 m^3 of water, a 16ft rotor will yield 21 –150 m^3, 20ft (39-227 m^3), 24ft (61-354 $m^{3)}$, and a 26ft (70–407 m^3) from a head of 10m (Balla, 2004). However, the amount of water discharged reduces as the head increases. At higher heads, wind pumps with rotor sizes of 20ft and above pump a relatively small amount of water but it would be sufficient to serve a small community or an institution but may not be enough for large-scale irrigation.

Table 16 presents a more detailed wind pump performance. These figures assume a matched cylinder, sufficient water in the source being pumped and no significant wind barriers within 100m. The table assumes a medium wind regime with 4-5 m/s average wind speed (Data from BHEL).

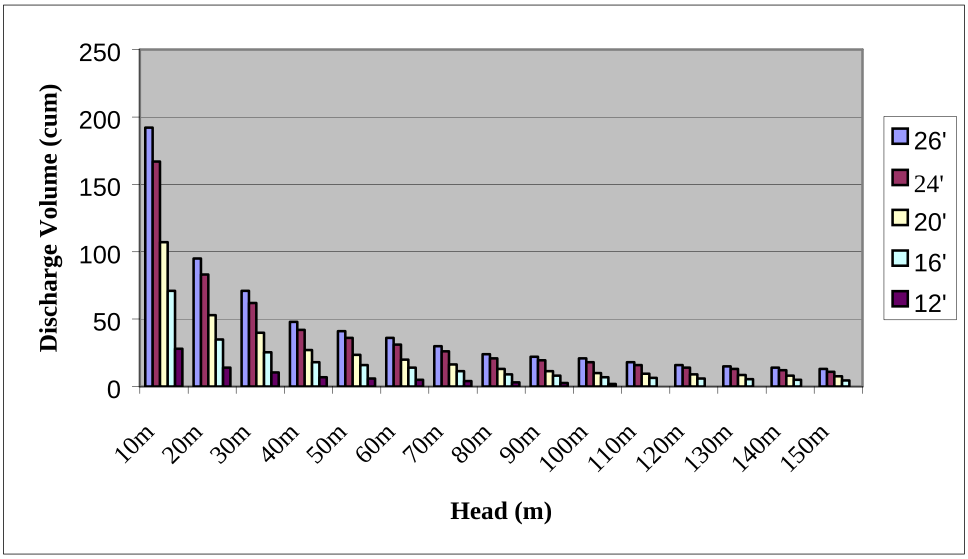
Table 16: Water Discharge Potential of Various Wind Pumps (m^3)

MODEL	12ft (3.7m)			16ft (4.9m)			20ft (6.1m)			24ft (7.4m)			26ft (7.9m)		
Wind (m/s)	Light 2-3	med 3-4	strong 4-5	Light 2-3	med 3-4	strong 4-5	Light 2-3	med 3-4	strong 4-5	Light 2-3	med 3-4	strong 4-5	Light 2-3	med 3-4	strong 4-5
Head (m) 10	10	28	59	21	71	150	39	107	227	61	167	354	70	192	407
20	5	14	29	10	35	75	19	53	113	30	83	177	35	95	204
40		7	15	5	18	37	10	27	57	15	42	89	17	48	102
60		5	11	4	14	28	7	20	43	11	31	66	13	36	76
80		3	7	3	9	19	5	13	28	8	21	44	9	24	51
100		2	6		7	16	4	10	24	7	18	36	8	21	41
120			5		6	12	3	9	19	5	14	29	6	16	33
150			4		4	9		7	14	4	10	22	5	13	28

Source: Adopted from BHEL, 2004a

The following figure (Figure 6) shows the wide divergence in the amount of water pumped at different heads and also how much more water is pumped with different wind pump rotor diameters.

Figure 6: Wind Pump Water Discharges at Various Heads



Source: Adapted form BHEL, 2004a

The successful exploitation of wind energy is highly site-specific and largely depends on the wind resources of the area being exploited. Electricity generation from wind energy requires a wind speed of > 5m/s. For wind pumps, lower wind speeds can be sufficient. However, most wind pumps will not start below a wind speed of 3m/s and will furl at about 12-15m/s (Karekezi and Ranja 1997). In Kenya, average wind speeds of 3m/s are experienced in over 50% of area (Fraenkel et al, 1993). In Tanzania, the wind regimes in some parts of the country exceed 3m/s and have shallow water tables. Feasibility studies are needed to ascertain appropriate sites and hence make use of the abundant resource available in the country for the well being of the community. However in areas with average wind speeds less than 3m/s and/or with a deep water table, irrigation by wind power is not practical. Some available average wind data indicates the following wind speeds in Tanzania as shown in table 17.

Table 17: Wind Speed in Tanzania Regions

Region	Estimated Wind Speeds (m/s)	Region	Estimated Wind Speeds (m/s)
Dodoma	4.8	Pwani	3.2
Mtwara	4.7	Kigoma	3.1
Mwanza	4.1	Zanzibar	3.1
Tabora	3.8	Dar es salaam/ Mara	3.0
Ruvuma	3.6	Lindi	2.6
Tanga	3.6	Kagera	2.2
Mbeya	3.5	Iringa	1.8
Arusha	3.2	Kilimanjaro	1.8
Pemba	3.2	Morogoro	0.9

4.1.3 Cost of Wind Pumps

The cost of wind pumps in Kenya and Tanzania varies from approximately US$ 3,000[2] to US$ 19,000 depending on the size of pump purchased. The estimated costs are exclusive of transportation fee, water storage, installation fee and maintenance costs. With average per capita incomes of about US$ 300, the costs of purchasing wind pumps are considered too high for majority of Kenyans (56%) and Tanzanians (50%) who live below poverty line and earn less than a dollar a day. As a result, the majority of the pumps are bought and installed as projects by donors, churches and institutions. . Table 18 presents the cost of the wind pumps and accessories based on the Kijito model from BHEL in Thika (2004 figures) marketed in Kenya.

Table 18: Cost of Kijito Wind Pumps

	Cost of Kijito Wind Pumps (Ksh.)					
	2008 Kijito	**12ft**	**16ft**	**20ft**	**24ft**	**26ft**
Machine price (Inclusive of tower)	144, 885	386,950	481,440	671,765	725,550	765,680
10 ft tower extension	0	34,750	34750	48,195	48,195	48,195
Shallow well adapter	0	16,475	16,475	18,165	18,165	18,165
Shallow well crossbeam	19,270	24,065	24,065	27,440	27,440	27,440
Stuffing box	12,410	24,075	24,075	24,075	24,075	24,075
2" pipefitting	11,220	23,830	23,830	23,830	23,830	23,830
2 $^{3}/_{4}$ deep well cylinder	0	82,640	82,640	82,640	82,640	82,640
3 $^{3}/_{4}$" deep well cylinder	0	0	122,480	122,480	122,480	122,480
2$^{1}/_{2}$" shallow well cylinder	44,750	0	0	0	0	0
8" shallow well cylinder	0	0	0	0	142,345	142,345
6" shallow well cylinder	0	0	0	131,650	131,650	131,650
3$^{3}/_{4}$" shallow well cylinder	0	0	69,780	69,780	69,780	69,780
Total (Ksh.)	**232,535**	**592,785**	**879,535**	**1,120,020**	**1,418,150**	**1,456,280**
Total (US$)	**2,981**	**7,600**	**11,276**	**15,641**	**18,156**	**18,670**
Other costs						
Pump rods (per foot)	240	355	355	355	355	355
Transport (per km)	55	82	82	82	82	82
Installation cost per day (3 man installation team)	10,610	10,610	10, 610	10,610	10,610	10,610

NB:

- Transport and pipes fittings for deep well and shallow well cylinders are inclusive of 16% VAT.
- Exchange rate for dollar is Ksh. 78 (2004).
- The same pricing structure for wind pumps in Kenya has been adopted in Tanzania. Exchange rate for a dollar in Tanzanian shillings is TSh. 1,050

Source: Modified from BHEL, 2004b

2 Price of pump rods exclusive

4.2 Treadle Pumps Technology

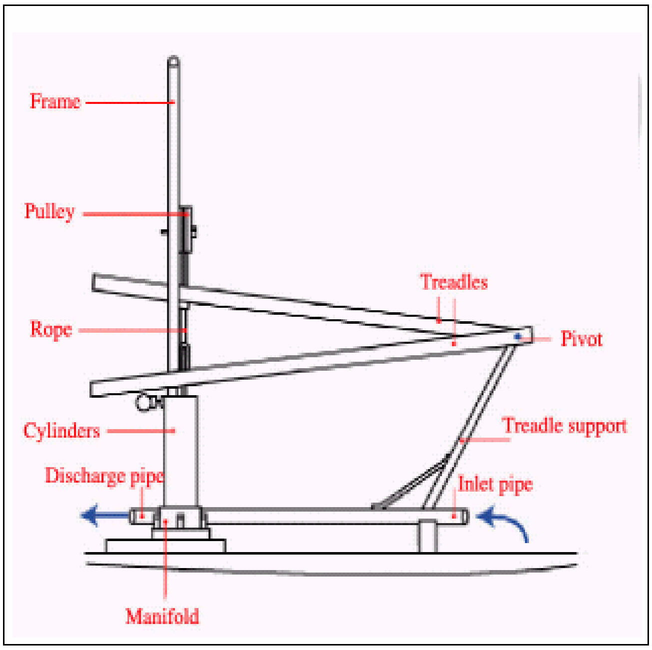
4.2.1 Key Features and Characteristics of Treadle Pumps

A treadle pump comprises of a cylinder fitted with a piston and some means of pushing the piston up and down. A pipe connects the pump to the water source and at the end of this pipe is a non-return valve that allows water to enter the pipe and stops it from flowing back to the source.

The piston and cylinder must have a close fit so that when the piston is raised, it creates a vacuum in the cylinder and water is sucked into the pump. When the piston is pushed down, the water is pushed through a small valve in the piston to fill up the space above it. When the piston is raised again, it lifts this water until it pours out over the rim of the cylinder and into the irrigation channel or tank. At the same time, more water is drawn into the space below the piston. The downward stroke of the piston once again pushes water through the small valve into the space above the piston and the process is repeated over.

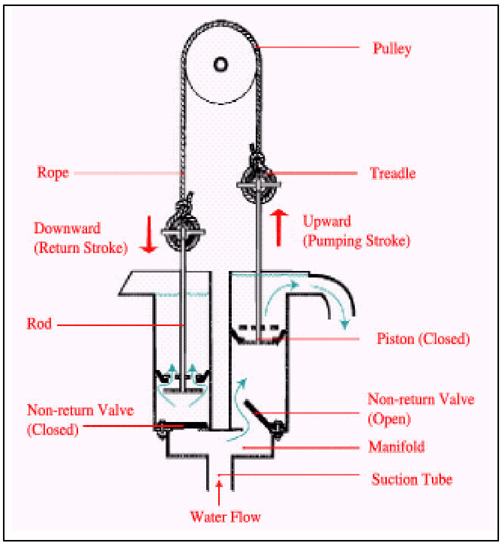
Figures 7 and 8 adopted from FAO (2000) show the basic components and operating principles of the treadle pump.

Figure 7: Basic Components of a Treadle Pump



Source: Adopted from FAO, 2000

Figure 8: Basic Operating Principles of Treadle Pumps



Source: Adopted from FAO, 2000

This is a very simple principle that has been used for centuries for lifting water from streams and wells. However, the amount of water that can be lifted this way is usually small. This is because the pumps that use this concept are normally hand operated.

This concept has skilfully been adapted for use in irrigation, where much larger volumes of water are needed. The most important innovation has been to change the driving force from arms and hands to feet and legs. The most powerful muscles are the legs and back muscles while arm muscles are relatively weak (Fraenkel, 1995).

Two cylinders are used instead of one. They are positioned side by side and a chain or rope, which passes over a pulley or a rocker bar, connects the two pistons so that when one piston is being pushed down, the other is coming up. Each piston is connected to a treadle. The operator stands on the treadle and presses them up and down in a rhythmic motion; just the same way you cycle a bicycle. This rhythmic method of driving the pump has gained wide acceptance among poor farmers and seems to be preferable to any mechanism that requires only one foot or arms and hands. (Balla, 2004)

Two pumps have been developed from this concept. The first was the suction pump to lift water from a shallow well and discharge it over a spout into a canal for gravity irrigation. This was developed in Bangladesh where farmers needed to lift large quantities of water through shallow lifts of 1-2 metres (Balla, 2004). The second development was the pressure pump. This works on exactly the same principles as the suction pump but the delivery end was modified so that water could be fed into a pipe under pressure for sprinklers or horse pipes. The pressure pumps are used when water sources are deep (more than 4 metres) and there is need to deliver water under pressure to sprinklers, drippers or to a head tank. This requirement may also be the result of irrigating undulating or steeply slopping land.

Both suction and pressure pumps are available in Kenya and many modifications have been made to them to suit local operating conditions. The development of the Kenya treadle pump has largely followed the design of the Bangladesh pump, with modifications to suit Kenyan conditions. This is essentially a suction pump, redesigned so that it can also be used as a pressure pump.

There are two types of treadle pumps and that are available in East Africa region:

- ApproTEC treadle pumps (figure 9 and 10)
- Swiss concrete treadle pumps (figure 11)

- **Figure 9: Super MoneyMaker Treadle Pump**

Source: IGAD, 2004

- **Figure 10: MoneyMaker Treadle Pump**

Source: IGAD, 2004

Figure 11: Swiss Concrete Pedal Pump

Source: Zumenstein and Kohler, 2000

Table 19 compares the key features and characteristics of the ApproTEC treadle pumps and the Swiss Concrete pedal pump.

Table 19: Specification of Treadle Pumps in Kenya

Pump Characteristics	ApproTEC		Swiss Concrete
	MoneyMaker	Super MoneyMaker	
Date introduced in Kenya	1996	1998	1998
Pump body	Metal	Metal	Concrete
Cylinder	Metal	Metal	Plastic
Piston	Metal, Rubber	Metal, Rubber	Metal, rubber
Other components	Metal, Rubber	Metal, Rubber	Metal, rubber
Method of joining components	Welding	Welding	Bolts, nuts and screws
Stroke length (mm)	108	72.8	-
Piston diameter (mm)	121	121	-
Weight (kg)	15	20	50
Cost (Ksh)	4,227	5,500	4,000
Cost (US$)	53	69	50

- indicates that data is not available

Source: Vijali and Okumu in Blank et al, 2002; FAO/IPRTID, 2000; ApproTEC, 2001; WTWA, 2001

4.2.2 Irrigation Potential of Treadle Pumps

The ability of treadle pumps to supply water for irrigation depends on a number of factors, such as the technical capacity of the pump, sources of water (wells or streams) and the motive power (in this case human energy). The general potential for treadle pumps in Kenya has been estimated by ApproTEC to be over 360,000 units, which represents farms near streams and water points that can be technically and economically irrigated.

The technical potential for irrigation of the two types of treadle pumps is illustrated in the following table (Table 20). From the table, it is apparent that ApproTEC's "Super MoneyMaker" treadle pump has the highest irrigation potential of 2.4 acres/day compared to 2.0 acres/day for the MoneyMaker and 1.1 acres/day for the Swiss Concrete pump. However, unlike wind pumps, treadle pumps appear to have a limited suction head of up to 7 meters. More specific use to demonstrate capabilities of these pumps has been explored under section 5 of this report.

Table 20: Irrigation Potential of Treadle Pumps in Kenya

Pump Potential	ApproTEC		Swiss Concrete
	MoneyMaker	Super MoneyMaker	
Maximum suction depth (m)	6	6	7
Maximum delivery head (m)	6.5	14	-
Maximum Discharge (l/min)*	100	90	100
Maximum Irrigation potential (acres/day)	2.0	2.4	1.1

- Indicates data not available

* Depend on water level and manual pressure applied

Source: Vijali and Okumu in Blank et al, 2002; FAO/IPRTID, 2000; ApproTEC, 2001; WTWA, 2001

4.3 Hydraulic Ram pumps

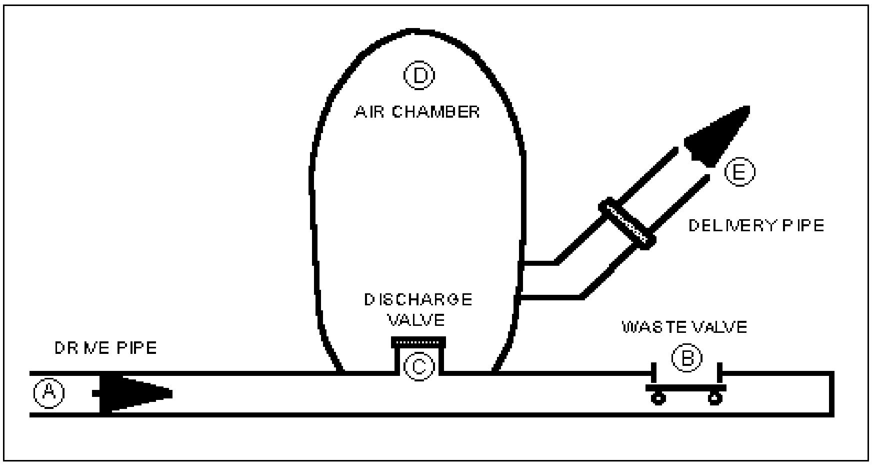
4.3.1 Key Features and Characteristics

Ram pumps (also referred to as hydraulic ram or hydram) are water-pumping devices that are powered by falling water. The pump works by using the energy of a large amount of water dropping a small height to lift a small amount of water to a much greater height. In this way, water from a spring or stream in a valley can be pumped to a village or irrigation scheme on the hillside. Wherever a fall of water can be obtained, the ram pump can be used as comparatively cheap, simple and reliable means of raising water to considerable heights (Jeffery et al 1992)

The ram pump was developed by the Montgolfier Brothers in 1796 and was extensively used in Europe and the USA in the first quarter of this century. The pump requires no external power source apart from the force exerted by water and runs automatically for 24 hours a day with minimum maintenance. The pump utilizes the pressure surge (water hammering effect) which develops when a moving water mass meets an obstruction, to produce power for water lift.

A ram pump consists of a drive pipe, which leads from the water source to the ram body. The ram body incorporates three valves: the impulse valve, which is equipped with a return spring; an air feeder valve; and, a delivery valve. As shown in Figure 12, water flows through the drive pipe to let water into the ram body; increased pressure on the underside of the impulse valve overcomes the return spring pushing it upwards thereby creating pressure on the delivery valve, which opens the delivery valve allowing water into the air chamber. Water through the delivery valve compress the air inside the air chamber at the same time discharging water through the delivery pipe. As momentum of water in the ram decreases, delivery valve drops down closing the opening and the water rebounds. This creates a sudden drop of pressure in the ram body allowing air to enter it through air feeder valve causing impulse valve to drop down and open quickly and the cycle continues. Adjusting the spring regulates the frequency at which the cycle is repeated. Once the spring is adjusted the ram pump needs no attention, provided water flow is continuous and no foreign materials get into the pump to block the valves.

Figure 12: Main Component of a Ram Pump



Ram pump sizes are rated by the supply and delivery pipe diameters, generally measured in inches (Table 21).

Table 21: Range of Drive Pipe Length for Various Pipe Diameters

Drive Pipe Size (mm)	Length (meters)	
	Minimum	Maximum
13	2.0	13.0
20	3.0	20.0
25	4.0	25.0
30	4.5	30.0
40	6.0	40.0
50	7.5	50.0
80	12.0	80.0
100	15.0	100.0

Source; TaTEDO, 2004

Ram pumps can only be used in situations where falling water is available, which restricts them to use in three main applications, namely:

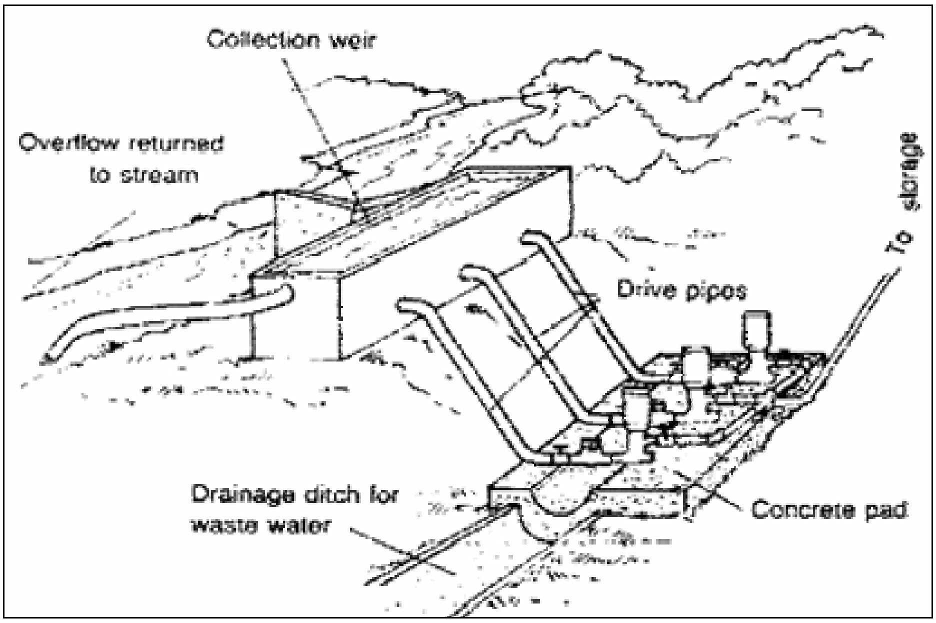
- Lifting drinking water from springs in valleys to settlements on higher ground.
- Pumping drinking water from clean streams that have a significant slope.
- Lifting irrigation water from streams or raised irrigation channels.

Ram pumps are mostly intended for domestic and livestock supplies in hilly and mountainous areas requiring small flow rates delivered to high heads. Ram pumps are less used for overhead irrigation purposes since it requires high flow rates that will entail the use of larger sizes of ram pumps with 4 to 6 inch drive pipes, which in turn imply high costs. However, they are suitable for drip irrigation.

The performance of ram pumps drops with decreasing ratio between driving and delivery head. Normally performance is about 60% with a ratio of 1:3 and about 20% with a ratio of 1:20. (TaTEDO, 2004)

The expensive traditional ram pumps, in small numbers, are still available in Europe and USA and can last up to 50 years. However, lighter designs, fabricated using a welded steel sheets construction are widely produced in Japan and other South East Asia, including Taiwan and Thailand. Jandu Plumbers of Arusha in Tanzania also produce them in the Arusha region. Lighter designs are cheaper when compared to the European design, but are only likely to last a decade or so (TaTEDO, 2004). Figure 13 shows an installation of multiple ram pumps.

Figure 13: Typical Installation of Multiple Rams with Common Delivery Pipe



4.3.2 Costs of Ram Pumps

One of the greatest benefits of ram pumps is that they have low running costs. There is no input of expensive petroleum fuels or electricity making the system very inexpensive to operate (Jeffery et al, 1992). The purchase cost of a pump, however, is usually only a fraction of the capital cost of a system: drive and delivery pipe work are usually the most expensive parts. The cost of typical commercial ram pumps ranges from US$ 2,500 for 2-inch drive-pipe size up to US$ 8,500 for 4 or 6-inch sizes[10]. The prices from Jandu Plumbers in Tanzania range from Tsh 703,000 (US$ 670) to Tsh 2,070,000 (US$ 1,971) for Jandu's Single Ram Pump and from Tsh. 1,207,800 (US$ 1,150) to Tsh. 6,900,000 (US$ 6,571) for Jandu's Twin Ram Pumps.

[10] Intermediate Technology Publications 1992 "Energy options"

4.3.3 Water Pumping and Irrigation potential

Currently, no data has been provided on the general potential for utilisation of hydraulic ram pumps though there is evidence of use. However, experience from Tanzania indicates that hydraulic rams pumps are durable and reliable for domestic water application and even for irrigation, if proper procedures are considered and observed. The experience in Arusha where the hydro ram of 6 inches size is employed, gives enough flow rate for the intended irrigation of the coffee farm, livestock, domestic needs and supply water to some other villagers supports the argument.

Field visits to Arusha, Tanzania revealed that while the small size (2 inches) are capable of pumping water between 5,000 – 6,000 litres per day, a big hydram (6 inches) with 3 multiple ram pumps is capable of pumping up to 6,000 litres per minute and used for irrigating a coffee farm, and providing water for domestic purposes. The multiple ram pumps were installed in 1979, an indication of the technology's reliability and durability of the technology. More that 70% of the visited sites with the technologies under consideration had been into existence more that 10 years ago. Examples have been provided for the other two communities hydro rams in Njombe district (Boimanda village) with 17 water supply points and in Mbeya rural district (Ikhoho village) with 12 water supply points, demonstrating the ability of hydraulic rams to supply water for rural use (see following section).

5.0 COUNTRY CASE STUDIES ASSESSMENT OF POTENTIAL ROLE OF WATER PUMPING AND IRRIGATION TECHNOLOGIES ON POVERTY REDUCTION

This section explores case studies of successful exploitation of water pumping technologies in Kenya and Tanzania. Specific examples have been provided for wind pumps in Kenya and Tanzania, treadle pumps use in Kenya and the use of hydraulic ram pumps in Tanzania

5.1 Assessment of Wind Pumping Technology in Kenya and Tanzania

5.1.1 Wind Pumps in Kenya

In Kenya, wind pumps have registered notable success and currently, over 360 wind pumps in total (inclusive of Kijito) have been installed in the country through the initiatives of donors, churches and individual communities and have indicated success in the provision of water for domestic and irrigation in beneficiary communities.

The manufacturing of wind pumps is now a well-established industry. Most wind pumps on the Kenyan market are manufactured locally, with the bulk of the components sourced from local stores and workshops. Some water pump accessories such as ball bearings are imported. However, this sector is well developed in Kenya as opposed to Tanzania. The local wind pump design is based on a criterion that reduces manufacturing cost, and facilitates domestic production and distribution. It is estimated that approximately 50 wind pumps are manufactured annually in Kenya for both local and export market.

Wind pump manufacturers acknowledge that the availability of adequately trained technicians is insufficient. While the experienced technicians existed in the past i.e. before 1950s, this is no longer the case. Manufacturers have to train the users on the basics of wind pumps and maintenance during the installation process. For example BHEL encourages its clients to undergo a 2 week maintenance course provided free of charge. Staff development has taken place over time and has been involved in pump designing, fabrication and installation in the field. However, available capacity may not match the potential needs for repairs and maintenance in case of major breakdown.

Wind pumps are too costly for the majority of poor rural Kenyans based on the prices quoted in table 18. The major markets for wind pumps, especially those of Kijito series have been projects and NGOs accounting for on average 77% and 23%, of the market respectively. Users of pumps include schools and hospitals (26%), livestock farms (26%), farming and irrigation (23%), community water supply (13%) and game reserves, refugee camps etc (12%). As can be seen from figures, a large portion of the Kijito wind pump sales has been to donor funded projects and institutions. Low sales to private end users and communities is attributed to prevailing high levels of poverty, lack of understanding of the benefits of wind technology and the poor image wind pumps have due to some experimental designs that failed in the past[1].

In areas where they have been installed and in use, wind powered water pumps have led to increased agricultural activity and improved water supply for remote rural populations. In addition, wind pumps have contributed to industrial development by giving rise to a new manufacturing industry as exemplified by the two companies that are actively involved in wind pump manufacture and assembly. Table 22 shows the potential of wind pumps in poverty reduction.

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[1] http://igadrhep.energyprojects.net/Links/Profiles/WindPumps/KijitoCS.htm Assessed on 24th June 2004.

Table 22: Poverty Reduction Potential of Wind Pumps

Poverty Reduction Potential of Wind Pumps	
Potential population to benefit	• About 60% of Kenyan Households in rural areas who have no access to safe water for drinking • 56% of Kenyans who live below poverty line. It can increase their income by providing irrigation services • Water supply to institutions, schools, hospitals, churches, refugee camps that serve the rural poor • Pastoralists, small and large scale farmers
Ability to satisfy as many needs as possible	• Provision of safe drinking water • Elimination of enteric and water borne diseases • Supply of water for irrigation in rural areas (which can in turn improve food security and nutritional status of households, as well as generate extra income) • Save time and money in searching for water • Reduce distances to water sources
Installed capacity	• Over 360 wind pumps have been installed and are in use in Kenya
Cost of wind pumps	• Wind pumps cost approximately between US$ 3,000 and US$ 19,000 • The cost excludes expenditure on pump rods, installation fee, operation and maintenance • Separate expenditure on drilling boreholes, installation of water tanks and distribution systems
Affordability	• The poor who constitute 56% of population cannot buy windpumps but can purchase services from existing wind pumps e.g. water • Large-scale farmers, institutions, and community self help groups can afford if appropriate financing mechanism are devised
Potential for income generation	• Income through selling water lifted and supplied • Income from selling crops (tree seedlings, vegetables, etc) as a result of irrigation • Improved yields of livestock products (milk, meat etc) which can be marketed • Source of employment for installers, pump manufacturers, distributors • Business opportunity for stockists of spare parts, and suppliers, individuals offering project development services, retailers of raw materials for wind pumps • Export market to the neighbouring countries who do not have capacities to manufacture the pumps locally
Replicability	• Wind pumps are highly replicable and can be developed in a module way • On average, wind speeds in Kenya are around 3m/s sufficient for water pumping • Available wind pump designs have been adapted to local conditions • Pumps are now manufactured locally • UNDP GEF Small grant programme is supporting wind pump initiatives and replication of successful case studies • Water pump uses have been replicated in neighbouring countries where they are exported

Source: World Bank, 2004; AFREPREN/FWD, 2004; BHEL, 2004a

Box 1: Case Study: Use of Wind Pumps in Kenya

One of the most successful self-help groups in the utilization of wind pumps has been Gatongora Development Group (GDG) located in Ruiru Kenya with a total of 40 members. The group recognized the high cost of electricity driven water pumps and opted for wind pump that was installed in 1999. The group members solicited for funds through a loan from a micro- financing institution. Once the project was completed, a committee was appointed by members of the community to oversee the project. Water is sold to the community with proceeds being used to repay the loan.

Other recent examples of use of wind pumps are the initiatives supported by UNDP GEF Small Grants Programme[3] to supply communities with water for irrigation and domestic use. One of the projects is in Mwiyoyo sub-location of Kieni west division in Nyeri District. Through a grant of US$ 38,000 to augment

[3] www.ke.undp.org/GEF-SGP/ for projects on maji moto and mwiyoyo. Assessed 20th June 2004

community contributions of US$10,000, a wind pump was installed to draw water from Labura dam and serve 200 homes. The water is mainly used for domestic purposes and watering livestock. Each household pays a monthly fee of Ksh.50 (US$ 0.6) for pump maintenance.

Several livelihood benefits have been noted since inception of the project. Farmers have started kitchen gardens to enhance food security. A total of 200 women save an average of 2 hours per day previously used in the collection of water. The beneficiaries have also developed a tree nursery of 30,000 seedlings ready for sale. Through another grant of US$ 20,000, GEF has supported Community Water for Poverty reduction (COWAPA) to revive a windmill near Maasai Girls School in Narok District. A wind mill was installed in the early 1990s at the spring and a pipeline laid for two kilometres to Maji Moto town and had been neglected due to lack of maintenance. The windmill was expected to provide water for the Maasai community living near the spring that is the community's major source of water.

Mugie Ranch located in the remote dry areas North of Rumuruti exhibits another successful example of application of wind pumping technology in hybrid with diesel pumps. The ranch rears more than 15,000 heads of sheep and using diesel pumps alone would be an expensive option to supply livestock water needs. BHEL installed the first wind pump on the site more than 15 years ago. Currently three more wind pumps are employed on the site installed in year 2000 to supply livestock water needs (Table 23).

Source: Adopted from BHEL, 2004a, b

Table 23: Summary of Specifications of Water Schemes at Mugie Ranch, Kenya

Site	Kifuruti	LionHill	Mutumayu	Kitenya
Customer	Mugie Ranch	Mugie Ranch	Mugie Ranch	Mugie Ranch
Kijito Size	20ft / 30ft	26ft / 40ft	26ft / 40ft	24ft /40ft
Inst Date	Dec 1987	March 2000	March 2000	March 2000
Water Source	Borehole	Borehole	Borehole	Borehole
Pump Depth	61m	73m	146.34m	91.46m
Cylinder	3¾”	3¾”	3¾”	3¾”
Water Rest Level	15.2m	37.8m	134.75m	91.46m
Use	Livestock	Livestock	Livestock	Livestock

Source: Modified from BHEL 2004a, b

5.1.2 Wind Pumps in Tanzania

Wind pumping is a mature technology and has extensively been employed in Tanzania for water pumping. The use of wind pumps in Tanzania is reported as early as 1950, where systems were produced and installed in Singida, Arusha, Dodoma, Mara and Kilimanjaro regions for community and livestock use. Some systems funded by UNDP/SGP are reported installed in Mara Rural, Tarime, Bunda, Magu and Ukerewe districts in the lake zone for irrigation purposes. In Mwanza and Mara regions, about five Kijito wind pumps funded through UNDP/SGP have been installed to pump water for irrigation, livestock and community domestic uses. By 1996, more than 140 units had been installed in the above regions from 120 in 1994. This figure is considered by the Ministry of Energy and Minerals to have risen to approximately 200 in the year 2004.

Already installed and working wind pumps in Dodoma and Singida regions are reported to have contributed in the increase of livestock number, availability of clean water for domestic purposes and hence healthier and more productive rural communities. The distance covered by women and children to fetch water has also been reduced from an average of 3-8km to less than a kilometre in Dodoma (Magessa, 2004)

As far as research and development and production of wind pumps is concerned, data from Tanzania indicate that there once existed local capacity in Arusha by the Arusha Appropriate Technology Programme in collaboration with Ujuzi Leo Industries, and successful reports of installations and operation of such pumps in the field in the 1970s, indicates that a sustainable local industry can produce the technology in Tanzania. This will not only provide employment opportunities to engineers and technicians, but also to installers and casual labour in the factories and sites for installation of wind pumps. Employment and enterprises could also be established for maintenance of such systems.

Availability of research institutions, production centres and a higher learning institution for related technologies and for production of machine tools and equipment for agricultural purposes is an added advantage for any decision to revamp the once promising industry. This will facilitate the provision of clean safe water in rural areas of Tanzania where access to fossil fuels and electricity for pumping is very low. Local organizations like CAMARTEC, TDTC, TIRDO, TEMDO, and Kilimanjaro Tools, to mention a few have the capability to make the technology locally.

The low capacity of local manufacturing for wind pumps implies limited availability of technical personnel for installation and maintenance services. As a result, expatriates and or volunteers install most of the imported wind pumps. For example, in Kongwa district villages, a Lay Volunteer of International Association based in the district headquarters does the maintenance of the wind pumps. In another case, maintenance of some of the Manyoni districts wind pumps in Singida region relies on a maintenance team from another region, Dodoma. As such, development of relevant local technical capacity, which is currently not in place, but is vital to project viability, creates a need for educational institutions and vocational centres to train students in such technologies.

The reported durability of wind pumps of most types, i.e. the first generation and second generation, adds value to reliability of the technology. While the Southern Cross wind pump type have been operated in some villages of Singida and Dodoma for more than more than 20 years with minimum maintenance, and the second generation i.e. Kijito type in the same regions and others of Tanzania for more than 10 years, suggests significant saving from both free fuel and minimum spare parts cost, and hence economic gain to beneficiaries (a wind pump in Manyoni district (Ngurwangombe/ Chang'ombe village is reported installed in 1950). As an example, maintenance cost of the wind pump in Kisigisa village of Kongwa district ranges between Tsh. 20,000 – 40,000 or twofold, which is reasonable per year for a community

Successful modification of the old massive and expensive design of the water pumps to modern light weight and other low cost wind pumps that can be manufactured in developing countries like the Kijito in Kenya and the Thai Bamboo-mat in Thailand provides flexibility and reduced production costs through utilization of local raw materials. This leads to less foreign imports of raw materials, which retains foreign currencies for other productive technologies and activities.

Box 2: Case Study: Kisigisa Village Community Water Project, Tanzania

In Tanzania, one case study of wind pumps in Kisigisa Village Community Water Project, Dodoma has been given. The Water Aid installed wind pump in Kisigisa Village, Kongwa district, in Dodoma more than 10 years ago with financial support from Lay Volunteer International Association (LVIA) at an estimated cost of Tsh. 7million. The scheme pumps an average of 4,000 litres per day, mainly for domestic, institutional and livestock use. Before installation, women and children walked for more than 15km to the nearest water supply in Msagara village. Though the water scheme is managed by Village Water Committee, who collects tariffs of between Tsh. 20 –30 per 20 litres for domestic and livestock respectively, the LVIA/Water Aid is still responsible for maintenance whenever the breakdown of the scheme occurs at an average cost of cost between Tsh. 20,000 – 40,000. One of the major problems exhibited by the scheme is the intermittent wind regime that affects water supply. This is evidenced by the study visits conducted in some parts of Dodoma and Singida regions, where low wind speeds and borehole/well water delivery is not adequate for village domestic requirements. Furthermore, the cost of 20 litres of water at Tsh 20 was considered already too high for people in the area to use the water for irrigation.

5.2 Assessment of Treadle Pumps in Kenya

Small-scale irrigation systems such as human powered pedal pumps emerged in Kenya in the early 1990s and have continued to gain popularity, making significant impacts on poor rural communities. The potential to use treadle pumps in Kenya is estimated at over 360,000 units, which represents farms near streams and water points that can be technically and economically irrigated.

One of the pre-requisite for successful uptake of pumps is to have it manufactured locally. It eliminates the need to import pumps and could lead to lower costs. The design and manufacturing infrastructure has been developed in Kenya, with ApproTEC developing designs, production tooling system (assembly jigs and fixtures and gauges), and then providing local private manufacturers with designs and material lists for mass production. Manufacturers are usually medium to large-scale engineering and fabrication companies with trained workforces and reasonably well-equipped machine shops. Manufacturers are further trained on mass production of pumps. ApproTEC checks and controls quality standards as pumps are being manufactured. ApproTEC has commissioned 5 companies, mostly located in Nairobi to manufacture the pumps.

The pumps are largely made from hot-rolled mild steel plates and sections. The steel is available locally. The piston cups, valve disks and leak valves used in the design are press-moulded or extruded from locally available natural and nitrite rubber. Extruded HDPE (high density polyethylene) pipe is used for three bushes in pressure pump. Thus, the local manufacturing capacity in Kenya is able to meet demand and the requirements of producing good quality treadle pumps.

Depending on the intensity of use, the “MoneyMaker” brand of pumps can last for 3-4 years. However, ApproTEC uses a conservative figure of 5 crop cycles, (approximately 2 years) for calculating the cost-benefit ratio. In areas of high salinity, this life expectancy can be reduced because of the impact of rust on metallic components of the pump. ApproTEC gives to the farmers, a one-year guarantee (free replacement and repair) against any manufacturing defects.

The ApproTEC treadle pumps are sold through dealerships. There are currently 150 dealer outlets in Kenya, over 76 in Tanzania and 4 in Uganda. Most of the dealers are agricultural and veterinary products stores, which are known and easily accessible to farmers. ApproTEC acts as a link between manufacturers and dealers since many dealers do not have the capital or the access to credit to work directly with manufacturers. ApproTEC also takes the responsibility for ordering and buying pumps from manufacturers and for sale and delivery to retailers or dealers. Dealers must purchase a minimum of 10 pumps but ApproTEC allows the first 10 pumps to be sold on consignment. This arrangement is common for new products in Kenya and came about from unwillingness of many dealers to take the financial risk of investment without proven local sales (FAO/IPTRID, 2000). Later batches are purchased with 50% paid upfront. Some dealers are however opting to pay in full at delivery.

Sales through dealership have proven to be by far the best mode of distribution. Commissioned sales people found it difficult to make a living solely from pump sales. ApproTEC originally targeted hardware stores in urban and peri-urban centres for pump dealership. The focus has now shifted to agricultural and veterinary products stores in small to medium sized towns that proved to have better access to customers (FAO/IPTRID, 2000).

Treadle pumps have been promoted principally through practical demonstrations on farmers’ field days, at agricultural shows, at markets, in farmers’ fields and the dealers’ shops. Other marketing activities have included advertising retail outlets and the pumps through the radio and TV programmes. NGOs and other organizations have also promoted purchase and use of the pumps.

Despite the marketing efforts undertaken to disseminate and promote the use of treadle pumps, certain conditions for commercial uptake must exist. The technology should be produced as close to the end users as possible. It must be affordable for the buyer and profitable for the producer. The technology must also function reliably and purchasers must be satisfied (FAO/IPTRID, 2000). No technology can be considered appropriate for all conditions, thus a proper site for the pumps must also exist. Appropriate criteria for site conditions are: A market for vegetable products, water source within 6m of the ground surface, an adequate water supply (>1 litre/ second per pump).

ApproTEC has been successful in training workers from various metal workshops in manufacturing the pumps. It has also imparted operation and maintenance skills to the dealers so that they can demonstrate to their customers how the pump is used. Farmers are also trained by ApproTEC to ensure proper operation of the pump. The trainees have on most of the occasions, paid a fee to attend training sessions. Initially farmers were invited for the training in a hotel and requested to pay a participation fee of Ksh. 200. This did not work well as farmers either lacked the fee or time to participate. The approach was later reviewed in preference for on-farm visits and farmers were not expected to pay for the service. Though this method proved effective, the cost of visiting all the pump users in remote areas is enormous and many farmers cannot be reached.

Impacts of Treadle Pumps

The use of treadle pumps in Kenya is rising steadily and several impacts have been recorded. There have been impacts on the farming practices, socio-economic and cultural aspects of users. The reported impacts on farming practices have been substantial and include:

- Increased land area under irrigation;
- Reduced work time compared with bucket irrigation;
- Full irrigation of fields resulting in improved crop quality;
- Reduced frequency of irrigation to two or three times a week;
- Less strenuous irrigation work compared to bucket irrigation;
- Additional and new crops grown each season;
- Increased number of growing cycles as crops are able to grow faster with full irrigation; and,
- Improved farm incomes.

The economic benefits of introducing treadle pumps can be significant. For example, improved income, cropping intensity and impacts on the whole supply chain (manufacture, sell and use of pumps). However, while the increase in crop yield can be attractive, higher yields can cause market glut when supply exceeds demand. This is a common problem with widely consumed crops and it is exacerbated by the tendency of farmers to grow the same crops at the same time of the year. The search for new, more distant markets may solve this difficulty but it can create different problems. Transport is costly and difficult to find in remote rural areas with poorly developed feeder roads. It is also unreliable.

IPTRID/FAO suggests the following strategies to avoid the glut problems:

- Adoption of alternative cropping patterns;
- Uptake of contract farming;
- Linking up with bulk buying companies;
- Introducing solar drying and food processing technologies; and,
- Adopting alternative low costs transport to target distant markets.

Better targeting of the right users for treadle pumps will go a long way in making this technology contribute to poverty reduction efforts. In Kenya, cultivating the crops, irrigation, weeding, fertilizing and harvesting of vegetables are generally considered to be women’s activities. Though over 70% of treadle pumps in use are purchased by men, women manage, control and benefit from additional incomes generated through use of these pumps. However, young men hired by women managers operate most of the pumps. Women should thus be targeted in disseminating treadle pumps. Women operate pumps without any traditional or religious constraint and see this as an opportunity for empowerment.

Box 3: Case Study of ApproTEC Treadle Pumps, Kenya

The use of treadle pumps has been ongoing in Kenya since 1991 when the first version was introduced in both rural and urban areas and generates a mix of results from users, manufacturers, promoters and retailers. The experience in Kenya shows that treadle pumps are purchased mainly through savings made by users. Other important sources of capital include selling of crops, livestock and retirement benefits. The majority of the treadle pump owners came to learn of these pumps by word of mouth and through live demonstrations of the technology and this attracted most of the people to purchase pumps. While males own 84% of the treadle pumps, women manage nearly three quarters of these pumps, which are mainly used for irrigating crops and to some extent in supplying water for household use and animals.

A reliable source of water to run the pump is a pre-requisite for a successful use of the pumps. During the 1999 survey by the monitoring department of ApproTEC, most of the pumps had been in use for over 8 months drawing water mainly from streams and wells of average depth of 14 feet. In rural areas, digging a well cost Ksh. 130 per feet and thus some farmers spent more on irrigation despite having purchased water pumps. There are those farmers who use water dams and swamps for irrigation. At the time of survey, 91% of the pumps had been active and had been used at least once. The reason for inactive pumps was attributed to increased depth of the water level in the well making the use of pumps impossible.

Most of the pumps are used on an average of approximately 3 hours per day with more time (4hrs) being spent to irrigate farms in Western Kenya than Central province. Areas under irrigation increased amongst users by 700% from an average of 0.03ha to 0.24ha in 1999 to 0.59 ha in 2004. Each pump sold is used by approximately 2 households as a third of the pumps are lent out to neighbours for use at no cost.

Farmers are engaged in producing high value crops such as tomatoes, kales and cabbages. There are those who plant French beans, cut flowers, passion fruits, green maize and onions. Potatoes, cowpeas, carrots, tea nursery, coffee, coriander, watermelon, spinach, sugar snaps and okra are also irrigated by a number of farmers. The increased crop intensity means that pump users are moving away from traditional crops that were mainly for subsistence and increasing the volume of cash crops. The number of crop cycles has also increased as a result of irrigation from 1.2-crop cycle before irrigation to an average of 2.3 for those not involved in irrigation before. One advantage associated with increased number of crop cycles was timing of cropping so as to have the crops when they fetch higher prices from the market.

Each pump sold allows for crop cycle sales income of Ksh. 46,031 (US$ 590). Out of this, Ksh. 5,943 (US$76) is spent on production costs leading to profits per crop cycle of Ksh. 40,088 (US$ 514). Thus, treadle pumps have increased incomes for poor families, created employment for operators and owners, made irrigation easy, provided food for poor families and created opportunities to invest in other income generating activities.

However, poor farmers face several challenges in the day-to-day operation with the pumps. These include mechanical problems, seasonal water sources for those using dams and wells, limited suction head of many wells whose depth is beyond reach of many pumps, pests and diseases and market glut for crops. In some areas, especially Machakos, Makueni and Kitui, there is a major problem of salty water that corrodes pumps. Sloppy lands in Central part of Kenya inhibit use of pumps. Farmers also complained of lack of knowledge of appropriate irrigation methods and were concerned that the tread pumps irrigate limited areas compared to the motorized ones.

Source: www.kickstart.org; ApproTEC, 1999

Box 4: Case Example of the Impact of Treadle Pumps in Transforming the Rural Poor

Not long ago Mr Moses Chumo and his family were living on his father-in law's farm trying to grow maize and using a bucket to irrigate less than 1/8th of an acre of kales from a local stream. Mr Chumo and his wife could not afford to keep their children in school and the family was barely getting by. Then he saw the super MoneyMaker pump being demonstrated at a local store. He liked what he saw and saved US$ 75 to buy a pump. The new pump allowed him to grow almost 1 acre of kales and enough good quality grass to feed his cows. This led to increased milk production and a greatly increased income allowing him to buy more and better cows, a chaff cutter to better feed them and eventually his new 7 acres piece of land. Mr. Chumo now plants tomatoes, French beans, kales & fruits and will have plenty of space left to grow Napier grass for his 5 cows. Already he and his wife are saving to send the first of their 5 children to a good secondary school.

Mrs. Janet Ondiek, a small-scale farmer in Kajulu, Kisumu, is a widow who manages her farm following the death of her husband in 1997. Janet's farm is next to a perennial stream. Using bucket irrigation she used to make a profit of just Ksh 7,000 (US$ 93) per season. In early 1999 Janet saw the Super MoneyMaker irrigation pump being demonstrated at Gita, a local market and liked it so much that she bought one on the spot. She has used it to transform her horticultural business. She now irrigates 2.5 acres, growing high value crops like bulb onions, tomatoes, and sweet peppers as well as kale and spinach, which she sells in Kisumu. In 1999, her profits topped Ksh. 240,000 (US$ 3,200), and she now employs 5 workers. After the death of her husband, Janet's 6 children almost dropped out of school due to lack of school fees, but now with irrigation she makes enough money to send them to college.

Source: www.kickstart.org

5.3 Assessment of Use of Hydraulic Rams in Tanzania

Ram pumps are a mature technology though not widely disseminated in Tanzania. Like wind technology, the ram pump technology is site-specific. Ram pumps are mostly intended for domestic and livestock supplies in hilly and mountainous areas, requiring small flow rates delivered to high heads. There is a limited number of hydro rams in the country as about 40 units are reported[11].

Ram pumps have proven to be useful in some parts of Tanzania. For example, ram pumps for community water supplies are installed in Njombe and Mbeya rural districts. These pumps supply water to about 1,300 and 1,500 inhabitants in Njombe and Mbeya, respectively. These installations have multiple domestic water points totalling to 17 and 12, respectively. Individual ownership of ram pumps also exists in some parts of Tanzania like Arusha, Kilimanjaro and Tanga regions. Apart from supplying water for domestic and livestock purposes, the ram pumps are on a small scale used for irrigation of bananas, coffee and other horticultural crops. Most of the ram pumps reported in Tanzania were locally manufactured by Jandu Plumbers and have been in operation for more than 10 years hence can be said to be reliable.

Although not originally designed for direct irrigation purposes, ram pumps are already used for this purpose. However, this requires significant investment in drive and delivery pipes to ensure the requisite high flow rates for irrigation purposes. Nevertheless, competition for water in the community for other domestic and commercial purposes can affect the water availability and economics of hydrams for irrigation purposes.

Most of the ram pumps installed in Tanzania are reported to have operated for more than 10 years in both domestic and economic activities such as irrigation of coffee farms and provision of water for animal husbandry. Such availability and reliability when combined with the few moving parts leads to minimal maintenance requirements, which suggests low running costs. The savings accrued from minimal running costs as compared to other pumping systems like diesel pumps is then available for other economic activities, which increases the potential for income generation.

Data from Tanzania indicates that use of ram pumps presents some opportunities for both users and manufacturers. For instance, local experts installed most of the ram pumps in Tanzania, especially in Arusha, Njombe and Kilimanjaro. As such, the technology has the potential of creating employment and income to Tanzanians, which eventually contributes to poverty reduction in Tanzanian communities. Need of metal works and construction of storage systems for pumped water provides a potential for income generation to metal workshops, masons and plumbers.

The technology normally makes use of elevated lands and gravity to pump water to a required point. The fact that no fuel is used makes such pumps independent of fuel supply and price volatility compared to diesel pumps. This property of hydraulic rams decreases dependence on fossil fuels. Income from irrigated coffee, animal husbandry and supply of water to other villagers as reported in one of the Arusha hydro ram owners show a direct earning, which reduces poverty to him.

[11] Jandu Plumbers estimation on units sold since 1980

The two community-owned hydro rams reported in Njombe and Mbeya Rural districts, with 17 and 12 domestic water points, indicate that there is potential for hydro rams to supply water in rural communities without fuel costs. More than 2,000 people are being served with clean water by the two systems. This has also reduced the walking distance of women and children collecting water. There also exists a potential of improved health of communities through supply of clean water by the use of hydro rams, which would reduce expenditure on health issues and minimize time spent on addressing health issues in communities.

However, despite these potential benefits, the prices of hydraulic rams are exorbitant, for instance ranges between US$ 300-2,600 depending on the capacity. However, typical commercial hydrams ranges from US$ 2,500 for 2-inch drive-pipe size up to US$ 8,500 for 4 or 6-inch sizes[12]. These prices are unaffordable and out of rich for most of Tanzanians.

Case of Hydram Use in Tanzania

A case study of two community-owned water supply schemes run on hydrams has been given (Table 24). Boimanda ram pump scheme is located in Matola ward 65km from Njombe District Headquarters. The pump was commissioned in 1991 and serves 1,300 people through 17 domestic water points. Ikhoho ram pump scheme on the other hand is located in Tembela division 35km from Mbeya Regional headquarters. The scheme was commissioned in 1994 and serves 1,500 people through 12 domestic water points. Both schemes are run on single ram pumps. Boimanda pump was constructed at the cost of US$ 174,503 while Ikhoho cost US$ 257,143. Anecdotal evidence indicates that the availability of the scheme at strategic domestic water points has helped reduce walking distance of women and children collecting water. There also exists a potential of improved health of communities through supply of clean water by the use of hydro rams, which would reduce expenditure on health issues and minimize time spent on addressing health issues in communities.

Table 24: Boimanda and Ikhoho Schemes in Tanzania

Name of the scheme	**Boimanda Ram Pump Scheme**	**Ikhoho Ram Pump Scheme**
Year of completion:	1991	1994
Number of water points:	17	12
1998 population:	1,017	1,566
Design Population at Construction:	1,300	3,065
Participatory Rapid Assessment Population	1,268	1,500
Design Population at Rectification:	1,300	3,065
Length of Transmission line (km):	1.95	1.27
Length of Distribution lines (km):	12.81	7.8
Design Flow (l/s):	0.3	1.04
Type of Source:	Stream	River
Construction Costs of Scheme (US$):	162,069	242,941
Rectification cost of Scheme (US$):	12,434	14,202
Total Cost (US$):	**174,503**	**257,143**

Source: Ministry of Water and Livestock Development

[12] Intermediate Technology Publications 1992 "Energy options"

6.0 POLICY ASSESSMENT

Based on the case studies of water pumping and irrigation technologies in Kenya and Tanzania presented in the previous chapter, this section assesses the barriers to wide scale dissemination of these technologies. In addition, policy outlines that highlight the major policy issues that need to be addressed are presented. This section also builds on deliberations of the policy dialogue by key stakeholders on factors necessary for the development and dissemination of renewable powered mechanical water pumps (such as wind, treadle and hydraulic ram pumps), and proposes policy options and strategies of introducing them in ongoing and future policy dialogue processes. Although the discussion is mainly based on water pumping technologies, the same issues are likely to apply to most non-electrical RETs.

6.1 Barriers to Wide Scale Dissemination of Water Pumping and Irrigation Technologies

6.1.1 Barriers to Wide Scale Dissemination of Wind Pumps in Kenya and Tanzania

Despite the role that wind pumps can play in national development and poverty reduction, their dissemination in Kenya has been fairly limited. Barriers limiting uptake have been provided below.

The cost of investing in water pumping technology has been identified as a major limitation of wind pumps and thus a barrier to its scaling up. Costs expressed in table 18 are far beyond reach to majority of people in East Africa living in poverty. Community groups interested in purchasing wind pumps for water supplies often have limited funds and cannot take a long-term view toward the technology. Governments of Kenya and Tanzania have not provided incentives to this sector and current pumps are too expensive for ordinary citizens who wish to undertake wind pump projects for water supply and irrigation.

The popularity of wind pumps to supply useful amounts of water without human attention for long periods, suggest a need for some storage system. This is further supported by the fact that water requirement for a particular community or user does not necessarily match with the existing wind pattern (Magessa, 2004). The extra investment costs in preparing water sources, storage and distribution makes it even more expensive for potential users. The figure below shows a wind pump connected to a storage tank in Kisigisa village, in Tanzania.

Figure 14: Wind Pump Supplying Water to Kisigisa Village in Kongwa District, Tanzania

However inadequate storage volume for pumped water has been reported in some cases. Most complaints regarding storage volumes were for the wind schemes with storage capacity volumes in the range of 3,000 to 6,000 litres. As such, the communities sometimes loose the scarce water when the tank is full, but the wind is blowing. Storage capacity for more than two days however, is not considered economical.

Lack of funds to develop wind-pumping technology has been a major barrier, and research, design and development of wind pumps have often been done with limited budgets. A few donors have been forthcoming in augmenting financial resources from wind pumps sold to raise the cash for research and development of pumps, as is the case with BHEL (Harries, 2002; BHEL, 2004a, b). However, in some circumstances it has been impossible to mobilize the funds to support development of pumps. As a result, the pace of research and development of wind pumps has been too slow.

According to Harries (2002), overwhelming needs of installation and maintenance of wind pumps have made it difficult for manufacturers of pumps to cope due to low number of staff and logistical problems. The use wind pumps also present the following installation challenges:

- Wind pumps are often installed in remote areas, some of which are insecure. These pose operational and logistical problems due to long distances covered to reach potential wind sites on inappropriate roads, thus it becomes expensive to disseminate these pumps in remote places.

- Wind pumps are also bulky and therefore require quite large vehicles for transportation. Installations are often done in remote areas where potential users have little experience in maintaining the mechanical pumps.

- There has also been a potential conflict in provision of water services due to scarcity of the commodity.

Despite training the communities on wind pump installations and maintenance, pumps in remote areas have not been maintained to the required standards since the trained technicians either leave the area to seek employment elsewhere or are technically incapacitated to carry out their work effectively (Harries, 2002). Technicians and buyers are often unfamiliar with wind pump technology, and pumps in remote locations often break down because of a lack of servicing, spare parts, or trained manpower. Pumps installed by churches, NGOs and government are more affected due to lack of community involvement and ownership and often wait for these institutions to come and fix any mechanical problems.

In Tanzania, the low capacity of local manufacturing for wind pumps implies limited availability of technical personnel for installation and maintenance services. As a result, expatriates and/or volunteers install most of the imported wind pumps. For example, in Kongwa district villages, a Lay Volunteer of International Association based in the district headquarters does the maintenance of the wind pumps. In another case, maintenance of some of the Manyoni districts wind pumps in Singida region relies on a maintenance team from another region, Dodoma (Magessa, 2004).

Wind pumps are considered old and inappropriate technology by government and other developers in Kenya and Tanzania. This has been as a result of lack of understanding of the role these pumps can play in supporting water supply and irrigation initiatives in areas where wind regimes are reliable and where there is no feasible future of introducing grid electricity. This sector had been neglected, as there has been no motivation and support to help develop infrastructure for local manufacturing, leaving it to private sector, which is mainly under-funded. In Kenya, State efforts to promote wind energy for generating electricity have been demonstrated with the installation of wind generators in Marsabit and Ngong. Similar enthusiasm has been lacking for the wind pumps.

According to Harries (2002), bad reputation for the technology in some circumstances has prevented widespread use of wind pumps. There have been some few short sighted projects that either introduced inappropriate technology, or did not set up long-term maintenance and repair infrastructure and resulted into policy makers forming a misguided opinion about this technology as a whole.

Mwihava and Towo (1994) report that about 40 units out of the 122 reportedly installed in Tanzania by the time of reporting were not working (Table 25). A study by Bianca (1996) reports that 44 out of 144 not working. Some of the reasons for the windmills not operating are:

- Lack of analysed data for wind regimes to guide proper installation and sizing
- Vandalism of wind pump parts by local people;
- Lack of skilled local technicians for troubleshooting and maintenance
- Low sense of system ownership by the local people;
- Lack of spare parts for windmill; and
- Limited capability for local manufacturing implying low affordability of such systems for Tanzanian communities. Most systems are installed as grants and aids from donors and missionaries.
- Also, there is poor management of wind pumps for community water projects. This was especially reported in some parts of Kongwa District regarding pricing and expenditure of money obtained from the wind pump
- Some wind pumps installed in the past are not operating and the fact is attributed to lack of adequate wind regime and/or inadequate availability of water in the ground. These failures indicate the need for better feasibility studies, which are central to successful and sustainable water-pumping schemes.

Table 25: Status of Installed Wind Pumps in Tanzania (1994)

Region	Number of Schemes		Total
	Operating	Not operating	
Dodoma	10	3	13
Arusha	-	2	2
Iringa	4	3	7
Kagera	1	-	1
Mara	3	1	4
Mtwara	1	-	1
Rukwa	3	-	3
Shinyanga	2	5	7
Singida	53	17	70
Tanga	1	6	7
Tabora	3	1	4
Kilimanjaro	-	1	1
Mbeya	-	1	1
Dar es salaam	1*		
Total	**82**	**40**	**122**

Source: Mwihava and Towo, 1994

Local adaptive research, development, and production of wind pumps once existed in Tanzania. In 1978, the Arusha Appropriate Technology Programme in collaboration with Ujuzi Leo Industries produced a wind pump of the type ULI 5000 with 5m-rotor diameter. Lack of relevant support from the government and failure to translate political will and interest into budgetary expenditure adversely affected sustainability of the initiative. As a result, all wind pumps currently installed in Tanzania and most of the associated spare parts are imported, which indirectly affects affordability and hence poverty levels due to high costs of the systems and the denied employment opportunities to Tanzanians from such industries.

The capacity to produce wind pumps in Tanzania is still available in some institutions like Camartec of Arusha, TDTC of the University of Dar es Salaam, TEMDO and TIRDO. However, it is vital to rejuvenate this capacity, as it would provide employment opportunities, increase economic activities, agriculture and livestock keeping and improve health through clean water provision.

Participatory approaches are central to the success of community projects. In most of the visited villages visited in Dodoma and Singida regions, the community did not know the costs for wind pump schemes. And where the information was known, it was just by a small group of local elites. As such, there is no sense of responsibility and ownership among the community, which threatens the sustainability of the schemes and increases the likelihood of vandalism.

6.1.2 Barriers to Wide Scale Dissemination of Treadle Pumps

Several barriers have been identified which limit promotion and adoption of treadle pumps technology. Although treadle pumps cost less than other irrigation technologies, a number of people in rural areas still cannot afford these pumps due to extreme poverty levels. The study found that more than 70% of the pump owners purchase them on cash basis from savings previously made while employed or in businesses. The majority of poor people in rural areas have low and sporadic incomes and savings, and thus cannot afford even the low cost treadle pumps. The purchase of pumps usually involves investing in related accessories such as sprinklers, hosepipes and agro-chemicals, investing in head tanks, drilling wells and boreholes etc. These increase the cost of owning and operating the pumps and further putting off the poor people from owning them.

ApproTEC has marketed its pumps through advertisements, demonstration and some results of uptake have been recognised. However, there is a problem of reaching very remote farmers mostly due to poor infrastructure and lack of resources. Some farmers who have purchased these pumps do not have adequate knowledge of operating the pumps, or lack knowledge on better irrigation practices and general skills to manage crops under irrigation.

Limited land and water resources on the other hand, can limit growth in small-scale irrigation. There are landless farmers who are not likely to invest and use treadle pumps. Others have limited land available. Availability of water for irrigation poses a challenge for rural areas with deep water table and peri-urban pump users who mainly depend on shallow wells or swamps. A drop of local water table by one metre or two metres will put the water beyond reach of many treadle pumps.

Quality of water is also a main concern to users located in the areas where sources of water are salty, silt or debris. Salty water corrodes the metal parts of the pumps reducing its lifespan. Salty water may interfere with fertility of the soil if used repeatedly for irrigation. During the dry season, when water for irrigation is required, most of the sources of water dry up rendering the pumps useless. Wells may dry up or water table moves deeper and cannot be reached by most pumps.

The potential for wider use of treadle pumps is still unexploited because of many factors, including:

- Rampant poverty;
- Limited policy attention to small scale irrigation systems;
- Slow research and adaptation of technologies;
- Lack of information and inadequate dissemination strategies;
- Mechanical operational problems;
- Lack of access to adequate and good quality water to run the pumps;
- Limited knowledge on irrigation methodologies;
- Inadequate land for potential users;

6.1.3 Barriers for Uptake of Ram Pumps in Tanzania

There are two major barriers to the development of ram pumps, namely:

- The price of ram pumps ranges between US$ 300-2,600 depending on the capacity. However, typical commercial hydrams range from US$ 2,500 for 2-inch drive-pipe size up to US$ 8,500 for 4 or 6-inch sizes[13]. The price range of hydro rams above is not in the reach of most Tanzanians.

- Availability of spare parts for the ram pumps was also reported as a major problem. For instance, ram rubbers are not available in Tanzania.

6.2 Policy Outlines

6.2.1 Policy Outline for Wind and Hydraulic Ram Pumps

Recently, there seems to be a tide towards utilization of wind energy and the government, aid agencies and individuals have started to appreciate it. However, the following need to be addressed at policy level to stimulate growth in the use of wind energy.

Initial costs of wind pumps are far above the average income of poor people in Kenya and Tanzania. The technologies under consideration have proven effective in improving the living standard of communities. Unless support and credit incentives are facilitated, poor communities cannot install such systems. However, the availability of clean water and reduced distance and time for women to go looking for water, has revealed a positive impact in communities' economy using such technologies. As an example, increased numbers of livestock for households, good houses, more shops and decreased water borne diseases were reported in some of the visited communities of Dodoma and Singida regions, which can result in more income and human energy for economic activities**.** As such it is recommended that deliberate efforts to facilitate friendly credit schemes and tax incentives for wind pumps and hydro rams be disseminated and promoted by the government and other players to increase affordability.

Harries (2002) proposes some of the financial mechanism that might help spread the use of wind pumps in future.

- Government subsidies or tax exemption for all wind pump installations.
- Availability of finances which would enable commercial operators to set up a revolving fund so that customers could pay for wind pumps installations over a long period.
- Provision of appropriate funding to help large-scale operators to set up a utility type wind pump installation, which would mean that maintenance of the system could be managed better.
- Private banking systems to provide low interest loans

State efforts in funding R&D for wind pump designs would be required to enable scaling up utilization of wind energy resources. Possible beneficiaries would be state universities; private entrepreneurs and other development organizations willing to research, design, manufacture and promote wind pump technology. There is need for the revitalization of stalled research and development initiatives that had been started in the 1970s. State interventions in research and development will help come up with much more affordable versions of wind energy technologies that will help communities' access to water for domestic, irrigation and livestock.

Feasibility studies are vital before installation of wind pumps as many systems are not working or are under-utilised. Problems include, on the one hand, lack of adequate wind for pumping water and insufficient underground water to be pumped. As an example, there is inadequate water for domestic purposes in some villages of Kongwa district, but the same type of wind pumps are employed in

[13] Intermediate Technology Publications 1992 "Energy options"

Tarime, Musoma rural, Bunda, and Magu districts of the lake zone for irrigation purposes. Proper planning, feasibility studies, design, availability of spare parts, local maintenance capabilities and participation are central to sustainable operation of the pumps for their intended applications. It is therefore recommended for the government and other development players to make deliberate efforts to develop relevant databases related to wind water pumping and hydro rams.

In Tanzania, about 30% of the schemes are not operational due to vandalism, lack of spare parts and lack of technical know-how. As such it is recommended that deliberate efforts be taken by the government and other players in the field to ensure adequate availability of technical capacity, spare parts for wind pumps and commitment and a sense of ownership at local levels to recover the bad reputation on the technology growing from schemes that are not operating.

Local capacity building and partnerships in project development, planning and implementation of technological interventions in community initiative has proven to be effective for sustainability of such interventions and in building a sense of ownership of the such projects among community members. As such, it is recommended for the Government and other stakeholders in development such as NGOs, Donors, and Financial/ Credit Institutions to use participatory approaches and avoid top-down approaches when planning and implementing projects at local levels. Table 26 presents a summary of the policy outline.

Table 26: Summary of Major Policy Issues for Wind Pumps in Kenya and Tanzania

Problem	Objectives	Strategic policy outline	Instrument	Activities
The cost of investing in wind pumping technology limits disseminating, uptake and scaling up	To make wind pumps affordable in areas of potential	Creation of incentives that will trigger affordability	Provide grants, subsidies, tax relief, credit systems	To identify and lobby for appropriate incentives to address specific cost reduction measures
Limited research and development of wind pumps. There is no reliable data on wind and ground water to guide installations	To promote research and development of wind pumping technology	Design of affordable wind pumps, develop reliable databases for wind and water resources	Grants for R&D, Solar and Wind Resource Assessment, feasibility studies	Lobby for increased state/private and donor funding for Research and Development of wind pumps
Lack of policy enthusiasm and interests in wind pumps technology	To create awareness of wind pumping technology amongst stakeholders	Increased support by policymakers and other stakeholders for wind pumping technology	Demonstration, Documentation and wide-scale dissemination of case studies.	Promote recognition of the potential role of non-electrical wind pumps amongst stakeholders To revive existing non-functional schemes
Poor management of schemes leading to failure of available installations	To increase success rates of community based wind pumping water supply installation	Promote community management of existing schemes	Participatory technology development and installation Local capacity development	To train local end users to install and maintain the technology To ensure adequate availability of technical capacity and affordable spare parts

6.2.2 Policy Outline for the Wide Scale Dissemination Treadle Pumps

In addressing the barriers mentioned in section 3.6, the following policy options need to be explored.

For treadle pumps to succeed, they need a stable financial support to ensure development and uptake from research, design, manufacturing, and commercialisation to end-users. Being a technology whose target end users are poor people, there is need for subsidies that are going to help roll out the technology while ensuring affordability. For example, incentives such as tax relief on raw materials should be provided to investors to manufacture and trade in the pumps as a way of making them affordable. However, this may not be realized without proper policy and legal framework being established.

Uptake of treadle pumps has been encouraging in areas where the public is aware about the technology and the impacts it can create in their farming practices. However, there are millions of people that have not been reached and need to be sensitised and encouraged to use treadle pumps. This calls for the action of government, non-governmental organizations, entrepreneurs and other interested stakeholders to help educate the public and provide mechanisms through which the people will adopt treadle pumps. Mass marketing of the technology to the rural poor will also help create the demand for the treadle pumps (Steenbergen, 2003).

Development and adaptation of treadle pumps to various conditions in different regions of the country should be encouraged. Efforts should be geared towards providing necessary environment for this to happen, such as provide research grants, training and develop manpower etc. On the other hand, the government, private sector, civil societies, research institutions and other interested parties should recognize the diminishing land resources due to sub-divisions as a result of population increase. This entails that the future of irrigation is in small-scale poor farmers (i.e. less than 2 acres) who strive to meet their needs in small plots and consequently design affordable and pro-poor technologies that fit farmers' plot sizes and meet their needs and perceptions.

Table 27 presents a summary of the policy outline.

Table 27: Summary of Major Policy Issues for Treadle Pumps in Kenya

Problem	Objectives	Strategic policy outline	Instrument	Activities
Limited policy attention to small scale irrigation schemes e.g. treadle pumps	To create awareness of potential role of treadle pumps in poverty reduction	Increased recognition of small scale irrigation by policymakers	Education, Policy advocacy, Demonstration, documentation	To promote wide scale dissemination of treadle pumps amongst policy makers
Unaffordable pumps to majority of people with low income	To develop mechanism for enterprise and consumer financing to influence purchases of treadle pumps and related accessories	Design and marketing of affordable treadle pumps	Tax and fiscal incentives, credit system, Research and Development	To provide tax incentives to producers and dealers in related accessories to promote uptake To provide fiscal incentives to financial institutions for affordable credit/loans
Slow research and adaptation of technologies	To accelerate research on appropriate treadle pump technology	Develop and manufacture affordable pumps adapted to local conditions	Demonstration, provide research grants, training	Encourage technical research Lobbying for research
Lack of information and inadequate dissemination strategies	To create awareness of treadle pumps amongst policy makers and end-users.	disseminate experiences widely to the public	Education, demonstration, documentation of experiences, mass marketing	To disseminate information on performance and role of treadle pumps in poverty reduction.
Lack of knowledge on good irrigation methods	To ensure proper use of treadle pumps	Educate the public	Agriculture extension, and demonstration	To educate the farmers on appropriate irrigation methods and proper

				utilisation of pumps

Source: Balla 2004

6.2.3 Cross Cutting Policy Considerations[14]

This section presents some of the cross-cutting policy issues for the non-electrical renewable energy technologies that could not be handled in isolation, as well as specific policy options for different stakeholders.

Treadle, wind and hydraulic ram pumps fall within different sectors (e.g. water, agriculture etc) creating a gap in coordination, as there is no clear-cut institutional mandate and responsibility to develop and promote these technologies in Kenya and Tanzania. Lack of ideal coordination model thus poses a barrier to dissemination. An institutional coordination model employed in the implementation of stoves programme could provide a basic example. In Kenya, the implementation of stoves projects was done by the ministries of energy, forestry and agriculture, and non-governmental organisations where the coordination role was provided by the GTZ. There is thus need for formation of such coordination model.

Past project failures in water pumping and irrigation technologies pose one of the challenges in the development and adoption. Identifying and documenting reasons for the failure of these technologies in meeting needs of poor people will go a long way in overcoming the barriers to development and adoption in future. Likewise, there are good case studies of use of mechanical water pumping and irrigation technologies that goes unnoticed due to lack of awareness and knowledge on their small-scale applications. In Kenya, especially the North Rift region, there is significant use of hydraulic and wind pumps, mostly fabricated and maintained by small scale informal artisans, who in most cases are unrecognised. Best practice exhibited by such groups have not been documented for sharing, a challenge that need addressed.

Financing capital investment in small-scale mechanical water pumping and irrigation technologies is a barrier to majority of poor people. However, the case studies of income generation potential of treadle, hydram and wind pumps noted above indicate their attractiveness in financial returns that can repay a loan. There are several financiers (banks, micro-finance, Agricultural Financial institutions etc) that have not designed appropriate loaning schemes for such small-scale technologies. In Kenya, there are a few financing options available which can benefit individuals investing in non-electrical RETs, such as Constituency Development Funds, Local Authority Transfer Funds etc. However, development of small technologies through such funds has not been proposed. There is need to repackage financing models to suit small investments such as non-electrical RETs.

While lack of capacity development in terms of training remains a barrier to sustainability of mechanical RETs, the role of informal technicians and artisans who have been innovative in the fabrication and maintenance of such technologies have not be recognised and could be an ideal entry point by promoters in maintenance programme. Curricula development at universities and colleges has not addressed needs of personnel and artisans for such technologies at local levels. There is thus need to review training curricula to suit the needs of low-income groups and technologies. Universities should also develop technology transfer channels to make technology accessible to low-income groups and monitor feedback on technologies

Specific recommendations targeting policy makers, private sector and SMEs, financiers, universities and research institutions, civil societies, users groups are summarized below:

<u>*Policy Makers:*</u>

1. There is need for clear institutional responsibility in harmonization of policies and mandate for implementation of non electrical RETs projects

[14] This section is based on a stakeholders policy dialogue meeting, where the preliminary policy options for non-electrical RETs were discussed. The meeting was held in Nairobi on 21st June 2005 (See Appendix I).

2. Create rural energy fund to cover a wide range of technologies. A technical team should be formed to make the case to minister of energy to lobby for revision of energy bill before it is passed. For example in Kenya, the Community Development Fund is one of the possible financing mechanisms for non-electrical RETs. There is need for a percentage of the fund to be set aside to be used for non-electrical RETs
3. Review policy on training to include maintenance of mechanical and non-electrical technologies
4. Review policy on micro financing to cover the needs of small scale farmers
5. Promote public private partnerships to support community based small scale initiatives

Private Entrepreneurs/ SMEs

1. Improve on business delivery models e.g. franchising
2. Guarantee standards and quality
3. Implementation of self-regulation systems for public sector and SMEs, but should not be a barrier to accessibility of the technology.

User Groups

1. Ownership of technology should be promoted, in order to ensure proper management, maintenance and training of technologies

Financiers/Banks

1. Repackage financing models to suit small investments such as non-electrical RET

Universities/Research Institutes

1. Review training curricula to suit the needs of low-income groups and technologies
2. Develop technology transfer channels in universities to make technology accessible to low-income groups
3. Monitor feedback on technologies

Civil Society

1. Should continue to lobby, advocacy and awareness creation
2. Facilitating financing for low-income groups
3. Research, dissemination of information and demonstration

7.0 SUMMARY OF KEY FINDINGS AND CONCLUSION

The study has described the potential role of renewable mechanical powered water pumps for irrigation and poverty reduction in Kenya and Tanzania, and has highlighted case studies of application of treadle and wind pumps. Several factors have been identified that limit uptake of each of these technologies and policy options to promote adoption have been suggested.

The available data, case studies and analysis is not sufficient to make a conclusive assessment of the potential of the small-scale non-electrical RETs examined in this report. However, the available information and data reveals the following;

- Agriculture is the mainstay of the economies of Kenya and Tanzania and currently accounts for 90% of rural incomes and provides 62% of the employment in Kenya. In Tanzania it contributes to 50% of GDP and accounts for 80% of rural employment. In both countries, state efforts to exploit irrigation potential is minimal as countries rely on rain fed agriculture, which is prone to weather vulgar. Both countries are unable to exploit irrigation potential due to inability to tap surface and ground water.

- The small-scale non-electrical RETs covered in this report have the technical potential for irrigation and water supply. Specifically, the technologies have the potential for enhancing food security through increased food production. In addition, they have the potential to meet other priority needs of the rural poor such as income and health.

- All the three selected technologies are fully locally manufactured and distributed and installed by the private sector indicating a high potential for local job generation. The technologies require limited owner/operator maintenance hence is ideal for the rural poor as well as for operation in remote rural areas.

- Available data on these technologies indicate high cost of some of the technologies, notably, wind pumps and ram pumps. These are, therefore, unlikely to be affordable to individual poor farmers. However, these pumps could benefit the poor if installed through self-help groups organised specifically to pool the requisite capital. Treadle pumps on the other hand can be affordable to the majority due to their low cost and their smallness in application.

- There are several barriers that inhibit uptake of these technologies and as a result, the potential for wider use mechanical pumps is still unexploited. This is attributed to rampant poverty; limited policy attention to small scale irrigation and water supply systems; lack of an ideal institutional coordination of such technologies, slow research and adaptation of technologies; lack of information and inadequate dissemination strategies; lack of access to adequate and good quality water to run the pumps; lack of knowledge on irrigation methodologies; lack of land to potential users; and poor management of community schemes leading to failure.

Conclusion

Non-electrical energy technologies have portrayed significant potential for water pumping and irrigation activities in East Africa. Recognising this potential and devising mechanism to address the above mentioned barriers would go a long way in rejuvenating these technologies to meet needs of the poor in rural areas of Kenya and Tanzania. There is an urgent need to create an enabling environment for the uptake of these small-scale technologies. Good policies and strategies backed by well-targeted public and private investment will ensure that poor people in rural areas have the right technology to meet their needs for water. However, good policies alone are not enough since there is need for a political will and commitment towards local technological initiatives for productive uses.

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9.0 APPENDICES

Appendix 1: Policy Stakeholders Dialogue on Non-Electrical RETs

A policy stakeholders' meeting was organised on 21st June 2004, to discuss the findings of this study and debate on the policy options. The meeting brought together a group of stakeholders from the public and private sector, involved in non-electrical technologies for water pumping. A summary of the proceedings of the meeting, key recommendations and participants is provided below:

Key issues raised:

- The non-electrical renewable energy technologies mentioned in the report are necessary in poverty alleviation. Successful case studies of policy interventions need to be highlighted. The technologies presented (treadle, wind and hydraulic ram pumps) fall within different sectors (e.g. water, agriculture etc) creating a gap in coordination. In addition, both short and long term R&D needs should be specified.

- Resource allocations in public investments are not streamlined by priorities for poverty alleviation, a factor that need to be corrected.

- Government investments and action research in such technologies is low. However, the key question that needs to be addressed is in spite of the current situation facing these technologies, how do we move forward. The use of wind pumps and hydram in the North Rift area of Kenya is significant, but little has been done in documentation of the cases. Hydrams and wind pumps were in being used by local people, with technical support from informal technicians.

- There is a role for market segmentation of pumps to meet the needs and incomes of different end users. For example, while Kijito wind pumps could target higher income groups, adoption of second hand pumps or renovation of disused abandoned pumps could be an option for those who cannot afford new ones.

- Key research centres such as universities and major polytechnics have not been supportive enough in research and development of RETs. There is a role for informal technicians and artisans who have been innovative in the fabrication of such technologies. Local level training, especially at youth polytechnic levels should be encouraged since artisans from these institutions are the one likely to run these technologies as opposed to graduates from universities.

- Manufacturers of such technologies need to encourage franchising of their activities with the local stockists to ensure availability of spare parts and other services. There are a few financing options available which can benefit individuals investing in non-electrical RETs, however, most financiers who do not have appropriate loan schemes for small technologies.

- The cost of running irrigation schemes is enormous and affordability issues need to be looked at, especially the cost implications with regard to individual farmers and group/community.

- Findings of the study can be fed to universities to take up R&D issues in the curricula. Participatory methods and gender issues also needed to be addressed as far as mechanical irrigation technologies are concerned. Women groups could be ideal entry points for dissemination of such technologies since most of them form the bulk group of users and need involved in the study. Wholesome dissemination of technologies should be adopted taking into account training needs, affordability, and environmental, social and economic issues.

- Institutional coordination for such technologies could borrow from the example of the stoves projects in Kenya, which was implemented by the ministries of energy, forestry and agriculture, where the coordination role was provided by the GTZ.

Specific Policy Recommendations:

Based on the discussions and case studies provided, the following policy recommendations were made targeting policy makers, private sector and SMEs, financiers, universities and research institutions, civil societies, users groups.

For Policy Makers:

1. There is need for clear institutional responsibility in harmonization of policies and mandate for implementation of non electrical RETs projects
2. Create rural energy fund to cover a wide range of technologies. A technical team should be formed to make the case to minister of energy to lobby for revision of energy bill before it is passed.
3. Lobby cabinet committee on food security and water on inclusion of non-electrical RETS their agenda
4. Community Development Fund is one of the possible financing mechanisms for non-electrical RETs. There is need for a percentage of the fund to be set aside to be used for non-electrical RETs
5. Review policy on curricula/Training
6. Review policy on micro financing to cover the needs of small scale farmers
7. Promote public private partnerships to support community based small scale initiatives
8. Developing and enforcing of standards to protect consumers, manufacturers etc
9. Develop mechanism to share public data with stakeholders

For Private Entrepreneurs/ SMEs

1. Improve on business delivery models e.g. franchising
2. Guarantee standards and quality
3. Implementation of self-regulation systems for public sector and SMEs, but should not be a barrier to accessibility of the technology.

User Groups

1. Ownership of technology should be promoted, in order to ensure proper management, maintenance and training of technologies

For financiers/Banks

1. Repackage financing models to suit small investments such as non-electrical RET

For Universities/Research Institutes

1. Review training curricula to suit the needs of low-income groups and technologies
2. Develop technology transfer channels in universities to make technology accessible to low-income groups
3. Monitor feedback on technologies

Civil Society

1. Should continue to lobby, advocacy and awareness creation
2. Facilitating financing for low-income groups
3. Research, dissemination of information and demonstration

List of Participants

	Name	Organisation, address
1	Mr. Julius Yegon, Water Engineer	Intermediate Technology Development Group (ITDG) P.O. Box 39493 -00623, Nairobi Tel. 020 2713540 Julius.yegon@itdg.or.ke
2.	C. S Macharia	Ministry of Agriculture
3.	Peter Ochieng	Ministry of Livestock
4.	John Mutua	Kenya Institute of Public Policy Analysis (KIPRRA) Tel. 2719933/4 mutua@kippra.or.ke
5	Ms. Pauline Wanjohi	Ministry of Agriculture Home Economic Department Tel. 2718870 Pauline_wanjohi@yahoo.com
6.	Hancox W. Jaoko	Ministry of Energy Department of Renewable energy Tel. 0721755531 hansjaoko@yahoo.com

	Name	Organisation, address
7	Stephen Karekezi	AFREPREN/FWD Tel. 566032 Afrepren@africaonline.co.ke
8.	James Muriithi	Ministry of Energy Department of Renewable Energy Tel. 0733949888 Jamesmuchira@yahoo.com
9	Tracy Pallister	Bob Harries Engineering Ltd. Thika, bobs@africaonline.co.ke
10	Waeni Kithyoma	AFREPREN/FWD, Tel. 566032 afrepren@africaonline.co.ke
11.	Patrick Balla	Intermediate Technology Development Group (ITDG) Tel. 2713540 Mobile: 0721 738 994 Patrick.balla@itdg.or.ke

Appendix II: Treadle Pumps in Kenya

1 ApproTEC Pumps

ApproTEC, a Non-governmental organization based in Kenya designs and manufacturers its own suction and pressure treadle pumps. Though these pumps operate on the same principle as the other treadle pumps used in Bangladesh, the design features are significantly different since ApproTEC adapted these pumps to suit Kenyan conditions. The following factors influenced the design of Kenyan treadle pump:

- The need for larger suction lifts because of lower water tables in Kenya.
- The need for pressurized delivery systems to overcome the undulating terrains on many farms.
- The need to allow use in plots located in different places and, for security reasons, to allow the user to carry it home.
- The need to have it easily maintained by the pump users/owner.
- The need to make it affordable to poor farmers.
- The need for robustness in design and operation.

ApproTEC developed a large suction pump in 1991, and trained a manufacturer to produce it. Over 200 pumps were sold between 1991 and 1996. However, the pump turned out to be too heavy to transport, awkward to operate and expensive. ApproTEC then developed a range of lower cost, smaller and portable pumps, namely: the MoneyMaker, Super MoneyMaker, and the MoneyMaker Plus and are discussed below.

MoneyMaker

The "**MoneyMaker**" was developed based on the IDE design from India. The pump is ideal for surface irrigation and was originally intended for Kano plains around Lake Victoria. However, this is not the typical terrain found in Kenya. Unlike India, flood and furrow irrigation is not commonly used in Kenya. While the pump did find a market, a feedback-monitoring report indicated the need for pressure pumps. The pump was released to the market in 1996 at a retail price of US$53, and as of May 2004, a total of 4,050 MoneyMakers had been sold. The "MoneyMaker' treadle pump bears the following characteristics:

- The pump is portable and weighs 15kg.
- Has a maximum suction lift of 6.0m and draws water into furrows.
- Is capable of irrigating 2 acres of land.

Super MoneyMaker

The introduction of the "**Super MoneyMaker**" in 1998 took over the market of suction pumps. The "Super MoneyMaker" responded to the stated needs of farmers in regions such as the Western, Rift Valley, Central and Eastern provinces characterized by shallow valleys and sloping land. They needed a pump that could lift water to higher ground and provide a pressure head for spraying with a hose or sprinklers. The following are the key features of the "Super MoneyMaker" treadle pump

- The pump has a maximum pumping pressure of 12m.
- It is portable and weighs about 23kg
- Can irrigate 2.0 acres of land per season using sprinklers.
- The price of the pump is US$69 and as at May 2004, over 18,908 pumps have been made and sold (ApproTEC, 2004).

MoneyMaker Plus

The design of the "**MoneyMaker Plus**" pump was completed in the year 2001. This pump has the following characteristics:

- Draws water from a depth of 20 feet (6m) from a river, lake, well, pond or dam.
- Pumps water straight up to a height of 63 feet (19m).
- Sprays water out up to 50 feet (15m) from the end of a hosepipe.
- The pump can be used for irrigating about 1.5 acres of land.
- It can operate 4 sprinklers when fully operational.
- The cost of a unit pump is approximately US$39, slightly over half the price of the "Super MoneyMaker".

As at June 2003, 3,825 units of the pumps had been sold.

2 Swiss “Concrete” Pumps

The Swiss Concrete Pedal Pump for small-scale irrigation is being introduced through an association known as Water for the Third World Association, based in Switzerland. These pumps were developed by Swiss engineers and introduced into Tanzania in 1998. By the year 2002, about 200 pumps had been manufactured through a project at Tushikamane Training Center in Morogoro, Tanzania.

A Kenyan participant who attended training at Tushikamane Center returned with the technology and in 1998 initiated a local production workshop at ICIPE’s Mbita Point Research Center where 10 pumps were manufactured. Unlike the ApproTEC treadle pumps, the engineers set out to produce a simple, robust suction pump that would not rust and would be easy to manufacture and assemble.

The result was a pump that comprises of PVC cylinders surrounded by a block of concrete to provide support (IPTRID/FAO 2000). The pump draws water from a maximum depth of 7m and discharges it directly for irrigation, usually by furrow leads to a water reservoir. Weighing 60 kg, the pump cannot be easily stolen. By using concrete for construction, the pump can be used in salty water and uses a minimum number of metallic components, which constitute about one quarter of the pump.

Users of Swiss concrete pumps claim the pump can be constructed locally in the villages at a cost of about $50, are easy to use and require little maintenance. Farmers have reported good returns on using this pump for irrigation, with tomato and tree seedling showing the highest returns.

The Swiss concrete pumps on the other side should be used on water that has no sand or gravel, which cause excessive wear and tear to cylinders. By using concrete for construction, the pump can be used with salty water and requires minimum replacement of metallic parts, which, as mentioned earlier, constitutes only one quarter of the pump.

The Swiss concrete treadle pump has not been promoted well in Kenya and as a result, its uptake has been low. By the year 2002, only 10 pumps had been disseminated in Kenya.

Appendix III: Summary of Methodological Approach to the Study on the Potential Contribution of Non-Electrical Renewable Energy Technologies (RETs) in Poverty Reduction in Tanzania and Kenya

I STUDY APPROACH IN TANZANIA

Introduction

The Tanzania Traditional Energy Development and Environment Organization (TaTEDO) have been contacted by AFREPREN/FWD of Kenya Nairobi to undertake a Study on the Potential Contribution of Non-Electrical Renewable Energy Technologies (NERETs) in Poverty reduction in Tanzania. Due to resource and time constraints, the study emphasis will focus on wind and ram technologies application for water pumping and irrigation respectively.

Study Approach and Activities

They involve conducting relevant literature review, interviews and site visits. The study team made use of available study reports and organized consultative visits to suppliers of such technologies in Tanzania and other sources like the Internet to select representative case potential sites for visits. Local suppliers will also be interviewed to establish the trend, status, barriers to wide adoption, achievements and recommendations of the same group to allow for increased uptake of such technologies in the country.

Meetings and interviews were organized with other stakeholders to establish information on policy and innovation level. Sample questions to different groups that were visited (institutions, users, manufacturers and suppliers) are attached as appendices. These include the Ministry of Energy and Minerals (MEM), Ministry of Agriculture and Food Security, Vice President’s Office responsible for Environment and Poverty Reduction, Commission for Science and Technology (COSTECH), Technology Development and Transfer Center of the University of Dar es salaam, Centre for Agricultural Mechanization and Rural Technology (CAMARTEC), Small Industries Development Organization (SIDO) and Vocational Education and Training Authority (VETA), just to mention but a few.

Manufacturers of such technologies such as Jandu Plumbers of Arusha (for hydro rams), TROSS of Arusha (for wind mills), were visited and interviewed to access their capabilities, processes, production costs and problems facing the industry and achievements established.

Beneficiary communities to the wind and ram pump technology users were visited and interviewed. For example, users of windmills in rural Dodoma and Singida regions were visited to assess the pumps that functional or non-functional. Other areas include Kongwa, Kibaigwa, Msagali, Kurio and Manyata in Dodoma region while on the other hand; Makiungu village (A Rural Mission Hospital) was visited in Singida rural. The socio economic differences made by the presence of such systems in selected communities were assessed.

Specific sites employing ram pumps were established in consultation with the sole manufacturer and distributor in Arusha (Jandu plumbers). The survey assessed the advantages and disadvantages of such technologies from user point of view, practical and experienced technical capabilities of the technologies, affordability, and suitability and availability issues. Potential financiers and credit facilities in the country were consulted to establish their willingness and terms for support of such technologies. The gathered information and data was compiled into a draft report as per Terms of Reference provided by AFREPREN/FWD.

List of interviewees in Tanzania

S/N	Name	Institution/ Village	Position	District/ Region
1	Ms. Lenifrida Masanzu	Miyuji South kwa Mwatano	Villager	Dodoma Municipal
2	Mr. Manyahi Benedict	Miyuji South kwa Mwatano	Village water committee chairman	Dodoma Municipal
3	Mr. Elias William Mapuru	Kinangali II	Village	Dodoma rural
	Mr. Juma Nyerere	Kinangali II	Water money collector	Dodoma rural
4	Mr. Soiti Mwaluko	Mautya	Villager	Kongwa/ Dodoma
5	Mrs. Soiti Mwaluko	Mautya	Villager	Kongwa/ Dodoma
6	Ms. B. Mwaluko	Mautya	Villager	Kongwa/ Dodoma
7	Ms. Evelina	Kisigisa Village	Water money collector	Kongwa/ Dodoma
8	Ms. Shida Mgandila	Kisigisa Village	Villager	Kongwa/ Dodoma
9	Mr. Mihinzo T. Chiloloma	Chingali/ Makambini- Kibaigwa	Villager	Kongwa/ Dodoma
10	Mama Magreth	Chingali/ Makambini- Kibaigwa	Villager	Kongwa/ Dodoma
11	Mr. Yona Mlekwa	Chingali/ Makambini- Kibaigwa	Villager	Kongwa/ Dodoma
12	Mama Agnes	Ngurwangombe/ Chang'ombe	Villager	Manyoni/ Singida
13	Mr. Hussein Bakari	Ngurwangombe/ Chang'ombe	Villager	Manyoni/ Singida
14	Mr. Hassan N. Mkmba	Ngurwangombe/ Chang'ombe	Villager	Manyoni/ Singida
15	Mrs. Hassan N. Mkmba	Ngurwangombe/ Chang'ombe	Villager	Manyoni/ Singida
16	Mr. Samwel Michael	Majengo	Villager	Manyoni/ Singida
17	Mr. Emanuel Elias	Majengo	Villager	Manyoni/ Singida
18	Mr. Mlendezi Laban	Kiwanja cha Ndege / Mwembeni B	Water pipe technician	Manyoni/ Singida
19	Mr. Shija Kingwe	Kiwanja cha Ndege / Mwembeni B	Villager	Manyoni/ Singida
20	Mr. Magiga	Kiwanja cha Ndege / Mwembeni B	Villager	Manyoni/ Singida
21	Majengo old man disabled camp	Majengo	Camp Manager	Manyoni/ Singida
22	Dr. A.D. Swai	N/A	District Medical officer	Manyoni/ Singida
23	Dr. Makala	N/A	Assistant District medical officer	Manyoni/ Singida
24	Eng. Lwena	Ministry of Agriculture and Food Security	Irrigation system Engineer	Dar es Salaam
25	Mr. Omary Said	Farm Tools	Sales/Marketing Manager	Dar es Salaam
26	Mr. Charles Sawaya	AfriTool (T) Limited	Managing Director	Dar es salaam
27	Mr. Charles Zakaria	Water Aid	Project Engineer	Dar es salaam
28	Mr. Ernst Doring	GTZ- Water Support	Project engineer	Dar es Salaam
29	Mr. David Songea	Drilling & Dam Construction Agency	Project Manager	Dar es salaam
30	Mr. Salum Chusi	Mechanical Engineer	Ministry of Water and Livestock	Dar es salaam
31	Eng. Ngosi Mwihava	Assistant commissioner for Renewable Energy	Ministry of Energy and Minerals	Dar Es Salaam

S/N	Name	Institution/ Village	Position	District/ Region
32	Mr. Darshi	Sales manager	Jandu Plumbers	Arusha
33	Mr. Steven Kitutu	Managing Director	Tropical Solar Systems	Arusha
34	Ms. Elda Kaaya	Appropriate Energy systems extension officer	Camartec	Arusha
35	Mr. Palangyo	Nshupu Village	Ram pump owner and user	Arusha
36	Mr. Rashid Urio	Nshupu Village	Ram pump owner and User	Usa River, Arusha
37	Mrs. F.A Faraji	Nkoanekoli village (Finca estate)	3 ram pumps owner	Arusha
38	Mr. Shaban	Water Aid Kongwa	District Water Engineer	Kongwa, Dodoma
39	Mr. Zephania Kingunga	Water Aid Kongwa	Assistant District Water Engineer	Kongwa, Dodoma
40	Mr. Abdi Musa	Lay Volunteer International Association	Director	Kongwa, Dodoma
41	Mr. Paulo Braden	Society of the Precious Blood (C.PP.S water project)	Assistant Water Project Manager	Dodoma Municipality

II APPROACH TO THE STUDY IN KENYA

Introduction
Non-electrical Renewable Energy Technologies, especially for irrigation, have been installed in various parts of the country, contributing to development of small-scale irrigation practices amongst farmers. Where they have succeeded, the technologies are helping communities to improve their livelihoods by supplying secure water for domestic use and irrigation, and where they have failed in some areas they are abandoned. The study explores the potential of these technologies to contribute to poverty reduction in Kenya.

In achieving this, the following approach will be used to help gather information and identify gaps that will lead us to develop appropriate policy interventions.

Literature review
The study involved a desktop review of documented information on the subject. Secondary sources of information included the Internet for online journals and peer reviewed articles on the irrigation practices and water pumping technologies in Kenya, government reports (from ministries of energy, water, regional development), reports from international organisations and companies promoting irrigation and water pumping technologies in Kenya (e.g. FAO, IFAD, ITDG, Commercial enterprises).

Fieldwork
The study involved conducting field visits to various parts of the country where the non-electrical RETs have been installed, especially, use of wind and treadle pumps. This involved

- Identifying, visiting and conducting interviews to various companies, firms and organizations involved in the manufacture, assembly and sales of pumps around the country. Through the interviews, technical features of the various wind and treadle pumps were being assessed, and the country distribution of pumps revealed.
- Conducted interviews with stakeholders in water and irrigation issues, such as Ministry of water, irrigation departments, Ministry of Agriculture.
- Identified areas where irrigation practices are immensely carried out and are benefiting local population. The study will assess the driving forces towards use of irrigation practices, technology assessment, socio-economic assessment
- Identified and interviewed 44 farmers using and benefiting from mechanical water pumping devices, especially the treadle pumps. Preliminary visit to the Ministry of water, irrigation board and some companies indicate highest usage of treadle water pumps in Central part of Kenya, western, especially Kisumu, in Machakos, Ngong and in Marsabit (for wind pumps).

Case study development
The case studies were developed based on the analysis of the findings from interviews and documented information on manufacture and use of pumps (successful and unsuccessful use, income generation, environment etc)

Due to time and financial limitations it was not possible to visit most of pumps proposed and users and stockists around the country. ApproTEC has been monitoring use of all its treadle pumps in six cluster areas mentioned. Data from these clusters were analysed further and case study developed from them on potential of these pumps to address poverty in the country. Some of the cluster areas APROTEC had monitored include:

Cluster 1 – Makueni, Machakos, Kitui
Cluster II – Thika, Kiambu, Maragua, Murang'a
Cluster III – Nyeri, Embu, Meru
Cluster IV – Laikipia, Nyandarua, Nakuru
Cluster V - Uasin Gishu, Trans Nzoia

The same was applied to wind pumps manufactured by BHEL in Thika, where information of most wind pumps were sort. BHEL provided information on dealers, stockists, and users of their pumps. Field visits were made to users of wind pumps installed within the reach of Nairobi such as Ngong, Ruiru etc. Most users of wind pumps in the country are dispersed and located in insecure areas (Northern parts of the country) and it was not be possible to visit these areas within the available resources and time

<u>List of interviewees in Kenya - Overview</u>
During the process of collecting data, the research team had interviews with several individuals and asked questions relevant to the study. Some of the key respondents to the interviews were:

- Mr. Fred Omondi of ApproTEC, head of Monitoring Department, ApproTEC
- Mr. Ocharo of ApproTEC, Head of Demonstration section, ApproTEC
- Mr. Mike Harries, Proprietor of BHEL, which manufactures Kijito wind pumps
- Mrs. Mbatia, Engineer at the Ministry of Water- Department of Irrigation and drainage.
- Mr. Mutahi, Department of Agriculture
- Mr. Ondieki, Department of Environmental Engineering-. They gave general views on agriculture and irrigation in Kenya.

Other Interviewees for Treadle pumps (based on ApproTEC's monitoring)

Cluster no. 1

Makueni District

Grace Mbithi
Box 19299, Nairobi
Kibwezi Div., Kasemeni Mkt.

Onesmus Nzeilli
Box 30260
Kilala Mkt

Machakos District

Joseph Mutiso Maoki
Box 369 Mutituni,
Central Div., Mumbuini Loc

Julius Gitau
Box 109 Donyo Sabuk,
Donyo Sabuk Mkt.

Benedit Muinde
Box 56 Ndonyo Sabuk

Mutuku Makao
Box 286 Mutituni
Central Div., Mutituni loc.,

Kitui District

Solomon Wambua Mbuvi
Box 243, Kitui,
Tungutu Sub

Francis Kariuki
Box 57 Kitui,

Cluster no. 2

Thika District

Elijah Kabugu Joshua
Box 592 Thika,
Gatanga Div., Kiumu Vill.

James Mwangi Ng'ang'a
Box 91 Gatura,
Gatanga Div., Kariara Loc.

Joseph Kinyanjui Kimani
Box 87 Thika
Kakuzi Div., Mitumbiri Loc.

Patrick Njoroge Koigi
Box 537 Kalimoni
Ruiru Div., Juja Loc

James Wainaina Gichuhi
Box 1391 Swani
Thika Div., Mitumbiri Loc., Makongeni Mkt.

Francis Mburu
Box 1210 Thika
Gatuanyaga Sub

Kiambu District

Paul Kuria Njoroge
Box 98 Kukuyu
Kamangu Vill.,

Paul Kamau Kuria
Box 130 Kikuyu
Karai Sub Loc

Maragua District
Sebastian Ngugi Ngige
Box 716 Thika
Kandara, Gatura Vill.

Moses Waithaka
Box 301 Thika
Dandara Div., Gaichanjiru

Samson M. Muiruri
Box 53 Sabasaba
Kandara Div., Nguruwe-ini Maria-ini Sub.,

Murang'a District
Maina Kimenderi
Box 177 Kiria-ini
Mathioya Div, Kamune Sub.

Joseph Ndenyeka Ngari
Box 177 Kiria-ini
Mathioya Div, Kamune Sub.

Peter Njoroge Thuna
Box 35 Kangema
Gakira Village

Cluster no. 3

Nyeri District

Joseph Gathuri Kamugo
Box 223 Kiganjo
Kieni East Div., Kabaru Loc.,

Peter Ndirangu Kuruga
Box 46661 Nairobi
Mathira Div, Kiangoma Sub.

Michael Wachira Wamugu
Box 7 Kiganjo
Kieni East, Ndathi Sub Loc.,

Joseph Gathuri Kamugo
Box 223 Kiganjo
Kieni East, Ndathi Sub loc.

Embu District

David Kahuthu Githinji
Box 96 Karurumo
Runyenjes Div., Kiringa Sub

Harun Njeru Ngige
Box 38 Embu
Runyenjes Div., Kanduri Mkt,

Cluster no. 4

Laikipia

Dominic Waweru
Box 537 Nanyuki
Central Div., Matanya Mkt

Mzee Ndovu Wanyonyi
Box 201 Nanyuki
Central Div., Muthaiga Sub

Benjamin Rono
Box 747 Nanyuki
Central Div., Umande Sub Loc.,

Nyandarua

Moses Mwangi Kiarie
Box 46 O. Jororok
Oljororok Div., Gitimu Sub Loc.,

James Kiragu Murage
Box 1345 Nyahururu
Oljororok Div., Oljororok

Simon Kanyingi Muraya
Box 265 Kinamba
Ng'arua Div., Tandare

Nakuru

Gideon Wanyotu
Box 60 Rongai
Rongai Div., Rongai

Lucy Njeri
Box 26 Rongai
Rongai Div., Rongai

Cluster no. 5

Kisumu

Samson Otieno Obila
Box 77 Akala
Kombewa Div., Okuto Mkt

Peter Olima Ayoma
Box 31 Akala
Kombewa Div., Reru Vill

Margaret Maragia

Box 2176 Kisumu
Winam Div., Kajulu Loc., Mamboleo Mkt

Joseph Onyango Hongo
Winam Div., Dago Mkt

Cluster no. 6

Uasin Gishu
Robinson N. Asira
Eldoret town, Elgon View Vill., Behind Hills School

Rebecca Lagat
Box 1179 Eldoret
Soy Div., Sirikwa Sub. Loc.,

Joscah Chelashaw
Box 118 Eldoret
Soy Div., Soy Loc., Merewet Mkt

Trans Nzoia
Joshua Murage
Box 3818 Kitale
Kiminini Div., Kiungani Mkt

Francis O. Owino
Box 48231 Nairobi
Kiminini Div., Mucharage Mkt

Appendix IV: Interview Schedules and Questionnaires

I Checklist of Information Required For both Treadle and Wind Pumps in Kenya

Information about the owner of the pump
- (Name, age, sex, location, level of education, occupation,)
- Water Pump information (Type,
- Source of capital to purchase the pump (Loan, savings, remittance, gift etc)
- Renting of water pumps?
- How the farmer/user came to know of the pump (demonstration, show grounds, from friends/neighbours etc)

Uses of the pump
- How long has the pump been put to use?
- To what use is the pump put to?
- How frequently
- If for irrigation, what kinds of crops are grown? How many seasons per year?
- Without pumps, how do farmers irrigate/source their water

Capacity development
- Have you had any training before using the pumps?
- Knowledge of operating and repairing the pumps
- Where do they go for skills to repair pumps

Sources of water
- Sources of water for pumping (wells, boreholes, rivers etc).
- If source of water is wells and boreholes, how deep are they?
- Are these sources reliable (i.e. availability of water throughout the year)?
- Are there any related costs to water lifting

Sources of labour (family, employees, etc)
- Number of people employed? Wages?

Income from farming
- What was your income before and after acquiring irrigation pumps?
- Investment made from incomes generated through use of the pumps

Impacts of the pumps
- Number of retailers, their sizes/employment levels
- Benefits of using the pumps/ direct and indirect impacts of the pumps on the environment, health, gender and other social relations
- Number of jobs created by every pump, wages paid, who holds these jobs (men and women)
- Who controls additional income generated as a result as a result of improved micro-irrigation?

Pumps manufacturers and entrepreneurs
- Who manufactures the pumps? Where? At what cost?
- Are there any parts/equipments that are imported?
- Have the local skills to manufacture, install and manage pumps been enhanced?
- Number of pumps they can sell
- Profits per pump sold
- How are pumps marketed?
- How the farmer/user came to know of the pump (demonstration, show grounds, from friends/neighbours etc)

Problems and challenges
- Problems faced by entrepreneurs, users, promoters in promotion, manufacture and use of the pumps
- Possible suggestions for improvements

Sample questionnaire for manufacturers, users, dealers and related institutions on windmills and Ram Pumps in Tanzania

Interview/ checklist questions to manufacturers of windmills/ Rams

1. General Information (Name, ownership, age, main product)
2. What products do you produce?
3. When did you start production of windmills/ram pumps?
4. Why did you start production of windmills/ram pumps?
5. How and where did you get the interest to produce windmills/ rams?
6. What is the price of each windmill/ ram pump?
7. Do you have special prices for different group of customers?
8. Where do you sell most of your windmills/ram pumps?
9. What are the frequently reported problems regarding your windmills/ram pumps?
10. What problems do you encounter in manufacturing windmills/ ram pumps?
11. What problems do you face in selling and distribution of your products?
12. What is your average monthly production of windmills/ram pumps?
13. What is your average monthly sell of windmill/ram pumps?
14. Where do you get raw materials?
15. What was your annual average income before starting selling windmill/ram pumps?
16. What is your annual average income after starting selling windmills/ ram pumps?
17. What economic changes have you noticed as a result of the new line in your business (windmills/ram pumps?
18. Are you comfortable with the government policy regarding windmill/ rams production, distribution and use?
19. Do you think the windmill/ram is user friendly?
20. Whom do you think are potential customers of windmills/rams and why?
21. Would you recommend modification of the windmill/rams?
22. Where did you get the money to establish windmill/ram production unit?
23. Do you regret having used your money for starting the business?
24. Do you consider increasing production of windmill/rams and why?
25. What do you think should be done to help more people to own windmills/ ram pumps in rural areas?
26. Do you get subsidies from the government?
27. What do you think should be done to motivate increased production and sell of your windmills/ram pumps?
28. What is your marketing approach?
29. How many units have you sold since the establishment of production?
30. What other technologies compete with yours in Tanzania?
31. Who are the other producers of similar technology?
32. Are you comfortable with the performance and capability of your systems?
33. Any other remarks in relation to your windmill activities?

Interview/ checklist questions to users of windmills / ram pumps

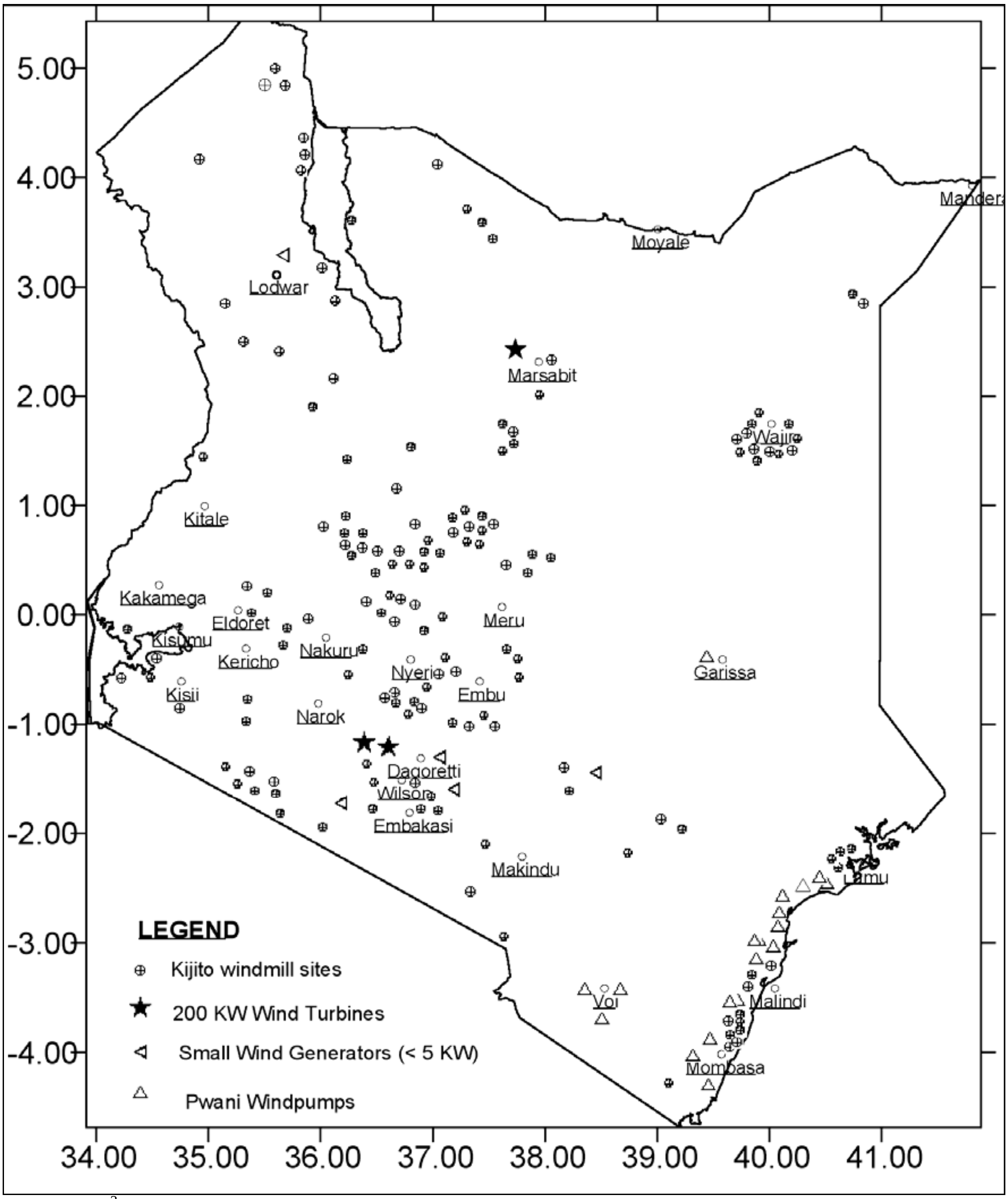
1. General Information (Name, village name, product used, age)
2. How and where did you get interest in windmills / ram pumps?
3. When was the windmill/ ram pump installed?
4. What do you use the windmill/ ram pump for?
5. What was your annual average income/ production before installation of the windmill/ ram?
6. What is your annual average income/production after the installation of the windmill/ ram?
7. What economic changes have you noticed as a result of the installed windmill/ ram pump?
8. Who installed the windmill/ram pump?
9. What are the regular problems of the windmill/ram pump?
10. What problems do you face using the windmill/ram pump?
11. What is the price of installing your system?
12. Who does the maintenance?
13. What are the uses of the water being pumped?
14. What is the average daily water production of windmill/ram?
15. Are you satisfied with the windmill/ram production capabilities?
16. What other uses would you recommend for the windmill/ram?
17. Do you think it is difficult to use the windmill/ram pump?
18. Would you recommend modification of the windmills/ ram pump?
19. Where did you get the money to buy the windmill / ram pump?

20. What other technology you would like to use instead of the windmill/ ram pumps?
21. Do you regret having spent your money to buy the windmill/ ram pump?
22. What do you think should be done to help more people and communities to own windmills/ram pumps in rural areas?
23. What improvement should be done on the windmills/ram pumps?
24. Any other remarks in relation to your pump activities?

Interview/ checklist questions for suppliers of windmills/ ram pumps

1. General Information (Name, Village name, age, main occupation)
2. How and where did you get interest to stock and supply windmill/ rams?
3. When did you start stocking windmill/ rams?
4. How many windmill/rams on average do you source per time?
5. How many windmill /rams have you sold so far?
6. How many units do you sell per month? Types and sizes?
7. What is the price of each complete unit?
8. Where do you source your units?
9. Where do you source other products of your store?
10. Are you comfortable with the distance you are covering to source your units?
11. What other types of pumps do you store?
12. How many customers, on average, do you get in a month?
13. In case of reported problems with the units who does the repair?
14. Are you able to repair the units you are selling?
15. What are the frequent problems of the units?
16. What problems do you face with your business?
17. Do you think it is difficult to get spareparts for your customers?
18. Do you think it is difficult to use the units?
19. Where did you get the money to stock units?
20. Do you regret having used your money to stock windmills/rams?
21. How long did it take you to gather money enough to stock windmills/rams?
22. What do you think should be done to help more people own the units?
23. On average how many people enquire about the units in a week/month?
24. How do you market your pumps?
25. Who are your customers?
26. What other technologies compete with windmill/ram pumps?
27. Who are the other suppliers of windmill/rams in East Africa?
28. What do you think should be done to improve your windmill/ ram business?
29. Any other remarks in relation to your pump activities?

Appendix V: Distribution of Wind Pumps and Wind Generators in Kenya



Source: ESDA[3] 2004

[3] Mutimba S (2004). Energy Services to meet the Millenium Development Goals: Key Issues and Considerations. A workshop presentation during the MDG work held on 29th July 2004, at KSMS.