Hindawi
Journal of Energy
Volume 2018, Article ID 3196567, 12 pages
https://doi.org/10.1155/2018/3196567

Review Article

Energy Poverty and Its Implication on Standard of Living in Kirinyaga, Kenya

Christine W. Njiru [1] and Sammy C. Letema [2]

[1] *Kagumo Teachers Training College, P.O. Box 18-10100, Nyeri, Kenya*
[2] *Environmental Planning and Management Department, Kenyatta University, P.O. Box 43844-00100, Nairobi, Kenya*

Correspondence should be addressed to Christine W. Njiru; christine.njiru26.cn@gmail.com

Received 7 April 2018; Revised 22 August 2018; Accepted 25 September 2018; Published 14 November 2018

Academic Editor: Jin-Li Hu

Copyright © 2018 Christine W. Njiru and Sammy C. Letema. This is an open access article distributed under the Creative Commons Attribution License, which permits unrestricted use, distribution, and reproduction in any medium, provided the original work is properly cited.

Energy poverty affects physical health, well-being, and ability to prosper. A large proportion of Kenyan population lack access to electricity because they are located far from the national grid where it is uneconomical to extend electricity. This paper assesses energy poverty situation in Kirinyaga and reviews its implication on standard of living. Kirinyaga is a rural county with the main economic activity being agriculture and a few agroprocessing factories. Most rural households in Kirinyaga rely on fuel wood to meet their basic energy requirements and lack access to electricity. Tea factories and educational institutions rely on fuel wood to minimize cost of electricity. Kirinyaga residents, therefore, experience energy poverty as indicated by low electricity access and reliance on traditional cooking fuels. Energy poverty in Kirinyaga has negative impact on indicators of standards of living, calorific intake, life expectancy, and literacy levels.

1. Introduction

Energy poverty is one of the main global challenges of this century despite major expansion of centralised electricity networks [1, 2]. Energy poverty in developing countries is caused by low levels of electrification and other forms of networked energy provision resulting from economic constraints and inefficient institutions [3, 4]. Energy poverty eradication can be achieved through implementation of Sustainable Development Goals (SDGs) Goal 7, which aims at sustainable development through provision of affordable and universal electricity access by 2030 [5]. Limited access to energy is a major challenge to achieving SDGs [4–8]. About 83% of households in sub-Saharan Africa rely on traditional fuels while 74% lack electricity [9, 10] and despite the fact that energy resources are more than sufficient to meet domestic needs, they remain underexploited and access to modern services is limited [11, 12]. The Global Network on Energy for Sustainable Development (GNESD) [13] states that majority of the world's poor live in rural areas with limited access to modern energy services and thus depend on traditional energy sources, e.g., biomass. The cost of energy causes a heavy economic burden to low income households in developing countries, with households spending even more than 20% of their total household income on energy uses [14]. Hence, governments in developing countries require innovative ways of tackling energy poverty in order to achieve universal energy for all citizens [15].

The most common types of fuel in Kenya used for cooking by households are firewood, charcoal, cow dung, and agricultural residues like maize and sorghum stalks and maize cobs [16]. Charcoal is used by over 82% of the urban population and 34% of rural households, with demand likely to rise with population growth, increased urbanization, and development of cottage industries [17]. Although these are renewable energy sources, their rate of exploitation may not be sustainable and may lead to depletion in future [18], thus need for alternative renewable energy sources. Further, large consumption of biomass for energy purposes could lead to biodiversity loss [19] and increased deforestation, desertification, and land degradation [20].

The challenges facing Kenya's energy sector are well documented. They include low electrification rate, reliance on imported fossil fuels, transmission inefficiencies, frequent power outages, high cost of rural electrification, demand for electricity outstripping generation capacity, and inability of power utility agency to connect all customers who apply for connection [21–25]. A large proportion of Kenyan population lack access to electricity because they are located far from national grid where it is not economically feasible to extend electricity [26, 27]. Most rural households in Kirinyaga County are not an exception to the electricity access situation prevailing in Kenya. Therefore, this paper reviews the energy poverty situation in Kirinyaga County and its implications on standard of living.

2. Assessing Energy Poverty and Its Implication

Energy poverty is defined differently depending on the context and the country of reference. Energy poverty may be difficult to define universally, but there are many people worldwide that suffer from some aspect of energy poverty. Energy poverty is as a multidimensional concept including calorific intake, life expectancy, housing quality, literacy, and access to energy among other factors. When expressed from a nonincome dimension, two energy indicators are found, lack of electricity access and reliance on traditional cooking fuels, e.g., wood, charcoal, and dung [28]. Energy poverty is caused by a complex combination of factors including lack of physical availability of certain energy types, lack of income, and high costs associated with using energy [29]. One way of estimating energy poverty is to assess the budget share a household spends on fuels and electricity. In the United Kingdom, a fuel-poor household is one that spends more than 10% of its income on all fuel use [30, 31]. Such a measure may not be applicable to developing countries that use cheap biomass fuels as this would underestimate the magnitude of energy poverty [30]. Households that spend more than 10%-15% of their income on energy per month or year are generally considered energy poor [28]. Energy development index, a composite measure of energy use in developing countries, which measure the progress of a country in implementing modern fuels in its energy systems, is also used to measure energy poverty [22, 32, 33]. The energy access-consumption matrix is an energy poverty indicator that describes energy poverty in terms of quantity of energy used and access to different energy sources [29, 30]. Authors in [34] have proposed multidimensional energy poverty index (MEPI) a measure composed of five dimensions representing basic energy services. MEPI measures the incidence of energy poverty and quantifies its intensity.

The standard of living is the level of welfare available to individuals or a group of people. It concerns the goods and services people consume and the resources they have access to [35]. It includes such factors as income, poverty rate, quality and affordability of housing, gross domestic product, inflation rate, affordable access to healthcare, quality and availability of education, and life expectancy among others [36]. One measure of living standards is Human Development Index (HDI), which has three dimensions: life expectancy, education level, and a decent standard of living measured by per capita income [35, 36]. Energy access directly or indirectly influences availability and consumption of goods and services, hence effects on standard of living.

Access to energy is one cause of duality in developed and developing countries [37, 38]. No country has been able to raise per capita incomes without increasing the use of commercial energy [39, 40]. Household consumption of energy enhances standards of living because health is improved through refrigeration; education enhanced through lighting and improved communication; income is improved due to increased productivity and the environment is conserved due to reduced pressure on traditional energy sources [41]. When people experience energy poverty it affects their physical health, well-being, and their ability to prosper [42]. However, despite the fact that electricity can cause societal change by providing new activities and services, social and economic development that improves quality of life and improves livelihoods of rural populations does not always occur [43].

In this article, energy poverty is reviewed based on life expectancy, literacy levels, calorific intake, and access to electricity and reliance on traditional cooking fuels. There is an overlap between the definition of energy poverty [28] and that of standards of living [35], hence the choice of indicators in reference [28]. This multidimensional approach offers a broad understanding of the complexity of energy poverty and its implications on standard of living of Kirinyaga residents.

2.1. Causes of Energy Poverty. Energy poverty in Kirinyaga is caused by several factors. There is low access to electricity because only 16.2% households have electricity while the rest are not connected [44]. Despite the government's effort to subsidize electricity connections many household cannot afford the initial connection charges, hence the low access. High cost of modern sources of energy also leads to energy poverty. In Kenya, the cost of electricity has been rising despite expansion of electricity generation capacity. The high cost of electricity reduces its consumption in households and some businesses raise cost of essential goods and services making them unaffordable [45]. The Kenya National Bureau of Statistics (KNBS) notes that, between 2017 and 2018, there has been a 22% increase in price of electricity for consumers of up 50 kWh monthly and a 14% increase for consumers of up to 200kWh [46]. Hence, many households cannot afford to use electricity for cooking but mainly use it for radio listening, television watching and lighting [47]. The number of households using LPG is about 3% [44] because in rural areas, there are poorly developed markets and distribution costs are high. Further, rural households living on less than a dollar a day cannot afford the initial cost of the cylinder and accessories costing about 400 US dollars. Rural people are also afraid to adopt LPG because of safety concerns [48]. Once they adopt LPG, they may not afford to continue refilling the cylinder [49]. According to [50], household in developing countries do not automatically switch to LPG when their income improves. In most cases, they practice energy stacking using LPG or electricity to cook light meals, e.g., tea, dung for simmering, and fuel wood for cooking meals that take long to cook. In Kenya, the share of households using LPG is 1.2% in rural areas and 13% in urban areas while use of fuel wood predominates.

The level of income affects choice of cooking fuels. Cleaner fuels are used by households with high levels of income while traditional fuels are used by households of lower socioeconomic profile [51, 52]. The net living wage for rural Mt Kenya region is about 128 US dollar per month [53]. This low income makes Kirinyaga rural households to depend on firewood for cooking and also partly because most of the firewood is collected not bought [53]. Hence low income leads to dependence on biomass fuels [54] which is a measure of energy poverty.

Failure to adopt cleaner renewable sources of energy also contributes to energy poverty. Biogas and solar energy are viable alternatives to fuel wood but only 0.8% of the households in Kirinyaga use biogas, while 0.1% use solar for cooking [55]. The reasons for low adoption of these technologies could be perceived demerits of biogas and solar cookers which are small and may not be used to prepare some staple foods [47]. Adoption of biogas is hampered by high initial investment costs, e.g., the cost of a family size floating drum plant in most African countries averages 1667 US$, whereas in Kenya, the fixed capital investment costs are 1535 US$ (8 m^3); 2198 (16 m^3); 12 176 (54 m^3); and 26,090 (124 m^3), which is not affordable to many households [56], hence retention of fuel wood as the main cooking fuel. Most of the rural households also lack information on the alternative sources of energy. Vandalism of transformers is a major hindrance to provision of electricity in Kenya [57]. This causes great losses to the service provider (Kenya Power) and the consumers. For instance, in 2012, Kenya Power spent 4 million US dollars replacing transformers, while on average, Kenyans stay without power for 25 days a year [58]. Continued use of fuel wood is also partly caused by cultural preferences. In Peru, some households believe that food cooked on biomass burning stoves is tastier than that cooked using LPG stoves, while collecting firewood and cooking are considered as vital normal chores that enhance social interaction [49]. In Kenya, some people believe that it is not possible to prepare some traditional meals using LPG because of taste preferences [59]. These cultural barriers trap some households in energy poverty.

2.2. Energy Consumption and Standard of Living. There is a nexus between energy consumption and living standards. According to [60], the Minimum Income Standard (MIS) explores annual incomes necessary for different family groups to be able to afford items needed for a minimum acceptable living standard in European countries. Proponents of MIS argue that goods and services necessary for decent living are influenced by prevailing standards and customs of a given society. Hence they differ between cultures and evolve over time. Hence there are differences in MIS in developed and developing countries and even within a country.

The living conditions in our homes notably hygiene, liveability, and basic amenities affect our well-being. Assessment of recent global trends in provision of energy access in relation to living conditions which include energy for cooking and electricity, water provision, sanitation, and nutrition indicates that growth rate of all these living conditions are far below those of gross domestic product. Further, deprivations in living standards are more prevalent among low income earners especially in sub-Saharan Africa [6]. Energy is vital in providing essential human services that improve living standards. Some essential aspects of human welfare include long and productive life, enjoying good health, access to knowledge and education opportunities, ability to earn adequate income to provide households with adequate nutrition, shelter and other material, and aesthetic needs. All these needs may be improved when modern energy services are provided. Modern energy sources also lead to job creation [61]. Use of modern fuels promotes communication and improves environmental sustainability by reducing deforestation and enhancing energy efficiency [62]. Energy poverty thus prevents people from meeting basic daily needs such as cooking, lighting, heating, cooling, and communication all of which are necessary for an acceptable quality of life [63]

3. Manifestation of Energy Poverty in Kirinyaga County

This section describes the contribution of households, tea factories and educational institutions to energy poverty in Kirinyaga. They were selected because they all rely on fuel wood, one of the aspects used to assess energy poverty. They also illustrate how high cost of energy and low access to energy can lead to energy poverty. Tea factories are the only large industries in Kirinyaga hence selected to showcase possible impacts of low access to energy on the economy of the regions where they are located.

3.1. Household Energy Poverty. Kirinyaga County is one of the 47 counties in Kenya. There are about 154,220 households in total land mass of 1478.1 ha giving a mean land holding size of 0.0958 ha/household. The economy is driven by agriculture where 87% of the population derives their livelihood from the sector and accounting for 72% of household income [64]; thus the county is rural in nature.

Major households' energy sources in Kirinyaga County are firewood (68.6%), charcoal (38.6%), and gas (18.8%) [31]. These energy sources are corroborated by sale of forest produce for firewood (Table 1) and a survey on households' sources of cooking fuel (Figure 1). National grid electricity connection to rural homes and urban areas accounts for 7.5% and 15%, respectively [64].

3.2. Tea Factories and Energy Poverty. Tea processing in Kenya experiences challenges of energy shortage, with about 99% of thermal energy used in the factories coming from fuel wood and other biomass and remaining coming from fuel oil [65]. Between 2008 and 2013, the 65 Kenya Tea Development Agency (KTDA) factories countrywide used 3,927,939 m^3 of firewood to generate thermal energy. During the same period, the factories released 20,490,923 seedlings to neighbouring communities for future supply of firewood. This is an equivalent to 4,740,559 m^3 of expected firewood. KTDA planned

Table 1: Sale of minor forest produce in Kirinyaga from 2003-2011.

Year	2003	2004	2005	2006	2007	2008	2009	2010	2011
Monthly fuel license (head loads)	2013	8666	10980	556	9987	6239	6083	7237	7828
Fuel wood (stacks)	7	75	537	-	3203	1561	1263	-	2699

The (-) means there are no sales in form of stacks. Source: [121].

Table 2: Fuel wood and electricity consumption for tea factories in Kirinyaga and man-hours lost due to power outages.

Factory	Electricity consumption (kWh)/Year		Fuel wood Consumption (m^3)/Year		Time lost due to power outage (Hours/Year)
	2013/14	2014/15	2013/14	2014/15	2014/2015
Kimunye	19 64020	1562872	19146	16397	597
Mununga	29 51323	2768678	22108	19441	300
Ndima	22390725	2187767	20989	15008	343
Kangaita	2253139	2101757	15046	11942	321
Thumaita	2455871	2215411	20302	10032	504

[122].

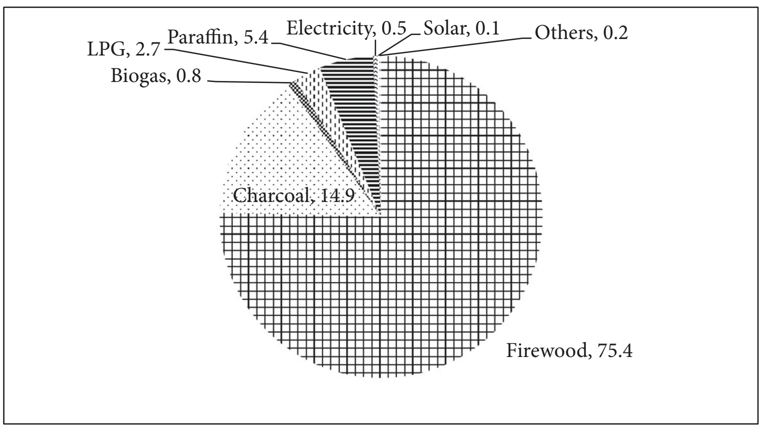


Figure 1: Percentage distribution of households by source of cooking fuel in Kirinyaga [55].

also to acquire and plant 40,300 acres of exotic trees for wood fuel and indigenous trees for conservation. It is estimated that between 1000-2500 m^3 of firewood is used per month per factory at a cost of 17-20 US$/$m^3$, which translates into US$ 102 of firewood per ton of tea produced. The high cost of fuel wood contributes to the overall high energy cost of tea production ranging between 25 and 40% [66]. KTDA intends to be using fuel wood in their operations for a long time to come because they are investing heavily on buying land to plant trees. Consequently, energy poverty will remain a problem, because of continued use of fuel wood [67]. Over the years, there has been a rise in the cost of electricity, furnace oil, wood fuel and diesel, eventually reducing the profit of smallholder tea farmers [68]. KTDA decided to reduce energy costs by converting boilers from using diesel to wood fuel consumption. This raised demand for wood and forced KTDA to venture into the wood energy project in order to provide a sustainable source of wood fuel for the factories [69]. The Tea Research Foundation of Kenya, however, warns that the switch from using grid electricity and petroleum based products should be done with care because it will exacerbate cutting down of trees for fuel, leading to reduced tree cover [70]. Essentially, a shift from expensive diesel and electricity to comparatively cheaper wood fuel is a shift from modern to traditional energy sources. This practice by the tea factories exacerbates energy poverty.

Kirinyaga County has five small holder tea factories managed by KTDA. They include Kangaita, Thumaita, Mununga, Ndima, and Kamugunda [64]. These factories consume a lot of fuel wood to fire the boilers, which generate steam for withering and drying tea leaves. The main source of fuel wood is decommissioned forests. However, some factories have their own fuel wood plantations; e.g., Kangaita Tea Factory has a 700-acres farm of which 150 acres of eucalyptus plantation was decommissioned and the remnants used as firewood in the factory. These factories also outsource the fuel wood from local farmers and other counties like Embu [66].

Table 2 shows the amount of fuel wood and electricity consumed by tea factories in Kirinyaga for two years. Although data available does not indicate consumption trends because it covers only two years, it shows high consumption of both traditional and modern energy. In the year 2014/15, total man-hours lost due to power outages were 2065, which is a common occurrence. This problem is confirmed

Table 3: Number of educational institutions in Kirinyaga.

Type of institution	Number of institutions	Enrolment
Early Childhood Development Education	348	14,672
Primary schools	326	111,400
Secondary schools	143	39,988
Tertiary institutions	29	-
Total	846	166,060

Source: [60].

by the Kenya Association of Manufacturers who document loss of between 12-36 hours of productive work every week because of power rationing during dry periods [69]. Lack of energy restricts labour productivity [40]. Additionally when electricity is unavailable the factories revert to using diesel generators. Each factory has two standby generators and on average, each generator consumes about 100 litres of diesel per hour translating to 200 litres per hour per factory [71]. The use of diesel to complement grid electricity confirms that the factories are facing energy shortages and this increases production cost of tea. Consequently, tea factories in Kirinyaga lack sufficient energy in terms of traditional and modern energy sources and thus are facing energy poverty. In a vicious circle, tea factories also contribute to energy poverty through use of fuel wood. Additionally, when there are power outages, there is lack of electricity access, a measure of energy poverty.

Production costs account for 60% of the tea prices attained at the Mombasa auction and at least 30% goes towards energy costs [72]. This lowers the profit margin of the small holder farmers who rely solely on tea farming since the cold climatic is not suitable for growing other food crops eventually reducing their purchasing power. The economy of the tea growing areas will also be negatively affected because tea factories are the only industries in Kirinyaga. Less profit will limit growth of the tea industries eventually lowering employment rate because local residents are mainly involved in tea plucking and other jobs. Tea factories are also involved in maintenance of roads in their areas of operation [73] whereby about 10% of the earnings is allocated to infrastructural development. Dwindling profits may hamper this activity negatively impacting on the whole region's economy because the roads allow movement of other commodities thus encouraging growth of other businesses in the area. When local residents engage in businesses, their income is improved thus raising their standard of living.

3.3. Educational Institutions and Energy Poverty. Kirinyaga has a total of 846 educational institutions with an enrolment of approximately 166,060 students (Table 3). Most of these institutions have boarding facilities and provide meals for their students. Some of the day schools also provide meals and the main source of fuel for cooking is firewood. A secondary school student uses about 0.524 kg of firewood daily without considering type of cooker, school type, and number of meals cooked [67]. Using this information, the estimated firewood consumption for the secondary schools is 39,988 × 0.524 kg = 20,954 kg per day. Since students are in school for about nine months in a year, the annual usage of firewood for 270 days is 5,657,580 kg/annum (5,658 tons/annum). This figure is an underestimate of firewood use by educational institutions because the Early Childhood Development Education, primary schools, and tertiary institutions are not accounted for. Suffice to say that educational institutions make a major contribution to energy poverty in Kirinyaga through use of firewood.

Apart from educational institutions, there are other major firewood users, e.g., prisons, hospitals, restaurants, and other common social gatherings like weddings and funerals [67, 74, 75]. In most cases, their contribution to energy poverty is ignored, but cumulatively and over a long period of time their use of firewood affects demand and supply and eventually prices of firewood.

4. Implications of Energy Poverty on Living Standards

4.1. Energy Poverty and Access to Energy. In many developing countries, biomass for cooking accounts for over 90% of household energy usage, with sub-Saharan Africa having the world's largest share of per capita wood fuel consumption when compared to the global average per annum [76]. This scenario is most pronounced in rural areas in developing countries because they have limited access to clean energy sources, especially for cooking. The share of poor household's income spent on fuels forms a significant proportion of their expenditure and sometimes can overtake other essential items like schooling and health costs when local fuel prices rise [77]. The average share of Africa's household spending used on energy is 13%; thus the households suffer energy poverty because they spends more than 10% of their income on all fuel [30, 31]. Poor people without access to clean and affordable energy spend a large share of their scarce income on expensive and unhealthy forms of energy, which provide poor or unsafe services, e.g., dry cell batteries, rudimentary and inefficient kerosene lamps, charcoal, and candles [77]. Eventually these people are trapped in a vicious cycle of poverty. Many households in Kirinyaga have experienced firewood shortages since the late 1800s. This was partly caused by the rising population and caravan traders from the coast that traded in foodstuffs and firewood. This led to tree felling and land clearing for settlement and growing of food items that were in demand. The fuel wood shortage continued in the 1900s because of land privatization, which ended the communal property regime that allowed people to collect firewood from communal land especially forests. Privatization also made some people landless and poor and unable to buy alternative fuels [78]. The problem has persisted, with most farms lacking trees and households face challenges sourcing fuel wood. Further, women and girls travel long distances to the forest to collect firewood; a chore that would take a whole day and sometimes crop residues are used despite their low calorific value [49]. Lately, supply of biomass is less than demand as forests decline and prices of fuel wood rising [69]. Fuel wood use in Kirinyaga is indicator of energy poverty. This can be observed from data showing sale of forest produce for firewood (Table 1).

Table 1 indicates that the community in Kirinyaga is facing fuel wood scarcity and that is why they go to buy fuel wood from the forest. Most of the fuel wood is sold in form of head loads because it is mainly for domestic use while the stacks are for commercial purposes. The data confirms consistent supply of wood for domestic use, a clear indication that residents near the forest are energy poor [71].

Figure 1 shows the types of fuels used by different households for cooking in Kirinyaga. It indicates that firewood (75.4%) and charcoal (14.9%) are the main sources of energy [55]. The firewood is mainly used by rural households and charcoal by urban residents. Firewood and charcoal account for 90.3% of energy for cooking, while all the other modern energy sources account for 9.7% (Figure 1). This high reliance on traditional energy is an indication of prevalent energy poverty. There is a higher incidence of poor health among the energy poor populations of most countries compared to nonenergy poor households [79]. Use of fuel wood for cooking causes indoor air pollution. It is estimated at indoor air pollution causes 3-4 million early deaths per annum and accounts for 18% of all ischemic heart diseases and 33% of lower respiratory infections globally [59]. Since Kirinyaga residents mainly rely on fuel wood, they are likely to face similar consequences. Poor health affects productivity within a household and can lower living standards especially if a lot of the resources are directed towards medication.

In Kirinyaga, there are 7.5% rural households with electricity and 40 trading centres are not connected to the national grid [64]. Energy consumption indicates heavy reliance on traditional cooking fuels (firewood and charcoal) and minimal access to gas and electricity (modern fuel sources), which indicate that rural household in Kirinyaga are experiencing energy poverty. Further, a study on living wage focusing on rural Mt Kenya area found that collecting and preparing firewood took half an hour to one hour per day [53] and this time would be spent on other productive activities or leisure thus improve living standards. In rural areas of developing countries, access to modern energy helps to raise the standard of living of rural populations by enabling them to acquire items like radios, television sets and mobile phones [80]. Low electricity access in Kirinyaga is thus a barrier to acquisition of these electrical items associated with higher standard of living.

4.2. Energy Poverty and Calorific Intake. Food access occurs when a household is empowered to provide a balanced diet for all its members [81, 82]. In Kenya, food availability is determined by cereal supply particularly maize. Per capita food availability has declined by more than 10% over the last three decades while per capita consumption of maize has increased by 3% per annum [83]. Maize, the staple food in Kenya, makes up more than a third of the calorific intake. Most people depend on *ugali* (a thick porridge of maize flour and water), accompanied by vegetables, meat, or fermented milk. *Githeri* (a dish of boiled maize and beans) or *irio* (mashed maize, beans, vegetables, and potatoes) are also common [84, 85]. Based on Food Agricultural Organisation's (FAO) recommendations, the daily per adult equivalent calorie requirement for Kenyans is 2250 Kcal/day [86]. Majority of Kenyans have not achieved the FAO target mainly because of high poverty levels, inadequate diversification of food production and consumption, and high cost of protein [83, 87]. The average per capita calories intake in Kirinyaga is 2405 Kcal [88], which is slightly higher than the recommended value of 2250 Kcal [86]. This is attributed to export horticultural farming, which seems to have a positive effect on food security status in the county. Despite Kirinyaga residents being food secure, their main diet consists of *githeri*, *ugali,* and rice together with vegetable or meat stew. Cooking of *githeri* using dry grains take about three hours, ugali take about 30 minute, and rice take about 40 minutes [89]. A household relying mainly on *githeri* as its main diet consumes 1400 kg more wood per annum than one relying on nonwhole grain meals [74]. Fuel wood is scarce and many households cannot afford to use modern fuels to cook *githeri* which is the main staple food and hence prefer to use fuel wood or charcoal. Use of these traditional sources of energy by Kirinyaga residents translates into energy poverty. Empirical studies show that fuel wood shortage affects food consumption patterns. This leads to fewer meals being cooked, cooking of foods that require less fuel, substitution of raw and colds dishes, increased time and effort to collect or purchase firewood, and consumption of less nutritious food [74, 90–92]. Many families also opt to buy food from street food vendors because of their life style [53], e.g., to reduce fuel cost, despite the negative health risks and also most street food is not balanced [93, 94]. Street foods are not always prepared and handled in hygienic conditions. They can cause food-borne illnesses that can lead to death of the consumers [95]. Energy poverty thus makes people consume street food that compromises their health, eventually affecting their living standards.

4.3. Energy Poverty and Life Expectancy. Energy is the driving force of human development and modern societies. Energy access promotes economic and human development and changes agrarian societies to industrial ones. Industrialization in turn improves household incomes, thus eliminating many contagious diseases, lowering child mortality rates, and improving life expectancy [96, 97]. Many healthcare facilities in developing countries are incapacitated due to lack of energy access which is essential for storing vaccines and carrying out life-saving operations [98]. Improved energy access in the healthcare facilities will help to raise life expectancy by ensuring timely provision of services. The

Table 4: Electricity consumption and life expectancy for selected countries.

Country	Electricity Consumption/kWh per capita (2014)[a]	Life Expectancy in Years (2015)[b]
Kenya	167	67
Australia	10 059	82
Canada	16 109	82
Singapore	8 845	83
United States	12 987	79

Source: [104, 123].

availability of energy and the efficiency with which it is used enable humans to improve their living standards, live longer, and increase their numbers [99]. High life expectancy is thus an indication of high access to food, medicine, shelter, education, and low levels of disease and violence [100].

China is a classic illustration of the relationship between energy poverty and life expectancy. A tripling of energy consumption since 2000 has raised female life expectancy from 73 years in 2000 to 78 years in 2014 [101]. Each tenfold increase in electricity access translates into ten years increase in life [102]. Consequently, energy poverty leads to reduced life expectancy. The low electricity access in Kirinyaga, i.e., 7.5% of rural households and 15% of urban centres [64], could be the cause of life expectancy of 63 years [103]. Kirinyaga residents life expectancy is slightly lower than the Kenya's life expectancy at birth, which is 67 [104], and much lower when compared to countries with higher electricity access (Table 4).

Other than electricity consumption, there are other factors influencing life expectancy. Socioeconomic inequalities in health status exist globally even in developing countries [105]. Countries with more income than the global average income have higher life expectancies by 6.4 years [106]. Within a country, people with higher incomes generally have a longer lifespan than poorer people [107]. For instance, in Canada life expectancy is slightly lower than Singapore despite the higher electricity consumption. This is attributed to inequalities in Canada where regions with lowest life expectancy also process high rates of smoking, obesity, and heavy drinking all of which lead to poor health. These regions also have long-term unemployment rates, lower levels of education, small immigrant populations, and higher aboriginal populations and are located in remote areas [108]. The aboriginal people in Canada have life expectancies that are five or more years less than those of the total Canadian population [107]. In Singapore, despite lower electricity consumption, the WHO ranked her third globally for average life expectancy. Singapore's success is attributed to having the largest proportion of births attended by skilled personnel and lowest mortality rate caused by unintended poisoning. Further Singapore ranked third for lowest traffic deaths, fourth position for lowest deaths due to air pollution, lowest deaths due to cardiovascular and chronic respiratory diseases, and lowest mortality due to unsafe water and lack of hygiene among others [109]

Nevertheless, there is a positive correlation between per capita energy consumption versus life expectancy [100]. Consequently, it can be postulated that if electricity access in Kirinyaga is improved, there is an expected increase in life expectancy in line with existing global trends. In Kenya only a quarter of all hospitals have uninterrupted electricity supply. Poor access to affordable and clean energy leads to high maternal and child morbidity and mortality in rural areas and negatively affects recruitment and retention of qualified staff in health facilities. Households in rural areas also spend more money seeking skilled maternal and newborn care [110]. Poor access to health access arising from poor energy provision negatively impacts on the life expectancy.

4.4. Energy Poverty and Literacy Levels. Energy poverty influences literacy levels. Cleaner and affordable energy leads to better provision of clean water, sanitation, lighting, and energy for cooking in boarding schools [111]. Rural electrification also entices qualified teachers to these areas due to improved quality of life associated with electricity access [112, 113]. Electricity allows digitization of learning through use of electronic equipment, e.g., computers and overhead projectors for learning [114–116]. Access to modern fuels also reduces time spent looking for fuel wood; hence rural children have more time available for learning [117].

Children in electrified homes attain higher education levels than those without electricity and improved study time at home results in better grades at school [118]. In Kirinyaga, areas with higher electrification rates, e.g., Kirinyaga Central Constituency, have more residents with higher education level than Mwea Constituency, which has lower electrification rates [119]. Hence access to modern energy sources improves literacy levels. A study conducted in Nicaragua showed a positive and significant relationship between a home having electricity and all the children completing primary school [120] and in Philippines, a similar study showed a correlation between energy access and education [81]. Education empowers individuals to get well-paying jobs, thus enhancing their consumption power which can translate to higher living standards.

5. Policy Implications of Energy Poverty

Based on the impacts of energy poverty on living standards described in this paper, it is imperative that steps are taken to mitigate against them. Kenya is a low income country and the government has a responsibility to raise the living standards of its people especially in the rural areas. Some of the suggested policy options include the following:

(i) Promotion of renewable energy technologies, e.g., biogas to replace fuel wood through government subsidies.

(ii) Lowering the cost of installing and consumption of electricity to make it affordable to all people.

(iii) Diversifying the energy mix to reduce dependence on hydropower and fossil fuels and hence enable reduction of electricity prices.

(iv) Educating people on the negative impacts of smoke from fuel wood.

(v) Promoting use of energy efficient cooking stoves and hence reducing indoor pollution.

(vi) Subsidizing the cost of LPG to make it affordable to poor rural populations.

6. Conclusions

Kirinyaga residents are facing energy poverty as manifested in reliance on traditional fuels by households, educational institutions, and agroprocessing industries, coupled with low access to electricity. Energy access directly or indirectly influences availability and consumption of goods and services and hence affects peoples' standard of living. Low energy access thus lowers people's living standards. The low access to electricity has led reliance on traditional fuels. Use of solid fuels leads to indoor air pollution which is associated with premature death caused by respiratory and heart ailments. Fuel wood scarcity and associated high cost have affected the dietary patterns of Kirinyaga residents through switching from their traditional foods that take long time to cook, to foods that demand less fuel, thus impacting on calorific intake. Some residents have resorted to street foods exposing themselves to health risks associated with street food. Diseases resulting from consumption of street food can lower living standards if household income is largely diverted to health issues. Regions with higher electrification rates have more residents with higher educational levels and life expectancy. Electricity access improves school completion rates, thus enabling the residents get well-paying jobs which in turn improves their purchasing power eventually raising living standards. Electricity access improves provision of health care and reduces maternal and child morbidity and mortality, thus raising the life expectancy. Access to modern energy services therefore has a positive impact on standard of living.

Conflicts of Interest

The authors declare that there are no conflicts of interest regarding the publication of this paper.

References

[1] D. M. Kammen, P. Alstone, and D. Gershenson, "Energy for sustainable and equitable development," http://www.casinapoioiv.va/content/dam/academia/pdf/es41/es4/-Kammen.pdf.

[2] O. J. Kuik, M. B. Lima, and J. Gupta, "Energy security in a developing world," *WIREs Clim Change*, vol. 2, pp. 627–634, 2011.

[3] S. Bouzarovski and S. Petrova, "A global perspective on domestic energy deprivation: Overcoming the energy poverty–fuel poverty binary," *Energy Research and Social Science*, vol. 10, pp. 31–40, 2015, http://dx.doi.org/10.1016/j.erss.2015.06.007.

[4] C. Cader, P. Blechinger, and P. Bertheaua, "Electrification planning with focus on hybrid mini-grids – A comprehensive modelling approach for the Global South," *Energy Procedia*, vol. 99, pp. 269–276, 2016.

[5] S. Selvakkumaran and S. Silveira, "Exploring synergies between the intended nationally determined contributions and electrification goals of Ethiopia, Kenya and the Democratic Republic of Congo (DRC)," *Climate and Development*, 2018.

[6] N. D. Rao and P. Shonali, "Energy Access and Living Standards: Some Observations on Recent Trends," *Environmental Research Letters*, vol. 12, 2017.

[7] J. Terrapon-Pfaff, C. Dienst, J. König, and W. Ortiz, "A cross-sectional review: Impacts and sustainability of small-scale renewable energy projects in developing countries," *Renewable and Sustainable Energy Reviews*, vol. 40, pp. 1–10, 2014, http://dx.doi.org/10.1016/j.rser.2014.07.161.

[8] S. C. Bhattacharyya and D. Palit, "Mini-grid based off-grid electrification to enhance electricity access in developing countries: What policies may be required?" *Energy Policy*, vol. 94, pp. 166–178, 2016, http://dx.doi.org/10.1016/j.enpol.2016.04.010.

[9] United Nations Economic Commission for Africa (UNECA), "A Green Economy in the context of Sustainable Development and Poverty Eradication: What are the Implications for Africa?" http://www.1.uneca.org/Portals/rio20/documents/cfssd7/1AfricaGE-BackgroundreportEn.pdf.

[10] M. Bildiricia and F. Özaksoy, "Woody biomass energy consumption and economic growth in sub-saharan africa," *Procedia Economics and Finance*, vol. 38, pp. 287–293, 2016.

[11] H. Ahlborg, F. Boräng, S. C. Jagers, and P. Söderholm, "Provision of electricity to African households: The importance of democracy and institutional quality," *Energy Policy*, vol. 87, pp. 125–135, 2015, http://dx.doi.org/10.1016/j.enpol.2015.09.002.

[12] N. S. Ouedraogo, "Africa energy future: Alternative scenarios and their implications for sustainable development strategies," *Energy Policy*, vol. 106, pp. 457–471, 2017.

[13] Global Network on Energy for Sustainable Development (GNESD), "Bioenergy: The potential for rural development and poverty alleviation," 2011.

[14] GNESD, "GNESD policy brief: Achieving Energy Security in Developing Countries," http://www.gnesd.org/downloadables/EnergysecurutydevCountries.pdf.

[15] N. Moksnes, A. Korkovelos, D. Mentis, and M. Howells, "Electrification pathways for Kenya-linking spatial electrification analysis and medium to long term energy planning," *Environmental Research Letters*, vol. 12, no. 9, 2017.

[16] T. Gathui and W. Ngugi, "Bioenergy and Poverty in Kenya: Attitudes, Actors and Activities, Working Paper prepared for PISCES (Policy Innovation Systems for Clean Energy Security)," http://www.acts.or.ke/dmdocuments/PROJECTS_REPORTS/bioenergy_poverty_in_kena.pdf, 2010.

[17] T. Gathui, F. Mugo, W. Ngugi, H. Wanjiru, and S. Kamau, *The Kenya Charcoal Policy Handbook: Current Regulations for Sustainable Charcoal Sector*, Practical Action Consulting East Africa, Nairobi, Kenya, 2011.

[18] Intergovernmental Panel on Climate Change (IPCC), *Renewable energy sources and climate change mitigation; Special Report of the Intergovernmental Panel on Climate Change*, IPCC, Geneva, Switzerland, 1988.

[19] F. D. Longa and B. van der Zwaan, "Do Kenya's climate change mitigation ambitions necessitate large scale renewable energy deployment and dedicated low-carbon energy policy?" *Journal of Renewable Energy*, vol. 113, pp. 1559–1568, 2017.

[20] M. González-Eguino, "Energy poverty: An overview," *Renewable & Sustainable Energy Reviews*, vol. 47, pp. 377–385, 2015.

[21] C. M. Haanyika, "Rural electrification policy and institutional linkages," *Energy Policy*, vol. 34, no. 17, pp. 2977–2993, 2006.

[22] Kenya Institute for Public Policy Research and Analysis (KIPPRA), "Strategies for securing energy supply in Kenya: KIPPRA Policy Brief No. 7/2007," KIPPRA, Kenya Institute for Public Policy Research, Nairobi, Kenya, 2007.

[23] J. K. Kiplagat, R. Z. Wang, and T. X. Li, "Renewable energy in Kenya: Resource potential and status of exploitation," *Renewable and Sustainable Energy Reviews*, vol. 15, pp. 2960–2973, 2011.

[24] A. Yadoo and H. Cruickshank, "The value of cooperatives in rural electrification," *Energy Policy*, vol. 38, no. 6, pp. 2941–2947, 2010.

[25] P. Newell and J. Phillips, "Neoliberal energy transitions in the South: Kenyan experiences," *Geoforum*, vol. 74, pp. 39–48, 2016, http://dx.doi.org/10.1016/j.geoforum.2016.05.009.

[26] T. L. Acker, D. H. Smith, B. Weathers, and A. Zinenko, "The Global Potentials for Small and mid sized Wind (10-500kW) Production: using a Kenyan Case Study. Energy Sources," *Part B: Economics Planning and Policy*, vol. 7, no. 1, pp. 91–103, 2012, http://dx.doi.org/10.1080/15567240903048051.

[27] S. Baral, D. Kim, E. Yun, and K. C. Kim, "Energy, exergy and performance analysis of small-scale organic rankine cycle systems for electrical power generation applicable in rural areas of developing countries," *Energies*, vol. 8, no. 2, pp. 684–713, 2015.

[28] B. K. Sovacool, "The political economy of energy poverty: A review of key challenges," *Energy for Sustainable Development*, vol. 16, no. 3, pp. 272–282, 2012.

[29] S. Pachauri and D. Spreng, "Measuring and monitoring energy poverty," *Energy Policy*, vol. 39, no. 12, pp. 7439–7504, 2011, https://doi.org/10.1016/j.enpol.2011.07.008.7504.

[30] A. Kemmler and D. Spreng, "Energy indicators for tracking sustainability in developing countries," *Energy Policy*, vol. 35, pp. 2466–2480, 2007, https://doi.org/10.1016/j.enpol.2006.09.006.2480.

[31] H. Winkler, A. F. Simeons, E. L. Rovere, M. Alam, A. Rahman, and S. Mwakasonda, "Access and affordability of Electricity in Developing Countries," *World Development*, vol. 39, no. 6, pp. 1037–1050, 2011.

[32] IEA, "The Energy Development Index," in *World Energy Outlook 2012*, OECD/IEA, Paris, France, 2012.

[33] W. Foell, S. Pachauri, D. Spreng, and H. Zerriff, "Household cooking fuels and technologies in developing economies," *Energy Policy*, vol. 39, no. 12, pp. 7487–7496, 2011.

[34] P. Nussbaumer, M. Bazilian, V. Modi, and K. K. YumKella, "Measuring Energy Poverty: Focusing on what matters," in *OPHI Working Paper No. 42*, Oxford Department of International Development, University of Oxford, Oxford, UK, 2011.

[35] D. Cvrlje and T. Ćorić, "Macro and micro aspects of standard of living and quality of life in a small transition economy: The case of Croatia," in *Working Paper Series Paper No. 10-02*, university of Zagreb, Zagreb, Croatia, 2010, https://hrcak.srce.hr/file/201920.

[36] Wikipedia, "Standard of Living," https://en.wikipedia.org/wiki/Standard_of_Living, 2018.

[37] B. Bridge, D. Adhikari, and M. Fontenla, "Household-Level Effects of Electricity on Income," http://digitalrepositor.unm.edu/cgi/viewcontent.cgi, 2013.

[38] Y. Akachi and D. Canning, "Inferring the Economic Standard of Living and Health from Cohort Height: Evidence from Modern Populations in Developing Countries," *Economics and Human Biology*, vol. 19, pp. 114–128, 2015, http://dx.doi.org/10.1016/j.ehb.2015.08.005.

[39] D. Anderson, "Energy and Economic Prosperity," http://file///c:users/user/Downloads/Chapter11.pdf.

[40] R. Day, G. Walker, and N. Simcock, "Conceptualising energy use and energy poverty using a capabilities framework," *Energy Policy*, vol. 93, pp. 255–264, 2016.

[41] R. Joyeux and R. D. Ripple, "Household energy consumption versus income and relative standard of living: a panel approach," http://www.fe.ualg.pt/conf/urct/prog/ps1/p2008.pdf, 2008.

[42] N. Simcock and C. Mullen, "Energy Demand for Everyday Mobility and Domestic Life: Exploring the Justice Implications," *Energy Research and Social Science*, vol. 18, p. 1, 2016, http://dx.doi.org/10.1016/j.erss.2016.05.019.

[43] H. Ahlborg, M. Sj, and M. Sjöstedt, "Small-scale hydropower in Africa: Socio-technical designs for renewable energy in Tanzanian villages," *Energy Research & Social Science*, vol. 5, pp. 20–33, 2015, http://dx.doi.org/10.1016/j.erss.2014.12.017.

[44] A. Basu, D. James, and J. D. Marett, "Access to Clean Energy in Rural Kenya through Innovative Market Based solutions," http://www.ss.undp.org/content/dam/LECB/docs/pubs-namas/undp-lecb-Kenya_Clean-Energy-NAMA-2016.pdf.

[45] N. Otuki, "High Power charges pile pressure on households, Daily Nation," https://www.bussinessdailyafrica.Com/economy/High-power-charges-pile-pressure-0n-households/3946234-4368048-14t8366z/index.html, 2018.

[46] KNBS, "Consumer Price Indices and Inflation rates for February 2018," 2018, http://www.theelepphant.info/uploads/2018/02/KNBS-Consumer-Price-Indices-and-Inflation-Rates-for-Feb-2018.pdf.

[47] R. Malonza and M. L. Fedha, "An Assessment of Gender and Energy in Kenya: The underlying Issues," *International Journal of Scientific and Technology Research*, vol. 4, no. 9, pp. 137–153, 2015.

[48] C. Otieno, "LPG Consumption in Kenya- Is there a Case for Subsidy?" http://www.lpgbussinessreview.com/2017/04/25/lpg-).Lpg-consumption-in-Kenya-is-there-a-case-for-subsidy?

[49] J. Hollada, K. N. Williams, C. H. Miele, D. Danz, S. A. Harvey, and W. Checkley, "Perceptions of Improved Biomass and Liquefied Petroleum Gas Stoves in Puno, Peru: Implications for Promoting Sustained and Exclusive Adoption of Clean Cooking Technologies," *International Journal of Environmental Research and Public Health*, vol. 14, p. 182, 2017.

[50] M. Kojima, "The Role of Liquefied Petroleum Gas in Reducing Energy Poverty," http://www.siteresources.worldbank.org/INTOGMC/Resources/LPGReportWeb-Masami1.pdf, 2017.

[51] KNBS and SID, "Exploring Kenya's Inequality: Pulling Apart or Pulling Together?" http://inequalities.sidint.net/Kenya/wp-content/uploads/sites/3/2013/10/%E2%80%A6..pdf, 2013.

[52] Q. Wu, S. Maslyuk, and V. Clulow, "Energy Consumption Inequality and Human Development," https://www.researchgate.net/publication/221928732_Energy_Consumption_Inequality_and_Human_Development, 2012.

[53] R. Anker and M. Anker, "Living Wage Report Kenya with a focus on rural Mount Kenya Area: Context Provided in Horticulture Industry June 2015 – with update to October 2016," https://www.isealalliance.org/sites/default/files/resource/2017-12/Kenya_Living_Wage_Benchmark_Report.Pdf, 2017.

[54] O. N. O. Nwankwo, N. Mokogwu, O. Agboghoroma, F. O. Ahmed, and K. Mortimer, "Knowledge, attitudes and beliefs about the health hazards of biomass smoke exposure amongst commercial food vendors in Nigeria," *PLoS ONE*, vol. 13, no. 1, 2018, https://doi.org/10.1371/journal.pone.0191458.

[55] KNBS, *Economic Survey 2013*, KNBS, Nairobi, Kenya, 2013.

[56] B. Amiguna and H. Von Blottnitz, "Capacity-cost and location-cost analyses for biogas plants in Africa," *Resources, Conservation and Recycling*, vol. 55, pp. 63–73, 2010.

[57] E. K. Kirunguru, Q. Huang, and P. N. Ayambire, "Design and Implementation of a Transformer Vandalism Monitoring System," *International Journal of Sensors and Sensor Networks*, vol. 5, no. 6, pp. 76–80, 2017.

[58] G. Andae, "Kenya Power transformers vandalism falls 40pc," https://www.businessdailyafrica.com/economy/Kenya-Power-transformers-vandalism-falls-40pc/3946234-4162694-7jlw6t/index.html, 2017.

[59] J. Rosenthal, A. Quinn, A. P. Grieshop, A. Pillarisetti, and R. I. Glass, "Clean cooking and the SDGs: Integrated analytical approaches to guide energy interventions for health and environment goals," *Energy for Sustainable Development*, vol. 42, pp. 152–159, 2018, https://doi.org/10.1016/j.esd.2017.11.003.

[60] G. Walker, N. Simcock, and R. Day, "Necessary energy uses and a minimum standard of living in the United Kingdom: Energy justice or escalating expectations?" *Energy Research and Social Science*, vol. 18, pp. 129–138, 2016.

[61] M. A. Hussein and W. L. Filho, "Analysis of energy as a precondition for improvement of living conditions and poverty reduction in sub-Saharan Africa," *Scientific Research and Essays*, vol. 7, no. 30, pp. 2656–2666, 2012.

[62] R. Mahmood and A. Shah, "Deprivation Counts: An Assessment of Energy Poverty in Pakistan," *The Lahore Journal of Economics*, vol. 22, no. 1, pp. 109–132, 2017.

[63] T. Kitchen and P. O'Reilly, "Energy poverty amidst abundance in Malaysia: placing energy in multidimensional poverty," *Development in Practice*, vol. 26, no. 2, pp. 203–213, 2016.

[64] Republic of Kenya (RoK), "Draft Kirinyaga County First Integrated Development plan 2013-2017,Kirinyaga County, Kutus," 2015, http://www.cog.go.ke/images/stories/CIDPS/Kirinyaga.pdf.

[65] J. Ngunjiri, "KTDA factories roll out plan for reliable wood fuel," 2013, http://www.businessdailyafrica.com/Corporate-News/KTDA-factories-roll-out-plan-for-reliable-wood-fuel/-/539550/1842904/-/oqulb7z/-/index.html.

[66] Land O' Lakes International Development and Winrock International, "Priority Geothermal Direct-Use Applications for Kenya: A feasibility Study for Crop Drying," 2015, http://www.idd.landolakes.com/gettachment/Resources/Publications/PAA-Crop-Drying-Study-crop-drying-study.pdf.aspx.

[67] A. Nyambane, M. Njenga, P. Oballa et al., "Sustainable firewood access and utilization: Achieving cross-sectoral integration in Kenya. Technical Brief May 2014, World Agroforestry Centre and SEI, Nairobi," 2015, http://www.sei-international.org/mediamanager/documents/Publications/ICRAF-SEI-2014-techbrief-Sustainable-firewood.pdf.

[68] C. K. Kimathi and F. M. Muriuki, "A showcase of Smallholder Agriculture in the EAC: The case of the Smallholder tea sector in Kenya," 2016, http://www.kilimotrust.org/documents/Final-Papers-PDFs/12.

[69] K. Ellis, A. Lemma, S. Mutimba, and R. Wanyoike, "Low carbon Competitiveness in Kenya," 2015, http://www.odi.org/sites/odi.org.uk/files/odi-assets/publications-opinion-files/8593.pdf.

[70] S Oirere, "Tea Industry Boosts Forest Cover in Kenya, But Will Trees Remain Standing?" 2015, http://www.earthisland.org/journal/index.php/elist/eListRead/tea_industry_boosts_forest_cover_in_kenya_but_will_trees_remain_standing/.

[71] E. E. Nordman, "Energy transitions in Kenya's tea sector: A wind energy assessment," *Journal of Renewable Energy*, vol. 68, pp. 505–514, 2014.

[72] Technical Centre for Agricultural and Rural Cooperation (CTA), "Agritrade: Informed Analysis, Expert opinions: Executive Brief," 2013, http://www.Publications.cta.int/media/publications/downloads/Tea_Executive_Brief_EN.pdf.

[73] Republic of Kenya, "Laws of Kenya: Tea Act Chapter 343," 2012, http://kenyalaw.org/kl/fileadmin/pdfdownloads/Acts/TeaAct-Cap343.pdf.

[74] E. Kituyi, L. Marufu, B. Huber et al., "Biofuel Consumption rates and Patterns in Kenya," *Biomass and Energy*, vol. 20, pp. 83–89, 2001.

[75] M. Njenga, N. Karanja, C. Munster et al., "Charcoal production and strategies to enhance its sustainability in Kenya," *Development in Practice*, vol. 23, no. 3, pp. 359–371, 2013.

[76] M. Liyama, H. Neufeldt, P. Dobie, M. Njenga, G. Ndegwa, and R. Jemnadass, "The potential of agroforestry in the provision of sustainable wood-fuel in sub-Saharan Africa," *Current Opinion in Environmental Sustainability*, vol. 6, pp. 138–147, 2014.

[77] S. Karekezi, S. Mcdade, B. Boardman, J. Kimani, and N. Lusting, "Energy Poverty and Development," 2012, http://www.iiasa.ac.at/web/home/research/Flagshipprojects/GlobalEnergyAssessments/GEA_Chapter-2development_hires.pdf.

[78] A. P. Castro, "Indigenous Kikuyu Agroforestry: A Case of Study of Kirinyaga, Kenya," *Human Ecology*, vol. 19, no. 1, pp. 1–18, 1991.

[79] H. Thomson, C. Snell, and S. Bouzarovski, "Health, Well-Being and Energy Poverty in Europe: A Comparative Study of 32 European Countries," *International Journal of Environmental Research and Public Health*, vol. 14, p. 584, 2017.

[80] J. Bell, G. Mora, E. Hagan, V. Rubin, and A. Karpyn, "Access to healthy food and why it matters: a review of the research," http://www.thefoodtrust.org/uploads/media_items/access-to-healthy-food.original.pdf.

[81] D. R. Thiam, "Renewable energy, poverty alleviation and developing nations: Evidence from Senegal," *Journal of Energy in Southern Africa*, vol. 22, pp. 23–34, 2011.

[82] C. Maslen, A. Raffle, S. Marriot, and N. Smith, "Food Poverty: What does the evidence tell us?" 2012, http://www.bristofood-policycounsil.org/wp-content/uploads/2013/08/Food-Poverty-Report-July-2013-for-Publication.pdf.

[83] RoK, "Updated Least Cost Power Development Plan Study Period 2011 – 2031," 2011, https://www.renewableenergy.go.ke/downloads/studies/LCPDP-2011-2030-Study.pdf.

[84] M. A. Wagah, E. Bader, C. Deligia, and M. C. Dop, "Kenya Nutrition Profile, FAO, Food and Nutrition Division," 2005, http://www.ftp/ftp.fao.org/es/Esn/nutrition/ncp/Ken.pdf.

[85] H. K. Mohajan, "Food and Nutrition Scenario of Kenya," *American Journal of Food and Nutrition*, vol. 2, no. 2, pp. 28–38, 2014.

[86] KNBS, “Basic Report on Well-being in Kenya: based on Kenya Integrated Household Budget Survey- 2005/2005. Ministry of Planning and National Development, Nairobi, Kenya,” 2007, http://www.googlke.com/#q=basic+report+on+wellbeing+in+Kenya.

[87] V. Kirogo, W. Kogi-Makau, and N. M. Muroki, “The role of irrigation on improvement of nutritional status of young children in Central Kenya,” *African Journal of Food Agriculture Nutrition and Development*, vol. 7, no. 2, 2007.

[88] J. Chege, J. Mburu, R. Nyikal, and B. Muriithi, “78- Impact of Export Horticulture Farming on Food Security of Small-holder Farmers in Mbooni and Kirinyaga Counties, Kenya,” http://www.ageconsearch.umn.edu/bitstream/160475/2/Jane.

[89] S. Collins, “Wonderbag, Laikipia, Kenya,” 2013, http://www.zeitzfoundation.org/userfiles/WonderbagsinKenya_reduced.pdf.

[90] C. F. Link, W. G. Axinn, and D. J. Ghimire, “Household energy consumption: Community context and the fuelwood transition,” *Social Science Research*, vol. 41, no. 3, pp. 598–611, 2012.

[91] V. S. Waris and P. Antahal, “Fuel wood Scarcity, Poverty and Women: Some Perspectives,” *ISOR Journal of Humanities and Social Science*, vol. 19, no. 8, pp. 21–33, 2014.

[92] I. M. Momodu, “Domestic Energy Needs and Natural Resources Conservation: The Case of Fuelwood Consumption in Nigeria,” *Mediterranean Journal of Social Sciences*, vol. 4, no. 8, pp. 27–33, 2013.

[93] J. Trafialek, E. H. Drosinos, and W. Kolanowski, “Evaluation of street food vendors’ hygienic practices using fast observation questionnaire,” *Food Control*, vol. 80, pp. 350–359, 2017.

[94] P. Moussavi, K. Liguori, and K. Mehta, “Street Foods in Central Kenya: Actors, Trends, and Opportunities,” *International Journal for Service Learning in Engineering, Humanitarian Engineering and Social Entrepreneurship*, vol. 11, no. 2, pp. 87–100.

[95] J. Clemente, “End energy poverty and empower women,” 2015, http://www.forbes.co.sites/judeclemente/2015/01/22/alleviating-energy-poverty-and-empowering-females/2/#5f8d2be799a.

[96] P. A. Trotter, M. C. McManusa, and R. Maconachie, “Electricity planning and implementation in sub-Saharan Africa: A systematic review,” *Renewable and Sustainable Energy Reviews*, vol. 74, pp. 1189–1209, 2017.

[97] K. Singh, P. Dudeja, N. Kaushal, and S. Mukherji, “Impact of health education intervention on food safety and hygiene of street vendors: A pilot study,” *Medical Journal Armed Forces India*, vol. 72, pp. 265–269, 2016.

[98] A. Franco, M. Shaker, D. Kalubi, and S. Hostettler, “A review of sustainable energy access and technologies for healthcare facilities in the Global South,” *Sustainable Energy Technologies and Assessments*, vol. 22, pp. 92–105, 2017.

[99] J. Lambert, G. Hall, C. A. S, S. Balogh, A. Gupta, and M. Arnold, “Energy, EROI and quality of life,” *Energy Policy*, pp. 153–167, 2014.

[100] R. Naam, “Income, Energy use and Life Expectancy,” http://remeznaam.com/2013/11/2014/income-energy-use-and-life-expectancy/.

[101] J. Clemente, “Remembering Stockholm: The Environment is People and their necessity for more Energy,” http://www.forbes.co.sites/judeclemente/2014/10/04/remembering-stolkholm-the-environment-is-people-and-their-necessity-for-more-energy/2/#32b4168c76f8.

[102] G. H. Boyce, “Fuelling the future with 21st Century Coal,” 2016, http://cornerstonemag.net/fuelling-the-future-with-21st-century-coal.

[103] KIPPRA, “Kenya Economic Report 2013,” http://www.kippra.or.ke/downloads/KenyaEconomicReport2013.pdf.

[104] World Bank, “Electricity Consumption (kWh per capita),” 2018, https://data.worldbank.org/indicator/EG/USE.ELEC.KH.PC.

[105] V. Bilas, S. Franc, and M. Bosnjak, “Determinant Factors of Life Expectancy at Birth in the European Union Countries,” *Collegium Antropologicum*, vol. 38, no. 1, pp. 1–9, 2014.

[106] A. Monsef and A. S. Mehrjardi, “Determinants of Life Expectancy: A Panel Data Approach,” *Asian Economic and Financial Review*, vol. 5, no. 11, pp. 1251–1257, 2015.

[107] The Conference Board of Canada, “Life Expectancy,” https://www.conferenceboard.ca/hcp/Details/Health?life-expectancy.aspx?AspxAutoDetectCookiesupport=1.

[108] L. Greenberg and C. Normandin, “Disparities in Life Expectancy at Birth,” Article ID 2011001, 2015, https://www/50/statcan.gc.ca/n1/pub/82-624-x/2011001/article/11427-eng.htm.

[109] A. Jamal, “Singapore ranks third in the World for Average Life Expectancy,” https://www.connecttoindia.com/singapore-ranks-third-in-the-world-for-average-life-expectancy-who-1543.html.

[110] M. Harsdorff and J. Peters, “On-Grid Rural Electrification in Benin. A Socio-economic Baseline Study on a GTZ Project, RWI Materialien, Germany,” http://en.rwi-essen.de/media/content/pages/publikationen/rwi-materialien/M_57_Baseline-Benin.pdf.

[111] H. Essendi, F. A. Johnson, N. Madise et al., “Infrastructural challenges to better health in maternity facilities in rural Kenya: community and health worker perceptions,” *Reproductive Health*, vol. 12, no. 103, 2015.

[112] Ministry of Foreign Affairs, “Renewable Energy Access and Impact: A systematic literature review of the impact on livelihoods of Interventions providing access to renewable energy in developing countries,” http://www.oecd.org/derec/netherlands/Renewable%20Energy%20Access%20and%20Impact.pdf.

[113] R. Shortall, B. Davidsdottir, and G. Axelsson, “Geothermal energy for sustainable development: A review of sustainability impacts and assessment frameworks,” *Renewable and Sustainable Energy Reviews*, vol. 44, pp. 39–406, 2015.

[114] A. C. Langat, “Barriers hindering Implementation, Innovation and Adoption of ICT in Primary Schools in Kenya,” *International Journal of Innovative Research and Development*, vol. 4, no. 2, pp. 1–11, 2015.

[115] S. Hirmer and H. Cruickshank, “The user-value of rural electrification: An analysis and adoption of existing models and theories,” *Renewable and Sustainable Energy Reviews*, vol. 34, pp. 145–154, 2014.

[116] P. A. Trotter, “Rural electrification, electrification inequality and democratic institutions in sub-Saharan Africa,” *Energy for Sustainable Development*, vol. 34, pp. 111–129, 2016.

[117] M. Mapako, *Energy, the Millennium Development Goals and the key Emerging issues*, Department of Environmental Affairs, South Africa, 2010.

[118] World Bank, “The Welfare Impact of Rural Electrification: A Reassessment of the Costs and Benefits,” 2008, http://www.siteresources.worldbank.org/EXTRURELECT/Resources/full_doc.pdf.

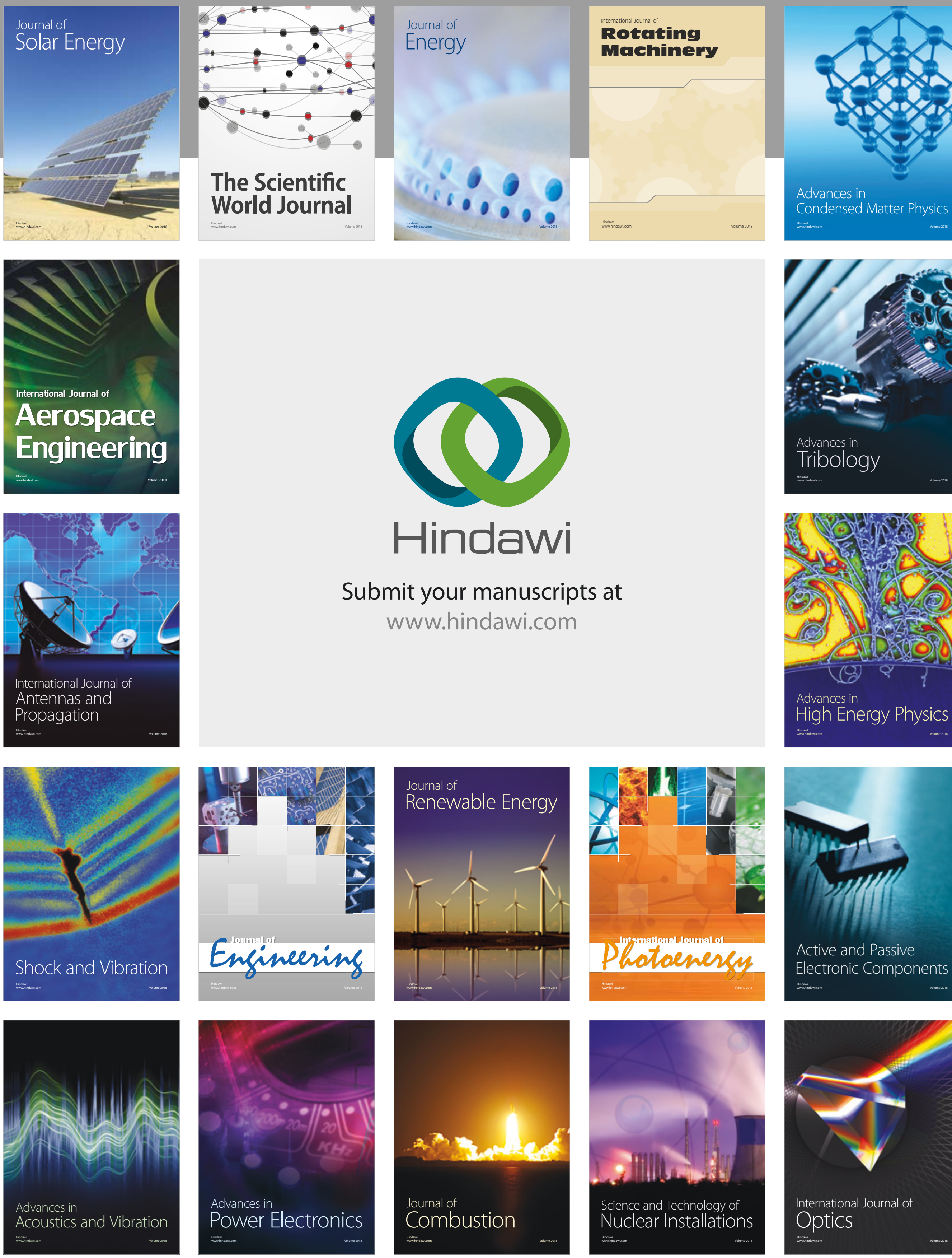
[119] Kenya National Bureau of Statistics and Society for International Development, "Exploring Kenya's Inequality: Pulling Apart or Pooling Together: Kirinyaga County," http://www.inequalities.sidint.net/Kenya/wp-content/uploads/sites/2/2013/09/Kirinyaga.pdf.

[120] B. Bridge, "Individual and household-level effects of energy poverty on human development," http://www.digitalrepository.unm.edu/cgi/viewcontent.cgi?article=1066&content=econ_etds.

[121] Kenya Forest Service, "Sale of minor Forest Produce by Kerugoya Station," 2003 - 2011.

[122] KTDA, Electricity and Fuel Wood Consumption in Kirinyaga Tea Factories 2015, 2015.

[123] World Bank, "Life Expectancy at birth, total (years)," 2018, https://data.worldbank.org/indicator/SP.DYN.LEOO.IN.


Journal of
Solar Energy
The Scientific World Journal
Journal of
Energy
International Journal of
Rotating Machinery
Advances in
Condensed Matter Physics
International Journal of
Aerospace Engineering
Hindawi
Submit your manuscripts at
www.hindawi.com
Advances in
Tribology
International Journal of
Antennas and Propagation
Advances in
High Energy Physics
Shock and Vibration
Journal of
Engineering
Journal of
Renewable Energy
International Journal of
Photoenergy
Active and Passive
Electronic Components
Advances in
Acoustics and Vibration
Advances in
Power Electronics
Journal of
Combustion
Science and Technology of
Nuclear Installations
International Journal of
Optics