HELIO International

Sustainable Energy Watch 2007

Improving Energy Resilience in Tanzania

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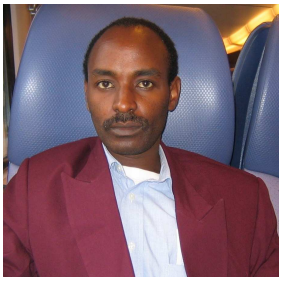
Summary of Report

Rural ecodevelopment is not just a question of addressing poverty but also about facilitating access to education, necessary social services and in particular, energy resources. However, addressing the country's energy needs must be done in the context of helping to increase the country's resiliency to the anticipated impacts of climate change. As climatic patterns alter, the quantity and quality of traditional energy resources will change. The provision of energy services therefore has to be implemented through an interdisciplinary process that addresses the interface between climate change, the provision of energy services and the role and needs of local people.

Author



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Executive Summary

Agriculture is the mainstay Tanzania's economy and currently accounts for 90% of rural incomes. It contributes 50% of the GDP and accounts for 80% of rural employment. State efforts to exploit the country's irrigation potential are minimal due to difficulties in tapping surface and ground water. The country relies on rain fed agriculture, which is prone to weather abnormalities

The energy sector is heavily dependent on wood biomass as its fuel source. Electricity provision is not considered to be a development priority especially in rural areas. Studies have shown that even with rural electrification the impact on income-generating activities among users would remain low. Even if electricity was to be supplied on a 24-hour basis, it is unlikely that there would be a change in usage levels; the predominate reason being that the rural poor do not have the tools and knowledge necessary for effective use. Rural ecodevelopment is then not just a question of addressing poverty but also about facilitating access to education, necessary social services etc. Effective rural development is about helping people overcome their poverty. The provision of energy services therefore has to be implemented through an interdisciplinary process.

Extension of the national grid is the preferred option for most end-users. However as this option is currently unrealistic other alternatives have to be utilised. In general, individual PV systems are most suitable for scattered settlements and can meet the needs for lighting and low-load service-oriented businesses in rural population centres.

In general, a smaller organisation such as a local private company or a co-operative is well placed to handle small-scale energy systems as they are closer to the client and traditionally are able to keep loan defaults low. As a result of government restructuring the national utilities are better equipped today to meet the challenges of a client-oriented approach. However it is unlikely that the private market alone can sufficiently provide the needed energy services. NGOs need to compliment this process by supporting organisations and end-users with awareness raising, training and demonstration and networking activities and research.

In the context of providing modern energy for rural development the challenges for developing a resilient society in Tanzania are two-fold. On one hand, a local anchorage is important for supporting income-generating activities and systems expansion. On the other hand, government financial support is required to fulfil social welfare needs and requirements. It is therefore likely that an organisation with governmental support, but with decentralized structure is the most constructive solution. To sufficiently support local organisations and facilitate the efficient utilisation of technologies, a mechanism is needed to ensure the installation and proper functioning of equipment, such as a second-hand market or leasing system. This could be put in place through a decentralised government institution or an appointed NGO. Either way the Tanzanian government needs to take responsibility for ensuring ecodevelopment and contribute the needed resources to achieve this goal. These contributions include: the regulation of,

and support to private organisations for system management; initiating and running demonstration projects; and, assuring basic social welfare. Furthermore, it is important that government institutions are transparent and that politicisation is avoided. Donors also need to continue contributing via foreign financing.

There are several barriers that inhibit uptake of modern technologies. As a result, the potential for wider use is still unexploited. These barriers include:

- rampant poverty;
- limited policy attention to small resilient energy 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 systems;
- lack of application knowledge; lack of information to potential private companies; and,
- poor management of community schemes.

Poverty is a compelling factor to engage in alternative sources of income-generating activities; it is often exacerbated by absence of reliable alternative employment. However, poverty is also an indicator of increasing population levels and a complex array of factors related to policy and market failures as well as macro-economic factors, most of which are interconnected and synergistic.

Improving income—as well as strengthening social and institutional structures—is an essential precondition to facilitating the mobilisation of resources and labour to overcome capital and technology limitations. Rural electricity cooperatives such as Urambo and Mbinga, private companies like TANWAT, Sao Hill Industries Ltd, Sugar Companies are illustrative that—with the appropriate incentives, legal and regulatory framework in place—it is possible for local private investors to invest in either rural electrification or generation using sustainable resources. This is, therefore, an important option for boosting rural electrification levels, especially for the poor. Financial institutions can finance modest local private power investments. Unfortunately, the terms and conditions of the local financial institutions are major constraining factors on the ability of local investors to mobilise finance locally.

Tanzania's power system master plan was prepared on a least cost approach, where the timing of the next generation of power generation was based on the lowest cost option. Unfortunately renewable energy resources such as solar and biomass co-generation are yet to qualify. However, the draft rural energy master plan currently being prepared is based on the results from studies of various indigenous energy resources including biomass, wind, geothermal, small hydropower, natural gas and solar. Since most of the Sustainable Energy Technologies (SETs) have high upfront costs, it is envisaged that the Rural Energy Fund would buy down such costs so as to ensure viability of SETs. Nevertheless, other resources like wind, geothermal and small hydro need to be thoroughly assessed so as to facilitate their future contribution in the country's energy mix. In addition to the government's efforts, support from industrialised countries is crucial to

securing an increased contribution of SETs in the national energy supply. Promoting incentive structures that encourage efficient resource allocation, market development and consistency of private decision making and community values are particularly important in a ‘change’ environment.

Country Overview: An introduction

Perception and Understanding of Climate Change

In Tanzania, increasing emphasis on environmental issues is seen in the different national and sectoral policies and strategies. Tanzania is also a signatory to the two international conventions: the United Nations Framework Convention on Climate Change (UNFCCC) and the United Nations Convention to Combat Desertification (UNCCD) (Agrawala, et al. 2003, URT-VPO, 2005), illustrating the government's commitment to reforming policies and drawing up plans and strategies to combat local manifestations of these two global phenomena. Unfortunately climate change however is perceived differently in terms of its impacts and is often confused with issues related to desertification.

Climate change is viewed as taking place within a global-scale environmental system, while desertification is often viewed as widely dispersed effects of local environmental degradation. Consequently, different types of measures have been suggested to combat each problem. Desertification mitigation measures have targeted local resource use and livelihoods; climate change remediation efforts have focused on reducing global greenhouse gas through establishment projects based on Kyoto protocol mechanisms (CEEST, 1999). However more attention is gradually being paid to climate adaptation and ameliorating local impacts of climate change and there is a growing awareness that climate measures and desertification measures at the local level increasingly complement each other.

The need to coordinate measures to implement both conventions can be viewed from two perspectives. First, implementation of such measures may affect local welfare. Rural households represent a large majority of Tanzania's population; 80% of the population live in rural areas (Lyimo, 2006, Sawe, 2005, Sawe et al 2003). It follows that enhancing the social and economic viability of these households is crucial for the welfare of a large section of the country's population. Rural households are in many cases the managers of local resources, and their activities are critical with regard to, for example, combating desertification (Eriksen, 2001). The Climate Convention aims at preventing the causes of climate change e.g., emissions, and mitigating the adverse effects of such change. It also recognises the need for humans to adapt to the impacts of climate change and commits Parties to prepare for such adaptation. The Desertification Convention aims both at combating desertification, or dryland degradation, and mitigating adverse effects of drought, with a view to achieving ecodevelopment in selected areas. As long as both conventions are concerned with safeguarding local welfare and resources, their efforts are normally coordinated (Mwandosya, 2006, Muyungi).

Second, in terms of implementation, Tanzania lacks the resources necessary to implement adaptation programs (Muyungi). The need to link the implementation of conventions in order to avoid duplicative or counterproductive measures is better understood but the local-level social context of natural resource management must also be taken into account.

This approach however can create more confusion as the possibility of actions is great, particularly in the light of observed negative consequences –the rapid depletion and degradation of natural resources; loss of biodiversity; higher temperatures; the loss of aquatic life; and, threats to health and livelihoods for the present generation (Agrawala et al,2003).

The question today in Tanzania is no longer whether climate is changing, but rather: what is the anticipated magnitude; how fast in terms of the rate of change; where in terms of the regional patterns; how should the most impacted regions cope with the impacts; and, what should the community do to deal with this catastrophe (Mwandosya, 2006).

It is clear however that if recent trends continue Tanzania will be heavily impacted both socially and economically through changes in water resources, agriculture, fisheries, human settlements, ecological systems—particularly forests and coral reefs—increase in diseases such as malaria and cholera and deteriorating infrastructure, e.g., roads, railways and bridges, destroyed by floods and cyclones. Thus, Tanzania's vulnerability to the impacts of climate change is increasingly becoming a national concern (Mwandosya, 2006).

Actions to Address Climate Change

A number of initiatives have been undertaken and policies, strategies, and programmes put in place to address environmental concerns. These include the National Environmental Policy; the Environment Management Act, 2004; Rural Development Policy; the Agricultural Sector Development Strategy (ASDS), the Tanzania Assistance Strategy (TAS); the National Strategy for Growth and Reduction of Poverty (NSGRP); and the Tanzania Development Vision 2025 (Mwandosya, 2006). For climate change, National Adaptation Programs Actions have been prepared and the climate change focal point is in the process of preparing the second national communication (Muyungi).

The Socio-economic Condition

Tanzania is one of the 49 Least Developed Countries (LDCs). Its population of approximately 34 million is growing at a rate of about 2.8% per year. The annual per capita income averages US$250. The economy, and most of the population, is heavily dependent on agriculture, which accounts for some 50% of GDP and provides about 85% of exports (URT-VPO, 2003). As such, Tanzania's economy is vulnerable to climate change and changes in climatic conditions—notably floods and drought—with some regions being particularly drought-prone. Both the service sector and the informal sector are increasingly becoming important sources of employment.

Promoting and managing balanced growth will mean addressing issues of poverty, equity, resource use and the underlying development constraints. A large percentage of the population lives in poverty. The level of per capita income, health and educational standards, and basic infrastructure are especially low in rural areas.

The main development challenge is widespread and persistent poverty. Currently 48% of the population lives below the basic needs poverty line (Loserin, Sawe, 2005). Poverty in Tanzania is characterized by low income and expenditure, high mortality and morbidity, poor nutritional status, low educational attainment, vulnerability to external shocks and exclusion from economic, social and political processes (Mwandosya, 2006). There are also important regional differences in the levels and specific dimensions of poverty. Those most at risk are young children and youths, the very old, women, those in large households and those involved in subsistence agriculture, livestock production and small-scale fishing (URT-VPO, 2003).

The need to reverse environmental degradation is embodied in UN Millennium Development Goals, number 7 (MDG7) on Environmental Sustainability and related targets including the need to "integrate the principle of sustainable development into country policies and programmes and reverse the loss of environmental resources" (Smith, 2002).

The role of the state in Tanzania has changed dramatically since 1985. After 25 years of centralised state dominance, the government has shifted from being the main engine of growth and provider of services, to facilitating growth, setting standards, and providing essential public services (Lyimo, 2006). Structural adjustment to address economic weaknesses has meant that the government has had to cut back on basic service expenditure. While this re-orientation has been vital it has created considerable challenges for achieving coordinated implementation of new policies and reform programmes. The government has maintained a stable macroeconomic environment for several years, with steady GDP growth, a stable exchange rate and lowering of interest rates and government deficits. The deficit reductions have been managed largely by reducing spending by operating a cash budget and supported by a steady flow of external assistance—over 30% of Tanzania's budget is externally financed. Rates of domestic revenue collection are low and account for 12% of the GDP (Mwihava and Mbise, 2005). The tax base is narrow and there are incidences of tax evasion. Despite the government's economic achievements, poverty in Tanzania still persists.

Energy Policy and its Contribution to Ecodevelopment

With more than 80% of the total population living in rural areas the current energy focus is to use market mechanisms to reach energy objectives and achieve sectoral efficiency while balancing national and commercial interests (MEM, 2003). This policy supports rural energy development by:

- supporting research and development and application of alternative energy in rural areas;
- promoting entrepreneurship and private sector initiatives;
- ensuring continued electrification of rural economic centres and low income customers; and,
- facilitating increased availability of grid and non-grid electrification for rural areas.

There is however no strategic energy policy implementation strategy, although there are emerging strategies to promote affordable and reliable

energy supplies nationwide, enhance ecodevelopment and utilise indigenous and renewable energy resources and technologies. To date, the main activities have been aimed at energy policy implementation including the establishment of Energy and Water Utilities Regulatory Authority (EWURA), the Rural Energy Agency (REA) and the Rural Energy Fund (REF) (Mwihava and Mbise, 2003). The Rural Electrification Master Plan parallels power utility reforms through the restructuring of energy services and establishing an adequate framework to facilitate investment, service expansion, efficient pricing mechanism and other financial incentives. However, appropriate energy laws and regulations are not yet in place, making it difficult to coordinate policy implementation along with other sectors and stakeholders (Sawe, 2005). The government has been advocating the need for energy education and building gender-balanced capacity in energy planning, implementation and monitoring. So far there have been several solar PV market development projects have been implemented under the guidance of the GVEP project (inception: 2005) (Sawe, 2005, Uiso and Mwihava, 2005). The actual extent of the contribution of these energy policies to ecodevelopment is unknown since there is no mechanism for monitoring and evaluating policy implementation. In addition, there is no significant commitment from the government to bridge the gaps between investor/entrepreneur.

Over the years there have been several efforts to improve Tanzania's energy situations through so called "electrification projects". The results have been poor; less than 10% of Tanzanians have access to electricity with only 2% of the rural population having access. The main reason is a weak rural energy infrastructure coupled with inadequate commitment and resources from the government and development partners (Lyimo and Mwakifwamba, 2002, Lyimo, 2006). Financial limitations, lack of rural energy financing mechanism (affordable credits) and an inability to pay for services further compound the problem. One option to offset this lack of access would be to enhance the woodfuels supply through better forest management and afforestration projects to offset growing scarcity (Kaale, 2005). Promoting the use of woodfuels substitutes such as kerosene, biogas, coal, LPG and electricity is another alternative. Other hurdles include:

- inadequate human resources, skills and capacity building as well as facilities for rural energy production and delivery;
- poor private sector participation due to limited rural energy awareness, lack of data and poor market conditions; and,
- policy and institutional limitations, inadequate institutional framework, policies, laws and regulations.

Anticipated Areas of Vulnerability and Associated Consequences

An analysis of recent climate trends reveals that climate change poses significant risks for Tanzania. The sea level is rising, causing salt water intrusion into coastal spring wells. Some of these are now completely abandoned due to sea water contamination which in turn is threatening the availability of fresh water to many poor communities. Maziwe, an island in the Indian Ocean in Pangani district in Tanzania has been submerged from rising sea levels. The gradual, yet dramatic, disappearance of glaciers on Mt. Kilimanjaro is a result of global warming. An estimated 82% of the icecap that crowned the mountain when it was first thoroughly surveyed in 1912 is now gone (Agrawala, 2003). According to recent projections, if recession continues at the present rate, the majority of the glaciers on Mt Kilimanjaro could vanish in the next 15 years (WWF, 2006). The snow and glaciers of Mt Kilimanjaro act as a water tower; several rivers are drying out in the warm season due to the loss of this frozen reservoir. The famous Mount Kilimanjaro ice cap is receding at an alarming rate, threatening tourism and the livelihood of the millions of communities around the mountain and beyond. The rainfall pattern is no longer predictable. There have been serious recurring droughts in recent years including a record drought in 2005 that affected the entire country and triggered a severe power crisis (Mwandosya, 2006).

Water Resources and Availability

Climate change is anticipated to cause variations in rainfall patterns and soil moisture due to changes in mean temperatures. These changes do not occur in any uniform or predictable pattern. In assessing the impacts of climate change on water resources the major factor is rainfall. Changes in precipitation will ultimately affect water availability and may lead to decreased agricultural production and potentially widespread food shortages. Regions with increased precipitation will experience increased runoff. It is anticipated that there will be changes in runoff volume of three major rivers in the country—the Pangani, Ruvu and Rufij. The Ruvu river feeds the Dare s Salaam city while Pangani basin feeds a hydropower station. The upstream Rufiji basin supports several hydropower stations (Agrawala et al, 2003). All three rivers have economic importance for power generation, extraction of drinking water and irrigation (URT-VPO, 2003).

In Tanzania, two of three rivers already have reduced flow due to declining rainfall, which has led to water shortages, lowered agricultural production, increased fungal and insect infestations, decreased biodiversity and variable hydropower production (Orindi and Murray, 2005). High temperatures and reduced rainfall during the dry months in the Tanzanian river catchments could reduce the annual flow to the River Pangani by 6-9% and by 10% in the River Ruvu (URT-VPO, 2003). The Pangani Basin is also fed by the glaciers of Kilimanjaro, which are estimated to disappear completely by 2015 - 2020 (WWF, 2006). The population living around the base of Kilimanjaro uses this meltwater and the fog water from the rainforests that cover the mountain’s flanks for drinking, irrigation, and hydropower. In addition, the Pangani Basin is one of Tanzania’s most agriculturally productive areas and is

an important hydropower production region. Climate change threatens the productivity and sustainability of this region's resources, which hosts an estimated 3.7 million people.

Crop Production

Nutrient leaching, the washing away of topsoil and water logging from increased rainfall will affect plant development, plant growth and yield. Climate change is bound to favour the occurrence of diseases and insect pests due to both increased temperature and rainfall. In response farmers are likely to use more agrochemicals and disease resistant cultivars, which will increase production costs. In general, changes in climate will shift the agro-climatic zones. Area that experience less rainfall will require irrigation; drought resistant varieties will also be required. Irrigation in such conditions is likely to be expensive because of reduced river runoff and the vulnerability of shallow wells, necessitating the development of deep wells (URT-VPO, 2003).

Tanzania is heavily dependent on rain-fed agriculture, making rural livelihoods and food security highly vulnerable to climate variability (IPCC, 2001). Increased variability i.e., deviation from the mean, of crop production is also a major concern to farmers. El Niño events produce abnormally high amounts of precipitation and can result in flooding and decreased agricultural yields. Climate change may also impact the region's fisheries. While many tropical fishes have evolved to survive in very warm water, many have a critical thermal maxima and can not survive temperatures that exceed a certain threshold. For example, spotted tilapia, (Tilapia mariae), native to parts of Africa, prefer temperatures between 25 and 33°C, depending upon acclimation temperature and have a critical thermal maxima of 37°C (WWF, 2006).

Grasslands and Livestock

The impact of global warming on animals is linked to diseases, pests, plant species and related plant distribution and productivity. There are both direct and indirect effects on plant productivity due to an imbalance between rainfall, temperature and evaporation. These variables affect productivity and reproduction in plant species and therefore the composition and distribution of the latter over the landmass.

Moreover, areas that receive low precipitation such as the central and coastal zones of Tanzania do not have good vegetation cover as compared to those areas in the northern, north-western and north-eastern parts of the country which have higher levels of precipitation (URT-VPO, 2003). With the changes in rainfall most of the plant species are in a transient state. In semi-arid areas, plant species are less tolerant and are slowly being replaced by the more drought tolerant species or being replaced completely by other species.

The vulnerability of grassland and livestock to climate change impacts in Tanzania is demonstrated by the change and composition of plant species where the most "palatable" species have been grazed out (URT-VPO,2003,

CEEST, 1994). These are being replaced by more climate tolerant species. In addition the overall carrying capacity of the rangeland is being reduced due to variations in rainfall, temperature and evaporation as temperatures increase. Changes in fodder—quantity, variety, availability—affect cattle's milk and meat production (WWW, 2006). Such conditions coupled with incidences of pests and diseases will force farmers to adjust their grazing habits and management to ensure livestock have enough to graze all year round. If anticipatory adaptive measures are not taken into account early enough the reactive adaptive measures taken by farmers will lead to huge economic losses.

Coastal Resources and Structures

Tanzania's coastline is about 800km long and extends from Kenya in the north to Mozambique in the south (URT-VPO, 2003). The width of the coastline ranges from 20km to 70km, and rises gradually to a plateau. The main features of the coastline are mangrove forests and swamps, corals, seasonal swamps, cliffs, sand and mudflats, rock outcrops, scrubs, palms, tidal marshes, salt works, woodlands, thickets, sisal estates and cashew nuts. The main rivers entering the Indian Ocean from the coastal belt are the Pangani and Umba in the north, the Ruvu and Rufiji Rivers in Dar es Salaam and Coast Regions, and the Matandu and Mbwemkuru and Ruvuma Rivers in the southern coast. The main islands along the coastal belt are Pemba and Unguja to the north and Mafia Island to the south. Other small islands include Mbudya, Pangavini, Bongoyo, Inner and Outer Nyakatombe, Kendwa, and Inner and Outer Sinda. Economic activities in the coastal area include tourism, industry, subsistence agriculture, mining and fisheries. These activities will all be affected by a rise in sea-level (Agrawala et al, 2003). The marine fisheries, which constitute 25 % of the total fisheries catch by weight in the country, would also be reduced (WWF, 2006).

Forestry Resources

Tanzania total land mass is 89 million ha of which approximately 44.5 million ha is forests and woodlands. Of this area, about 1.5 million ha are closed forests and mangroves, and about 43 million ha are open woodlands. Plantations occupy about 0.15 million ha (Kaale, 2005). The dominant vegetation type in Tanzania is woodland—subtropical dry forest—which covers 78.8 % of the total land; the remainder consists of forests—subtropical moist forest—bush-land, grasslands and thickets e.g., subtropical thorn woodland (URT-VPO, 2003). Climate change may alter vegetation. For example, subtropical dry forest and subtropical moist forest life zone classes will likely change, to tropical very dry forest, tropical dry forest and tropical moist forest. Studies indicate that the subtropical thorn woodland currently in existence will be completely replaced. Subtropical dry forest and subtropical moist forest are anticipated to decline by 61.4% and 64.3% respectively (URT-VPO, 2003). There will be an increase in tropical very dry forest, tropical dry forest and tropical moist forest, which are likely to replace the existing ecological zones.

Wildlife and Biodiversity

Tanzania has the highest number of habitats in sub-Saharan Africa the most prevalent being the miombo woodlands, Acacia-dominated savannas and woodlands, Acacia-comiphora thornbush, coastal forest, moist savannah/forest mosaic and montane forest. Tanzania's protected areas cover 38 % of the total land area (URT-VPO, 2003). These areas are interspersed within 19 broad habitats that support over 40 million ungulates. Wildlife contributes about 12 % to the GDP and supplies more than 50% of the meat consumed by the communities in surrounding areas (URT-VPO, 2003).

Tanzania's National Parks are areas designated for tourism, site seeing, camping and photographing. They also act as buffer zones for human activities and licensed hunting. Some of Africa's endangered species are found in Tanzania; these include the wild dog, the black rhinoceros, the African elephant and the Nile crocodile. Weather extremes can also affect biodiversity in complex ways. For example, in African elephants (Loxodonta africana), breeding is year-round, but dominant males mate in the wet season and subordinate males breed in the dry season (WWF, 2006). A change in the intensity or duration of the rainy versus drought seasons could change relative breeding rates and, hence, genetic structures in these populations (WWF, 2006). Productive mangrove ecosystems along coastal areas serve as a buffer against storm surges by providing protection from erosion and rising tides associated with sea-level rise. However, mangroves are at threat from deforestation, coastal erosion and extreme weather and have been identified as the most vulnerable species to sea-level rise and inundation (IPCC, 2001).

Health Sector

Malaria is the major public health problem in the country. Malaria, together with prenatal mortality and AIDS are the three largest causes of mortality. According to data, malaria accounts for 16.67 % of all reported deaths in Tanzania while prenatal mortality accounts for 13.34 %. Malaria is also one of the leading causes of morbidity in all regions of Tanzania which ranges from 24.4 % to 48.9 % (URT-VPO, 2003).

Malaria transmission occurs throughout the year and is increases with high temperatures and humidity; the peak transmission occurring after the rainy season. Climatic factors effect the life-cycle of mosquitoes and thus also on controlling them. Low coastal belts and the lake shores have the highest transmission rates. Recently malaria has been observed in high altitude areas like Kilimanjaro and Arusha (the north eastern zone) and in Iringa (the southern highlands) (Agrawala et al, 2003).

The malaria vectors found in Tanzania are Anopheles spp, and species of malaria parasites is Plasmodium falciparum, The mosquito vector survives best between 12C and 35C with the optimum survival conditions being between 25C to 30C and with a relative humidity of 60% (URT-VPO, 2003). Climate change is expected to affect the ecology of malaria in a given

geographical location, and among the climate, human and mosquito subsystems. Climate change will most likely lead to an increase in incidences of malaria diseases across the country (Mwandosya, 2006). The costs of malaria control would increase depending on vector resistance and their distribution.

Climate variability and extreme weather events, such as high temperatures and intense rainfall events, are critical factors in initiating malaria epidemics especially in the highlands of Tanzania (WWF, 2006). While other factors, such as topography and health preparedness can influence the spread of malaria, scientists have found a correlation between rainfall, unusually high maximum temperatures and the number of malaria cases (URT-VPO, 2003). In addition to longer seasons that favour the spread of malaria, temperatures have also been warming in formerly cooler, higher-elevation areas. The result is that populations in these higher elevations which had not been previously exposed to the disease are now experiencing a rise in incidence.

Socio-economic Repercussions

Tanzania's vulnerability to the impacts of climate change is becoming a national concern. Extreme weather events negatively impact agriculture. Infrastructure such as roads, railways and bridges is destroyed by floods and cyclones. The economy grew by 6.9% and 5.9% in 2005 and 2006 respectively (Mwandosya, 2006). This decline in growth is attributed to the drought—a climate related phenomenon—that the country suffered. Tanzania's environmental resources are the chief source of people's livelihoods and are the backbone of the country's main productive sectors, e.g., agriculture, tourism, fisheries, forestry and water. The economy and the very survival of the majority of communities—as in many Least Developed Countries (LDCs)—depend on such climate sensitive sectors.

Impacts on Energy Systems

Tanzania has abundant and diverse indigenous energy resources that have not been adequately tapped. These sources include: wood fuel and other biomass-fuels, hydro-power, natural gas, coal, uranium, wind, geothermal and solar (MEM 2003).

Electricity generation, transmission and distribution in Tanzania are provided by the Tanzania Electric Supply Company (TANESCO). The company is 100% government-owned and is responsible for 98% of the country's electricity supply (Mwihava and Mbise, 2003). The country's new energy policy allows independent power producers to generate electricity from different sources including new and renewable sources of energy, particularly for the rural population.[1] Petroleum, hydropower and coal are the major source of commercial energy in the country. The biomass energy resource—which comprises fuel-wood and charcoal from both natural forest and plantations—accounts for 92 % of total energy consumption. The electricity sub sector

[1] About 80% of the population lives in the rural areas where energy requirements are mostly met by wood fuel, resulting in deforestation and land degradation (Sawe, 2005, Kaale, 2005).

contributes about 0.6 % of total energy consumption. Over 50% of Tanzania's installed capacity is hydro powered (Lyimo, 2006).

Droughts have had severe effects on the electrical power supply as was witnessed in 2006. Blackouts and power rationing as a result of low water levels in the hydro dams have forced TANESCO to rely on gas-powered generators and to look increasingly at thermal and gas projects for future capacity increases. Only a few parts of the country—mainly urban areas—are connected to the national grid.[2] Tanzania has a per capita electricity consumption of 46 kWh per annum, which is growing at an estimated rate of 11-13 % (Lyimo, 2006). Hence, the government is encouraging investment to expand generating capacity, distribution systems and developing indigenous sources of energy.

Renewable energy technologies currently in use in Tanzania include: photovoltaic (PV) equipments, solar thermal, wind pumps and biogas. Quantitatively, the contribution of new and renewable sources of energy (NRSE) in Tanzania is estimated to be about 1.2 MW and is used mainly used in the telecommunication sector (ECON 2004).

Impacts on the Population

Energy is considered essential to achieving both the MDGs and NSGRP objectives especially where human physical power is the main source of energy as in agriculture and transport in rural areas. The poor spend more than 35% of their household income on energy, while the better off spend about 14.45% (Smith, 2002, Sawe, 2005).

Climate change will have major implications for Tanzania's policies of development and environmental management. Some scientific studies and findings on climate change indicate that Tanzania is likely to suffer significant physical and socio-economic impacts. Primary sectors, such as agriculture and forestry, will experience greater impacts than secondary and tertiary sectors, such as manufacturing and retailing.

[2] An estimated 8,200 villages were supplied with electricity to curb deforestation and ensure sustainable development and poverty eradication (Karekezi et al, 2005).

Country Assets Likely to Reinforce Resilience and Adaptation

The key sectors that can reinforce resilience and support adaptation measures are described below:

Agriculture sector
In areas where rainfall would be reduced and where temperatures would rise, there would be a shortening of the growth period. Increase in the precipitation, would lead to the leaching of nutrients, soil erosion (especially in upland areas) and water logging. The changes in rainfall and temperature will affect both crop and livestock production. Farmers would need to adapt to these changes (URT-VPO, 2003). The adaptation measures for crop production mainly involve in land use and management related changes. Changes in land use involve changes in farmed area, in the crop type to suit the changes in climate conditions and in crop location. Changes in management will require the introduction of the irrigation system and different crop cultivars, improved manure/fertiliser use, control of pests, weeds and diseases, change in planting dates and efficient use and interpretation of climate and weather data.

In areas where rainfall has decreased there will be a need to grow drought resistant crops; to introduce crop varieties whose maturities varies widely and which have climate tolerance, provide irrigation to supplement moisture precipitation (URT-VPO, 2003). The application of minimum and reduced tillage technologies, the planting of cover crops and green manure crops to restore nutrient loss, mulching to reduce evaporation and improve water retention are other methods that can be employed to offset impacts. Current traditional irrigation schemes will require substantial improvement to reduce water loss by evaporation and infiltration. In addition, food programmes should be in place to provide insurance against local food supply changes due to anticipated crop failure.

Industrial Sector
Tanzania's industry is dominated by simple consumer goods and agricultural processing for export. During the post-independence economy, the government adopted the Basic Industry Strategy (BIS) (Mwihava and Mbise, 2005) to enhance local value-added goods by exploiting the local resource base for raw materials and to produce intermediate and capital goods. The implementation of the ambitious BIS was limited by investment resource constraints and poor infrastructure support as most of the industries were publicly owned (parastatal). Based on the lessons learnt from the unsuccessful BIS the government embarked on an economic reform programme specifically for the manufacturing sector. The sector was subjected to trade liberalisation and demand-restraint measures. The result was the transformation of existing industrial policies and the favouring of the private sector which collectively led to a strong, diversified and resilient industrial sector. By late 1980s, through increased production efficiency and capacity utilisation of the existing industries, the private sector was responsible for virtually all goods production for both the local and foreign

markets. New industries were also established through this privatisation process.

The change in policy to involve private sector has benefited the industrial sector and the overall economy. Many of the major manufacturing industries have increased the use of domestically available materials and expanded employment opportunities. The government remains as the regulator and ensures that the industrial sector explores potential opportunities to increase and diversify the sources of export earnings, ensuring the best use of resources towards potentially efficient enterprise and protects the environment from industrial pollution. The government also promotes technology research and development through the use of established research centres. To date most of the industries are established in major towns and cities where infrastructure is relatively developed compared to rural areas—where the raw materials are obtained. A proper policy environment has to be put in place in order to achieve and promote small-scale and medium scale industries for the purposes of increasing industrial output, employment generation, sectoral linkages and rural industrial development (Mwanyika, 2005).

Energy Services

The availability and reliability of energy services is a prerequisite for the proper functioning and development of all other sectors of the economy. To develop reliable, economically accessible and appropriately priced energy supplies that facilitate the development of other activities in the economy, it is necessary to establish an efficient energy production system. This system must take into account procurement, transportation, distribution and the end-users in a manner that is environmentally sound manner and takes into consider gender issues (MEM, 2003, Sawe, 2005). To satisfy the energy demand of all economic sectors of the economy may require the government to develop indigenous sources of energy such as natural gas, coal, solar, wind, geothermal, hydropower and biomass fuels to augment or substitute imported petroleum products (Kaale, 2005, Mwihava and Mbise, 2003, MEM, 2003).

Successful adaptation will require improved availability, reliability and security of energy supply through the rehabilitation of the existing energy systems and the expansion of the power generation and distribution capacity. The development of indigenous sources requires further exploration, exploitation, capacity building by training, research and development of technologies, and strengthening of energy information systems. This goes in hand with improvement of efficiency in energy chains including tariffs, management, maintenance and training. The government should promote and disseminate affordable technologies through the demonstration of efficient technologies, rural electrification and decentralized energy systems and encouraging the participation of the private sector, Non Governmental Organizations (NGOs) and Community Based Organizations (CBOs).

Transport Sector

The transport sector provides vital spatial and sectoral links in the economy and facilitates trade with other land-locked countries in the region. This sector—despite covering road, air, rail and water transport—does not

currently provide an extensive and efficient transport system internally or externally although the transport policy does provide an outline on how efficient and effective domestic and international transport services should be. Maximising both foreign and local revenue generation for the transport sector, and minimising transport–related environmental hazards need to be priorities.

The role of the government is limited to policy formulation, monitoring and evaluation hence major players are parastatals and the private sector (URT-VPO, 2003). However since parastatals are 100% government-owned it is difficult for the private sector to participate. Improving rural and urban transport needs major improvement so as to benefit welfare of the population as well as to encourage private sector investments. Domestic and foreign investments coupled with regional cooperation can help promote the adoption of new and emerging technologies.

Existing Institutions

To reinforce resilience and adaptation measures several institutions need to be in place. Coordination of these can be achieved through the responsible ministries collaborating with various stakeholders. The stakeholders include the power and petroleum industries, Ministries of Finance, Industries & Trade, Health, Natural Resources, Environment, Education, Science & Technology, R&D institutions, consulting firms, NGOs, CBOs and the donor community. The 1997 National Environmental Policy particularly stressed the need for formulating environmental legislation and sectoral legislation in a multi-sectoral fashion. Thus the legislation should set out standards and procedures, duties and limits, and create obligations for all stakeholders that are in-line with human activities and govern resources sustainably. There exist a number of sectoral-related educational and research centres for example Forestry, Wildlife, Fisheries, Engineering, Finance, Mining, Energy, Water, Lands, Local Authorities and Urban Authorities; there are more than 150 registered Community Based Organisations (CBO) and non-Governmental Organisations (NGOS) (URT-VPO, 2003). The challenge is to have as much participation by the private sector and individuals in the process. Furthermore, the government should use its influence in collaborating institutions and agencies such as CBOs / NGOs to implement various programmes both in rural and urban areas. The media—radio, TV, press, newspaper—has played a significant role in sensitising the public and undertaking various education programmes on environmental issues thereby cultivating public / private interest, commitment and awareness on environmental management and conservation aspects.

National Mode of Resilience

The national mode of resilience must be in-line with the major economic sectors that are potentially vulnerable to the climate change. These sectors are compared under two scenarios: moderate global warming—equivalent to the goal of maximum warming of 2C—and the maximum resilience that follows requirements of the precautionary principle. The economic sectors that will be experience the greatest impact are agriculture, forestry, energy, industry, health, transport and ecosystem. It should be noted that the country mode of resilience will depend on the capacity to share information.

Table 1: Comparative Description of the National Mode of Resilience

Criteria/Issues	National mode of resilience	Moderate Climate Warming	Maximum Resilience
Agriculture, water availability	Irrigation and short term crop rotation, use of mature, plant drought resistant crops, establish food security fund.	Large-scale infrastructure development e.g., dams, irrigation, and water management facilities	Distribute climate data to farmers regarding seasonal climate forecast
Forests	Planting new and fast growing forests to reduce deforestation, replant the harvested forests	Planning for long-term demographic and consumption transition	Build the capacity of the natural resource managers to assess vulnerability and adapt management responsive strategies
Health	Campaigns on health issues, establish health centres	Urban planning and zoning to avoid climate-related hazards	Involve communities at grass root level to plan and make decisions on responsive measures
Ecosystem and Biodiversity	Protection of the ecosystem through policies and plans	Policies and plans for natural areas and ecosystem conservation	Integrate climate change into management and improve resource use technologies

Increasing Resilience and Ensuring a Good Quality of Life

Pre-conditions for Successful Sustainable Energy Investments

Due to social, cultural and economical issues providing rural access to sustainable energy sources is challenging. Integrated rural development should be the overall priority in meeting the energy challenge. The need for rural energy needs and required investment should be established in which multi and cross-sectoral cooperation is a central component (Karekezi et al, 2005). Based on the level of development of a particular location, greater efforts should spent on increasing investments from government, private sector and development partners. Policy formulation process and supportive implementation instruments should be in place and enforced. Efforts should be made to promote local energy institutions and entrepreneurs and on developing effective financial and technical delivery mechanism.

A special effort needs to be made to establish appropriate policy and regulations for the combined use of various sustainable energy technologies, depending on the preferences and energy needs. The success of the above pre-conditions is subject to the level of involvement of the local people in all stages from the designing to the implementing of sustainable energy investments.

Implementation of Institutional Measures
The national energy, forest, environment and science and technology policies recognise the essential links between sustainable development and sound environmental management. They provide statements on climate change mitigation and measures on what should be done in order to meet the minimum technological and behavioural requirements of sustainable development (Mwihava and Mbise, 2005).

Recognising the importance of energy in the development process, Tanzania's energy policy intends to ensure the availability of reliable and affordable energy supplies and their use in a rational and sustainable manner in order to support national development goals (MEM, 2003). It further calls for the establishment of an efficient energy production, procurement, transportation, distribution and end-use systems in an environmentally sound and sustainable manner, this includes developing appropriate institutional arrangements.

In order to operationalise the energy policy, a Rural Energy Agency (REA) and Rural Energy Fund (REF) are being established. The Rural Energy Act of 2005 was passed; arrangements to physically establish the REA and REF are at advanced stage. Environmentally sound energy technologies are key candidates for promotion under REA and REF (Mwandosya, 2006).

Possible Economic and Fiscal Instruments

Economic instruments are incentive systems that are flexible and provide a better understanding of the significance of the people's behaviour and response to different market signals. Economic incentives to influence people's behaviour to achieve social objectives in the most cost-effective manner include tax breaks, subsidies, dispatching preferences, generation capacity, etc. Economic instruments help internalise environmental degradation and resource depletion costs in a flexible and efficient way (Sawe, 2005). The objective of internalisation is to alter behaviour by reducing the incentives for environmentally harmful activities and enhancing the incentives for environmentally preferable activities.

Tanzania's national budget for fiscal year 2006/2007 has been dubbed as a 'green budget' especially on energy sector. The government budget has the following components (Mwandosya, 2006):

- Exemption from Value Added Tax (VAT) Liquefied Petroleum Gas (LPG) and LPG cylinders to encourage the use of gas as an alternative source of energy instead of charcoal and firewood with a view to preserving our environment;
- Reduction of the excise duty rate on kerosene (IK) from shillings 122 per litre to shillings 52 per litre to encourage the use of kerosene as an alternative source of energy instead of charcoal and firewood with a view to preserving the environment;
- Increase of excise duty rates on plastic bags not banned, from the current rate of 15% to 120% with a view to protecting the environment;
- Imposition of an excise duty of 20% on imported used non-utility motor vehicles aged 10 years or more;
- Elimination of import duty on gas cylinders in order to promote the use of gas and protect environment;
- Exemption of all solar powered equipment and specialized accessories from import duty. The aim is to promote the use of alternative sources of energy given the current energy crisis; and,
- Reduction of the duty rate on energy saving bulbs to zero percent. The measure is aimed at reducing the consumption and cost of electricity.

Since 1999 there have been attractive financial terms for potential investors to develop the country's vast renewable energy resources (URT-VPO, 2003). Procedures for investing in solar, wind and micro-hydro projects have been simplified and include a 100% depreciation allowance in the first year of operation, exemption from excise duty and sales tax and concessionary customs duty on the first import of materials used in renewable energy projects (Mwihava and Mbise, 2005). In addition, extensive guarantees are provided to investors under the investment promotion centres certificate of approval. Such guarantees are ownership of properties, dispensation of assets, and repatriation of income (URT-VPO, 2003).

Finance is a vital component for a successful implementation of any rural energy strategy. To adequately mobilise finance to achieve the goal of any rural energy strategy should be a priority task of all stakeholders, although the rural sector may not easily attract the private sector (Sawe et al, 2003). Considering the importance of ecodevelopment to ensure good quality of life for all Tanzanians, the government, NGOs, private sector should scale up

efforts to mobilise adequate financial resources to effectively implement a sustainable rural energy strategy. In the energy sector for example the government's efforts to establish REFs are commendable. As the bulk of modern technologies are widely unknown to the majority of the population, appropriate a limited number of "smart" subsidies could be provided to support the implementation of such technologies until they become better well-known and affordability has improved. The government, in collaboration with NGOs, should continue to support selected rural energy initiatives by strengthening energy extension services. When the users and the business community have embraced the technologies, gradual withdrawal of the government and NGOs support along with increased contribution from the rural beneficiaries and the business community should be promoted. Local financial institutions e.g., banks, Savings and Credit Cooperative Societies (SACCOS) and leasing and credit schemes, need to increase their roles in social and economic development and be urged to fund the implementation of adaptive programs by providing affordable soft loans. Technical and financial assistance programmes should be initiated hand-in-hand with a "bottom-up" approach. This should be further support by donor community and other appropriate multilateral and bilateral organizations to assist the Government, NGOs, private sector in effective implementation of any rural energy strategy.

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