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Community-based Environmental Resource Management Systems for Sustainable Livelihood and Climate Change Adaptation: A Review of Best Practices in Africa

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ABSTRACT The study used secondary sources to review best practices in community-based environmental resource management systems for sustainable livelihood and climate change adaptation in Africa. The best practices were drawn from different parts of the continent. They included water, community/school gardens for food security and renewable energy projects. They demonstrated the importance of putting all knowledge systems including indigenous knowledge on an equal footing to expand the global pool of knowledge. This holistic approach of indigenous knowledge systems (IKS) is in line with the African philosophy of Ubuntu which emphasizes the symbiotic relationship between humans and other forms of life. The paper recommends the importance of interfacing knowledge systems to produce sustainable strategies and best practices for community-based environmental resource management systems.

INTRODUCTION

There is a growing realization among scholars that just as world resources are used globally, knowledge systems should also be placed on the same plain of significance in order to expand the global knowledge base where all human beings can meet the challenges of achieving sustainability, climate change adaptability, food security, health, and poverty eradication and political stability (Illen and Thomas 2000; Claire et al. 2008).

In the context of this discussion community-based environmental resource management refers to the interaction between the community human practices and the natural environment. It tries to identify factors affected by conflicts that rise between meeting needs and protecting resources, both biotic and abiotic (Bogan and English 1994; Nash and Ehrenfeld 1997). It also involves the relationships of the human environment, such as the social, cultural and economic environment with the biophysical environment (Bhaduri 2005). The issue of environmental resource management is of increasing concern globally, as reflected in the Brundtland Commission's *Our Common Future* which highlighted the integrated nature of environment and international development. This is due to the realization that the environment determines the nature of every object around the sphere, i.e. the behaviour, type of religion, culture and economic practices (World Commission on Environment and Development 1987). This holistic approach to community-based environmental resource management is in line with the African *Ubuntu* philosophy which emphasizes the symbiotic relationship between human practices and other forms of life in environmental natural resource management (Flippin Jr. 2014).

This paper presents examples of best practices in community-based environmental resource management systems for sustainable livelihood and climate change adaptation. A best practice refers to a method or technique that has consistently shown results superior to those achieved with other means, and that is used as a benchmark (Andean Watersheds Project 2003). In the context of this discussion, a best practice in the context of the interface between indigenous and modern technological systems, refers to examples and cases that illustrate the good utilization of indigenous knowledge and modern technologies in the development of cost-effective and sustainable survival strategies for sustainable livelihood and climate change adaptation. In the collecting of data for this discussion the study was not interested in the details of the indigenous or modern knowledge itself, but in the ways in which that knowledge has been adapted and applied to promote sustainable community livelihood and development (Bretschneider et al. 2005).

METHODOLOGY

The study used secondary sources to provide examples of best practices on community-based environmental resource management systems for sustainable development and climate change adaptation in Africa. Secondary sources used in this study included relevant past research reports, textbooks and journal reports. The major advantages of using secondary data in this study were that they are economical as data were less costly and less time-consuming than collecting primary data (Tonkiss and Seale 2004).

RESULTS AND DISCUSSION

Community-based Knowledge in School Water and Storm Water Projects

Various schools and local communities in countries such as Kenya, Tanzania, Zimbabwe, Nigeria, Senegal, Ethiopia, Zambia and Malawi are involved in using community-based knowledge systems to identify areas of water wastage and devise ways of minimizing the waste to meet changing climatic conditions. In the Tanga Region, Tanzania, for example, some secondary schools are reducing water use by incorporating rainwater tanks for gardening activities or using rainwater for flushing toilets. A rainwater tank provides a tool for learners to learn about water management issues and allows them to be involved in planning the size, location and uses of a tank. Kagusa (2011) shows that learners and teachers in these schools were conscious of the amount of water leaving the school grounds through storm water drains and how this affects the local catchment. As part of a storm water audit learners were able to collect information on the quality and quantity of water that leaves the school site and create a storm water management plan to improve the quality of local waterways. The teachers had the view that using a creek or wetland near the school learners could devise simple water monitoring programmes on how these ecosystems are changing over time. By monitoring water quality learners could identify emerging catchment issues and see whether activities to protect and restore waterways are having the desired effect.

These projects provide best practices because they assist to raise knowledge and awareness of teachers and learners about water conservation. Senior learners were engaged in measuring and analyzing the impact of the rainwater tank on school water usage, while all learners demonstrated awareness of leaking taps and cisterns and the need to report these promptly. The water conservation project was part of a broader sustainability program in which learners, teachers and local community members were involved in activities to highlight the importance of water and environmental conservation practices using community-based knowledge systems.

Indigenous Flora and Fauna Habitat Conservation Projects

The incorporation of indigenous gardens into the school grounds and community parks provides useful habitat for a variety of indigenous flora and fauna species. These places around the school can provide learners with opportunities to learn about flora and fauna habitat and their conservation. Salim (2010) provides examples from two secondary schools in the South Coast of Kenya as discussed below.

In collaboration with local knowledge holders and practitioners, the staff and learners of the two schools in Msambweni in the South Coast of Kenya have created a 'safe house' for indigenous fauna within their school grounds by protecting existing palm like cycad trees and increasing habitat areas through replanting. Cycads display a number of important biotic interactions, particularly in pollination, seed dispersal, and the acquiring of nitrogen nutrients. The seeds of cycads are quite large, and are often brightly colored; red, purple, and yellow seeds are common. These colorful seeds are displayed as the cone matures and the seed-bearing leaves separate from each other; the colors attract birds and a variety of mammals which disperse the seeds.

The learners get knowledge and experience on the needs of the local community through class research. With assistance from the community leaders, knowledge holders and the Ministry of Agriculture and Environment, they set about identifying, mapping and labeling significant cycad habitat trees within the school grounds. Overlaying recorded flora and fauna sightings on the map helped the learners determine which areas of the school would benefit the most from new tree plantings. Part of the project involved designing changes to the school playground to support the plant population. One tree in particular provided a home to several birds over the years. Learners had established a playground in the school where equipment such as, climbing poles and a sandpit had been constructed using natural materials. A wooden deck provides an area for sitting, reading or games which will not disturb the birds. Learners with the assistance of parents and other knowledge holders in the local communities had learned what to do if they see a sick or injured bird. Forty square metres of new habitat was planted with tube stock, and learners were actively involved in the planting, mulching and monitoring of the new plants. Learners were communicating the outcomes of the project through social media which provided information about the status of the local bird population.

Best Practice Indigenous Food Gardens

One way of promoting indigenous knowledge in schools is through involving learners and teachers in indigenous food gardens. Pitso (2012) demonstrates that indigenous food gardens are an ideal way for children to develop indigenous knowledge and practical skills in community-based knowledge garden maintenance, environmental monitoring, organic recycling and food production. They also provide the opportunity to promote healthy eating and a sustainable lifestyle. Practical activities in designing, creating, growing and harvesting from indigenous food gardens using the knowledge of community knowledge holders and practitioners can be linked to a wide range of curriculum areas including science, arts, literacy, and numeracy. It also helps to mitigate the contradiction between the school and the local community by integrating community experience into the classroom knowledge using local language. He provides an example of a best practice of the school garden below from Sannieshof in North-West Province, South Africa:

Sannieshof High School (North-West Province, South Africa) - *We dig our Veggie Garden*

The students of Modimolle High School, North-West Province (South Africa) are enjoying the benefits of their school garden which they designed and constructed in collaboration with community knowledge holders and practitioners. They do not have to buy food during lunch. They harvest vegetables and buy other food items from the proceeds of selling their school garden products. The project also allowed learners from all years to learn about the environment, sustainable ecosystems, food production and nutrition through a combination of classroom, garden activities and knowledge of community knowledge holders and practitioners. They learn the names of the indigenous vegetables in the Setswana local language and biological names from their science classes. The garden includes compost bins, a worm farm and a water tank, so that all of the water, fertilizer and mulch needed to maintain the garden are available on the school site. Once the produce is harvested the children enjoy the fruits of their labor by learning how to cook with their vegetables. The students have turned their vegetables into nutritious sauces, salads, pastas, and bread, helping them to understand the food cycle from production through to consumption. In collaboration with their science teachers, and community knowledge holders, the learners have gained practical skills in seed harvesting, soil maintenance, water conservation, crop rotation and harvesting of produce. Learners have also learned about organic methods of pest control using garlic, chilli, soap flakes and herbal infusions, etc.

Community-based Knowledge, Renewable and Alternative Energy Sources and Uses in Africa

Renewable energy projects in various African countries have demonstrated that renewable energy sources can directly contribute to poverty alleviation by providing the energy needed for sustainable livelihood including job creation (World Health Organization (WHO) 2005). They also provide energy for cooking, heating, and lighting in homes and schools. This helps to reduce the time that women and children spend out of school collecting firewood (Williams 2001). In addition, the replacement of traditional fuels such as firewood reduces the health problems from indoor air pollution produced by burning those fuels (Karekezi 2002; Skelton et al. 1999). In the context of this discussion renewable and alternative energy refers to energy coming from resources which are naturally replenished such as sunlight, wind, rain, tides, waves and geothermal heat. Renewable energy can be a particularly suitable for the poor in Africa because in the rural and remote areas, transmission and distribution of energy generated from fossil fuels can be difficult and expensive. Renewable energy sources are community-based, hence more accessible and affordable. Therefore, producing renewable energy locally can offer a viable alternative. They replace conventional fuels in the following ways: electricity generation, air and water heating/cooling, motor fuels and rural energy services (World Bank 2005; Omar et al. 2014).

UK Department for International Development (DFID) (2002) stipulates that most African countries are popular locations for the application of renewable energy technology. They already have small-scale solar, wind, and geothermal devices in operation providing energy to urban and rural populations. These types of energy production are especially useful in remote locations because of the excessive cost of transporting electricity from large-scale power plants. The application of renewable energy technology has the potential to alleviate many of the problems that face Africans every day, especially if done so in a sustainable manner that prioritizes human rights and involvement of community energy experiences and knowledge systems.

Examples of Best Practices of Use of Renewable and Alternative Energy Sources in Africa

The Global Environment Facility (2001) shows that large-scale solar power facilities are under development in various countries in Africa including projects in South Africa. World Bank (2005) indicates that although solar power technology has the potential to supply energy to large numbers of people, and has been used to generate power on a large scale in developed nations, its greatest potential in Africa may be to provide power on a smaller scale and to use this energy to help with day-to-day needs such as small-scale electrification, desalination, water pumping and water purification.

Examples of utility-scale solar farms in Africa include the 8.5MW plant at Agahozo-Shalom Youth Village, in the Ramayana District, Eastern Province of Rwanda. It leased 20 hectares (49 acres) of land from the village which is a charity to house and educate Rwandan victims. The plant uses 28,360 photovoltaic panels and produces 6 percent of total electrical supply of the country. The project was built with U.S., Israeli, Dutch, Norwegian, Finnish and UK funding and expertise. There are also several cases of small grid-linked solar power stations such as photovoltaic 250 kW Kigali Solaire station in Rwanda. Under the South Africa Renewable Energy Independent Power Producer Procurement Program, several projects have been developed, including the 96MW (DC) Jasper Solar Energy Project, the 75MW (DC) Lesedi PV project, and the 75MW (DC) Letsatsi PV Project, all developed by the American company Solar Reserve and completed in 2014 (Omar 2014).

In West Africa, there is Power Up Gambia, a non-profit operating in the Gambia. It uses solar power technology to provide power to Gambian health care facilities, providing a reliable source of electricity for lighting, diagnostic testing, treatments, and water pumping. In Sierra Leone is the Energy for Opportunity (EFO). It uses solar power for Schools, Health Clinics and Community Charging Stations, as well as teaches Photovoltaic installation classes at local technical institutes. In particular its solar powered Community Charging Stations have been recognized as an innovative model to provide electricity to rural communities in the West African region.

Solar Water Pumping

The Global Environment Facility (GEF), (2001) states that one of the most immediate and critical problems facing many developing countries, especially in Africa is the availability of clean drinking water. It is envisaged that Solar powered technologies can help alleviate this problem with minimal cost using a combination of solar powered well pumping, a water tower or other holding tank, and a solar powered water purifier. These technologies require minimal local community maintenance, have low operational costs, and once set up, will help provide clean water for drinking and agriculture. With large enough reservoirs for the water that has been pumped and purified with solar powered technology, a community will be better able to withstand drought or famine. This reservoir water could be consumed by humans, livestock, or used to irrigate community gardens and fields, thus improving crop yields and community health. A solar powered water purification system can be used to clean many pathogens and germs from groundwater and runoff. A group of these devices, filtering the water from wells or runoff could help with poor sanitation and controlling the spread of waterborne diseases.

World Bank (2005) gives an example of a solar powered water pump and holding system that was installed in Kayrati, Chad, in 2004 as compensation for land lost to oil development. This system utilizes a standard well pump powered by a photovoltaic panel array. The pumped water is stored in a water tower, providing the pressure needed to deliver water to homes in the area. It demonstrates an example of the use of oil revenues and accruing profits in Africa to build infrastructure to advance the standard of living in rural areas. Many solar water pumping stations in Sudan fulfill a similar role, involving various applications of different systems for pumping and storage. Over the past 10 years approximately 250 photovoltaic water pumps have been installed in Sudan (UN-Energy 2005; National Rural Electric Cooperative Association International Ltd. 2000).

Balla (2005) shows that The Water School uses SODIS Solar disinfection in target areas of Kenya and Uganda to help people drink water free of pathogens and disease causing bacteria. SODIS is a UV process that kills microorganisms in the water to prevent water borne diseases. The science of the SODIS system is proven with over 20 years of research. He adds that even though solar technology may have a higher starting cost than that of conventional fossil fuel, the low maintenance and operation cost and the ability to operate without fuel makes the solar powered systems cheaper to keep running. A small rural community could use a system like this indefinitely, and it would provide clean drinking water at a negligible cost after the initial equipment purchase and setup. In a larger community, it could at least contribute to the water supply and reduce pressures of daily survival. This technology is capable of pumping hundreds of liters of water per day, and is limited only by the amount of water available in the water table. Secou (2005) reveals that with a minimum of training in operation and maintenance, solar powered water pumping and purification systems have the potential to help rural communities in Africa achieve one of their most basic needs for survival. Combined with sustainable agricultural practices and conservation of natural resources, solar power is a prime candidate to bring the benefits of technology to the remote rural areas of Africa.

The study adds that supplementing the well water would be collection of runoff rainwater during the rainy season for later use in drought. Flavin et al. (2005) inform that Southern Africa has its own network of information sharing called SEARNET which informs farmers of techniques to catch and store rainwater, with some seeing increased yields and additional harvests. This new network of farmers sharing their ideas with each other has led to a spread of both new and old ideas, and this has led to greater sustainability of water resources in the Southern African Development Community countries. The water could be used for agriculture or livestock, or could be fed through a purifier to yield water suitable for human consumption.

Wind Power for Sustainable Community Livelihood and Development

World Bank (2005) shows that The Koudia Al Baida Farm in Morocco is the largest wind farm in Africa. Kenya plans on building a wind farm the Lake Turkana Wind Power (LTWP) in Marsabit County. The first 50 - 90 MW from (LTWP) are scheduled for 2015. LTWP is planned to produce 300 MW of wind power at full capacity. Secou (2005) indicates that in January 2009, the first wind turbine in West Africa was erected in Batokunku, a village in The Gambia. The 150 kilowatt turbine provides electrical power for the 2,000-person village. The South African REIPPP has resulted in several wind farms already in commercial operation in the country. These wind farms are currently in operation in the provinces of the Eastern, Northern and Western Cape. It is estimated that 10 farms are already under construction or in operation with 12 more being approved with the 4th Round of the REIPPP (Leone 2011).

Geothermal Power as Alternative Energy Source for Sustainable Development

UN-Energy (2005) reveals that it only Kenya which has managed to exploit the geothermal potential of the Great Rift Valley as an alternative energy source. It is estimated that Kenya has 10,000 MWe of potential geothermal energy and has twenty potential drilling sites marked for survey in addition to three operational geothermal plants. It was the first country in Africa to adopt geothermal energy, in 1956, and houses the largest geothermal power plant in Africa. Olkaria II operated by Kengen, who also operate Olkaria, I. A further plant, Olkaria III, is privately owned and operated. Balla (2005) shows that Ethiopia is home to a single binary-cycle plant but do not utilize its full potential energy output for lack of experience in its operation. Zambia also has several sites planned for construction but their projects have stalled due to lack of funds. Preliminary explorations for potential geothermal sources have been undertaken in Eritrea, Djibouti and Uganda but have not constructed any type of power plant.

CONCLUSION

Environmental resource management is recognised as an issue of global concern for sustainable development and climate change adaptation. The paper emphasized the importance of putting all knowledge systems including indigenous knowledge on an equal footing in order to expand the global knowledge pool to meet global challenges of achieving sustainability, climate change adaptability, food security, health, and poverty eradication and political stability. The contribution of community-based knowledge systems and practices tend to be marginalized. The holistic approach of community-based or indigenous knowledge systems is emphasized due to its recognition of the symbiotic relationship between human practices and other forms of creation including the natural and spiritual aspects of life. Various examples of best practice projects are provided from different parts of Africa to demonstrate the significance of community-based environmental resource management practices. These include water conservation, renewable energy and community/school gardens for food security.

RECOMMENDATIONS

The paper makes the following recommendations: First, emphasis on the holistic approach to environmental resource management practices based on the African *Ubuntu* philosophy. This emphasizes symbiotic relationship between human practices and other forms of creation. Second, the need to arrange all knowledge systems including indigenous knowledge on the same plain in order to expand the global knowledge base on which all human beings can rely to meet global challenges.

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