Wind, sun and tea: Lessons from development of wind and solar energy in Kenya

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ABSTRACT

"Green Products", or products that are developed in a manner that reduces humanity's ecological footprint, have attracted much attention since the initiation of the "Go Green Initiative" in 2002. This was necessitated by intense carbon emission into the atmosphere that led to Global Warming and Climate Change. Although the concept of "Green Products" is still relatively new in Africa, the Kenyan Tea Industry can develop Green Labels for its local and global markets, thereby adding value to its products. One way of doing this is to diversify its energy sources to renewables such as wind and solar. Several wind farms and solar facilities have been developed or proposed throughout the country, and the Tea Industry can borrow critical lessons learnt from the process involved in their development. Kenya has reshaped its policy to allow for the development of energy from renewable sources, from which the Tea Industry can benefit. Because Kenya is signatory to a number of international treaties that call for sustainable development, development of Green Tea Products presents a win-win scenario at all levels, for example, Global Sustainability Objectives including Millennium Development Goals; National Development Agenda; and Proponents in the Tea Industry. Furthermore, Kenya is endowed with abundance of wind and solar resources. Development of renewable energy offers other business opportunities in the long term, including carbon trading, where tea proponents may engage in Carbon Markets by selling Carbon Credits (credits gained by the amount of carbon equivalent that would have been emitted if they were using non-renewable energy sources). Key lessons learnt from the process of developing renewable energy systems in Kenya relate to: land tenure issues; biodiversity impacts; conformation to international safeguards; and capacity development (human, technical and technological). Renewable energy offers numerous opportunities to improve tea production in Kenya and diversify products in its value chain.

Key words: "Green Products", Renewable Energy, Sustainable Development, Biodiversity, Carbon Trading, Climate Change.

BACKGROUND

Ecosystem products and services, such as resources, waste absorptive capacity, and space to host urban infrastructure are relied upon by humanity for sustenance (Ewin *et al.*, 2001). Environmental changes globally such as deforestation, collapsing fisheries, and carbon dioxide accumulation in the atmosphere show that humans may have exceeded the regenerative and absorptive capacity of the biosphere. This calls for careful management of human interaction with the biosphere to ensure posterity. The ecological footprint is a measure of human demand on the earth's ecosystems, and provides a measure of demand for natural capital that may be contrasted with the planet's ecological capacity to regenerate. The footprint represents the amount of biologically productive land and sea area necessary to supply the resources a human population consumes, and to assimilate associated waste. This assessment estimates how much of the earth (or how many planet earths) it would take to support humanity if everybody followed a given lifestyle. For example, in 2007, humanity's total ecological footprint was estimated at

1.5 planet earths, which means that humanity uses ecological services 1.5 times as quickly as the earth can renew them (Global Footprint Network, 2014).

As such, the need to reduce humanity's footprint globally is serious and urgent. There has been a dramatic rise in environmental consciousness, especially associated with global climate change, carbon emissions, oil independence, and human health. In the face of global warming and climate change, coupled with the need to manage carbon emissions and oil independence, the food industry should also undergo scrutiny in order to analyze options for sustainable production. In the United States, for example, food production consumes 19% of energy and contributes 37% of carbon emissions (Pollan, 2008). There lacks a systematic strategy for this in the food industry. However, many consumers are searching for ways to make a positive environmental impact while improving their personal and family's food consumption and lifestyle by engaging in "Green Consumerism" (Alves and Edwards, 2008). Green Consumerism leads people to purchase products with limited or positive environmental impacts, including foods that have been produced in an environmentally sensitive manner. The appeal of green products has led to an influx of a lucrative industry and food manufacturers are re-focussing their production systems to become more environmental sensitive. Such companies advertise their products' benefits through eco-labels which inform their consumers that the product is less environmentally harmful compared to similar products.

However, the shift to an environmentally sustainable system is expected to take time because firms need to move from an environmental management regime that focuses on clean up and control to one that embraces avoidance of environmental harm through entire product life cycle (Handfield *et al.*, 2005). This requires adoption of more comprehensive means to reduce pollution, including deliberate actions at every stage of the product life cycle. These include raw material extraction, transportation, manufacturing, product use, recycling, and disposal (Matos and Hall, 2007). Specific environmental actions may include environmental impact assessment (EIA), waste minimization and pollution prevention. Eltayeb and Zailani (2009) outlined the steps taken by business organizations towards sustainability (Figure 1) as follows: i) Defensive compliance, where in the initial stages firms are reactive in environmental management to simply comply with existing regulations to avoid penalties, and view environmental compliance as an expensive regulatory nuisance (Handfield *et al.*, 1997); ii) Waste minimization or cleaner production, where firms adopt technologies that produce less wastes iii) Eco-efficiency, which constitutes delivery of competitively priced goods and services designed to satisfy human need and enhance quality of life, while progressively reducing environmental impacts in line with the earth's estimated carrying capacity (WBCSD, 2006); iv) Design for environment, which incorporates considerations of material's recyclability and reusability as well as their long term impact on the environment, the amount of energy required for the product's manufacture and use, the capability for easy disassembly for remanufacturing, and considerations of the product's durability and disposal characteristics (Sarkis, 1998); and v) Green supply chain, which involves evaluating total environmental effects of the firm's products through entire life cycle of products and services (Handfield *et al.*, 2005).

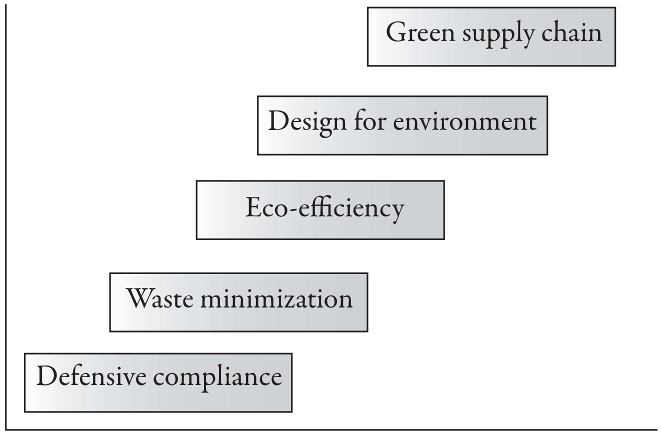
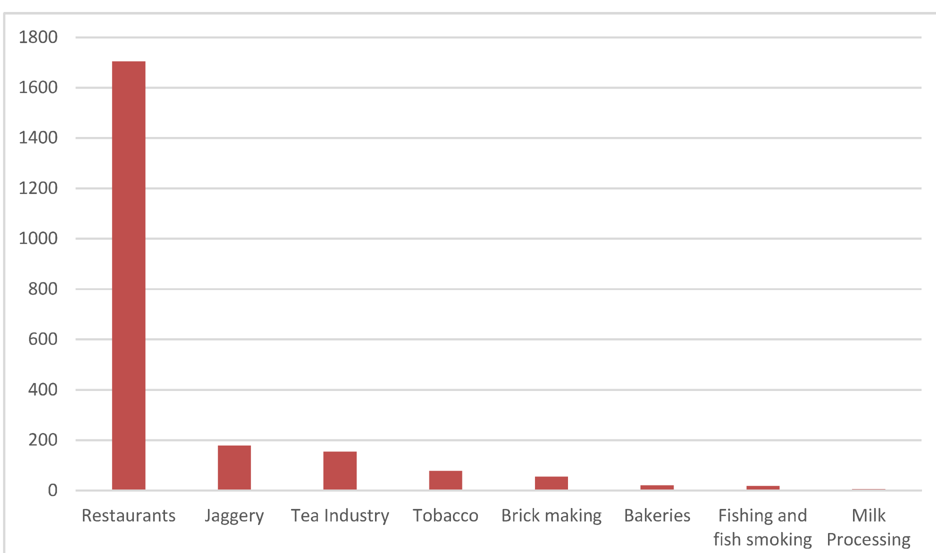


Figure 1: The shift in environmental management (Source: Eltayeb and Zailani, 2009).

Tea and water are two of the most consumed beverages in the world, with a projected 19 billion tea cups consumed daily. Tea production in East Africa contributes 30% of total global market supply. However, despite these highly favourable conditions, the industry has suffered from unreliable, expensive and insufficient energy supply, particularly in remote regions. Electricity is crucial in tea production; a critical part in tea production process requires it, for instance, in withering and drying of tea leaves to the actual processing. To counter the effects of power blackouts, most tea factories install generators which contribute to greenhouse gases release into the atmosphere. Tea factories experience regular power outages as well as poor electricity quality due to the strain they place on the national power grid. In addition, the Tea Industry has heavy reliance of wood fuel as a major power source for its boilers (Figure 2) (Kamiri *et al.*, *in press*), thereby putting unprecedented pressures on the environment, especially forests. Although interventions such as campaigns on use of more efficient cooking stoves and the establishment of Nyayo Tea zones to act as a barriers between the communities and the forest, there is need to put in place further initiatives to curb environmental degradation in tea growing areas. Tea producing areas lack a framework for managing environmental impacts of tree cutting for curing tea. There is no collective effort to curb deforestation in the tea growing regions of Kenya.



Source: Government of Kenya, 2002.

Figure 2: Fuel wood use (in metric tonnes) of in major industries in Kenya.

Inadequate production of wood fuels has had adverse effects on the environment and biodiversity (Kamiri *et al.*, *in press*). In addition there is intense competition between energy users, especially the tea sector and the rural households whose only source of energy for heating, lighting and cooking is wood.

Kenya is endowed with an abundance of renewable energy resources, including wind (Table 1), solar, geothermal, hydro and biomass. The Kenyan government has initiated mechanisms for development of energy from renewable sources, including the promotion of energy efficiency and innovations in renewable energy technologies (National Climate Change Response Strategy, 2010). This is envisioned to lead to the country benefiting from carbon markets, meet the growing demand of energy and reap various benefits including reducing foreign expenditures on crude oil and other petroleum products.

Table 1: Wind power potential in Kenya.

Region	Mean annual wind speed m/s	Class No.	Classification	Area covered (in km^2)
Kirinyaga	7.41	4	Good	1481
Embu	7.5	4	Good	2760
Nyeri	7.44	4	Good	3359
Lamu	8.26	5	Very good	6878
Meru	7.61	5	Very good	7172
Baringo	6.79	4	Good	10942
Kilifi	8.26	5	Very good	12310
Isiolo	7.83	5	Very good	24881
Mandera	7.73	5	Very good	28302
Nakuru	6.52	4	Good	29286
Tana River	8.32	5	Very good	38610
Garissa	7.73	5	Very good	44459
Wajir	7.75	5	Very good	53413
Turkana	7.11	5	Very good	61353
Marsabit	9.27	6	Excellent	75596

In addition, international agencies have initiatives geared towards reducing humanity's footprint. For example, UNEP has developed a programme aimed at transferring usable renewable energy solutions to key players, with four factories getting involved. This initiative provides a win-win scenario for environment and production, as it reduces carbon footprints and at the same time increase productivity and income.

The use of free, renewable energy enhances the competitiveness in the global market by reducing production costs. The Tea Industry can label its products "Green" and exploit the already environmental conscious international market, taking advantage of the popularity of Kenyan tea globally. The reduced carbon footprint can engage in green incentives, such as those offered by the United Nations Framework Convention on Climate Change (UNFCC) via carbon credits.

WIND AND SOLAR DEVELOPMENT IN KENYA

Environmental policy and institutional framework

Kenya is a party to several conventions that aim at conserving and protecting key ecosystems and their biodiversity. These include the African Convention on the Conservation of Nature and Natural Resources, the Convention on Biological Diversity (CBD), the Convention on Wetlands (Ramsar Convention), the Convention on the Protection of the World Cultural and Natural Heritage, the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES), the Convention on the Conservation of Migratory Species of Wild Animals (CMS) and (under the CMS) the African-Eurasian Waterbird Agreement (AEWA). The Convention on the Conservation of Migratory Species of Wild Animals (or Bonn Convention) aims to conserve terrestrial, aquatic and avian migratory species throughout their range. AEWA is the largest agreement developed so far under CMS auspices and focuses on migratory waterbirds. Regarding wind power, CMS has developed guidelines under its resolution 7.5 on "Wind Turbines and Migratory Species" (CMS, 2002). It calls parties to: i) Identify areas where migratory species are vulnerable to wind turbines and where wind turbines should be evaluated to protect migratory species; ii) Apply and strengthen, where major developments of wind turbines are planned, comprehensive strategic environmental impact assessment procedures to identify appropriate construction sites; iii) Evaluate the possible negative ecological impacts of wind turbines on nature, particularly migratory species, prior to deciding upon permission for wind turbines; iv) Assess the cumulative environmental impacts of installed wind turbines on migratory species; and v) Take full account of the precautionary principle in the development of wind turbine plants, and to develop wind energy parks taking account of environmental impact data and monitoring information as it emerges and taking account of exchange of information provided through the spatial planning processes.

In addition to global treaties and standards, Kenya is a signatory to regional treaties that address the balance between development and environment. The Nairobi Convention, for example, provides a mechanism for regional cooperation, coordination and collaborative actions, and enables the Contracting Parties to harness resources and expertise from a wide range of stakeholders and interest groups towards solving interlinked problems of the coastal and marine environment.

At the national level, the Kenya's Vision 2030 provides much of the policy framework regarding energy development in the country. Energy is one of the infrastructural enablers of the three developments pillars, namely the economic, social and political aspects. The current energy policy objectives in Kenya emphasize the need for energy availability and accessibility at cost effective prices. The policy also supports sustainable socio-economic development while protecting and conserving the environment. The Environmental Management and Coordination Act of 2009 provides the framework for EIAs in Kenya. The National Environment Management Authority (NEMA) is the key institution mandated to take charge of environmental matters, and works closely with other institutions, including Kenya Wildlife Service, Kenya Forest Service, and National Museums of Kenya, among others.

Lessons learnt from wind and solar development in Kenya

Kenya is classified as the world leader in adopting solar power systems, although this is largely within households. Over 30,000 very small solar panels, each producing 12 to 30 watts, are sold in Kenya annually (Freling, 2010). Development of solar energy on a larger, commercial scale is hindered by intermittency of solar energy, high initial cost of installation and over reliance of fossil fuels. Technological interventions are required to fully realize Kenya's high solar energy potential. Regarding wind power, there is currently a high influx of wind power proposals throughout the country, with one fully operational wind power project producing electricity. The development of wind-energy is a vital component of the Kenya Vision 2030 objectives to increase the proportion of energy derived from renewable sources, thus helping to reduce the emission of greenhouse gases and propelling the economy to greater heights. However, a number of lessons have been learnt from upcoming wind power initiatives as described below.

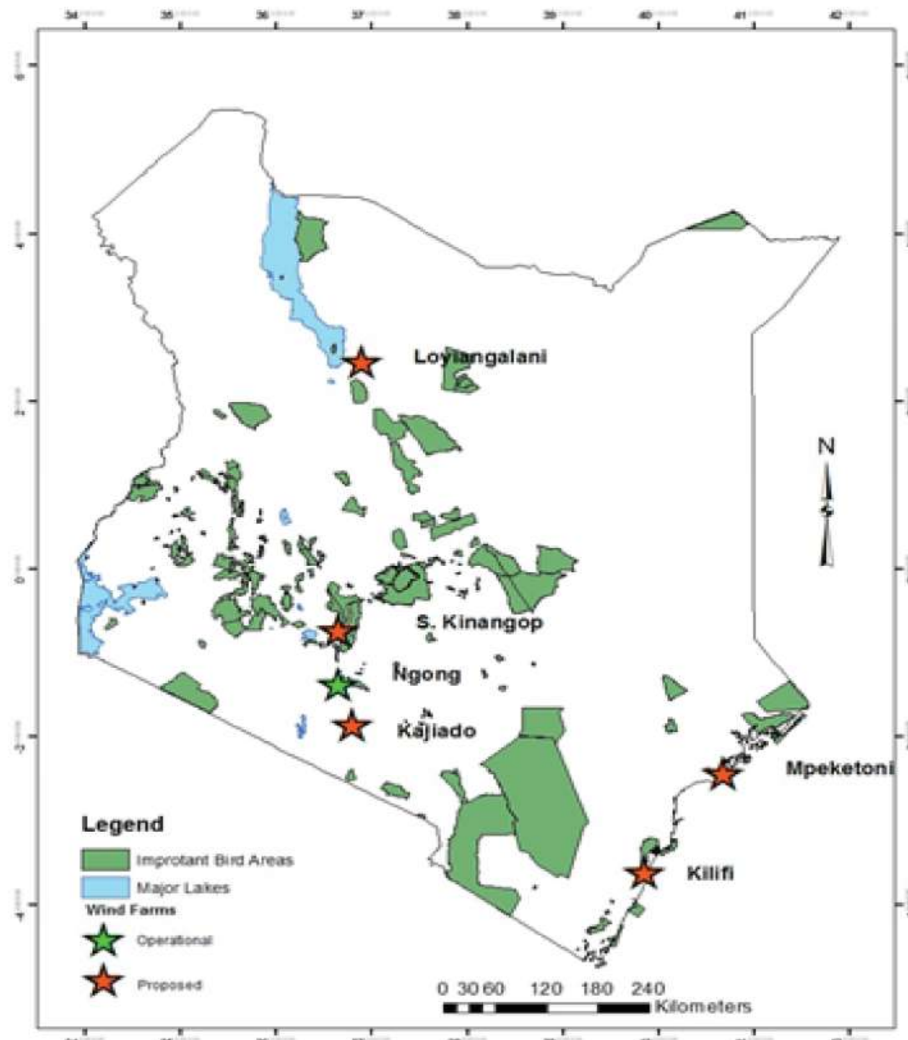


Figure 3: Map showing the distribution of Operational and Proposed Wind Farms in Kenya.

Environmental issues associated birds and bats at wind farms

In Africa, few studies exist to show the impacts of wind farms on birds and bats. In the United States and Europe, studies have shown that the impacts of wind turbines on birds and bats vary, depending on site selection, species and season. Most documented impacts include direct collision with wind turbines, including collision mortality, barotrauma, loss of foraging habitat, barrier effect on migrating routes and emission of ultrasound by wind turbines.

In Kenya, little is known about impacts of wind turbines on birds and bats because only one fully operational wind farm currently exists and no systematic studies have been done to profile the impacts. However, these impacts have been comprehensively studied in the USA and Europe. Understanding these impacts alone presents numerous opportunities for meaningful employment for researchers, field personnel and environmental officers (employed by the project proponents) as well as trainers. These impacts are described below.

Disturbance and collision mortality

This is the most evident impact by wind farms, as has been shown by several studies (for instance, Dürr and Bach, 2004). Site selection of the wind turbines is a crucial factor, since most dead bats are found in highly structured landscapes (for instance, where hedgerows lead to and from the turbines) (Dürr and Bach, 2004) or around turbines within forests (Arnett *et al.,* 2005; Behr and Reisinger, 2005). Most of the proposed wind farms in Kenya are located in highly structured habitats and may potentially lead to bat collisions. Disturbance by turbines and associated infrastructure may lead to displacement or exclusion, collision mortality and loss or damage to habitat. These effects are variable and are species-specific, season-specific and site-specific. The overall level of impact is determined by the scale of habitat loss, the extent of availability and quality of other suitable habitats that can accommodate displaced birds and the conservation status of affected birds. To minimize collision mortality, sites rated as high for bird use should be avoided. Sites with species of conservation concern, breeding, roosting and feeding areas should be also avoided. The risk of collision is influence by wind speed, wind direction, air temperature, humidity, flight type, time of day and topography. Additionally, the species involved, age, behaviour and stage of the bird's annual cycle are also associated in collision aspects. In conditions of low visibility, such as foggy weather, rain and dark nights, collision risk would be expected to be higher. This is also the case during periods of strong winds.

Barotrauma

Moving wind turbine blades create zones of low pressure as the air flows over them. Animals entering these low pressure areas may suffer barotrauma. Echolocating bats have been shown to detect moving objects better than stationary ones (Jen and McCarty, 1978), but there has been a relatively high fatality rate of bats at turbines (Kunz *et al.,* 2007). This is mainly caused by barotrauma, which involves tissue damage to air-containing structures caused by rapid or excessive pressure change. Pulmonary barotrauma is lung damage due to expansion of air in the lungs that is not accommodated by exhalation. Ninety per cent of bat fatalities at wind farms involve internal haemorrhaging consistent with barotrauma (Erin *et al.,* 2008). Air pressure change at turbine blades is an undetectable hazard and explains high bat fatality rates. Bats are especially more vulnerable to barotrauma than birds. This is because the respiratory anatomy of birds is less susceptible to barotrauma than that of mammals.

Loss of foraging and roosting habitat

This impact is likely to occur at both the construction and operation stages. Bats have been shown to avoid wind parks as foraging habitat. For example, Bach (2002) showed that serotine bats (*Eptesicus serotinus*) in Germany avoid wind parks as foraging habitat and thus lost previously used habitats. On the other hand, pipistrelle bats (*P. pipistrellus*) used their foraging habitats independently from the wind turbines and some habituation can occur. The situation is more critical in forests, where bats forage at or over canopy level and are likely to encounter the rotating blades. Leisler's bats and noctules as well as pipistrelles are among the species most affected. The loss of tree roosts and foraging habitats by the installation of the wind turbines adds to this problem. However, there is still a need for systematic and long-term studies to quantify the problem of site selection and loss of habitats.

Barrier effect

Wind turbines may also act as barriers to bird movement, preventing birds from flying within the wind farm. Instead, birds may choose to fly around the outside of the turbine cluster. Although it has been demonstrated that birds may deliberately bypass wind farms (for instance, Kahlert *et al.*, 2004), it is debatable whether or not this is a problem because many factors come into play, including the size of wind farm, the spacing of turbines, the extent of displacement of flying birds and their ability to compensate for increased energy expenditure. Wind farm design may alleviate barrier effect, for example allowing wide corridors between clusters of turbines. Wind parks can also potentially interfere with commuting routes of local bat populations or with migration routes of long-distance migrating bats. Little information is currently available on this problem, especially about the secrets of bat migration. It is not yet known how bats exactly orientate during their long-distance migration: do they use vision and echolocation and to which extent or even some other navigation cues (for instance, magnetism). The finding of dead migrating bats at wind turbines however indicates the problem. Large wind farms situated at migration routes might act as barriers. Such critical places are for example mountain passes used by migrating birds and bats, ridges along large river valleys used as corridors or coastlines. But also short-distance migrating local populations migrate from their summer to their winter roosts and thus can be affected as well.

Noise and ultrasound

The influence of ultrasound noise emitted by the rotating turbines is thought to potentially disturb foraging bats since some wind turbine types have been found to emit noises at around 30 kHz (Schröder, 1997), a frequency used by several species of echolocating bats. Bats can be attracted by ultrasound noise and be lured into rotating blades, causing collision mortality.

Capacity gaps

In view of the technical expertise needed to carry out a comprehensive EIA on a wind farm and to subsequently successfully run them, and the lack of sufficient expertise in the same, Kenya is faced with situation that threatens the development of wind power projects. However, this scenario can be countered by making deliberate efforts to train professionals in this area to ensure that the country meets the requirements stipulated by various conventions that it is signatory to as well as the international safeguard standards. One of the key challenges is the capability of biodiversity research professionals to effectively carry out bird and bat research. Only a few bird and bat experts have the necessary skills to carry out these studies. This is countered by the fact that these skills take years of field experience to perfect. For example, accurate identification of Cisticolas, a genus of birds that has very close resemblance to each other, require preliquisite knowledge of distribution patterns, habitat, microhabitat selection, social behaviour, and the birds' vocalization (call or song). In addition, gaining such a high level of skill requires training from adequately skilled people. Nature Kenya, a locally-based conservation NGO, runs "bird walks" every week in which highly experienced experts train people in bird identification. This is, however, largely done as a past time, although a number of experts have emerged from this training. Another opportunity that has emerged for training in bird research is offered by Tropical Biology Association, an International NGO that develops capacity for upcoming professionals in the field of tropical ecology and conservation. Through its month-long field course, the Tropical Biology Association exposes guardians of the environment to a host of skills they need to conserve biodiversity on the ground, and connects them to a global support network that helps them apply their news back home. The Tropical Biology Association also runs an annual course named "Fundamentals of Ornithology" (FoO). FoO is tailored for tour guides, but it may present a good opportunity for EIA experts interested in wind power projects to gain skills in bird identification and survey methods. Equally important, the Tropical Biology Association is helping companies with agricultural operations and supply chains to assess their risk, impacts, dependencies and opportunities for biodiversity. This they do by applying a tool-based approach that can easily be main-streamed in company operations. This tool can be tailored for wind farms.

One of the key limitations in bat research is the lack of a comprehensive "Bat Call Library". A bat call library is a database of bat calls that can be used to identify bats using acoustic records. A bat call library has been proposed and is being developed by bat experts. Such a database will collate, describe and archive echolocation signals for bat calls and create a reference library. Information developed from this undertaking will be used by proponents of wind farms to identify hotspots and monitor current projects. It will also be used by national institutions to determine distribution patterns of different bat species. This information will also be made available to the public, thus encouraging continuous feedback from a broad audience. Because this library is currently under development, bat assessment using acoustic surveys is faced with challenges at the moment. In addition, there exist capacity gaps in terms of equipment. Most bird and bat studies require highly specialized equipment to perform and operate. These include mist nets, bird ringing (banding) equipment, bat detectors, and infra-red sensors among others.

Land administration and related political issues in Kenya

The governance of land in Kenya is a complex process which has unfortunately resulted in conflicts, violations and afflictions in the society (KHRC, 2011). Land administrators is Kenya have been put to task historically, particularly in view of the so-called historical injustices. The squatter problem, for example, is a direct consequence of the colonial land policy and law (Kenya Land Alliance, 2004). Politically instigated land clashes have also led to the displacement of people from their lands in certain parts of the country, thereby further compounding the land issues. Several communities have also claimed that they were cheated out of their ancestral land by both the colonial and subsequent governments. The Pokot people, for example, claim that the British government did pay compensation to the Kenyatta Government for onward transmission to the community, and have frequently agitated for compensation or resettlement. Minority communities such as the Ogiek who are dependent on forest habitats have been displaced and forced to adopt to unfamiliar lifestyles. For renewable energy systems to take root in Kenya, harmonization of land and land-based issues must be achieved.

TECHNOLOGICAL ISSUES

Wind and solar energy is known to be intermittent and poses significant limitation for the Tea Industry since tea processing requires a reliable energy supply. A solution to this is to develop diversified systems that maximize the contribution of renewable energy sources but compliment it with other sources from the national grid. However, this would require development of technology that distributes and allocates power depending on its availability and demand. This could mitigate the intermittent nature of wind renewable energies in the long term.

CONFORMITY TO INTERNATIONAL SAFEGUARDS

International Standards and Safeguards relate to the quality of Environmental and Social impact Assessment for new projects. These Safeguard Policies are contained in IFC's Performance Standards on Environmental and Social Sustainability (IFC, 2012).The IFC performance are globally recognized as relevant for renewable energy sources and are usually applied to ensure sustainable use and management of ecosystems. IFCs guidelines are stipulated in "Guidance Note 6" on Biodiversity Conservation and Sustainable Management of Living Natural Resources. The extent, magnitude, and type of analysis of the EIA process depend on the nature, scale, and potential environmental impact of the proposed project. Policy guidelines are aimed at ensuring sustainable project implementation.

HIGH CAPITAL COSTS

Historically, renewable energy sources have had a difficult time breaking into markets that have been dominated by traditional, large-scale, fossil fuel-based systems. Compared to conventional systems, renewable and other new energy technologies have not yet achieved full mass production, due to high capital costs relative to more conventional systems. In addition, the discovery of oil and gas in Kenya is likely to slow down adoption of renewable energy systems, particularly wind and solar.

CONCLUSION AND RECOMMENDATIONS

Production of "Green" tea can be sustainable if there are efforts geared to providing energy in tea factories using free and renewable sources. There is need for concerted effort and partnerships from players in both private and public sectors in the renewable energy implementation process. The Government of Kenya has already put in place relevant policy to enable development of green energy sources. Players in the tea industry should take advantage of environmental consciousness in the global market and popularity of the Kenyan tea internationally and develop eco-labels for their products. Such products will fetch higher prices and attract carbon incentives and engagement in carbon trading, thereby providing an avenue for new business opportunities. Most importantly, "Going Green" will help reduce humanity's footprint on earth's ecosystems.

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