

Climate change: causes, effects and the need for science education for sustainable development

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ABSTRACT

The world we live in has witnessed some drastic environmental imbalance in recent times. These imbalances have threatened sustainable development- which is the ultimate goal of man-environment relationship. This paper reviews the causes and effects of climate change on man and his environment with a view to using science education to solve the problems posed by climate change. Literature shows that climate change results mainly from human activities such as rapid deforestation for agricultural and industrial purposes, carbon dioxide emission from fossil fuel burning, carbon dioxide emission from burning gasoline for transportation, usage of chemical fertilizers on cropland and methane emission from animals, agriculture and arctic sea beds. The consequences of these activities include global warming, ozone layer depletion, greenhouse effect, rising sea level and acid rain. It is recommended here that the whole educational process be re-packaged to emphasize science education as a panacea for sustainable development. The argument here is that the educational institutions are the best media for the inculcation of proper morals and values. It is also recommended that teacher education programmes should allocate more funds to research in, and teaching of science in schools.

Keywords: climate change; science; science education; global warming; sustainable development

1. INTRODUCTION

Towards the turn of this century various governments and researchers became perturbed with regard to the expectations of the new millennium. This gave rise to formulation of many development agenda intended to guide nations in channelling their efforts and resources appropriately to targets and/or goals conceived as critical for the survival of the human race in the new millennium. One of the results of such efforts gave birth to the formulation of the millennium development goals (MDGs) in September 2000, made up of eight goals, eighteen targets and forty-eight measurable, time-bound indicators aimed at eradicating poverty, hunger, disease, illiteracy, environmental devastation and discrimination against women. These development efforts no doubt are to cater for the well-being of the of the present as well as the future generations, having in mind the desire to leave our world better or at least not worse than we met it. It is obvious then, that science and its applications must play a vital role in this regard. Although science and its applications strive to satisfy human needs, they also take their toll as many activities carried out in the process of development turn out to endanger our environment and as such render it unsustainable.

Many undeveloped and developing nations like Nigeria conceive rapid industrialization as the key driver of sustainable development. Hence, industries are sited haphazardly and

often without proper assessment of their inherent effects on our environment. Some of the developed nations tactically relocate their manufacturing and industrial activities to the poor developing countries with the intent to 'develop the undeveloped' countries. This action, rather than address the growing anthropogenic pollution, merely changes the jurisdiction of the pollution created from the 'rich' to the 'poor' world. The resultant effect of such activities is an alarming increase in global climate change occasioned by global warming, ozone layer depletion, greenhouse effects, rising sea water level, improper monsoon and acid rain (all of which threaten man and his environment). It becomes very important, therefore, that the masses, especially people in the developing nations be proper education about our natural environment as well as how we can protect and preserve it for the future generation. Science education must of necessity come into play if we wish to achieve any remarkable level of environmental sustainability.

Educational institutions are the most appropriate places where meaningful contact can be made with the younger generation of pupils, engineers and scientists. They are the best media for the transmission of worthwhile norms and values to the society from generation to generation, especially on issues that have to do with changing the peoples' mindset on crucial issues as climate change. On this premise, therefore, science education is presented here as a panacea for climate change. This paper shall focus on climate change, its causes and effects and how science education can address it in order to achieve sustainable development.

2. WHAT IS CLIMATE CHANGE?

The Oxford Dictionary (online version) defines climate change as the changes in the earth's weather, including changes in temperature, wind patterns and rainfall, especially the increase in the temperature of the earth's atmosphere that is caused by the increase of particular gases, especially carbon dioxide. Although this definition places more emphasis on carbon dioxide, other gases such as the chlorofluorocarbons (CFC's), ozone (O₃), methane (CH₄), water vapour, etc are in significant measures to global warming. Climate change is a long-term change in the statistical distribution of weather patterns over a long period of time. It may be limited to a specific region, or may occur across continents.

Until the past century, natural factors caused atmospheric CO₂ concentrations to vary within a range of 180 to 300 parts per million by volume (ppmv). A report by the U.S. National Research Council (NRC, 2010) shows that the figure had risen to 390 ppmv in the last century. Similarly, the National Oceanic and Atmospheric Administration, NOAA's Annual Greenhouse Gas Index (2010) also shows that radiative forcing from human-added greenhouse gases (GHGs) has increased by 27.5 % between 1990 and 2009. In its analysis, increases in CO₂ concentration in the atmosphere are responsible for 80 % of this rise. It further stated that the contribution of radiative forcing by methane (CH₄) and chlorofluorocarbons (CFCs) has been nearly constant or declining for the same period. USA, for instance with about 4.5 % of the world's population, consumes an estimated 25 % of the world's resources and produces an estimated 26 % of global pollution (Govindaswamy, n.d.).

These increases in the atmospheric composition of our natural environment have had devastating effects. In Nigeria, for instance, the flooding pattern that occurred in recent times is a warning signal that needs urgent attention to forestall its reoccurrence. The National Emergency Management Agency (NEMA) has repeatedly given warnings that people of the southern parts of the country are likely to experience greater flood disaster this year (2013). This means that if left unchecked, there is the tendency for such changes to occur

progressively. Although NEMA and other similar agencies prescribe temporary measures like relocation of the inhabitants of such perceived disaster-prone areas, a more permanent measure is needed. Such measures should be lasting and sustainable rather than palliative. It can only be achieved if the causes of climate change are made known to all so that there would be a collective effort towards finding a lasting solution.

3. CAUSES OF CLIMATE CHANGE

It has been widely accepted that the major causes of global warming are from us, the human race and the effects on us will be severe. For instance, The Citizen newspaper of 21 June, 2013 (online version) reports that no fewer than 171 plant species were classified as endangered and vulnerable; and that these plants are harvested from our forests through commercial activities that cause rapid deforestation at about 400,000 hectares per annum. The disappearance of the affected species could disrupt the nation's genetic resource with resultant threat to our biodiversity. The same newspaper reported that the government of Delta State, Nigeria needs over 200 billion naira to tackle ecological. Before humans, changes in climate resulted entirely from natural sources such as changes in earth's orbit, changes in solar activity, or volcanic eruptions. But since the industrial era began, human activities have had an increasing effect on climate, particularly by adding billions of tonnes of heat-trapping gases to the atmosphere. The main GHGs directly discharged by humans include CO₂, CH₄, N₂O, and several others. Derek Markham (2009) identified the following as the causes of global warming:

- 1. Carbon dioxide emission from fossil fuel burning power plants:** Man's increasing addiction to electricity has led to establishment of several coal burning power plants which release enormous amounts of carbon dioxide into the atmosphere. The U.S. Environmental Protection Agency (EPA, 2010) noted that 40 % of U.S. carbon dioxide emissions come from electricity production, and burning coal accounts for 93 % of emissions from the electric utility industry.
- 2. Carbon dioxide emission from burning gasoline for transportation:** With the increasing demand for modern means of transportation and distribution of globally sourced goods, automobiles are increasing in number yearly. In the U.S., for instance, the EPA (2010) notes that about 33 % of the emissions emanate from automobiles. For developing countries like Nigeria with a very high population figure, the demand for both new and used cars and consumer goods keeps increasing. This translates to increasing use of fossil fuels for transportation and manufacturing, often without sourcing for alternative energy resources and consequently increasing carbon dioxide concentration in the environment.
- 3. Methane emissions from animals, agriculture, and from Arctic seabed:** When organic matter is broken down by bacteria under oxygen-deficient conditions (anaerobic decomposition) as in rice paddies, methane is produced. A similar process takes place in the intestines of herbivorous animals, and with the increase in livestock production, the levels of methane released into the atmosphere is increasing. Also, methane from methane clathrate (a compound containing large amounts of methane trapped in the crystal structure of ice) increases the rate of global warming significantly, as methane escapes from the Arctic seabed.
- 4. Rapid deforestation for agricultural, commercial and industrial purposes:** Man's quest for urbanization, industrialization as well as production of food crops has led to increasing deforestation in the tropics. Forests remove and store carbon dioxide from the

atmosphere. Deforestation releases large amounts of carbon, as well as reduces the amount of carbon capture on the planet.

5. **Increase in usage of chemical fertilizers on croplands:** In recent times, due to rapid population growth, especially in the underdeveloped nations, there is increasing demand for food and higher crop yields. This has led to more use of chemical fertilizers than animal manure. It has been established that nitrogen oxides have up to 300 times more heat-trapping capacity per unit of volume than carbon dioxide. Also the run-off of excess fertilizers creates 'dead zones' in our oceans. In addition to these effects, high nitrate levels in ground water due to over-fertilization calls for human health concern.

4. EFFECTS OF CLIMATE CHANGE ON MAN AND HIS ENVIRONMENT

1. **Rise in sea levels globally:** Scientists predict an increase in sea levels worldwide due to the melting of two massive ice sheets in Antarctica and Greenland, especially on the East coast of the United States of America. However, many other nations including Nigeria are already experiencing the effects of rising sea levels (and flooding of the coastal lands), which has displaced millions of people.

2. **Massive crop failures:** A recent research by the NOAA as reported by the *Climate Watch magazine* (April 18, 2013) indicates that there is a 90 % chance that 3 billion people worldwide will have to choose between moving their families to milder climes and going hungry due to climate change within 100 years. This is so because the impact of climate change on water supply would be severe. Shortages in water supply will affect food production, reduce sanitation, and hinder economic development and damage ecosystems. Climate change causes violent swings between floods and droughts.

3. **Rapid and widespread extinction of species:** For a balance in the ecological system to be maintained, there is need for the existence of diverse species of plants and animals on earth. Climate change presents a great threat to a vast number of plant and animal species inhabiting the earth. Rising temperatures could lead to widespread species loss, and lists of endangered species keep growing. This has attracted attention on many fronts.

4. **Disappearance of coral reefs:** Despite the immensity of oceans (about 71 % of the earth's surface with an average depth of 4km), there are indications that it is approaching its tipping point. A report on coral reefs (WWF, n.d.) says that in a worst scenario, coral populations will collapse by 2100 due to increased temperatures and ocean acidification. The bleaching of corals with a small but prolonged rise in sea water temperature is a severe danger for ocean ecosystems, and many other species in the oceans that rely on coral reefs for their survival.

5. **More killer storms:** The severity of storms such as hurricanes and cyclones experienced in recent times across the globe is on the increase. Scientists are of the belief that global warming will significantly increase the intensity of the most extreme storms worldwide. This has been associated with rising ocean temperatures.

From the above analysis of the causes and effects of global climate change on man and his environment, it is very clear that individual and government intervention is needed to forestall this negative trend. Government's intervention, particularly in conservation efforts, is very important if the much desired sustainable development is to be achieved- through science education.

5. WHAT IS SUSTAINABLE DEVELOPMENT?

The idea of sustainable development resulted from the 1987 report of the Brundtland Commission to the United Nations World Commission on Environment and Development. The objective is to provide all kinds of people with educational opportunities that enable them to acquire knowledge and values, as well as adopt the behaviour and lifestyles that are necessary to make the future worth living and to bring about positive social change. According to this report, sustainable development is the “development that meets the needs of the present without compromising the ability of future generations to meet their own needs”. It promotes the idea that social, environmental and economic progresses are attainable within the limits of our earth’s natural resources.

Sustainable development approaches everything in the world as being connected through space, time and quality of life. In terms of the earth being connected through space, it implies that whatever environmental practices being carried out in one country has the capability to impact on another country. For instance, the air pollution being emitted here in Nigeria has the capability of affecting the quality of air in not just the neighbouring countries like Cameroun, Chad or Niger but across continents. In terms of the earth’s connection to time, this could be demonstrated in how the choices of the present generations are either benefitting or suffering the present generation or how our own decisions could affect the future generations. To illustrate this, consider what environment our children and grand children will live in if we fell all the trees now without replanting or if we embark on the use of chemicals to hunt for the aquatic creatures. The result is obvious- many species will be extinct. For any development to be considered sustainable, therefore, it should seek to address the following issues:

- **What is to be developed?** All development should consider first, the people in terms of child survival, life expectancy, equal opportunity, etc. It should also consider the economy (wealth creation, productive sectors, consumption), and the society (institutions, social capital, regions). Any development effort that is not geared towards improving these factors is not worth embarking upon.
- **What is to be sustained?** In trying to answer this question, we consider the effects of such development on nature (earth, biodiversity, and ecosystems), life support (ecosystem services, resources, and environment) and community (cultures, groups and places).
- **For how long will it be sustained?** Here we critically look at the span of such development. Are the results of such development going to have immediate, future or everlasting effects on the components listed above? Questions regarding the effects of such development effort should also be addressed (U.S. National Research Council, 1999).

To achieve sustainable development, therefore, we have to seek for ways of addressing our social and economic problems of the present without exhausting the earth’s finite natural resources, which are expected to support the future generation live a kind of life that will not be of lower quality than ours. One major way of addressing the environmental problems created by man’s activities is education, especially in science through the schools since the school is the most appropriate medium through which issues concerning the society can be related to the younger generation. This role rests heavily on science educators.

6. WHAT IS SCIENCE EDUCATION AND WHY DO WE NEED IT?

The word science probably makes us think of thick textbook, white lab coat, laboratory instruments, microscopes, a naturalist in the rainforest, Einstein's equation written on whiteboard, the launch of space shuttle and etc. However, those pictures only reflect some aspect of science, but they do not provide the whole picture of science. So, what is science? Science can be said as part of everyday life, where it exists all around us. Science has many disciplines such as chemistry, physics, biology and engineering. To conclude what science is, let's see the diagram below;



Science is composed of **attitude, skill and knowledge** (ASK), each of which has different domains involved. For example, knowledge involves cognitive domain and skill involves cognitive and psychomotor domains. This is because science process skill involves critical thinking in attributing. However, we use cognitive domain. In science, we also have manipulative skill that uses psychomotor domain. Lastly, attitude such as accuracy, involves affective domain. Each of these domains are covered for in the process of education.

Science education can be defined as a discipline or field of study concerned with the integration of science content and processes with pedagogy in order to promote meaningful understanding and application of science among learners, or the study of science content and process with emphasis on how best to promote their teaching and learning in order to achieve optimum benefits. (Nworgu, 2010). Education for sustainable development, on the other hand, comprises the subjects of environmental protection, the efficient utilisation of natural resources, the maintenance of the ecosystem and responsible attitudes among members of society and the business community. Science education is thus an integral aspect for sustainable development.

It goes beyond to science education than simply learning about our theories and laws. It also includes learning how to protect the environment. This is impressively demonstrated by the anti-littering campaigns that are regularly implemented in many towns and cities in Nigeria, and throughout Europe. Such initiatives where citizens clean up towns and cities do not just have the effect of cleanliness. They encourage citizens to act in a responsible way and to appreciate the environment. Education generally influences behaviour but science education specifically makes people aware of which environmentally harmful acts are prohibited.

The Nigerian national policy on education (FRN, 2004) recognizes the place of the child's environment in the child's life and overall well being. Hence the child's learning is always designed in a way that it can enable him/her fit into his/her environment. At the pre-

primary level, Education should among others (i) inculcate social norms, (ii) inculcate in the child the spirit of enquiry and creativity through exploration of **nature, the environment**, art, music and playing with toys, etc. (p.11). At the primary school level, education should also develop in the child the ability to **adapt to their changing environment**, among others (p.14). Similarly, the UN designated the period 2005 to 2014 as the decade of “Education for Sustainable Development”. The objective is to integrate the concept of sustainable development in education process around the world. Science education is an integral aspect of this concept. Environmental problems such as climate change jeopardize our prosperity and our economic development and can best be handled by science educators.

For the child to understand that his environment changes and be able to adapt to it, therefore, he should understand the components of the environment. Such knowledge can best be provided by giving the child proper science education. In fact, the importance of science and technology in today’s world is overwhelming and therefore the education system throughout the world has to gear itself to provide the required training in scientific skills to meet this growing challenge. Undoubtedly the application of science and technology have transformed the world through dramatic advances in almost all fields including medicine, engineering, electronics, aeronautics etc. and in more recent times dramatic leaps in computer technology have revolutionised in particular the information and communications sector.

The evidence of the correlation between science and technology and economic/industrial development is overwhelming. In fact, many countries have transformed themselves from poor feudal type economies through the increasing application of science and technology. In this regard, China and India are two outstanding examples as they have grown to become economic and industrial power houses and in several ways compete effectively with developed countries. Had it not been for science and technology, Europe would not have been able to rebuild in such a relatively short time after most of the countries there were flattened during World War II (Prakash, 2011). So it is not whether scientific and technological road is an optional one it is an imperative and has to be vigorously pursued, especially Nigeria, which, because of a multiplicity of factors lags in scientific and technological development. What has been troubling is that the number of students at the secondary and tertiary levels pursuing science has been decreasing, especially in physics and chemistry. Then there is also an attitudinal problem with respect to science where many students feel that science subjects are too difficult and therefore shy away from it. Therefore it would seem that the issue has to be tackled on two fronts - providing the incentives and motivation for the pursuit of science and changing the attitude of students. Achieving these tasks will not be easy because of the numerous difficulties and complexities involved but a good start is to equip our school system to make them science friendly. This of course has been recognised by the Ministry of Education and it has begun formulating policies and programmes to address the issue. This indeed will always be a challenge in developing countries but perhaps one of the avenues that should be pursued to help alleviate this difficulty is seeking support from the private sector, particularly industries, which ultimately will benefit from scientifically qualified trained personnel coming out of the education system. However, another which should come under closer scrutiny is the science curriculum to determine whether its content and structure are towards meeting objectives and stimulating children’s interest in science. This is a crucial area and should not be overlooked.

7. CONCLUSION AND RECOMMENDATIONS

From the foregoing, it is imperative that science education should be given serious attention in school curricular considering the benefits derivable from it. For the child to be well informed about his environment, he has to interact with his environment, and by so doing, gain a first-hand and deeper knowledge and information about his environment. Such knowledge can only be impacted by those who have sound science background. It is therefore recommended here as follows:

- A) Nations of the world should repackage their various schools curricular to emphasize science education.
- B) Sciences should be made compulsory at least up to senior secondary school level especially considering the challenges posed by climate change which many people contribute to ignorantly.
- C) Science teacher education programmes should be given adequate attention in terms of funding so as to increase or enhance teachers' commitment to their duties.
- D) Rather than spend scarce resources on controlling environmental degradation resulting from climate change, such resources should be channeled towards educating the pupils on proper environmental practices, through science education. This is preventive rather than palliative. In conclusion, the effects of climate change can have far-reaching negative effects on man and his environment, if nothing urgent is done to enlighten the masses of the dangers of certain activities we engage in as we pursue industrialization. This enlightenment campaigns cannot be effectively carried out using the mass media only. The school is the best avenue for addressing this issue, especially through the inclusion of environmental education as a core subject in school curricular.

References

- [1] Climate Watch (2013). April 1st Global temperature update. Retrieved from www.noaa.gov
- [2] Environmental Protection Agency (2010). Global Warming: Executive Summary. Retrieved from <http://yosemite.epa.gov/OAR/globalwarming.nsf>.
- [3] Federal Republic of Nigeria. (2004). National Policy on Education. Lagos: NERDC press. Govindaswamy, V. (n.d). Importance of Environmental Education for Sustainable Development. Retrieved from www.ces.iisc.ernet.in
- [4] Markham D. (2009). Global Warming – effects and causes: a top 10 list. Retrieved from <http://www.10top.com>
- [5] National Research Council (1999). Our common journey: a transition toward sustainability. Washington, DC: National Academy Press. Retrieved from <http://www.sustainabledevelopmentinfo.com>.
- [6] National Research Council. (2010). America's climate choices. Retrieved from http://nas_sites.org.
- [7] NOAA (2010). Annual greenhouse gas index. Retrieved from <http://www.esrl.gov/gmd/aggi>

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- [8] Nworgu B. G. (2010). Research in science education in Nigeria: conceptual, methodological and analytical issues. Guest lecture delivered at the 2nd national conference of the School of Sciences, Federal College of Education, Okene, August 10-13.
- [9] Prakash J. (2011). What is the importance of science education as a school subject? Retrieved from <http://www.preservearticles.com> DOI: 201105216961.
- [10] The Citizen Newspaper (2013, June 21). Nigeria's endangered species. Online version retrieved from www.thecitizen.com/public-affairs.
- [11] United Nations (1987). Brundtland Commission report of World Commission on Environment and Development. Retrieved from <http://www.un.org/documents/ga/res/42/ares42-187.htm>.

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