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Global Carbon Cycle:Its Impact On Terrestrial Ecosystem, Environmental Cahange, Composition Of Atmosphere And Sustainability

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Abstract

Atmospheric greenhouse gases mainly carbon dioxide is responsible for the equilibrium between natural biological and geochemical processes in the atmosphere. this balance is being changed due to anthropogenic-related increase in the atmospheric concentration of these gases, mostly from burning of fossil fuel and modifications in land use/land cover (LULC). This is consequently causing the prevailing climate change being experienced by the global community. The current paper is aimed at reviewing existing literature relatively to terrestrial carbon stocks through time. Here, it has been demonstrated that climate change is a global problem to which responses have been focused on reducing greenhouse gases' release into the atmosphere, as well as the observation of carbon taken up by the terrestrial ecosystem. In addition, the long-term net flux of carbon from the biosphere to the atmosphere is somewhat dependent on the alterations in land use/land cover, as well as the modifications in forest biomass due to forest management and regrowth. Terrestrial Carbons sinks may be responsible for taking up about 1/3 of all the carbon dioxide that is released into the atmosphere.

Keywords: Biomass, carbon stocks, deforestation, carbon dioxide, LULC

Introduction

Global warming poses more or less the most severe threats to the global ecosystem in the course Nthe atmosphere; it is also referred to as the 'greenhouse effect' or 'greenhouse warming'. Greenhouse gases obstruct the outward infrared radiations more than they obstruct inward solar radiations, and in so doing; they make the Earth to be warmer than it would have been in their absence [1-3]. The major greenhouse gases that contribute to the greenhouse effect include water vapour (H_2O), carbon dioxide (CO_2), methane (CH_4), chlorofluorocarbons (CFCs), hydrogenated chlorofluorocarbons (HCFCs), ozone (O3), nitrous oxide (N_2O) [3,4], sulphur hexafluoride (SF_6) and Perfluorocarbons (PFCs) [5]. Of all the GHGs, methane and carbon dioxide has the greatest impact. Moreover, carbon dioxide is seemingly the most important GHG that instigate greenhouse warming.

Empirical research on terrestrial carbon (C) may be dated back to the beginning of the 17th century, with general studies on greenhouse gases. But, the earliest academic and quantitative studies on the greenhouse warming of CO_2 was essentially done in 1896 by Svante Arrhenius, a Swedish Nobel chemist who advanced a simple mathematical model for transferring radiant energy via the atmosphere-surface systems, and solved it logically to demonstrate that doubling the atmospheric concentration of CO_2 would result in surface warming by as much as 3-5K. Subsequently, and more recently, studies on greenhouse warming of carbon have concentrated more on the land sector, that is, the terrestrial carbon stocks. Terrestrial carbon stocks refer to the mass of carbon that is accumulated in the biosphere as living and dead biomass, soil carbon, and animal biomass For instance, undisturbed forests are generally highly productive and accumulate more biomass and carbon per unit than other ecological unit in the biosphere [6], as such; they are indispensable typical 'brake' on climate change [7]. The amount of carbon in above ground biomass, litter and soil of the whole global forest is approximately 750 billion tons with mean carbon content of 160 ton per hectare [8]. However, this has constantly changed over the years due to modifications in LULC. Deforestation and forest degradation allows carbon stored in the shoots (leaves, branches, stems) and roots to be released into the atmosphere, and as a consequence, deforestation, especially in the tropical region, is the major cause of CO_2 emission [9].

Global Carbon Cycle-Global Carbon cycle refers to the exchanges of carbon within and between four major reservoir***:***the atmosphere, the oceans, land and fossil fuels Carbon is the most imperative building block from which all plants and animals are made, and it occurs in both organic and inorganic molecular forms. The inorganic-organic change of carbon as in photosynthesis or organic-inorganic change as in respiration essentially explain the actions of living creatures, and for that reason, plays a distinctive and indispensable function [10]. Thus, carbon is often used to establish the extent of basic metabolic or environmental processes, from specific cells to the entire ecosystems.

Understanding global carbon cycling, as well as the future changes in atmospheric CO2 requires the knowledge of the various carbon pools or reservoirs and carbon exchange or flux among the pools (figure 1). Carbon pool can be defined as a system characterized with the capacity to sequester or release carbon, [11] including atmosphere, biosphere, hydrosphere, and geosphere [12].

The ***atmosphere*** is mainly composed of N_2,O_2, Ar, and H_2O [13], and it also includes a multitude of trace gases. The gases in the atmosphere are frequently divided into constant and variable gases. The most important constant gas are: Nitrogen (N_2) 78%, Oxygen (O2) 21%, and Argon (Ar) 1%, whereas, the major variable gases are: Carbon dioxide (CO_2) 0.038%, Water Vapour (H_2O) 0-4%, Methane (CH4) trace, Sulphur dioxide (SO_2) trace, Ozone (O_3) trace, and Nitrogen oxides (NO, NO_2, N_2O) traces [14] . The ***biosphere*** includes plants and non-living organic materials, such as soil carbon. Five carbon pools have been identified by the Kyoto Protocol including above-ground biomass, and below-ground biomass, the dead mass of litter, woody debris and soil organic matter [15]. The ***hydrosphere*** includes Dissolved Organic Carbon (DOC) and Dissolved Inorganic Carbon (DIC) as well as living and non-living marine biota. Oceans are of course another carbon sink of significant importance as they take in more carbon than they emit. The ***geosphere*** or sediments include fossil fuels and the Earth's interior. Fossil carbon is formed from dead organic matter that did not decompose. In the course of time, plants on earth have caused the alteration in concentration of atmospheric and oceanic carbon dioxide into several of inorganic and organic compounds both on the land and in the marine [16]. Anthropogenic activities now allows the modification of normal movement of carbon from the atmosphere to the oceans, as well as to the land which leads to emission of CO_2 due to burning of coal, oil, or natural gas; and alterations in land use [16,11]. Of course, burning fossil fuel supports swift weathering of buried hydrocarbons; and deforestation quickens the normal speed at which forests die and decompose, which in consequence emits carbon back to the atmosphere.

Terrestrial Carbon

Terrestrial ecosystem occupies a central part in the global carbon cycle, basically as carbon sink and source. This is because it accrues and regulates carbon through several metabolic processes. For this reason, terrestrial climate change will continue to be influenced by the carbon cycle [17]. As carbon sink and source, the biosphere gains and losses carbon dioxide respectively with respect to the atmosphere instance, in the process of photosynthesis, carbon is taken in by plants as CO_2 and it is converted into sugars, starches and other important materials [16]. Furthermore, when animals consume plants and other animals, the result is normally a transfer of carbon up the food chain. Current estimates imply that worldwide photosynthesis takes away approximately 115Pg C annually from the atmosphere [18]. Similarly, [19] suggested that the constant storage of carbon occur in the context of even greater flux, with annual gross photosynthesis and respiration in the range of 78-100 Pg, or approximately 14% of the total carbon in the atmosphere.

Moreover, dead remains of flora and fauna decays, from which CO_2 returns to the environment. For plants, they release CO_2 to the atmosphere during the process of autotrophic respiration (Ra). The decay normally releases CO_2 which is returned to the atmosphere and retaken by other plants through photosynthesis. This process of carbon cycling involving the release and intake of CO_2 results in a perpetual sequence. Plant respiration match up to about half (50 Pg C/year) of the CO_2 that normally return to the atmosphere in the terrestrial component of the carbon cycle [18]. Similarly, soil respiration, known as heterotrophic respiration (Rh) is considered as one of the principal sources by which carbon go again into the atmosphere as CO_2. Photosynthesis usually takes away carbon dioxide from the atmosphere and replaces it with oxygen; while on the other hand, cellular respiration takes away oxygen from the atmosphere and brings in carbon dioxide, thereby balancing each other out [20].

Forests are significant components of the terrestrial ecosystem and are normally responsible for regulating the exchanges between vegetation and atmosphere. The quantity of biomass in certain forest actually corresponds to the difference between production throughout photosynthesis and consumption in the course of respiration, mortality, harvest and herbivory [21]. International negotiations to restrict greenhouse gases necessitate an understanding of the present and the potential anticipated role of forest carbon discharge and sequestration in both managed and unmanaged forests [22].The Kyoto protocol suggested that from 2008 to 2012, the net sink of carbon dioxide due to modifications in land use and forestry can be quantified and used to determine decrease of GHGs' emissions to be used eventually for purpose based on the international agreement. Nevertheless, the developing nations are required to adopt afforestation/reforestation (A/R) strategies for mitigation as part of the Clean Development Mechanism (CDM), but under strict guideline [16]. Considering the usual and most important role in the basic functioning of the terrestrial ecosystem by regulating the global carbon cycle, forests clearly decrease atmospheric carbon content significantly [23]. Thus, despite the devastating impacts of global climate change, forests are able to stabilize the concentration of carbon dioxide in the atmosphere thereby mitigating global warming and climate change.

Land Use/ Land Cover and Biomass Carbon Stocks

Recognizing and mapping LULC is of great significance in studies that involves monitoring in a pervasive field of activities. This is because land use/ land cover is essentially used for comprehending how anthropogenic activities are related to the ecosystem and thus, it is necessary for simulating changes [24]. Moreover, time series land use/land cover information makes it possible to perform a spatiotemporal investigation of a certain geographical area through change detection. Change detection deals with the process of recognizing the alterations in the condition of features or occurrences by observing it at disparate epochs.

Land use/ land cover alteration based on human-induced processes significantly results in global environmental change [25]. The past few centuries has witnessed a great deal of change in natural lands for anthropogenic use, with the last two to three decades experiencing more of this change [26], and this change is expected to continue with respect to anthropogenic factors [27]. Declining vegetal cover is often a function of Land use (LU) and land use change (LUC) [8, 28]. When forests and grasslands are converted to agricultural use and pastures, it is usually linked to rising demand for food and fibre, with greatly affects the carbon stocks [29].

Nearly all changes in land use have great impact on the quantity of carbon held in vegetation and soil, thus, either emitting carbon dioxide to or taking it out from the atmosphere [30]. Three significant factors strongly influence carbon emissions from land use land cover change. These include the amount of carbon in the phytomass and soils, the spatial distribution of carbon stocks, and the impacts of land management on phytomass and soil [31]. The highest flux of carbon is fundamentally due to the conversion of forests to open lands and/or afforestation and reforestation. Rapid population growth and the resultant anthropogenic events have exerted great stresses on the natural and man-made environments. Majority of these activities such as agriculture, urbanization, road construction, mineral exploitation, industrialization among others are driving factors to global deforestation and forest degradation [32], and in consequence influences the atmospheric concentrations of GHGs, especially carbon dioxide.

To end this section, it is proper to state that, there is a need for frequent assessment of different land uses and land changes as well as their impacts on carbon sequestration so as to better understand the impacts of LULCC. Moreover, it is easy to understand the historical and present human actions and the impact of such actions on the environment based on LULC information.

International Synergy to Reduce Global Carbon Emission

There is apparently a significant global consciousness about the causes and consequences of climate change. Climate change is no doubt a global issue, and climate governance is aimed at addressing the menace internationally. Thus, Multilateral Environmental Agreements (MEA) is involved, starting with the United Nations Framework Convention on Climate Change (UNFCCC) which emerged in 1992.

Being the first and foremost milestone in the history of climate diplomacy, the UNFCCC is principally targeted at stabilizing the atmospheric concentrations of carbon dioxide and other greenhouse gases in a manner that dangerous anthropogenically related impact on the climate system could be avoided. In order to achieve this goal, the process was designed such that climate change would not affect the ecosystem negatively, and thus, there will be no issue with food production and economic growth [16]. Moreover, a sequence of transitional objectives was negotiated to enhance the purpose of the convention. This include submitting national reports on GHG emissions and sinks, reducing the emissions and increasing the sinks, sharing the financial burden of these activities, and helping developing countries to achieve some initial targets [33]. Furthermore, the UNFCCC highlights the common, but differentiated responsibilities (CBDR) of the constituent nations, the basis for precautions, as well as the importance of sustainable economic development [5].

For over twenty years when countries agreed to limit greenhouse gases emissions at the 1992 Rio Earth Summit, there have been far-reaching changes in the comprehension of, and reaction to, climate change. An agreement was reached in Paris on 12 December 2015 on a successor to the Kyoto Protocol that will apply to all signatory states, not just developed countries [36, 5]. The core of Paris Agreement is concern with restricting global mean temperature to below 2ºC above pre-industrial levels, and to further ensure that this increase in temperature is limited to 1.4ºC above pre-industrial levels. Equally, the agreement aimed at enhancing the capacity to adapt to the unfavorable impacts of climate change, and to afford financial need for low greenhouse gas emissions.

Unlike the other climate change conferences, an official agreement on worldwide greenhouse gas emissions is embedded in the 'Paris' even though it is subject to ratification [37]. Considering the international discussions on climate change, one can view the Paris Agreement as the final point of the third stage [35] towards full operation of United Nations Framework Convention on Climate Change. One very unique aspect of this agreement is the fact that it indicates a new technique for global climate control which apparently differs from the traditional distinction between developed and developing countries' obligations, and gives states more autonomy to determine for themselves the level and form of climate response commitment they will undertake through Nationally Determined Contributions (NDCs) [38].

Conclusion

This review has been able to reveal various features of terrestrial carbon stocks in relation to other components of the global carbon system. The existence of carbon dioxide and other greenhouse gases in the atmosphere serve as a cover over the earth's surface, thereby making it warmer than it would otherwise be. This is possible by the absorption of infra-red radiation from the earth's surface. This natural 'greenhouse effect' has been in existence for many decades. Of course, it is crucial to the provision of our present climate to which ecosystems and humans have adapted. Nevertheless, the actual quantity of heat trapped in the atmosphere is now in a fragile balance with the climatic systems and hydrosphere. The Earth is confronted with serious danger as a result of the incessant rapid increase in atmospheric concentrations of CO_2 and other GHGs being experienced since the beginning of the industrial revolution around 1755. This has continued to influence the change and variations in the global climate system. The result is global warming and climate change, which poses more or less the most severe threats to the global ecosystem in the course of human history.

The UNFCCC has been at the forefront at reducing and then stabilising the atmospheric concentration of greenhouse gases such that precarious human interference with the climate system would be avoided. In this regard, accounting for variation in the forest carbon stocks due to deforestation as well as forest degradation and regrowth are suggested to be crucial for estimating carbon emissions.

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