Review Article

Tropical Forest: the cheapest resource to address climate change in Ghana

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ABSTRACT

Climate variability and change has become a global phenomenon with many countries including Ghana working to mitigate the effect or develop strategies for adaptation to climate change. However, tropical forest has been identified to have the capacity to mitigate the impact of climate change and improve the general environment. The forest plays a critical role in the climate system, hydrology and the carbon cycle, and provide livelihood for over 2.5 billion rural dwellers in developing countries. This article therefore seeks to highlights the importance of the forest to potentially help in addressing the challenges of climate change and the need for policy makers, stakeholders and the general public to seriously adopt positive approach to the management of the forest resources. The article was carried out through extensive review of literature, official reports and policy documents. The paper outlines the threat of climate change, the state of Ghana's forest and climate, and the role of the forest to mitigate climate change. It also highlights the socio-economic benefits of the forest in mitigating the changing climate. The documents reviewed showed that the state of Ghana's forest has dwindled over the years through anthropogenic activities and the climate is also changing. It was also established that trees can remove a substantial amount of CO_2 from the atmosphere for storage. The paper concludes with suggested recommendations to employ the service of the tropical forest for climate change mitigation (Just state the key recommendation(s)).

Keywords: climate change, tropical forest, forest resources, climate variability, CO_2 carbon dioxide emissions, deforestation, mitigation

1. INTRODUCTION

The issue of climate change has become a global phenomenon with its attendant consequences. The search for food, clothing, shelter, improved standard of living as well as technology and energy use has altered the atmosphere negatively through the introduction of Greenhouse Gases (GHGs) in higher concentrations which cause climate change [1]. The rising concentrations of the GHGs mainly CO_2 in the atmosphere has been attributed mainly to anthropogenic activities such as the extensive use of fossil fuels like coal, oil and gas, deforestation, burning of vegetation, loss of wetlands, agriculture among others. The GHGs are mainly carbon dioxide (CO_2), methane (CH_4), water vapour (H_2O), nitrous oxide (N_2O), ozone (O_3) and the halocarbons which create a thick blanket in the atmosphere to prevent infrared radiation (heat) from escaping thus resulting in global warming [2, 3]. There is high evidence of global warming with Africa being more susceptible to rising land temperature [3] and this will affect water resources, agriculture, health and the socio-economic development of many nations. Due to the negative impact of climate change, many international bodies are therefore making frantic effort to curb the rising global temperature.

One of the long term goals of the 2015 Paris Agreement was to keep the increasing global average temperature to well below 2℃ above pre-industrial levels and possibly limit the increase to 1.5℃ leading to a net zero GHG emissions to significantly minimize the risks and the impacts of climate change. One of the key measures considered was the forest and its restoration. The forest, apart from its ability to sequestrate carbon to mitigate the changing climate, serve as food, water purification, shelter, energy among others for billions of vulnerable people in developing countries. Despite its importance, research has shown that the forest has over the years suffered from severe disturbances through anthropogenic activities such as deforestation, degradation and desertification. Such disturbances have been a major concern and the European Union (EU) has made commitment to end deforestation and forest degradation possibly by 2030 globally with over 3 billion euros invested in addressing deforestation through REDD+ programme [4]. The Sustainable Development Goal 2015, goal 15.2 also demands the implementation of sustainable management of all types of forests, halt deforestation, restore degraded forests and increase afforestation and reforestation by the year 2020. It is estimated that 13 million hectares of forests are lost annually while continuous degradation of drylands has led to the desertification of 3.6 billion hectares and this affect poor communities negatively [5].

The Reducing Emissions from Deforestation and Forest Degradation (REDD+) has become a major component of the Paris Agreement in Article 5 which states that (1) “Parties should take action to conserve and enhance, as appropriate, sinks and reservoirs of GHGs” as indicated in Article 4, paragraph 1(d), of the Convention, including forests. Also, parties are encouraged to take action to implement and support agreement under the Convention to reduce emissions from deforestation and forest degradation, enhance forest carbon stocks in developing countries and adopt an integral approach towards sustainable management of forests [6]. Afforestation, reforestation and forest restoration are therefore measures that can mitigate the changing climate. This article therefore seeks to emphasize on the importance of the tropical forest and the need for policy makers, stakeholders and the general public to seriously adopt positive approach to the management of our forest resources.

2. THE STATE OF GHANA'S FOREST

Research has shown that global forest reserves are declining speedily which require urgent attention to address the problem (provide appropriate citation). The Sustainable Development Goal 2015, goal 13 demands an urgent action to combat climate change and its impacts. This is a clarion call and Ghana cannot be left out. FAO [7] estimated that an alarming rate of 13 million hectares of forest is lost globally each year from 2000 – 2010 through deforestation. In sub-Saharan Africa, agricultural productivity has mainly centered on widening the area under cultivation [8] and this has also influenced deforestation and forest degradation. About 70-80% of the forest is lost through agricultural expansion [9] in addition to other factors such as population growth and other land use change. According to [10] Nigeria lost about 90% of its primary forest through logging, mining and agricultural plantations and the situation is not different from Ghana.

In Ghana, it is estimated that 2% (135, 000 ha) of the forest cover is lost annually and about 60% of the forest cover is lost since 1950 [11]. Ghana's forest of about 8.2 million hectares at high forest with a transition zone of about 1.1 million hectares and savanna vegetation covering about 14.7 million hectares between 1900 and 1950 has been reduced to 4.2 million hectares [12]. An average of 46 000 hectares of Ghana's closed forest is lost annually from 1990-2010 and arable land expanded from 2.70 million hectares in 1990 to 4.70 million hectares in 2013 [13]. Recently the Forestry Commission impounded about 19 trucks carry illegal sawn lumber including Rosewood in the Eastern, Volta and Western regions and this illegal activities have been part of the forest degradation activities [14]. A speech read by Prof Mrs. Esi Awuah, former Vice Chancellor of the University of Energy and Natural Resources, also revealed that "between 2005 and 2010, the rate of Ghana's deforestation is about 2.19 percent per annum, being the sixth highest deforestation rate globally for that period. The Forestry Commission also estimated that the cost of environmental degradation is between 5-10% of GDP as at 2010 with about 63% from the forest sector [15].

UNDP has estimated that 1.6 billion people depend on the forests for their livelihoods for varied reasons [3]. Cairns and Meganck [16] argued that tropical forests are being harvested at a rapid pace and the use of the forest to sequester carbon will fail unless the economic, social and political needs of the local people are addressed. The consistent degradation of forest resources will heighten atmospheric carbon concentration causing climate variability such as changes in temperature and rainfall pattern which causes floods, droughts, and alter watershed and biochemical processes [17]. Research has also revealed that large-scale and regular burning of vegetation in the tropics also add a great deal of gases, inter alia, carbon dioxide, nitrous oxide, carbon monoxide, methane in addition to aerosols to the atmosphere [18]. Northern Ghana experiences rampant bush burning annually and this also affects the vegetation and soil fertility in the regions. According to [19] incessant fires also affect the growth of woody vegetation. Whelan [20] also affirms that, the burning of forest causes death of individual trees, loss of soil nutrients, changes the surface soil organic layers and land scape among others. Ghana's Readiness Preparation Proposal (GRPP) also identifies the principal drivers of deforestation and forest degradation as agricultural expansion (50%), wood harvesting (35%), population and development pressures (10%), mining and mineral exploitation (5%). According to the [21] Ghana's economy has for a long time depended heavily on its natural resources such as timber, cocoa, minerals among others which contributes about 48% to GDP, 90% of foreign exchange earnings and 70% of total employment, and this may partly be responsible for the rapid degradation of the forest resources. The degradation of our forest also comes with cost to the nation. During the fifth Annual Environmental and Natural Resource Summit in Sunyani, it was revealed that the cost of forest depletion, agricultural soil degradation and environmental health damage in Ghana by 2010 was estimated at 3.7% of Gross Domestic Product (GDP) [22]. This

therefore calls for stringent measures to address issues related to deforestation and forest degradation.

3. DEFORESTATION – A DRIVING FORCE OF CLIMATE CHANGE IN GHANA

Deforestation has become one of the major challenges to climate change especially in Africa where timber and other forest resources are overexploited for economic gains. According to [1] deforestation is said to be the second most dreadful agent that causes climate change apart from the use of fossil fuels. The continues deforestation and forest degradation will therefore intensify climate change events leading to drought, floods, extreme weather conditions, erratic rainfall patterns, sea level rise among others. The annual contribution from deforestation and changing land use is 23% of the total emission of CO_2 to the atmosphere [23].

Conversion of forests to agricultural land is estimated to be 13 million hectares annually and this releases carbon stored in trees as CO_2 emissions into the atmosphere [24]. It is also estimated that large-scale commercial agriculture is responsible for 40% of deforestation, subsistence agriculture which provides livelihood to many poor households in Africa including Ghana account for 33% as well as infrastructure and urban development including mining account for about 27% in the tropical regions with high population growth [13]. According to [7] deforestation has resulted in the emission of CO_2 between 4-12% globally and 4-12 billion tonnes of CO_2 equivalent annually of which 9% are all attributed to agricultural land clearing. Additionally, the annual net global deforestation is said to contribute about 2 gigatons of carbon emissions to the atmosphere. Carbon loss from conversion of terrestrial ecosystems to agriculture ranges from 21 to 46% [25]. Carbon released into the atmosphere from tropical forest harvesting amount to about 11 to 3.6 pentagrams of carbon annually [26] and this is likely to have a devastating consequences due to such anthropogenic activities. Excessive CO_2 in the atmosphere resulting in climate variability and change will affect agriculture output, energy delivery, food security and the socio-economic development of many nations. The impacts will hard-hit the very poor in society who depends on environmental goods and services for their survival.

4. CARBON DIOXIDE EMISSIONS - THE ENEMY OF CLIMATE CHANGE

The sun's energy is the life sustaining resource that drives the earth's climate and weather [27] and the main source of life for plants and animals. Naturally, the climate system is designed to be self-sustaining through a balanced reaction of gases that envelope the universe especially Oxygen (21%) and Carbon dioxide (0.003%). The relationship that exists between plants and animals also play a key role in the maintenance of the self-sustaining climate systems. Plants use CO_2 to produce food and release oxygen as a by-product through photosynthesis while humans/animals use oxygen and give out CO_2 through respiration. Plants and animals are therefore supposed to co-exist harmoniously to sustain the climate systems but due to the overexploitation of the natural forest and other activities, such harmonious co-existence has been affected leading to imbalances of certain chemicals such as CO_2 in the atmosphere causing changes in the atmospheric parameters.

The roots, trunks, stems, branches and leaves of trees store carbon removed from the atmosphere making the forest an indispensable component of the carbon-energy cycle. When the leaves fall and plants die, the carbon is transferred into the soil for keep through decomposition by micro-organisms. This basically implies that the more forest we have, the more carbon will be removed from the atmosphere for storage and vice versa. Unfortunately, overexploitation of the natural forest and anthropogenic activities such as deforestation,

forest degradation, poor land use management, agriculture and illegal forest mining over the years have altered the natural cycle of the carbon in the atmosphere [1]. These anthropogenic activities among others have partly been responsible for the changing climate through the release of certain Greenhouse gases (GHGs) such as carbon dioxide (CO_2), methane (CH_4), water vapour (H_2O), nitrous oxide (N_2O), ozone (O_3) and halocarbons [3]. The higher concentration of the GHGs especially CO_2 which is a good absorber of infrared radiation, creates a thickening layer of pollution above the earth, trapping in heat which eventually causes global warming [25, 28] and climate change. According to Houghton et al. (1990) cited in [23], CO_2 alone contributes about 55% to global warming. It is estimated that a km^2 of tropical forest is made up of about 25,000 biomass (existing trees) which contains about 12,000 tonnes of carbon and 2/3 of this amount is converted into CO_2 [29]. This therefore shows how important the forest is in maintaining a sound environment and avert or mitigate the challenges on climate change.

5. THE ROLE OF FOREST IN CLIMATE CHANGE MITIGATION

The forest in Ghana has suffered drastic decline over the years through resettlement, clearing of land for farming and building projects, illegal chainsaw milling and logging, wood fuel and charcoal production in addition to bush burning, infrastructural development and mining activities especially in the three regions of the north [30]. The forest is known for its ecosystem services, biodiversity conservation and maintenance of its cultural heritage for generations and forms a major component of human existence. The forest plays a vital role in controlling CO_2 concentration in the atmosphere and global hydrological cycle through the mediation of surface runoff, groundwater recharge and GHG mitigation strategies [7]. Through photosynthesis, the forest absorbs carbon from the atmosphere thus reducing the concentration of CO_2 in the atmosphere. CO_2 is also stored in the various parts of the plants and the more plants we have, the more CO_2 is extracted and stored. According to [31] every tree stores about 50% of carbon which is extracted from the atmosphere and for every tonne of carbon stored, 3,667 tonnes of CO_2 is taken from the atmosphere. Lawrence [32] has also estimated that old-growth tropical forests store between 120-400 tonnes of carbon per hectare of land. Nair *et al*. [33] also reported that agro-forestry systems like inter-cropping with about 50 trees/ha can store 100 to 147 tonnes of CO_2 equivalent/ha in semi and arid lands. An FAO document on building greener cities also suggests that mature trees can absorb up to 150 kg of CO_2 per year [34]. The forests contain twice as much carbon as the atmosphere and metabolize more than 14% of atmospheric carbon each year [35]. These facts, unequivocally, make the forest an indispensable resource for the extraction and storage of atmospheric carbon to mitigate climate change.

Apart from the forest serving as carbon sequester, it also provides a cooling effect to reduce the heat within the environment. Boaunoua *et al*. [36] has observed a year-round cooling of 0.8℃ in the tropical areas of Africa due to increased vegetation cover. According to [37] shading and vegetation cover reduces the mean and variance of groundwater temperature. FAO document on building greener cities also suggests that trees located at certain areas can help cool the air between 2-8 ^{0}C which will influence the heat island effect in urban cities [34]. The cooling effects of protecting and restoring forest cover in the tropics may be even greater than originally estimated.

Deforestation and forest degradation therefore inhibit the forest from performing its multipurpose functions. All the carbons stored in the forest plants find their way back into the atmosphere when the forest is cleared and burnt. The ability of the forest to remove CO_2 is denied thus increasing the concentration of carbon in the atmosphere. Burning of the forest also incapacitate the trees from absorbing CO_2 in the atmosphere. Deforestation and forest degradation through burning therefore enhance the concentration of CO_2 in the atmosphere

leading to global warming and climate change. Restoration and proper management of the forest will therefore play a key role in mitigating the changing climate.

6. THE SOCIAL AND ECONOMIC BENEFITS OF THE FOREST

The social and economic benefits of the forest cannot be overemphasized. The forest, apart from maintaining ecological balance, provides environmental goods and services to support the livelihood of millions of poor people in developing countries. The forest provides medicine, shelter, energy, food, and clothing; enhance soil fertility, water quality and improve soil structure and texture among others. It is estimated that the forest provide livelihoods to about 1.6 billion people and a home to over 80% of all terrestrial species of animals, plants and insects [5]. However, lack of economic opportunity, poverty and hunger compel poor people in low income countries to exploit the natural resources around them especially women. Sunderland et al. [38] observed that, women lack the opportunity to generate adequate income as men even though they tend to commercialize the forest products better than men.

Deforestation is directly linked to poverty levels in that as deforestation increases in developing countries due to population explosion, demand for agriculture lands and unsustainable forest resource exploitation also increase. However, developed nations forest keeps increasing while population decreases [13]. Many governments in the continent also exploit the raw forest timber and other forest products to generate foreign exchange, even though, some hardly re-invest part of the proceeds to restore the lost forest. In Ghana, the forest sector generated about US$283.2 million in 2013 through export [13]. According to [39] about 40% or 2.4 billion people living in developing countries depend on wood fuel for cooking and these are mainly women. It is estimated that about 88% of household energy in Ghana for cooking comes from wood fuel and charcoal [40]. The savannah zone with low forest resources also provides about 70% of Ghana's total annual firewood and charcoal requirement estimated at 16 million m^3 [41]. The situation is not only limited to the north but across the entire country. It is true that the continuous dependence on the forest for energy and income through various means have adversely affected the forest cover. However, due to the economic circumstances of many rural dwellers that depend on the forest, appropriate policies could be developed to specifically assist these rural dwellers to ease the pressure on the forest. The adoption of urban and peri-urban forestry will also improve nutrition and food security, ensure climate change mitigation and possible adaptation as well we as providing ecosystem services. According to FAO, trees in cities could bring substantial benefits such as provision of food and nutrition, safety of urban biodiversity, mitigate urban pollution, climate change, regulate urban water and air flows, sustain conducive environment and increase esthetics, physical and mental health and property value of the cities [34]. However, the underlying cause of illegal logging, felling of trees for charcoal production and wood fuel as well as poor agricultural expansion must first be addressed to reduce deforestation and forest degradation. With proper investment and value addition to the forest products, the challenges of deforestation and forest degradation could be minimized.

7. CONCLUSION AND RECOMMENDATIONS

This article has outlined the role of the forest in mitigating climate change and also provides additional benefits to the economy and society as a whole. The importance of the forest to mitigate climate change through CO_2 sequestration cannot be overemphasized. Carbon dioxide which is the major driver of climate change is a threat to our environment and the forest as a carbon sink can play a key role to avert the negative consequences of the changing climate. It has already been established that the forest has the capacity to remove substantial amount CO_2 from the atmosphere and clearing such forest resources will cause climate variability which may have serious consequences on water resources, food production, energy and socio-economic development of many African countries.

Besides, the forest provides many benefits to the socio-economic and cultural existence of mankind. Human life and the climate without doubt depend on the forest. The saying that "the day the last tree will die, the last man will also die" indicates that our human life is actually linked to nature. Adopting intensive afforestation and reforestation globally and proper land use and agricultural management, efficient energy use, and frantic effort to prevent deforestation and land degradation could be the way forward in mitigating the effect of climate change. Let's therefore protect our forest for posterity. The following are suggested recommendations to promote the forest resources for climate change mitigation in Ghana.

1. Eliminating Poverty - Poverty is indeed the underlying cause of forest and environmental degradation. Charcoal production, illegal forest mining and other anthropogenic activities stem from people's effort to make ends meet. An alternative means of livelihood will reduce if not eliminate the rate of deforestation in Ghana.

2. Empowering local communities - chiefs, opinion leaders and assembly men in communities can effectively manage the forest around them if given the mandate to do so. This is a shared responsibility.

3. Develop and implement REDD+ Policy - proper adaptation and implementation of the REDD+ will result in socio-economic and environmental benefits leading to the mitigation of climate change, economic growth, job creation, livelihoods enhancement, food security, forests conservation and promotion of sustainable development.

4. Enforcement of laws and institutional empowerment Strengthen institutional framework for enforcing the law and management of natural resources- institutions should be empowered to enforce laws and regulations pertaining to illegal forest mining and trade including land use.

5.Support/promote woodlots production and agro-forestry - encourage the planting of woodlots for wood fuel and charcoal production including incentives for agro-forestry promotion to free the forest from further encroachment.

6. Promote/undertake massive afforestation and reforestation including Urban and Peri-urban tree planting - deliberate planting of trees on all degraded lands including settlements have diversified benefits.

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