Climate change mitigation measures in Ghana

Nii Nelson

Department of the Natural and Built Environment, Sheffield Hallam University, Sheffield, UK. Corresponding author: N. Nelson, zumasti@gmail.com

Abstract. There is a strong correlation between energy, the environment and sustainable development. In an ideal world, a society seeking sustainable development must utilize only energy resources which have little or no environmental impact. Technological changes such as energy savings on the demand side, efficiency improvements in energy production, and replacement of fossil fuels by renewable energy are typical strategies for sustainable energy development. This research paper discusses the concept of sustainable energy, energy efficiency, and the role of carbon sinks in climate change using Ghana as a case study. International agreements and strategies for addressing climate change in Ghana are also discussed.
Key Words: sustainable, climate change, energy, fossil fuels, carbon sinks, zero-carbon economies.

Introduction. Energy is undeniably one of the major challenges facing the world today as it touches on all facets of our lives (Adam et al 2013). There is a universal agreement in both the scientific and development communities with regards to the significance of energy as a catalyst for development at global, national, and local levels (Kankam & Boon 2009). Access to energy, especially modern sources, is essential to the realization of any development initiative and it is vital to figure out the determinants driving their usage in developing countries like Ghana (Adam et al 2013). The major global energy challenges, according to Gyamfi et al (2015) are:

- securing a sufficient energy supply to meet growing demand;
- providing everybody with access to energy services;
- controlling energy's contribution to climate change.

In developing countries, access to cheap and dependable energy services is essential to poverty reduction, health improvement, increase in productivity, boosting competitiveness and promoting economic growth (Gyamfi et al 2015). Kemausuor et al (2011) suggest that the need to secure future energy in the forms of electricity and modern cooking fuels is perceived as crucial to the attainment of the Millennium Development Goals, particularly poverty reduction, promising improved education, health, water supply and environmental sustainability.

In this report, the researcher critically evaluates:

- the role of carbon sinks in climate change;
- the concept of energy efficiency and zero-carbon economies;
- the concept of sustainable energy using Ghana as a case study;
- international agreements and strategies employed by Ghana to address climate change.

Climate change and carbon sinks. Munasinghe (2010) describes climate change as an emerging issue of major global concern for everyone in the universe. It threatens to aggravate the intimidating problems of development we face today like poverty, food security, diseases, and water and energy scarcities. In Darfur, where several hundred thousand people have died in recent years, climate change has already intensified water and land shortages (due to increasing desertification), undermined agriculture, and incited conflict for these scarce resources among the poor. Many Pacific islands (and the Maldives) - only centimetres above sea level are often threatened with torrent by rising seas on the other side of the globe. In the distant north, melting of the sea ice is affecting polar wildlife, and undermining the already tricky livelihoods of native people (Munasinghe 2010).

Climatic conditions are constantly changing in recent times, which affects livelihood. A number of reasons can be assigned to these constant climatic changes but most important of all is global warming which is primarily caused by the emission of Green House Gases (GHG). GHG in the atmosphere include; nitrous oxide, methane, carbon dioxide (CO_2), chlorofluorocarbons (CFCs) etc. Out of these gases, CO_2 contributes 50% to global warming making it the biggest culprit (Niharika & Arvind 2014). Although the main human source of GHG emission is combustion of fossil fuels for energy generation, non-energy emissions (including from agriculture and land-use changes) contribute more than a third of the total GHG emissions worldwide (McMichael et al 2007).

According to Canadell et al (2007), the growth rate of atmospheric CO_2 reflects the balance between anthropogenic carbon emissions and the dynamics of a number of terrestrial and ocean processes that remove or emit CO_2. There has been a substantial change in global carbon balance with major increases in anthropogenic emissions and changes in land and ocean sink fluxes due to climate variability and change (Canadell et al 2007). The ocean covers 70% of the Earth's surface and contains about 50 times more soluble inorganic carbon than the atmosphere. The flow of CO_2 between these two geophysical fluids is quantifiable, averaging approximately 100 Pg per annum. During glacial periods, for instance, the ocean serves as the major sink for atmospheric CO_2, while during glacial-interglacial transitions, it is a source of CO_2 to the atmosphere (Raven & Falkowski 1999).

Lewis et al (2009) postulate that the response of terrestrial vegetation to changing climatic conditions is pivotal to the prediction of future levels of atmospheric CO_2 due to the carbon-densed and highly productive nature of the forest. Old-growth forests remove carbon dioxide from the atmosphere at rates that vary with climate and nitrogen deposition. The sequestered CO_2 is stored in live woody tissues and slowly decomposing organic matter in litter and soil (Luyssaert et al 2008). It is estimated that the tropical forest stores 40-50% of carbon in terrestrial vegetation and processes approximately six times as much carbon through photosynthesis and respiration as humans emit from fossil use, making the tropical forest an essential component of the global carbon cycle (Lewis et al 2009).

Energy efficiency and zero-carbon economies. Due to growing public concern over the impacts of anthropogenic carbon emissions, the terms ''Carbon Neutral'' and ''zero-carbon'' have significantly increased in response to concerted efforts to reduce carbon emissions (Kennedy & Sgouridis 2011).

Energy efficiency is the most cost-effective way of reducing CO_2 emissions and improving households and businesses. It can also have many other additional social, economic and health benefits, such as warmer and healthier homes, lower fuel bills and lower cost of running businesses (Omer 2008a). Although environmental issues have generally influenced developments in the energy sector for some time, climate change poses a different kind of challenge entirely. World population is expected to double by mid-21st century, and economic development will certainly continue to rise. Global energy demand is expected to increase by 2050, with primary energy demand expected to increase by 1.5-3 times. Concurrently, energy-related environmental concerns such as acid precipitation, stratospheric ozone depletion and climate change are likely to increase (Dincer & Rosen 1999). Globally, buildings account for approximately 40% of the total world annual energy consumption. Most of this energy is used for lighting, heating, cooling, and air conditioning (Omer 2008b). A zero-carbon economy may contain zero-carbon buildings but that is not enough. Flexibility on how to mitigate emissions as well as tighter institutional integration between utilities, service providers, citizens and regulatory agencies is essential (Kennedy & Sgouridis 2011).

Capture of CO_2 from distributed sources is often neglected as a viable solution to the global problem of CO_2 emissions management. Many research are currently being actively pursued to find alternative means of reducing carbon emissions in the transport sector (Damm & Fedorov 2008). Carbon Capture and Storage (CCS) is the most likely technology to quickly deliver large-scale reductions in anthropogenic CO_2 emissions (Nader 2009). CCS involves capturing and storing CO_2 at the point of generation (e.g. on the vehicle) so that the vehicle could empty its CO_2 exhaust at a final collection point. Other available options include:

- electric vehicles – would require electricity transfer and storage in batteries on vehicles. The electric energy would be converted to mechanical energy and facilitate the vehicle's movement without any emissions. The energy density and charging time of batteries remain a barrier;
- hydrogen-fueled vehicles – use hydrogen as fuel. It requires hydrogen to be stored on-board the vehicle at high pressures or in metal hydrides and burnt in an internal combustion engine or electrochemically converted to electricity in a fuel cell. However, there are several economic and technological barriers such as refuelling and on board hydrogen storage;
- carbon-neutral biofuels – biofuels are carbon neutral (or negative) if they are synthesized from biomass using renewable energy sources. Lack of resources such as land to produce enough energy from biomass is a limitation (Damm & Fedorov 2008).

Sustainable energy (Ghana's renewable energy potential). Sustainable energy is energy that, in its production or consumption, has minimal negative impacts on human health and the healthy functioning of vital ecological systems, including the global environment (Omer 2008b). It can also be described as a form of energy obtained from renewable or inexhaustible sources.

In Ghana, a considerable amount of energy supply is met from woodfuels (firewood and charcoal), accounting for about 71±1% of total primary energy supply and about 60% of the final energy demand. As shown in Figure 1 woodfuel contributed about 72% of the primary energy supply to the country in 2008 with crude oil and hydro making up the remaining percentage (Arthur et al 2011).

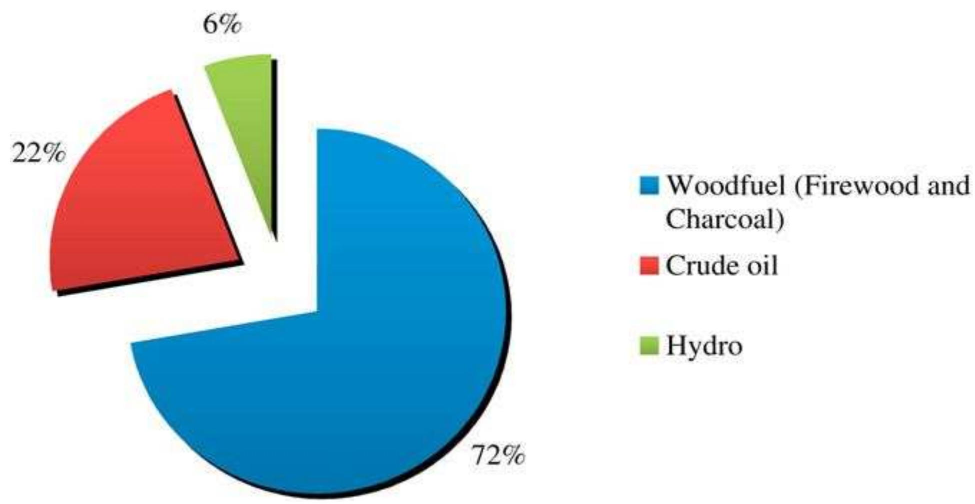

Figure 1. Primary energy supply in Ghana for 2008 (Arthur et al 2011).

The huge dependence of Ghana's energy sector on biomass (woodfuel), hydro, and crude oil makes it less resilient to the impacts of climate change (Edjekumhene & Cobson-Cobbold 2011). According to a report presented by Ghana's Ministry of Environment, Science and Technology (2015), renewable energy is site specific and technology-driven. Potential renewable energy resources in Ghana include: hydro, solar, wind, and bioenergy. Table 1 evaluates the current status of renewable energy resources in Ghana.

Figure 2 shows small and medium hydro sites in Ghana whiles Figure 3 depicts the solar map of Ghana.

Table 1

Summary of Ghana's renewable energy potentials

Resource	*Resource potential*	*Current status*
Hydro (small and medium)	Ghana has an estimated additional hydropower potential of 2000 MW, of which 1200 MW is expected to be generated from proven large hydro sources, with the rest coming from small and medium-scale hydro sources. Over seventy (70) small and medium hydro sites have been discovered in Ghana (Gyamfi et al 2015).	None of the small and medium hydro sites have been exploited for power generation (Kemausuor et al 2011; Gyamfi et al 2015). Small hydro sites not developed due to cheap power from the main hydro power plants at Akosombo and Kpong.
Solar	On average, Ghana receives 4.0-6.5 kWh/m^2/day of solar radiation and sunshine duration of about 1800-3000 h per year. Technologies available include: solar crop drying, solar water heating (e.g. for hospitals), solar photovoltaic (PV) (e.g. for rural micro-enterprises), and solar cooking.	Over 6000 solar stand-alone home systems with installed capacity of 3.2 MW have been installed mainly for electrification in off-grid regions. This is relatively low compared to the huge potential of the country. The major challenge is the cost of procuring solar panels.
Wind	The monthly average wind speed at 12 m is 4.8-5.5 m/s, which shows Ghana has adequate wind resources for power generation (Park et al 2009). The wind energy potential of Ghana is estimated to be 5,600 MW.	Wind power generation has not been largely tapped. One of the major challenges is how to store the energy produced during blustery periods.
Bioenergy	An estimated 18 million metric tonnes of woodfuel is produced every year from the natural forest whereas the climatic and soil conditions are suitable for large-scale cultivation of early-maturing tree species. Apart from the wood biomass potential of Ghana, the country produces large volumes of crop and animal residue that could be converted into electrical or heat energy. Starchy crops such as maize, sugar crops such sugar cane, and oil crops such as oil palm are available as feedstock.	Aside the traditional uses of biomass for cooking, the modern bioenergy potential of Ghana has not been substantially tapped. However, some biomass-fired co-generated projects have been implemented in the oil-palm industry with installed capacity of 1,954 kW with an average annual production of 7.0 GWh. The major challenge is how to avoid the food-fuel conflict. Nonetheless, non-food crop feedstock such as jatropha can be promoted in Ghana.

Source: Author.

Figure 2. Map showing small and medium hydro sites in Ghana (Kemausuor et al 2011).

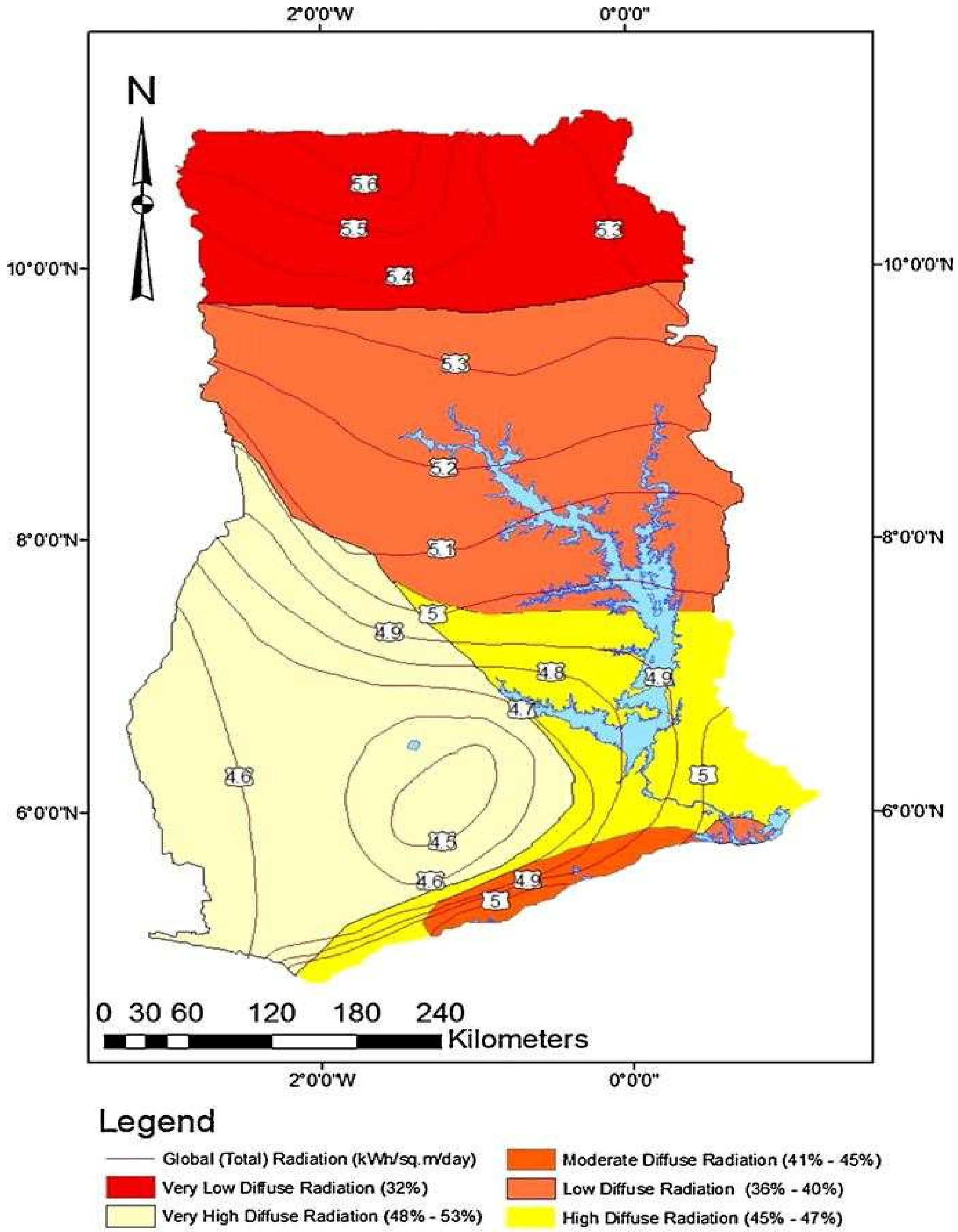

Figure 3. Solar map of Ghana (Ministry of Energy, Ghana).

Ghana and zero-carbon development strategy. The Intergovernmental Panel on Climate Change (IPCC) has been assessing global efforts to avoid emissions and create sinks for GHG, since 2001. The creation of carbon markets as an instrument for developed countries to neutralize some of their CO_2 emissions is one of the major outcomes of IPCC's actions (Gonzalez-Estrada et al 2008). There has been numerous efforts in the past on capacity building for carbon market and Clean Development Mechanism (CDM) in Ghana but these efforts have not yet resulted in a registered CDM project (Würtenberger et al 2015).

The Government of Ghana is a signatory to the United Nations Framework Convention on Climate Change (UNFCCC), and has been an effective participant in the international climate negotiations since time immemorial. Consequently, Ghana's national activities in relation to climate has been formulated around the international climate regime since mid-1990. Ghana is currently working on its second national communication to the UNFCCC including the GHG inventory update after a first national communication was made in 2001 (Würtenberger et al 2015).

Since 2010, Ghana has initiated a process towards establishing a comprehensive national climate change policy dubbed the National Climate Change Policy Framework (NCCPF). The aim of the NCCPF is to ensure a climate resilient and climate compatible economy while achieving sustainable development and equitable low carbon economic growth for Ghana (Edjekumhene & Cobson-Cobbold 2011).

According to Edjekumhene & Cobson-Cobbold (2011), the National Climate Change Committee (NCCC) under the supervision of the Ministry of Environment Science and Technology (MEST) came out with a discussion document entitled Ghana Goes for Green Growth (GGFGG) in November 2010. The document analyzes what climate change means for Ghana, and measures necessary to control low carbon growth, adaptation and social dimensions of climate change. Although GGFGG does not set priorities for sectors, regions, technologies or instruments,the motive is to outset a national discourse among key stakeholders that will result in a general agreement on what Ghana needs to do in order to achieve sustainable development (Edjekumhene & Cobson-Cobbold 2011).

In order to address climate change, a number of low carbon options have been adopted by Ghana. Some of these options include;

- compact-fluorescent lightbulbs (CFLs): in 2007, the Government of Ghana implemented the free replacement of 6 million traditional light bulbs by CFLs and banned the import of incandescent light bulbs as a way of reducing energy consumption especially among residential users. Consequently, in 2009, only 3% of all lightbulbs in the country were still incandescent (Tilburg et al 2011). The project resulted in a significant electricity savings and it is estimated that a total CO_2 savings of more than 100’000 tonnes of carbon dioxide equivalent (100’000 t CO_2e) was observed in 2008/2009 compared to previous years (Würtenberger et al 2015).

- refrigerators: Ghana has instituted a program where old and inefficient refrigerators which may still be using CFCs as cooling agents can be cashed in for new environmentally friendly ones (Würtenberger et al 2015). Similar programs are in place for the promotion of efficient air conditioners, improved cook stoves and improved charcoal production (Tilburg et al 2011). In spite of the strenuous efforts by Ghana to control climate change, there has not been any explicit focus on the transport sector.

Ghana’s efforts to address climate change have been hindered by a number of barriers in the areas of policy, regulation and finance. Access to reasonable funding to help bridge the gap between zero-carbon options and their commercial viability is the most difficult hurdle that has impeded the uptake of cleaner energy and energy efficient technologies in Ghana. Other barriers include relatively low level of awareness and capacity constraints both in project development and regulation (Edjekumhene & Cobson-Cobbold 2011).

Conclusions. There are convincing scientific evidence that the average temperature of the earth’s surface is rising as a result of high concentration of CO_2 and other GHG in the atmosphere. Climate change is a reality and is mainly caused by anthropogenic factors such as burning of fossil fuels. Climate change and development are closely intertwined. The challenges of climate change and sustainable development can both be overcome although they are two complicated issues. The huge dependence of Ghana’s energy sector on biomass (woodfuel), hydro, and crude oil makes it less resilient to the impacts of climate change. Even though Ghana like many African countries has some of the lowest per capita global warming emissions on the planet, it is likely to suffer from some of the worst consequences of climate change such as droughts, famine, desertification, and population displacement due to its vulnerable geography and lesser ability to cope with damage from severe weather and rising sea levels. There is the urgent need for Ghana to make every effort to increase energy efficiency by harnessing and utilizing sustainable energy resources. Apart from the conventional use of biomass for cooking, the modern bioenergy potential of Ghana remains untapped. The major challenge to bioenergy is how to avoid the food-fuel conflict. Ghana can however overcome this challenge by promoting non-food crop feedstock such as jatropha, corn residue such as corn stalks and wheat straw that do not impact on food production. Solar and wind power potential of Ghana also remain largely unutilised. The major barrier to solar energy in Ghana is the cost of procuring solar panels. It is therefore essential for Ghana to take a more holistic approach to the concept of cost and consider the systemic benefits of diversified energy procurement that may compensate for the additional cost of a renewable energy source.

References

Adam F. W., Brew-Hammond A., Essandoh E. O., 2013 Relationships between energy use and income levels for households in Ghana. European Scientific Journal 9(16):233-245.

Arthur R., Baidoo M. F., Antwi E., 2011 Biogas as a potential renewable energy source: a Ghanaian case study. Renewable Energy 36(5):1510-1516.

Canadell J. G., Le Quere C., Raupach M. R., Field C. B., Buitenhuis E. T., Ciais P., Conway T. J., Gillett N. P., Houghton R. A., Marland G., 2007 Contributions to accelerating atmospheric CO_2 growth from economic activity, carbon intensity, and efficiency of natural sinks. Proceedings of the National Academy of Sciences of the USA 104 (47):18866-18870.

Damm D. L., Fedorov A. G., 2008 Conceptual study of distributed CO_2 capture and the sustainable carbon economy. Energy Conversion and Management 49:1674-1683.

Dincer I., Rosen M. A., 1999 Energy, environment and sustainable development. Applied Energy 64:427-440.

Edjekumhene I., Cobson-Cobbold J., 2011 Low-carbon Africa: Ghana. Christian Aid, London, pp. 1-14.

Gonzalez-Estrada E., Rodriguez L. C., Walen V. K., Naab J. B., Koo J., Jones J. W., Herrero M., Thornton P. K., 2008 Carbon sequestration and farm income in West Africa: identifying best management practices for smallholder agricultural systems in northern Ghana. Ecological Economics 67:492-502.

Gyamfi S., Modjinou M., Djordjevic S., 2015 Improving electricity supply security in Ghana - the potential of renewable energy. Renewable and Sustainable Energy Reviews 43:1035-1045.

Kankam S., Boon E. K., 2009 Energy delivery and utilization for rural development: lessons from Northern Ghana. Energy for Sustainable Development 13:212-218.

Kemausuor F., Obeng G. Y., Brew-Hammond A., Duker A., 2011 A review of trends, policies and plans for increasing energy access in Ghana. Renewable and Sustainable Energy Reviews 15(9):5143-5154.

Kennedy S., Sgouridis S., 2011 Rigorous classification and carbon accounting principles for low and Zero Carbon Cities. Energy Policy 39:5259-5268.

Lewis S. L., Lopez-Gonzalez G., Sonké B., Affum-Baffoe K., Baker T. R., Ojo L. O., Phillips O. L., Reitsma J. M., White L., Comiskey J. A., Djuikouo K. M. N., Ewango C. E., Feldpausch T. R., Hamilton A. C., Gloor M., Hart T., Hladik A., Lloyd J., Lovett J. C., Makana J. R., Malhi Y., Mbago F. M., Ndangalasi H. J., Peacock J., Peh K. S., Sheil D., Sunderland T., Swaine M. D., Taplin J., Taylor D., Thomas S. C., Votere R., Wöll H., 2009 Increasing carbon storage in intact African tropical forests. Nature 457(7232):1003-1006.

Luyssaert S., Schulze E. D., Borner A., Knohl A., Hessenmoller D., Law B. E., Ciais P., Grace J., 2008 Old-growth forests as global carbon sinks. Nature 455(7210):213-215.

McMichael A. J., Powles J. W., Butler C. D., Uauy R., 2007 Food, livestock production, energy, climate change, and health. Energy and Health, 370, 1253-1263.

Ministry of Environment, Science and Technology, 2015 Ghana's blue print for a sustainable energy. Available at: http://www.stoffstrom.org/fileadmin/userdaten/dokumente/Veranstaltungen/KWK10/2MEST_Germanypresentation__Kompatibilitaetsmodus_.pdf. Accessed: March, 2018.

Munasinghe M., 2010 Addressing the sustainable development and climate change challenges together: applying the sustainomics framework. Procedia - Social and Behavioral Sciences 2(5):6634-6640.
Nader S., 2009 Paths to a low-carbon economy – the Masdar example. Energy Procedia 1:3951-3958.
Niharika P., Arvind N. K., 2014 Carbon sequestration. Journal of Environmental Research and Development 9(1):255-259.
Omer A. M., 2008a Energy, environment and sustainable development. Renewable and Sustainable Energy Reviews 12:2265-2300.
Omer A. M., 2008b Green energies and the environment. Renewable and Sustainable Energy Reviews 12:1789-1821.
Park G. L., Schafer A. I., Richards B. S., 2009 Potential of wind-powered renewable energy membrane systems for Ghana. Desalination 248(1-3):169-176.
Raven J. A., Falkowski P. G., 1999 Oceanic sinks for atmospheric CO_2. Plant, Cell and Environment 22:741-755.
Tilburg X. V., Würtenberger L., Rivera R., Atta-Owusu F., 2011 Policy brief: low carbon options for energy demand. Available at: ftp://ftp.ecn.nl/pub/www/library/report/2011/o11023.pdf. Accessed: April, 2017.
Würtenberger L., Bunzeck I. G., Tilburg X. V., 2015 Initiatives related to climate change in Ghana: Towards coordinating efforts. Available at: http://www.ecn.nl/docs/library/report/2011/e11010.pdf. Accessed: April, 2017.

Received: 11 May 2018. Accepted: 28 July 2018. Published online: 17 August 2018.
Authors:
Nii Nelson, Department of the Natural and Built Environment, Sheffield Hallam University, Howard Street, S1 1WB, Sheffield, United Kingdom, e-mail: zumasti@gmail.com

How to cite this article:
Nelson N., 2018 Climate change mitigation measures in Ghana. AES Bioflux 10(2):97-105.