Introduction

Heightened industrialization, booming international economies, and a growing global population collectively contribute to the scarcity of resources around the world. Despite its positive aspects, the rapid global development within the past two decades comes with negative repercussions, the most significant of which are associated negative environmental impacts. As natural resources have depleted considerably, nations around the world struggle to sustain their communities. For this reason, environmentally sustainable alternative energy sources have the potential to elevate societies both economically and socially. The widespread environmental impact of globalization brings into question the role of international governments, NGOs, and other international actors in supporting sustainability.

Ghana and Sustainable Development

Ghana, located in West Africa, is one such example of a developing nation with emerging alternative energy technologies that can benefit considerably from environmentally sustainable initiatives. The potential for biomass, hydrokinetic, and wind energies has been explored and studied in recent years and with effective implementation, these projects can combat the build-up of greenhouse gasses, bolster the nation’s economy, and promote social well-being. They can also potentially offset the negative impacts of colonialism and corruption that continue to plague Ghana.

While the nation’s gross domestic product (GDP) was reported to have grown by 5 percent in 2004, and the value of exports increased by 11 percent, an estimated 40 percent of Ghanaians continued to live beneath the poverty level, with a per capita income of less than $1 per day and unemployment remaining high. Ghana opted for debt relief under the Heavily Indebted Poor Country (HIPC) program and was included in a Group of Eight (G-8) debt relief program in July 2005. This measure significantly
reduced the country’s external debt from $6.2 billion in 2001 to $2.2 billion in 2006. Additionally, Ghana was one of sixteen countries awarded funds ($547 million) by the U.S. government through its Millennium Challenge Account toward poverty alleviation in 2006.1

Ghana’s financial vulnerability and extreme poverty indicate it would benefit greatly from environmentally sustainable projects. In particular, sustainable energy contributes to a virtuous cycle of human, economic and social improvements that are essential to sustainable development in developing countries. Sufficient supplies of clean energy are the basis for raising standards of living, improving the quality and quantity of human capital, enhancing the business and natural environment, and increasing the efficiency of government policies. Demand for energy is growing exponentially in developing countries due to rapid population growth and rapid economic expansion; increases in demand are projected to lead to a near doubling in primary energy use, much of it unsustainable, by developing countries in the next two decades.2 Ghanaian’s ability to develop initiatives that keep up with energy demand and preserve their natural resources will undoubtedly help alleviate poverty throughout the nation as well as facilitate new economic growth.

**Biomass Energy**

The concept of biomass as an energy source is gaining prominence around the world as a result of rising demands in energy, the increasing cost of fossil fuels, and fossil fuels’ contribution to the “greenhouse effect.” Biomass represents all plant and animal matter on the Earth’s surface and also includes materials dubbed as wastes, such as discharge from food manufacturing, muddy deposits, manures, industrial organic by-products and the organic fraction of household waste. Bioenergy, which is derived from biomass, involves utilizing the likes of crops, trees and dung to generate power.3

Traditional biomass, which is most widely used in developing nations, often serves as a non-commercial energy source. Its primary drawbacks are that it is not produced in a sustainable manner and its impact on the environment is harmful. However, modern biomass is produced in a sustainable manner; it excludes traditional uses of biomass, such as fuel wood, but includes agricultural remnants, forest residues and solid waste. Modern biomass is used for electricity generation, heat production, and transportation fuels. While an emerging energy source in several developing countries, biomass is only renewable and sustainable under certain conditions.4

In Ghana, resources for sustainable biomass include wood wastes, agricultural crops and their waste by-products, municipal solid waste, animal wastes, wastes from food processing, aquatic plants and algae. Generally, cellulose is the largest fraction of biomass, typically constituting roughly 38–50 percent of biomass by weight. Sugarcane, sweet sorghum, maize, cassava, oil palm, coconut, sunflower, soy bean and jatropha are some Ghanaian crops with potential as biodiesels, as residues from these crops have a high potential for energy production.5

Like other wastes, agricultural residues are lignocellulosic biomass, meaning they contain a high amount of organic constituents including cellulose, hemicellulose and lignin. These constituents have a high-energy content which facilitates power generation. Based on benefits of energy recovery and environmental protection, they can be recognized as potential sources of renewable energy.

![Biomass Energy Diagram](image)

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The residue-to-product ratio of each crop varies depending on factors such as crop variety, water and nutrient supply, and the use of chemical growth regulators. The relative proportions of the different constituents determine the suitability of each residue as a potential biofuel feedstock. The crops with higher ratios and concentrations of each sugar will be better candidates for energy production.

In 2005, a draft National Biofuel Policy (NBP) on the production and use of biofuels in Ghana was prepared and submitted to Parliament. The NBP aims to accelerate the development of the biofuel industry and focuses on jatropha. It also recommends the replacement of 15 percent of motor fuel with biodiesel by the year 2010. The NBP also recommends the replacement of 20 percent of petroleum diesel with biodiesel by the year 2015.

In both developed and developing countries, fossil fuel price fluctuations and climate change have raised interest in biofuels. As developed countries move from voluntary to obligatory legislations, market share increases. At the same time, growing interest in biofuels from voluntary to obligatory legislations, market share increases. At the same time, growing numbers of African countries are becoming suppliers of feedstock. This is the result of development of large-scale plantations of energy crops driven by demand in the EU and the USA. In Ghana, the local production of biofuels is becoming suppliers of feedstock. This is the result of development of large-scale plantations of energy crops driven by demand in the EU and the USA.

Hydrokinetic energy is another emerging sustainable initiative in Ghana. Hydrokinetic technologies harness the kinetic energy of a body of water, the energy that results from the motion of tides, waves, ocean currents, and free-flowing rivers. Hydrokinetic technologies produce renewable electricity by representing an untapped, powerful, and clean energy resource.

While 81 percent of urban households in Ghana have access to electricity, only 24.9 percent of rural dwellers have access. In regions where modern energy is not readily available, residents use kerosene lamps for indoor lighting. However, this...
produces harmful emissions which often lead to poor respiratory effects. Implementation of hydrokinetic power (HKP) within nearby streams can provide low impact, robust energy to rural communities. Such a system lends itself to a simple design which can be used as a stand-alone power system (SAPS). As Ghana’s renewable energy policies come to fruition, the implementation of this technology is becoming more economically and socially viable. A review of the Ghanaian topography and population density maps in combination with a review of Ghanaian electrification systems demonstrates that electrification actually neglects over 50 percent of the overall population. As part of the United Nations Millennium goals, the national development planning commission of Ghana has outlined energy development as a priority. Access to energy influences many aspects of general well-being, such as health, prosperity, and gender equality.

Hydrokinetic power (HKP) generation extracts kinetic energy rather than potential energy, which is the mode of energy generation currently used in almost all large and small hydropower systems. These are referred to as hydropotential power (HPP) systems. HKP systems avoid many of the problems encountered with HPP, such as large population displacement, high infrastructure costs, and large decreases in downstream flow. They utilize a simple design that can be maintained by local residents for low cost. Furthermore, HKP can be easily installed into a stream and modified with small effort to enhance energy extraction. HKP and HPP are competing technologies due to their similar power extraction amounts, however, HKP’s benefits greatly outweigh those of HPP. In particular, HKP systems require a lower cost per unit of energy extracted and are economically comparable with other distributed systems, ultimately making them a better choice from a policy perspective.

Since the mid-1980s, the Ghanaian government has financed projects using small levies on petroleum products. The money is paid into an energy fund and used to promote renewable energy and energy efficient projects. A strategic national energy plan was adopted earlier this decade and covers the period between 2006-2020. In this plan, the government hopes to achieve 15 percent penetration of rural electrification through decentralized renewable energy by 2015; it hopes to expand this percentage to 30 percent by 2020. The energy plan also sets a target of 10 percent of overall contribution from renewable energy by 2020. In complement to this strategic plan, a renewable energy law is being drafted and will soon be passed to parliament for adoption.

The implementation of hydrokinetic turbines for energy access in rural Ghana will benefit society in many ways, thus contributing toward a global impact. Energy access can make everyday tasks more simple and safe and directly impacts community health. For example, electrification is important for rural health centers in maintaining vaccine refrigeration. Cheap, widespread electricity, such as that generated by HKP, directly addresses the UN Millennium goals of eradicating extreme poverty and hunger, promoting gender equality, and improving maternal health. HKP’s innovation succeeds where previous methods fell short.

Further, implementing environmentally friendly energy sources in a developing country proactively keeps overall global emissions and CO contribution under control. Developing countries that lack a solid energy infrastructure generally contribute less to global climate change, however, they are likely to be affected most. These countries cannot afford to develop an infrastructure that might be controlled or prohibited by future environmental standards, and therefore, it is in their best interest to build a base of sustainable technologies.

Wind Energy

Energy harnessed from wind is another sustainable initiative gradually gaining prominence in Ghana. The kinetic energy in wind can be converted into mechanical or electrical power. For centuries, windmills have converted wind energy into mechanical power to grind wheat into flour. Now, improved turbine technology allows wind generators to affordably produce electricity.

Wind energy potential depends on the area swept by the wind, its density, and its velocity. Areas of the world that lack fresh water often have an ample supply of wind or solar energy. As a result, renewable energy is a lucrative option as a power source for desalination systems. The use of renewable energy driven reverse osmosis (RO) membrane filtration systems can be a viable alternative to other methods of filtration. It can be especially beneficial for remote communities with poor potable water and energy supplies. While certain renewable energy sources
generate sporadic supplies of power, wind power’s technology is relatively mature. This makes it easier when matching an energy technology to the water requirements of a small community. Wind power allows greater flexibility than the nation’s existing solar powered system.\(^\text{16}\)

A recent study in Ghana found that only 62–70 percent of people in urban areas and 35–40 percent of people in the rural areas have access to treated water. As a result of intensive gold mining, Ghana’s water contains undesirable contaminants such as arsenic. There are also many water sources in northern Ghana that have high levels of fluoride, giving rise to dental and skeletal fluorosis. A filtration system powered by wind energy can purify water for underserved communities in a sustainable, environmentally-conscious manner.\(^\text{17}\)

The Solar and Wind Energy Resource Assessment (SWERA) program began in Ghana in August 2002. It was part of a global project to supply high quality renewable energy resource information. The assessment of the wind resource covered the whole of Ghana with the primary focus being on the potential for large-scale grid-connected wind turbines. The collection of dependable data on the wind resource in Ghana only began in 1999 when the Energy Commission started taking measurements at 11 coastal sites east and west of the Meridian (around Accra). The monthly average wind speed at 12 m is 4.8–5.5 m/s, which shows that Ghana has an adequate wind resource for power generation, as average wind speeds of greater than 4 m/s are generally considered to have generation potential.\(^\text{18}\)

Around the world, wind power will become increasingly important as concerns increase over climate change and pollution caused by the burning of fossil fuels, and as technology makes it a cheaper, more accessible option. If the trend in installing wind power generators continues, wind will supply 10 to 12 percent of the global electricity demand by the year 2020. If this amount of wind power is used to generate electricity, a reduction in carbon dioxide (CO\(_2\)) emissions of 1.7 tons (1.5 metric tons) per year can be expected.\(^\text{19}\)

**Conclusion**

Sustainable development proves to be an effective solution for the environmental deterioration and widespread economic inequalities present throughout the world. Developing nations like Ghana, which are especially hit hard by unsustainable practices, can alleviate poverty and improve the livelihood of its citizens through such initiatives. Emerging technologies including biomass, biofuels, hydrokinetic energy, and wind energy are positive strides Ghana should continue taking. As far as the government is concerned, interest groups, NGOs, and Ghanaian citizens should continue advocating for policies and programs including the National Biofuel Policy, the National Renewable Energy Plan, and the National Renewable Energy Laboratory. While some distance remains when it comes to gaining the Ghanaian government’s full support, these emerging initiatives represent the nation’s opportunity to move forward. Additionally, while international actors such as the United Nations and Commission for Sustainable Development are not able to offer a quick fix, their presence facilitates the gradual switch to sustainability. Despite the challenges related to environmental sustainability, the international
community as a whole continues to make gradual strides toward environmentally sound practices and policies.

Reference


6. Ibid.

7. Ibid.

8. Ibid.


11. Ibid.

12. Ibid.

13. Ibid.

14. Ibid.

15. Ibid.


17. Ibid.

18. Ibid.