Trees Alone cannot be the Answer to Climate Change of Present Millennium

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Abstract

Climate change is caused by emission of greenhouse gases (GHGs) through anthropogenic activities including land-use change, deforestation, biomass burning, draining of wetlands, soil cultivation and fossil fuel combustion. Consequently, the concentration of atmospheric greenhouse gases and their radiative forcing have progressively increased with increase in human population, especially from the onset of industrial revolution around 1850. Thus, unless necessary steps are not taken to reduce CO_2 emissions by increasing carbon sinks in terrestrial ecosystem alone, it is not possible to stabilize or reduce concentration of CO_2 in the atmosphere.

Keywords: Greenhouse, population growth, carbon dioxide, methane, nitrous oxide

Introduction

Trends in rise in atmospheric carbon dioxide concentration

Anthropogenic greenhouse gas emissions have increased since the pre-industrial era, driven largely by industrial and population growth, and are now higher than ever. This has led to atmospheric concentrations of carbon dioxide, methane and nitrous oxide reach to unprecedented levels. Their effects, together with those of other anthropogenic drivers, have been detected throughout the climate system and are extremely likely to have been the dominant cause of the observed warming since the mid-20th century. Changes in many extreme weather and climate events have been observed since about 1950 (IPCC, 2014). Some of these changes have been linked to human influences, including a decrease in cold temperature extremes, an increase in warm temperature extremes, an increase in sea level and an increase in the number of heavy precipitation events in a number of regions. It has been observed that CO_2 emission is on the rise and may continue to rise for many more years due to our dependence on fossil fuels (IPCC, 2007).

Trees alone cannot be the answer to climate change

Accumulation of CO_2 in the atmosphere is a dynamic function of the balance between the amount of CO_2 emitted by the world and the total amount of CO_2 sequestered by the planet (through photosynthesis) during a given period of time.

$$\textit{Atmospheric } CO_2 \textit{ concentration} = CO_2 \textit{ Emission} - CO_2 \textit{ Sequestration} \text{ ---------- } \textit{Eqn. (1)}$$

From the above equation, it is evident that growing more trees can reduce atmospheric CO_2 concentration. Globally, the rate of deforestation is much larger than that of reforestation. Recent studies

estimated a net emission of GHGs from the Mato Grosso region of Brazilian Amazon, ranging from 2.8 to 15.9 Gt CO_2-eq from 2006 to 2009 (Galford, 2010) It was reported that between 1996 and 2005, the Brazilian Amazon rainforest was deforested by 19,500 km^2 per year and converted to pastures and farmland releasing 0.7 to1.4 Gt CO_2- eq yr^{-1} to the atmosphere (Daniel *et al.,* 2009). Avoided deforestation is the best means of aforestation, new and massive efforts at planting more trees should be a parallel strategy in order to reduce build-up of CO_2 in the atmosphere.

Many governments around the world, including India have taken up massive tree planting programmes with the slogan that trees are the answer to global warming. While growing trees is a good idea and tree planting programmes should continue with greater zeal for their numerous ecosystem services, the present analyses shows that as long as the present emission trends continue, even if we manage to convert the entire land on the planet into a forest, that will not be adequate to completely offset the current rate of build-up of CO_2 in the atmosphere and prevent or limit global warming. It has been reported earlier that if all countries in the world would have emitted GHGs into the atmosphere at the same rate as some developed nations did, we would need nine planets to keep the atmospheric concentration of GHGs at the present level (HDR, 2007). Published data on the global carbon budget shows that build-up of CO_2 in the atmosphere is determined more by the amount of global CO_2 emission rather than the CO_2 sequestration by the planet and therefore, proactively reducing emission is more effective than planting more trees in reducing and stabilizing the concentration of CO_2 in the atmosphere.

Long term data on CO_2 emission and atmospheric CO_2 concentration were obtained from authentic published sources (*http://data.worldbank.org/indicator*). Data on terrestrial and ocean CO_2 fluxes were taken from the fourth assessment report (AR4) of the Intergovernmental Panel on Climate Change (IPCC, 2007). Using these data, rate of increase in GHG emission and removal from the atmosphere and increase in the concentration of CO_2 in the atmosphere were calculated through regression analysis. The present rate of terrestrial and oceanic removal of CO_2 and the rate of build-up of CO_2 concentration in the atmosphere were used to estimate the area of land and ocean that is required to fully offset the rise of CO_2 in the atmosphere. Linear regression analysis shows that the annual rate of increase in CO_2 emission between 1950 and 2008 was 411.30 Mt CO_2 per year (R^2 = 0.98) and the atmospheric CO_2 concentration increased at the rate of 1.30 ppm per year which is equivalent to 10151.06 Mt CO_2 per year (R^2 = 0.97) . Between 1950 and 2008, CO_2 emission (including fossil fuel combustion and land use changes) increased from 9450 Mt to 34939 Mt. During the same period, atmospheric CO_2 concentration increased from 311 ppm to 386 ppm (**Figure 1**).

The increase in CO_2 emission was 270% while atmospheric CO_2 concentration increased only to the tune of 24%. Despite the huge increase in CO_2 emission, the atmospheric CO_2 did not increase to the same extent and this indicates that the amount of CO_2 sequestered by the planet must have increased at a rate greater than the rate at which CO_2 increased in the atmosphere between 1950 and 2008.

Terrestrial removal of CO_2 during 2000-2005 was 0.9 Gt C yr^{-1} (IPCC, 2007) and this is equal to 3303.0 Mt CO_2 per year. Total vegetation area on earth surface is about 15000 M ha (Dixon *et.al.,* 1994). From this it is calculated that the terrestrial carbon fixation rate comes to 220 Kg CO_2 per hectare per year. At this rate, we need an additional land area of around 46141.0 M ha for planting trees so as to fully offset

the current rate of increase in atmospheric CO_2 concentration, which is roughly 1.30 ppm yr^{-1}, averaged for the period 1950-2008 (**Figure 2**). This is equal to the terrestrial vegetation area of three planets. From the emission and atmospheric CO_2 concentration data, I calculated the amount of CO_2 sequestered as the difference between the former two. The rate of CO_2 emission (including fossil emissions and land use changes) from 1950-2008 was 0.12 Gt C yr^{-1}. The rate of removal of CO_2 from the atmosphere (including land and ocean sinks of CO_2) and the rate of addition of CO_2 to the atmosphere were identical (0.06 Gt C yr^{-1}) (**Figure 1**). The rate of emission was much greater than the rate of removal and the difference was 0.06 Gt C yr^{-1}. This indicates that even if we take the sequestration capacity of the land and ocean together, we will still require one more additional planet to remove the current rate of CO_2 emission to maintain equilibrium between the present emission and removal and thus keep the atmospheric CO_2 concentration stabilized at the present level.

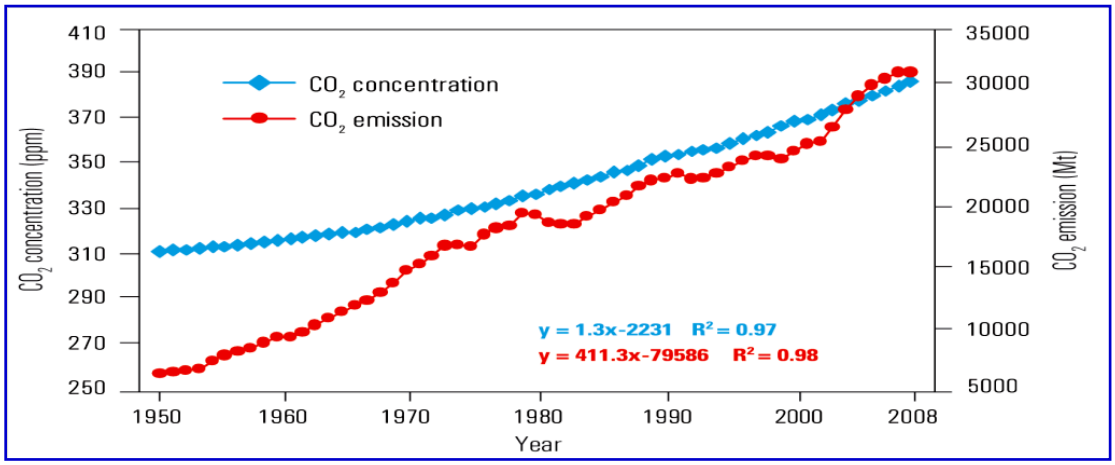

Figure 1. Rate of increase in the world CO_2 emission and atmospheric CO_2 concentration between the period 1950 and 2008 [Calculation based on the data from Carbon Dioxide Information analysis Center (CDIAC) and World Resource Institute (WRI)].

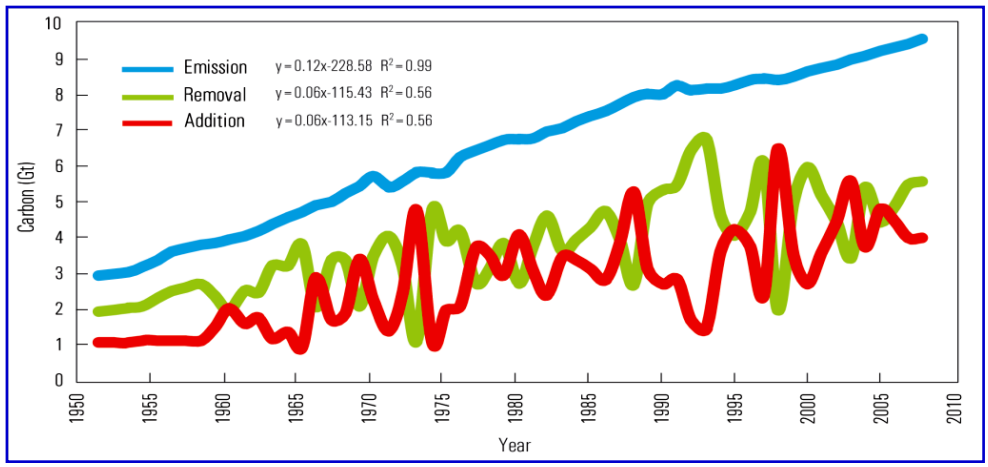

Figure 2: Global carbon balance sheet between 1950 and 2008

Over the years, concentration of CO_2 in the atmosphere has been increasing at an increasing rate. For example, atmospheric CO_2 concentration had been increasing at the rate of 2.07 ppm per year between 2000 and 2008 as against 1.30 ppm per year between 1950-2008. Therefore, afforestation programmes will be even inadequate to offset the build-up of CO_2 in the atmosphere today than in the past. We would require a terrestrial vegetation area equivalent to 4.9 planets and a combined area of land and ocean equivalent to 1.6 planets to fully offset the recent rate of increase in atmospheric CO_2 concentration.

What are the policy implications of this finding in the Indian and global contexts? Renewed efforts to green more land area is one of the major national action plans to mitigate global warming. The annual rate of sequestration of CO_2 by Indian forest cover is calculated as 1.94 tons per hectare per year (Jagadish *et al.,* 2009). At this rate, the presently existing total forest and tree cover in the country (76.87 M ha) can sequester 138.15 Mt of CO_2 every year. The total fossil fuel emission from India was 1494.88 Mt CO_2 in 2008. To offset this amount of CO_2 emission, India should have a forest area of 770.55 M ha and all of that should fix carbon at the same efficiency of 1.94 tons per hectare per year. This additional area is equivalent to 2.3 times the geographical area of the country. In other words, going by the present emission and sequestration rates, the world will not sequester what it emits nor will India sequester what it emits. At the present rate of anthropogenic CO_2 emission, our planet will not be able to sequester enough CO_2 through the natural process of photosynthesis to prevent further rise in its concentration in the atmosphere, even if we manage to plant trees in every bit of land on the planet and they all fix carbon with the same efficiency. Indian scenario is also not any different; planting trees alone will not take care of our rising emissions. Once Mahatma Gandhi reflected on how many planets might be needed to sequester the total emission if India were to follow Britain's pattern of industrialization. Carbon capture and storage (CCS), which amounts to physically trapping CO_2 at its source and storing it in large underground geological formations is perhaps the only way we can continue to emit CO_2 at the present levels and yet stabilize its atmospheric concentration at some specified level, but this technology is yet to be fully harnessed. While planting trees is not only option for mitigation of climate change but reducing or even stabilizing the concentration of CO_2 in the atmosphere at the present level cannot be achieved, unless there are deliberate efforts in reducing the amount of anthropogenic CO_2 emission into the atmosphere (IPCC, 2007).

Conclusion

It is clearly shown that the world is emitting much more CO_2 than it can sequester and hence, inequilibrium is on the rise. The result is that CO_2 concentration in the atmosphere is increasing at an alarming rate. Planting trees is not only the option to bring this equilibrium back, unless there are deliberate efforts in reducing the amount of anthropogenic CO_2 emission into the atmosphere.

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