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Accountability of Carbon Budget in Changing Global Environment

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Abstract- Carbon dioxide emissions arising from anthropogenic activities land, water and atmosphere are decisive factors in global carbon budget. Various carbon emission sources like fossil fuel, oceans, terrestrial activities, land-use changes are resulting imbalance in global carbon budget. The accounting of carbon source and sink reported that anthropogenic disturbances are the main causes of impairment in natural carbon cycle. The increasing industrialization activities are causing a decisive changes in greenhouse gases, most important being the carbon which is a matter of serious concern. At present the Paris agreement to limit 1.5^0c global temperature remains a big challenge in front of policy makers. Various forest models reveals that global wilderness are decreasing at an alarming rate and special emphasis should be given on carbon regeneration and harvesting. Although International efforts are on to mitigate carbon imbalance through various accords, conventions, protocols but in the present scenario there is a need for a concrete action on those entities that are mainly responsible for carbon emission and impairment of Global carbon stocks. This article overview the historical events of global carbon emission, important causes of reduction in carbon stocks, assessment of global carbon budget models along with their potentiality, necessity and amendments. In conclusion several 'green strategies' like afforestation, wasteland restoration, agroforestry, organic farming, ex-situ conservation altogether play a significant role in regulating carbon cycle and environment sustainability.

Keywords-greenhouse gases, carbon cycle, carbon budget, carbon emission estimation modelling, international accord

I. INTRODUCTION

In the last 650,000 years the earth climate has witnessed significant variations and drastic changes in their temperature. The ice record data of the past 420,000 years reveals that, CO_2 concentrations have increased from 280 to 400 ppm. Looking into the historical fossil fuel emissions, the event that started even before industrialization era, was a significant human induced phenomena and is still thickening with the time. [1]. US based NOAA's ESRL reported that at present annual global growth rate of CO_2 is estimated as 0.11 ppm/year [2]. The historical emission data analysis reveals that the GHG emission has risen from 2.8 to 50 gigatonnes, whereas carbon emission increases 2.1 to 38 gigatonnes from industrialization era 1850 till 2014 (Fig. 1) [3]. The year 1950 took a major twist when the rise in CO_2 started gaining momentum from 300 to present status of 400 ppm [4]. The year 1963 to 1987 witnessed a significant atmospheric temperature change which is mainly attributed to human activities and other natural uncertainties [5], and this process continuous even today showing wide impact in carbon budget [6]. The continuous deforestation is reducing forest land and unbalancing carbon stocks in nature [7]. The greenhouse gases are causing variations in hydrological cycle [8].The forest carbon stocks mainly the tree biomasses are affected by combined effects of disturbance factor like grazing, species richness and slope [9]. In order to improve carbon budgeting the forest litter fall analysis for estimating nitrogen availability and organic matter cycling and climate changes is another strategy in understanding this process [10].

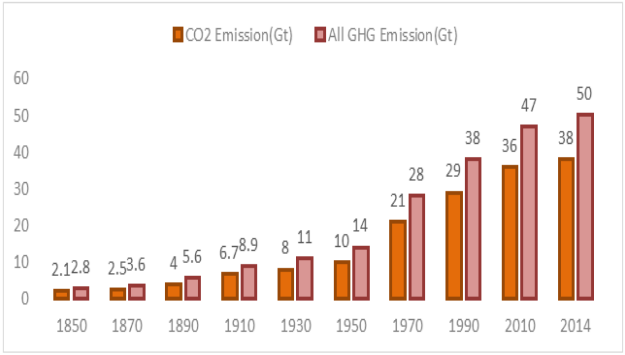

Fig: Historical global green house gases (GHG) and CO_2 emission in gigatonnes (Gt)

II. CARBON BUDGET ESTIMATION MODELLING AND THEIR POTENTIALITY

The efficacies of models based on global carbon budget should be tested for all format of global wilderness [11]. Kuemmerle *et al.* [12] using KK11 and HYDE 3.1 land change framework proposed LPJ

dynamic global vegetation model that represented forest transitions scenario of Eastern Europe during period 1700-2010. This model observed modest uptake in carbon due to a continuous decline in forest area. The forest regeneration requires high sequestration potential due to CO2 fertilization, climate change and land change actions. Scott *et al.* [13] suggested forest system model using forest ecosystem operation and forest products life cycle inventory model for computing carbon balance and enhancing carbon stocks in managed forest in the Midwestern US. The forest carbon budget was found positive compared to industrial budget and net carbon uptake increased by 22% over the next 100-years under optimum harvesting regime. Ito [14] used VISIT (Vegetation Integrative Simulator for Trace gases) model to assess the global change response on eco-physiological processes at four sites, including 3 in Japan and 1 in China and predicted $1\text{-}3^0$ warming by 2050.The Gross primary production (GPP) increases i.e. respiration and photosynthesis will increase and these sites would act as carbon sink.

Campioli *et al.* [15] promoted eddy-covariance (EC) and biometric methods (BM) for quantification of net ecosystem production (NEP). In former case which is a micro-meteorological technique is more effective provided standard post-processing procedures, whereas in later case which was ecology based techniques found prone to low estimation of NPP and overestimation of leaf respiration. These two methods provide different results however the variations were found significant for respiration phenomena and gross primary production (GPP) for global forest ecosystems. In case of boreal forests the findings are more appealing as carbon fluxes are low. Similarly, Ma *et al.* [16] advocated tree-based FORCCHN model for estimating carbon budget of forest ecosystems. The CO_2 flux results of forest eddy-covariance reported low net ecosystem production (NEP) due to less GPP and ecosystem respiration (ER). However, the model shows merit for deciduous broadleaf forest as it exhibit quality performance in estimating the temporal modifications and magnitude of carbon fluxes. Starting from 1982 for the next 30 years, the carbon fluxes in the forest, reported high value of GPP, ER and NEP mainly attributed to large carbon storage which were found comparable with other global data's.

Smiley & Trofymow [17] using Carbon Budget Model-Canadian Forest Sector (CBM-CFS3) version developed carbon budget of 100 year period of a Canadian lake. The dissolved organic carbon, a small C flux in temperate forests shows humified soil carbon losses ranging from 2.5 to 6.5% exhibiting long term indication for C storage in this aquatic system. The deforestation, harvesting and logging are the important factors causing reduction in forest carbon budget in the region. In order to study the above-ground carbon budget arising due to logging, Piponiot *et al.* [18] proposed a model which is based on three sub-models including emission caused due to logging damage, extracted wood, and carbon accumulation during post-logging recovery. Using this model the net carbon balance was found in the range 0.12 and 1.33 gigatonnes C, with a median value 0.64 gigatonnes. However, the model requires correction in accurate estimation of large woody necromass decay and logging damage.

Friend *et al.* [19] judged seven global vegetation models for analyzing the impact of future climate change and rise in atmospheric CO2. These model exhibited significant variation, indicating an enhancement in global vegetation carbon in boreal forest. Most of these models reported an increase up to 4°C, can affect productivity and biomass. The integration of these models predicts 30% more variation in vegetation carbon change. According to OSCAR v2.2.1 model suggested by Gasser *et al.* [20] the CO_2 and CH_4 emissions released from tipping process of the Earth system which in other words known as permafrost thaw, plays a significant role in carbon budgeting. If net emission for 2^0C is feasible, non-feasible or overshot then the target reduces by 8, 13 and 16% respectively, whereas in case of 1.5 °C target, reductions are in range of nearly 10 to more than 100%.

The spatial resolution of meteorological data also influence the phenology and carbon budget. It was reported that under low-resolution data, ecosystem model overestimated gross primary production (GPP) and ecosystem respiration (ER), whereas under high-resolution data, canopy phenology and carbon budget were found satisfactory and outstanding. The Sensitivity examination reveals that net ecosystem production (NEP) increases with the rise in temperature mainly due to CO_2 fertilization [21].

III. INTERNATIONAL AGREEMENTS FOR MANAGEMENT OF GLOBAL CARBON BUDGET: CHALLENGES AND ISSUES

The UN Stockholm Conference of 1972 was the first international effort focusing global environmental issues. The declaration put forward various principles for environment protection, management and development. The UN Convention on Climate Change held in 1992 an effort to prevent human interference with the climate system mainly aimed for establishing national GHG inventories caused by human induced emissions, and their removals. The Kyoto Protocol of 1997 the first legal document to reduce GHG emission based on the scientific opinion with two concepts- that global warming is occurring and anthropogenic activities are responsible for CO_2 emission that causes it. To cut short the emission to a level that prevents dangerous anthropogenic interference, the first commitment period was set in between 2008-2012. In another development, Washington declaration of 2007 accepted the existence of anthropogenic induced climate change and agreed to an emission cap and a unique emissions trading for both developing and developed countries. The Copenhagen accord 2009 gave relief to the countries representing over 80% of global emissions that

they are not legally bounded to Kyoto Protocol to cut short emission up to 2012. Among various actions some, like implementing air pollution laws to control reductions in black carbon and ozone layer and decrease in short-lived GHGs emission if ensured, can achieve less than 10% and 50% of 2°C emission barrier before 2050 and 2100 respectively [22]. To fulfil the targets, the Kyoto Protocol further extended the commitment period from 2012 to 2020.

The Cancun declaration of 2010 first agreed in principle for establishing "Green climate fund" and also focused on developing "low-carbon society". This accord get consolidated in Durban conference 2011 that paved way to develop green climate fund and give economic support to the countries for climate impact management. The Paris Agreement of December 2015 for a sustainable low carbon future to combat climate change by maintaining temperature below 2^0C above preindustrial levels and to make efforts to reduce even up to 1.5^0C, (i e, a 66% chances of keeping temperatures below 1.5^0C warming and 33% chance of keeping temperatures above 1.5^0C warming) considered as a landmark convention to maintain global carbon stocks. This agreement aims to make countries capable to counter the impacts of climate change, by cutting short GHG emissions and adopting climate-resilient pathway [23]. Paris' accord has originally taken 1850 as the base and 2050 as target year for CO_2 emissions estimation and management.

The present status of emission management the developing countries are not going to achieve their full target and will fall short of their entitlement [24]. Considering 1 trillion tonnes of carbon budget by global scientific community, total emission of CO_2 starting from the industrial revolution era (1861-1880) comes out to be nearly 52% and the remaining 48% of the carbon budget is going to exceed in 2045, seriously worrying the climate experts [25]. The Intended Nationally Determined Contributions (INDCs) report submitted by the countries shows a median warming of 2.6–3.1^0C by 2100 exceeding the desired target thus possessing a big challenge to keep the warming below 2^0C [26]. The increase in land use change (LUC), decrease in aerosols and high emission of non-CO_2 can cause fossil fuel (FF) carbon budget for a long-term, decreasing the targeted 1.5 °C parameter. Currently CO_2 emissions from total (FF + LUC), non-CO_2 gases and aerosol estimated to be 699, 510 and −180 PgC respectively. These changes can be compensated through negative emissions, and requires about 11 more years for prescribed 1.5 °C temperature stabilization [27]. The changes in tree canopy and sizes are best indicator of biotic and abiotic stresses [28]. The genetic assessment of tree species has potentiality in understanding the threat of climate changes. Moreover, forest laws and regulations plays decisive role in minimizing GHG emission [29]. The raising of rare and extinct tree species using modern biotechnological techniques helps in conserving and also improving carbon budget [30].

IV. CONCLUSION

The carbon budget estimation serves as receiving updated information of anthropogenic causes and disturbance rate of carbon imbalance. It will help climate scientist, policy maker and society in mitigating human induced climate change. It helps in better understanding and proper functioning of carbon cycle and to control the remaining or excess CO_2 before it exceed the proposed emission target.

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