# Environmental Sustainability in Developing Economies – The Nigerian Perspective

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## Abstract

Research studies show that developing countries contribute to environmental pollution. Governments, in an attempt to protect the environment impose regulations, but many times these are ignored and/or not enforced. Nigeria, a country rich in oil and natural resources is not an exception. The Nigerian government supplies only about 10 percent of the electricity needed in the country, forcing Nigerians to utilize other energy sources that have a direct impact on the environment, like burning wood and using diesel generators. In addition, oil exploration a major industry in the country, is another contributor to the pollution problem. Gas flaring is oftentimes the preferred and only way of disposing the by-products of this industry, mainly due to cost. Gas flaring however, introduces toxic chemicals such sulphur dioxide into the atmosphere leading to the formation of acid rain and greenhouse gases. Two major issues arise from this practice: the burning process of fossil fuels is a direct contributor to respiratory problems and oil spills pollute the land and ground water. This paper focuses on the environmental pollution experienced in Nigeria as evidenced by the burning of fossil fuels and crude oil spills. The authors propose practical ways of ending this problem by having an emphasis on environmental sustainability at the heart of every oil operations.

## Keywords

Pollution, sustainability, Energy, Economic Development, Global Issues

## Introduction

Ever since the Brundtland Commission produced the paper "Our Common Future"[1] where the most globally accepted definition of Sustainability/Sustainable Development was coined, the attention of the world has shifted to the concept of "Sustainability". Sustainable development was defined in this report as "development that meets the need of the present without compromising the ability of future generations to meet their own needs". Sustainability is viewed from three standpoints: economic, social and environmental sustainability. Governments across the globe are making concerted efforts to ensure developments in their countries are conducted in an environmentally friendly manner.

In "The Concept of Environmental Sustainability"[2] Goodland succinctly made a case for environmental sustainability showing the connections between both economic/social sustainability and environmental sustainability. While economic sustainability focuses on the portion of the natural resource base that supply physical inputs, both renewable (e.g. forests) and non-renewable (e.g. minerals), environmental sustainability looks at the physical inputs put into

production, emphasizing environmental life-support systems, without which neither production nor humanity could exist. These life support systems include air, water, and soil, all of which are to be healthy, meaning that their environmental service capacity must be maintained. For example, a healthy ozone shield protects biota (such as humans and crops) from excessive ultraviolet radiation. Environmental sustainability or maintenance of life-support systems was noted to be a prerequisite for social sustainability. According to Goodland[3]countries truly capable of sustaining themselves, rather than liquidating their resources, will be more peaceful than countries with unsustainable economies.

Research studies show that developing countries contribute to environmental pollution[4-5]. Nigeria is one of the major global polluters. Nigeria with proven crude oil reserves of over 37 billion barrels and a daily crude oil production rate of about 2 million barrels is a major contributor to environmental pollution, according to the Organization of Petroleum Exporting Countries (OPEC) [6.]

Nigeria with a population of over 155 million inhabitants[7] has approximately 40 percent of its population connected to the national electricity grid. These 40 percent, supposedly connected to the grid, experience power availability problems 60 percent of the time[7]. Due to the lack of reliable electricity, most homes and businesses cater for their electricity needs using diesel generators. It is estimated that 90 percent of businesses in Nigeria run generators for their power needs[8.] This huge reliance on generators that utilize fossil fuels such as petrol and diesel contribute negatively to environmental problems such as ozone layer depletion and emission of greenhouse gases. Additionally, the burning of wood is common practice in rural areas of Nigeria due to lack of other sources of energy. This in itself, aside from adding significantly to total greenhouse gas emissions, also releases toxic gases into the atmosphere. More troublesome is the pollution arising from the activities of the oil industry, since it could be avoided. Oil and gas operations in Nigeria continue to flare associated natural gas (a byproduct of crude oil exploration) as a cheaper alternative to processing the gas for sale or re-injecting it into the earth[9]. This procedure adds significantly to greenhouse gas emissions and releases gases that cause acid rain. Oil spillage is another environmental pollution that is common in the Nigerian oil and gas industry. The cause of spillage could be accidental, operational or due to negligence. Kadafa[10] states that oil spillage is a perennial environmental problem in the oil producing communities of Nigeria that result in damage to farmlands, surface waters, underground waters and the atmosphere.

**Power Distribution Problems in Nigeria**

Nigeria is endowed with several energy sources such as crude oil, coal and natural gas. However, despite its abundant energy sources, Nigeria has, for many years, been unable to meet its energy needs[8-11.] Nigeria is the most populous country in Africa with a population of over 155 million[7]. Of this population, only 40 percent is connected to the national power grid and the 40 percent connected to the grid does not have access to energy 60 percent of the time[7-8].

The main sources of electricity generation in Nigeria are hydropower and thermal with fossil fuels such as natural gas and coal being the feed fuel for the thermal plants. Aliyu[7] noted that hydropower plants could not be relied upon. He stated that the oscillatory nature of energy output from hydropower plants (mainly due to seasonal changes) and the negative impacts experienced due to climate change are decreasing the water levels required to run the hydropower plants. The dilapidated state of the hydropower infrastructure also reduces significantly their energy output when compared to their projected capacity. The thermal plants utilize mostly natural gas as feed fuel and the lack of adequate natural gas is a leading cause for the underperformance of these plants[11-12]. According to Somefun[12] some of the factors responsible for the poor energy supply in Nigeria include inadequate gas supply, power infrastructure deficits, poor maintenance and age of existing electricity assets and shortage of technical skills.

Nigeria is rich with abundant natural gas deposits. The country is said to have the seventh largest deposit of natural gas in the world[7]. Despite having huge deposits of natural gas, Nigeria has been unable to meet its need of gas for electricity generation, mainly because of limited refining infrastructure. This occurs at the same time that associated natural gas found during crude oil production is being flared. The Nigerian government has over the years employed different approaches to discourage gas flaring, but all have yielded very minimal results[9]. Vandalism of gas pipelines by disturbing youths in the Niger Delta is also a contributory factor towards the inadequate supply of natural gas to these thermal plants.

The ageing and lack of proper maintenance of these assets are factors responsible for the underperformance of Nigerian power plants. These factors as well as the presence of infrastructure deficit make it difficult to meet the energy needs of Nigerians. While the government recognizes the need for more electricity, it has had great difficulty funding and organizing this endeavor[8]. In 2005, the government, in an attempt to tackle this problem divided the National Electric Power Authority (NEPA) into two sectors; one responsible for power generation and the other for power distribution. As part of the efforts to finance and organize the needed development of infrastructure, the government sought to privatize the new business sectors, but the people met the attempt with fervent resistance. Nigerians seem to oppose the idea of privatization, as it is perceived as a precursor to increased costs. This resistance according to Ariyo[13] is due to the negative experience of Nigerians following the introduction of the private sector in the water supply industry. While the government requires the financial intervention of the private sector to develop the needed infrastructure, the people are not in favor of privatization.

Due to the lack of constant electricity, most energy consumers (private and businesses) in Nigeria have resorted to use generators to meet their energy needs. According to Kennedy-Darling[8] well over 90 percent of businesses in Nigeria utilize generators. Aside the fact that the use of generators increases the cost of doing business, the emissions from combustion of fossil fuels in generators causes environmental pollution as it increases significantly the available volume of greenhouse gases causing global warming and climate change. In rural areas, burning of firewood is usually the means to meeting Nigerian's energy needs.

The emissions from burning firewood are toxic, especially when the burning is conducted indoors and inhaled, which is frequently the case in rural areas. Burning of firewood also contributes to deforestation having a negative effect on the survival of the eco-system and has debilitating effects on climate change.

**Oil Spillage and Gas Flaring in Nigeria**

As cited by Orubu in Hassan & Kouhy[9] Nigeria has large deposits of natural gas and ranks seven in the list of oil producing countries. The authors state that the majority of the gas found in Nigeria is associated natural gas (ANG), while the rest is non-associated (NANG). According to the Society of Petroleum Engineers (SPE) associated gas is considered a byproduct in the production of crude oil while the non-associated gas is primarily developed to produce gas. Thus the distribution of this resource must be close to the recipients to make it an economically viable source of energy[14]. In petroleum-producing areas where insufficient investment was made in infrastructure to utilize natural gas, flaring is employed to dispose of this associated gas[15].

About 52 percent of Nigerian proven gas reserves are associated and it is regarded as an undesirable byproduct of the oil industry. This byproduct is not re-injected, but flared, or vented. The World Bank Organization published in 2011 a brochure called "Global Gas Flaring Reduction Partnership", in which it states that gas flaring and venting are necessary measures in the oil production industries to maintain safety at production facilities. However, it is noted that these measures are to be taken when emergencies require it (during power and equipment failures or during any other disturbances in oil production). However, many oil-producing countries use it irrespectively[16]. Gas flaring, a common practice in Nigeria[17] is not only damaging to the environment, but it also is a waste of "valuable energy resources" as stated by Edino, Nsofor & Bombom[18]. Despite the environmental damage caused by gas flaring, it remains common practice where the proper transportation infrastructure to end-users is missing or where the market is not large enough to make it profitable[19]. Nigeria is the second largest country flaring gas after Russia[20] Dung et.al state that Nigeria could be able to satisfy all its energy needs, and even those of its neighboring countries, with the amount of ANG gas currently being flared. The World Bank reports that approximately 150 billion cubic meters are being flared annually, corresponding to approximately 25 percent of the United States' gas consumption or 30 percent of Europe's gas consumption.[16]

According to Hassan and Kouhy[9] Nigerian's flaring of ANG is the highest contributor to total greenhouse gas emissions in Africa, increasing the proliferation of acid rain. Randolph, Masters & Gilbert[21] stated that acid rain causes acidification of lakes and streams and contributes to the damage of trees at high elevations and many sensitive forest soils; it accelerates the decay of building materials and paints, including irreplaceable buildings, statues, and sculptures. The United States Environmental Protection Agency (EPA) reported that many scientific studies have shown a relationship between sulfate and nitrate particles found in acid rain and health issues such as heart and lung disorders, asthma and bronchitis[22]. Nriagu's study of the health risks experienced in the Niger Delta as a consequence of the oil industry found that extraction of oil

occur in over 50 percent of the region leading to the overabundance of roads, pipelines, wells, glass flaring, dredged spoils and flow stations located close to human settlements[23]. He stated that poor maintenance of the present infrastructure has led to pipeline corrosion increasing spills and leaks, human error, theft of oil and vandalism. However, the amount of spills in the area remains unknown. Jernelov as cited by Nriagu[23] estimates that the oil spill in Nigeria might be in the region of 9 to 13 billion barrels over 50 years, approximately 1.5 million tons annually. This amount, Jernelov states, is equivalent to one Exxon-Valdez accident annually for the past 50 years. According to Shah[24] the Ogoni and Ijaw people in the Niger Delta have suffered the most devastating consequences of the oil industry in the region, in health and economic terms. In the Essential Action and Global Exchange report, as cited by Shah, the oil industry in the region has caused serious environmental pollution, making farming and fishing extremely difficult, polluting even the drinking water consumed by the local population, leading to increased poverty, malnourishment and disease. In a study conducted by Cheong et.al[25] it was found that oil spills are not isolated but recurrent problems, but their report is usually limited. Nriagu[31] noted "the oil pollution in the Niger Delta is not an isolated phenomenon, but an ongoing chronic disaster and an environmental adversity with no end in sight"[31].

Although the presence in Nigeria of large oil multinational corporations is touted as having a positive effect in Nigeria's economy and development, Shah[24]stated that reality shows the opposite. He observed that the oil companies operating in the Niger Delta do not hold the environmental, public, health and human rights standards required elsewhere. This situation, Shah noted, is based primarily on the corruption of government experienced in Nigeria, which western governments and oil corporations seem to support. According to Ajugwo[15] the Nigerian government has shown little to no interest in enforcing any laws to deter companies from flaring. This, he stated, is a consequence of the monetary profits the government receives from the oil industry. For the companies operating in the area, it is more profitable to pay an "insignificant fine" rather than to re-inject the gas back into the oil wells and since there is no market for gas in rural areas, gas capture is not even given any consideration.

Although policies to reduce flaring, have been in place since 1969 their implementation have not been observed. The Nigerian government has used several approaches to stop gas flaring by providing tax reductions, imposing penalties and by implementing regulations, but all have yielded minimal results[9]. In 1985, the penalties imposed for flaring amounted $0.22 per 1000 cubic feet, rising to $0.46 per 1000 cubic in 1999; however the oil industry persists in paying the fine, rather than eradicating the problem. The Human Rights Watch[26] report dated 1999, found that according to the Nigerian National Petroleum Corporation, approximately 2,300 cubic meters of oil are spilled in 300 separate incidents annually; however the report stated the real numbers might be ten times higher.

The non-realization of flare out policies in Nigeria is linked to the following issues: market and institutional barriers; limited and insufficient market for gas and its related products (CNG, LPG, methanol etc.); low and noncompetitive gas and gas products prices; lack of gas infrastructure;

poor generation, transmission and distribution of electricity; difficulty in securing funding for associated gas utilization projects and security issues. Some argued however that in the Nigerian context, the reasons stated by Hassan & Kouhy might not be the main reasons why natural gas is still being flared in such large quantities. According to Orubu[17] the main reason is the reluctance of the oil companies to commit sufficient resources for gas reinjection and utilization projects, since their goal is to exploit and extract oil, not the associated gas. He also mentioned that high costs would be incurred with gas utilization and reinjection and that it is cheaper to burn the associated gas rather than to invest in gas utilization and reinjection equipment.

**Environmental Regulations in Nigeria**

Environmental regulations in Nigeria did not start up as an attempt to protect the environment but most of the earlier environmental legislations were accidental. Like most developing countries, the Nigerian government after declaring independence, was concerned with meeting basic social needs and focused on economic development. Environmental concerns were of secondary character, since they were considered as luxurious and viewed as impediments to the country's strive for industrialization[27]. As a result, the protection of the environment was neglected. The spark to environmental consciousness came in 1988 after an Italian company introduced and deposited several tons of toxic waste in Koko, Delta state in Southern Nigeria. The toxic waste found its way into the neighboring settlements putting at risk the lives of the people in that community.

The "Koko" incident prompted the Nigerian government into taking real action about environmental protection. The Harmful Waste Act was enacted[28]. The Act criminalizes activities involving the sale, purchase, transportation, importation, deposit, or storage of harmful waste, either singly or in conjunction with others on Nigeria's soil, air, or sea. Following the enactment of the Harmful Waste Act, the Military Government at the time also promulgated the Federal Environmental Protection Agency (FEPA) Act [27-28]. This Act provided the Federal Environmental Protection Agency with broad powers to manage and protect environmental resources and to develop environmental research technology. The Act also empowered states within the Federation to set up their respective state environmental protection agencies, primarily to maintain good environmental quality in relation to pollutants within the state's control (Ogunba, 2015). In 1989, the Federal Environmental Protection Agency formulated the National Policy on Environment. According to Adegoroye[27], the creation of the Federal Environmental Protection Agency and the subsequent launch of a National Policy on Environment put Nigeria at the same level of other developed countries in this area.

The Federal Environmental Protection Agency Act prohibits the discharge of hazardous substances (including crude oil) into the air or upon the land and the waters of Nigeria. This law provides for both criminal sanction and civil liability for its breach and consequent damage. Regarding civil liability, section 21 of the Act categorically states that any person (particularly an oil company) who contravenes the prohibition of section 20 shall, in addition to the penalty

specified in the section, be liable for: (a) the cost of removal thereof including any costs which may be incurred by any Government body or agency in the restoration or replacement of actual resources damaged or destroyed as a result of the discharge and (b) costs of third parties in the form of reparation, restoration, restitution or compensation as may be determined by the Agency from time to time[29].

## Conclusions

While consciousness of the need for environmental protection and sustainability in Nigeria started rather slowly and in a reactive manner, the level of awareness of environmental issues today is very encouraging. While the country might still not be considered environmentally sustainable, it is moving towards that direction. Institutional frameworks such as the creation of appropriate Agencies and Ministries to drive the environmental agenda have been put in place. A number of laws have been enacted to regulate the activities of people and business entities with regards to protecting the environment. However, some of these laws will require strengthening to achieve the purpose for which they were enacted in the first place. A vivid example of increased regulation needed is in the case of the frequent gas flaring taking place in Nigeria. So far, the fines imposed on oil and gas companies for flaring natural gas are cheaper than the cost of processing the gas. Hence, the oil companies prefer to continue flaring and pay the inexpensive fines. If Nigeria and other developing countries are serious in their approach to combat environmental pollution, governments at all levels must evade corruption and enforce the environmental laws already enacted. As noted by Kaseke & Hosking (2013), the development of any nation is tied to its utilization of electricity. Thus, the government needs to solve the problem of electricity supply and availability to all Nigerians. A real energy emergency needs to be declared in the power industry as this will not only radically lead to economic advancement for the nation, but it will also help to drastically reduce environmental pollution arising from use of private generators and also burning of firewood in rural Nigeria.

## Recommendations

The major environmental problems Nigeria faces are the burning of fossil fuels (gas flaring and use of generators) and oil spillage. These problems could be approached from a governmental and individual perspective.

From an individual point of view, it is recommended the use of solar panels by businesses and middle class Nigerians instead of fossil fuels (diesel or petrol) as an alternative source of energy. The initial capital cost of a solar panel may be slightly high, but it is an efficient and reliable method without having to tap into fossil fuels or the vulnerability of the electric grid. The use of solar cookers has already been tested in third world countries, and it would be a suitable solution for Nigerian rural dwellers. The construction of solar cookers is very basic; they are a do-it-yourself item and require low maintenance. The advantages of solar cookers rely in the elimination of smoke previously inhaled while cooking, and also the purification of contaminated water to drink.[34] From a governmental point of view, it is recommended that tougher policies be drafted and implemented forcing oil and gas companies to be watchful of the

environment by imposing substantial fines for incidences of unnecessary gas flaring and negligent oil spills.

This government action will force companies in the industry to launch measures that reduce spillages while building an infrastructure capable of capturing associated natural gas. Neglecting such measures would be economically unwise since fines would amount to prohibitive proportions. Corruption is another factor that needs to be addressed. Transparency in the agreements reached by the government and the operating oil companies must be a requirement for obtaining operational permits. Companies that display repeated occurrences of environmental violations should be disciplined with the removal of their rights to operate in the country for a given amount of time or permanently. This punitive measure would send a crucial message about Nigeria's serious commitment to environmental preservation and transparency. If the government is capable of reducing the frequency of gas flaring to a minimum, the captured gas could be processed and utilized to meet the natural gas requirements for electricity production, which would boost the electricity generation capacity in the country and provide the needed energy Nigerians need and demand.

The professional body for engineers in Nigeria – the Nigerian Society of Engineers (NSE) also has a vital role to play in shaping the discussion about environmental sustainability in the country. The NSE needs to advocate for the enactment of stronger legislations against environmental pollution in the country. The organization should also be a vital voice in the review of the engineering curriculum at institutions of higher education, making environmental sustainability an integral part in this area of study. Currently, environmental related courses at universities and polytechnic institutes are taught as general elective courses[32]. There is a need for the prompt inclusion of sustainability topics in the curriculum of engineers and in academia in general. The NSE is the professional engineering body in Nigeria having the right acumen to lead the path setting the benchmark for environmental standards to be applied. The NSE is the organization that can set pressure on the government to create environmental regulations for current and future oil extraction operations in the country. The NSE emphasizes the need to "enforce the maintenance of discipline and strict standards of ethics in the practice of the engineering profession in Nigeria"[33], however ethic courses do not seem to be part of the engineering curriculum at Nigerian universities. As long as ethics is not part of the academic curriculum, Nigeria will continue to suffer from corruption and remain classified as a developing country despite its richness in natural resources.

**References**

1. Brundtland, G., Khalid, M., Agnelli, S., Al-Athel, S., Chidzero, B., Fadika, L., ... & Singh, M. (1987). Our common future (\'brundtland report\').
2. Goodland, R. (1995). The concept of environmental sustainability. Annual review of ecology and systematics, 1-24.
3. Goodland, R. (1994). Environmental Sustainability: Imperative for Peace. Environment, Poverty, and Conflict, Oslo: International Peace Research Institute, 19-47.

4. Smith, K. R. (1993). Fuel combustion, air pollution exposure, and health: the situation in developing countries. Annual Review of Energy and the Environment, 18(1), 529-566.
5. Smith, K. R., & Mehta, S. (2003). The burden of disease from indoor air pollution in developing countries: comparison of estimates. International journal of hygiene and environmental health, 206(4), 279-289.
6. Ifeadi, C. N., Nwankwo, J. N., Ekaluo, A. B., & Orubima, I. I. (1985). Treatment and disposal of drilling muds and cuttings in the Nigerian petroleum industry. In NNPC Seminar on the Petroleum Industry and the Nigerian Environment, Kaduna.
7. Aliyu, A. S., Ramli, A. T., & Saleh, M. A. (2013). Nigeria electricity crisis: Power generation capacity expansion and environmental ramifications. Energy, 61, 354-367.
8. Kennedy-Darling, J., Hoyt, N., Murao, K., & Ross, A. (2008). The energy crisis of Nigeria: an overview and implications for the future. The University of Chicago, Chicago.
9. Hassan, A., & Kouhy, R. (2013, June). Gas flaring in Nigeria: Analysis of changes in its consequent carbon emission and reporting. In Accounting Forum (Vol. 37, No. 2, pp. 124-134). Elsevier.
10. Kadafa, A. A. (2012). Oil exploration and spillage in the Niger Delta of Nigeria. Civil and Environmental Research, 2(3), 38-51.
11. Obadote, D. J. (2009, June). Energy crisis in Nigeria: technical issues and solutions. In Power sector prayer conference (pp. 1-9).
12. Somefun, O. A. (2015). The Erratic Electric Power Supply in Nigeria: Causes and Remedy. International Journal of Engineering Science Invention (IJESI). Vol3, #7, July 2014 pp. 51-55
13. Ariyo, A., & Jerome, A. (2004). Utility privatization and the poor: Nigeria in focus. Global Issue Papers, 12, 1-24.
14. Society of Petroleum Engineers SPE (2016). Retrieved from http://petrowiki.org/Associated_and_nonassociated_gas
15. Ajugwo, Anslem O. (2013). Negative Effects of Gas Flaring: The Nigerian Experience. Journal of Environment Pollution and Human Health, 2013 1 (1), pp 6-8. DOI: 10.12691/jephh-1-1-2
16. The World Bank (2011). Global Gas Flaring Reduction Partnership Improving Energy Efficiency & Mitigating Impact on Climate Change.
17. Orubu, C. O. (2005). A quantitative assessment of gas utilization and flare reduction policies in the Nigerian petroleum industry. Petroleum Training Journal, 2(1), 63-74.
18. Edino, M. O., Nsofor, G. N., & Bombom, L. S. (2009). Perceptions and attitudes towards gas flaring in the Niger Delta, Nigeria. The Environmentalist, 30, 67–75.
19. Union of Concerned Scientists USA, 2016. Natural Gas Flaring, Processing, and Transportation Retrieved from http://www.ucsusa.org/clean-energy/coal-and-other-fossil-fuels/natural-gas-flaring-processing-transportation#.WG_xrGQrK2w
20. Dung, E., Bombom, L., Agosumo, T. The effects of Gas Flaring on Crops in the Niger Delta, Nigeria. GeoJournal 73(4):297-305 · December 2008. Retrieved from

https://www.researchgate.net/publication/226770764_The_effects_of_gas_flaring_on_crops_in_the_Niger_Delta_Nigeria
21. Randolph, J., Masters G. Energy for Sustainability (Island Press, Washington DC, 2008)
22. Environmental Protection Agency (EPA) . Effects of Acid Rain. Retrieved from https://www.epa.gov/acidrain/effects-acid-rain
23. Nriagu J.O. Oil industry and the health of communities in the Niger Delta of Nigeria. Encycl. Environ. Health. 2011;4:558–567.
24. Shah, Anup. (2010). "Nigeria and Oil." Global Issues. 10 Jun. 2010. Retrieved from http://www.globalissues.org/article/86/nigeria-and-oil
25. Cheong, Hae-Kwan et.al, (2010). Hebei Spirit Oil Spill Exposure and Subjective Symptoms in Residents Participating in Clean-Up Activities. Environmental Health and Toxicology. Vol 26:2011
26. Human Rights Watch, The Price of Oil: Corporate Responsibility and Human Rights Violations in Nigeria's Oil Producing Communities, 1 January 1999. Retrieved from http://www.refworld.org/docid/3ae6a82e0.html
27. Adegoroye, A. D. E. G. O. K. E. (1994, April). The challenges of environmental enforcement in Africa: The Nigerian experience. In Proceedings of 3rd International Conference on Environmental Enforcement, Oaxaca (pp. 43-54).
28. Ogunba, A. (2015). An Appraisal of the Evolution of Environmental Legislation in Nigeria. Vt. L. Rev., 40, 673.
29. Akpomuvie, O. (2011). Tragedy of commons: Analysis of oil spillage, gas flaring and sustainable development of the Niger Delta of Nigeria. Journal of Sustainable Development, 4(2), 200
30. Kaseke, N., & Hosking, S. G. (2013). Sub-Saharan Africa Electricity Supply Inadequacy: Implications. Eastern Africa Social Science Research Review, 29(2), 113-132.
31. Nriagu, J., Udofia, E., Ekong, I., Ebuk, G. Health Risks Associated with Oil Pollution in the Niger Delta, Nigeria. International Journal of Environmental Research and Public Health. 2016 Mar; 13(3): 346. Published online 2016 Mar 21. doi: 10.3390/ijerph13030346
32. Robinson, J. O. (2013). Environmental education and sustainable development in Nigeria: Breaking the Missing Link. International Journal of Education and Research, 1(5), 1-6.
33. The Nigerian Society of Engineers (NSE) http://www.nseph.com/Nse_Coren.Htm
34. Aid for Africa. Solar Cookers International. http://www.aidforafrica.org/member-charities/solar-cookers-international/?gclid=CjwKEAiA_9nFBRCsurz7y_Px8xoSJAAUqvKCfEKAvailZDo-bRDn0J88Cr4hCzPx-L75PjvwOkLwshoC4hLw_wcB

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