The science, politics and economics of global climate change: Implications for the carbon sink projects

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We live at a time when the global climate is experiencing unprecedented changes. The realization that anthropogenically emitted greenhouse gases (GHGs) caused these changes led to protracted international negotiations resulting in the adoption of the Kyoto Protocol in 1997. These negotiations were marred by political and economic overtones and the science of climate change was largely sidelined by the US, the single largest GHG emitter which eventually withdrew from the Kyoto Protocol in 2001. With Russia finally ratifying it, the Protocol came into force on 16 February 2005. The Kyoto Protocol fixes legally binding quantified emissions limitation and reduction commitments (QELRCs) on the industrialized countries, while exempting the developing and the least developed countries from any emission restrictions. The Clean Development Mechanism (CDM) is a market instrument under the Kyoto Protocol to help the industrialized countries meet their QERLCs cost effectively while developing countries can also benefit. The implications of CDM for carbon sink projects in the country are briefly discussed.

Keywords: Carbon sink projects, global climate change, greenhouse gases, Kyoto Protocol.

GLOBAL climate change, considered to be one of the most serious threats to the global environment, has been at the centre of scientific and political debate in recent years. Today, more than at any time in the past, there is an almost unanimous consensus among scientists, politicians, policy makers, administrators and the common people alike that climate has changed and that it is still changing. Global climate change, more precisely global warming, is a reality[1,2] (Figure 1), but there are considerable uncertainties existing about the extent of warming[3], the resultant meltdown of the arctic snow cap, rise in sea levels, changes in the cloud formation and rainfall pattern, etc. There is an increasing concern that our planet is becoming more unpleasant for human habitation and that human interference with the world's fragile climate system may trigger run-away global warming that cannot be reversed.

According to David King, Chief Scientific Advisor to the British Prime Minister, 'climate change is a greater threat to the world than terrorism is. Delaying action for a decade or even just years is not a serious option'. Donald Kennedy, Editor-in-Chief, *Science* has categorically stated, 'there is no dispute that the temperature will rise'. The disagreement is only on how much the warming will be. There is a real potential for sudden and perhaps catastrophic changes that cannot be reversed. The US National Academy of Sciences has stated that global warming may be the most pressing international issue of the 21st century. The adverse effects of climate change on natural resources, food supply, human health and national economy have already begun to appear. The poor countries and the economically weaker sections of the societies will bear much of the brunt of climate change.

It is a known fact that poverty breeds pollution and environmental degradation, which in turn aggravates poverty. But affluence too has contributed towards the present poor state of the planet's health, through over-consumption of energy and resources. The average per capita gasoline consumption in the US during 1997 was 1.26 gallons/day/person[4], contributing to a large per capita CO_2 emission of 5.3 metric tons (MT) of C/person/yr compared to roughly 0.3 MT of C/person/yr in India (Table 1). Similarly, in terms of consumption of commercial energy or even food, the rich countries are far above the poor countries. For example, the mean commercial energy consumption in the US during 1997 was about 350 giga joules (GJ)/person/yr, whereas this was as low as about 13 GJ/person/yr in India (Figure 2). The annual per capita consumption of meat comes to about 123 kg/person/yr in the US, while this is a meagre 3.4 kg/person/yr in India (Figure 3). It may be noted that on an average, it takes about 1790 l of water to produce 1 kg of wheat compared to 9680 l to produce 1 kg of beef. Thus the rich countries consume more resources and energy than the poorer nations of the world, where bulk of the world's population lives.

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Table 1. Per capita CO_2 emission in a few Annex I (identified by*) and non Annex I countries (MT C/head)[4] during 1996 and total CO_2 emission during 1990 and the quantified emissions limitation and reduction commitments (QELRCs) set under the Kyoto Protocol for selected Annex I countries[13,51]

Country	Per capita CO_2 emission, 1996 (MT C/head)	Total CO_2 emission, 1990 (Gg)	Percentage of total Annex I emission (1990)	QELRCs (% below 1990 emission)
USA*	5.3	49,57,022	36.1	7
Russian Federation*	2.9	23,88,720	17.4	0
Japan*	2.5	11,73,360	8.5	6
Germany*	2.8	10,12,443	7.4	8
UK*	2.6	5,84,078	4.3	8
Canada*	3.8	4,57,441	3.3	6
Italy*	na	4,28,941	3.1	8
Poland*	na	4,14,930	3.0	6
France*	1.7	3,66,536	2.7	8
South Korea	2.4	–	–	Not applicable
China	0.7	–	–	Not applicable
Brazil	0.4	–	–	Not applicable
India	0.3	–	–	Not applicable
Nigeria	0.1	–	–	Not applicable

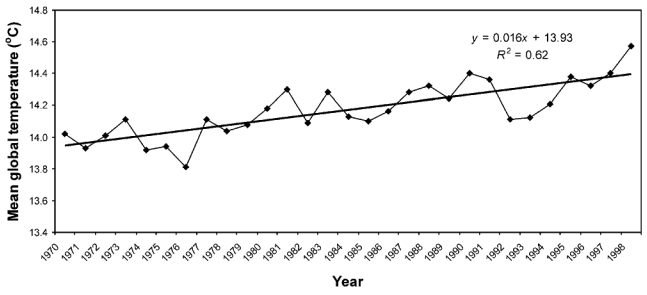

Figure 1. Mean global temperature (1970–98)[2]. The straight line is a linear regression showing the trend in rise in temperature with year.

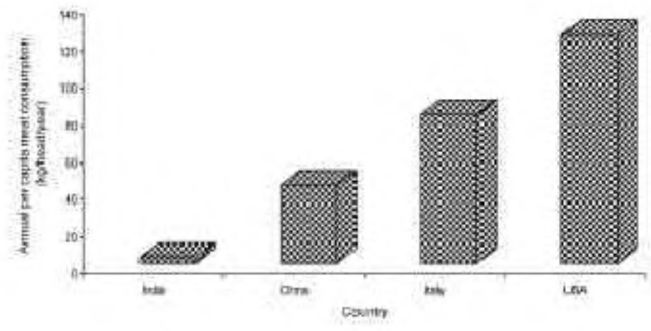

Figure 3. Annual per capita meat consumption in a few countries (kg/head/yr)[4].

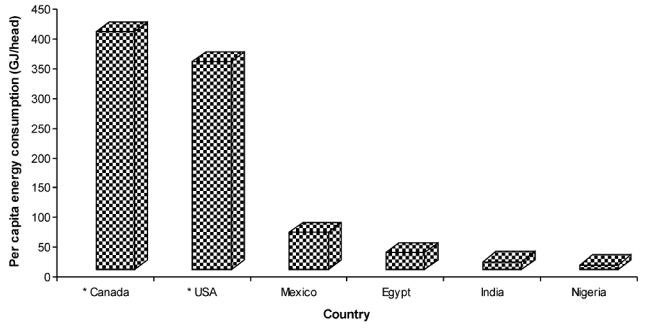

Figure 2. Per capita commercial energy consumption (gigajoules/head) in a few Annex I (identified by *) and non Annex I countries (1997)[4].

The science of global climate change

Consumption of resources and energy results in the generation of various by-products that interfere with the environment. Climate change is largely a man-made problem, mostly by the rich industrialized countries that polluted the earth's atmosphere in the name of industrialization and development, which resulted in the release of large amounts of the so-called greenhouse gases (GHGs) into the atmosphere. They are CO_2, methane, nitrous oxide, hydrofluorocarbon, perfluorocarbon and sulphur hexafluoride. The major anthropogenic activities that have contributed to increased concentrations of GHGs, chlorofluoro carbons (CFCs) and other ozone-depleting substances in the atmosphere are fossil fuel burning, cement manufacture and changes in land use pattern, especially deforestation[1]. The peculiar chemistry of GHGs and CFCs is responsible for global warming, penetration of harmful radiation to the earth surface, etc.

GHGs are important for human survival on this planet. Their presence in the atmosphere at the right levels ensures that the planet is maintained at a temperature of +14°C, warm enough for life to exist. Without GHGs, the mean temperature of the planet will be only –17°C. The problem of GHG-forced climate change occurs when GHG concentrations in the atmosphere increase to such a high level that the warming they cause is too severe to interfere with the planet's sensitive climate system[1].

The rising concentration of CO_2 in the atmosphere, which has perhaps contributed the most to global warming, requires special mention. For several thousands of years prior to the industrial revolution, its concentration in the atmosphere remained around 270 ppm. Between 1850 and 1998, the gross emission of CO_2 into the atmosphere[5] has been about 405 Pg, sufficient to raise its concentration in the atmosphere by about 190 ppm. Today, the atmospheric CO_2 concentration[6] is around 372 ppm, suggesting that approximately 187 Pg CO_2 has been refixed into terrestrial and oceanic ecosystems from the atmosphere during the above period. Out of approximately 100 ppm rise in CO_2 concentration in the atmosphere that has occurred between 1850 and 1998 (roughly @ 0.67 ppm/yr), almost 60 ppm rise has occurred in the second half of the 20th century alone, suggesting a higher rate of CO_2 build-up in the atmosphere (@1.2 ppm/yr) during this period.

The 1980s and 1990s saw even greater rate of increase in atmospheric CO_2 concentration[7,8], largely due to increased fossil fuel combustion and cement manufacture, which together released roughly 5.4 Pg C/yr in the 1980s and 6.3 Pg C/yr in the 1990s. During this period, land use change, mostly deforestation and conversion of pastures into agricultural lands, released nearly 1.6 Pg C/yr. Estimates[7,8] show that after accounting for terrestrial and aquatic sequestration, a net amount of about 3.3 Pg C was stored in the atmosphere every year (equivalent to an increase of nearly 1.6 ppm CO_2/yr) during the 1980s and 1990s. Thus, the anthropogenic addition of CO_2 into the atmosphere is increasing at an alarming rate.

It is indicated that at the present rate of CO_2 emission, its concentration in the atmosphere would go up to 800–1000 ppm by the turn of the current 21st century, if no efforts are made to reduce emission and increase its sequestration from the atmosphere. Since 1970, the mean global temperature has gone up by more than 0.5°C (Figure 1), which is extremely significant at the global scale[2]. Given that close to 90% of the world commercial energy production is from fossil-based fuels[4] (Figure 4), this trend is likely to continue. The continued large dependence on fossil-based fuels coupled with increased rate of deforestration still occurring in many parts of the world, will further increase the concentration of CO_2 in the atmosphere unless effective mitigation efforts are taken.

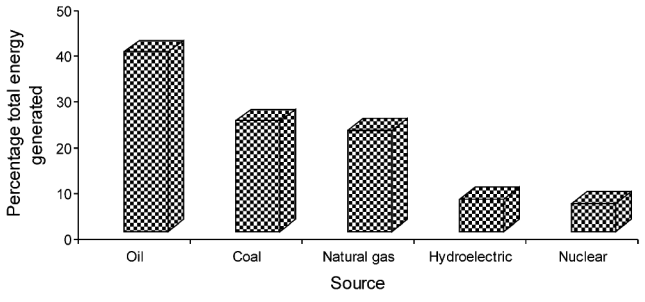

Figure 4. Percentage of world commercial energy production from various sources (1997)[4].

One direct consequence of global warming is melting of the polar ice caps that results in rising sea levels. During the 20th century, the average sea level had risen[1] by 0.1 to 0.2 m. Since the 1960s, the polar snow cover has decreased by 10% and it is generally expected that the mean sea level will rise by another 0.09 to 0.88 m in another century[1]. Of late, extreme climatic events such as floods, droughts and wild fires have been occurring with greater frequency in many parts of the world. The hottest year since instrumental data collection[2] began in the late 1800s was 2002, followed by 1988 and 2001. When the earth's climate gets warmer and droughts occur in places like the Amazon forests, the risk of the carbon stored in the forest biomass getting released into the atmosphere due to uncontrollable wild fires is a significant threat. Fire is a real and constant threat to the Amazon and other tropical forests, which together form the single largest repository of the carbon contained in terrestrial vegetation[9–11]. Runaway wild fires in the major biomes of the world, particularly those in the tropics, have the potential to create sudden and catastrophic environmental consequences that cannot be reversed.

A doubling of the atmospheric CO_2 concentration could raise the mean temperature of the earth's surface by 1.5 to 4.5°C, but due to the uncertainties in the estimates[3], this could be lower than 1.5°C or higher than 4.5°C. To keep global warming to less than 2°C, we need to limit CO_2 to below 550 ppm in the atmosphere, which is roughly twice the pre-industrial level. The vulnerability of the earth's climate system, on which the entire living world so closely depends, to human interference cannot be ignored any longer[1]. The prevailing uncertainties about climate change and its consequences are sufficient reasons to take appropriate steps to limit the emission of GHGs and stabilize their concentrations in the atmosphere sooner than later.

Global climate change negotiations and the genesis of the Kyoto Protocol

Until the 1980s, international debates on global climate change have been largely confined to the domains of scientists, naturalists and environmental activists. During the 1980s, issues related to global warming and other aspects of global climate change started to take a central place in international political, diplomatic, trade and economic circles. A brief summary of some of the major milestones in international global climate change negotiations is given in Table 2. The adoptions of the Vienna Convention for the Protection of the Ozone Layer in 1985 and the Montreal Protocol on Substances that Deplete the Ozone Layer in 1987 with the objective to phase out CFCs and other stratospheric ozone-depleting substances, were perhaps the first most tangible achievements of climate-related international negotiations. The establishment of the Intergovernmental Panel on Climate Change (IPCC) in 1988, jointly by the World Meteorological Organization and the UNEP, was

Table 2. Major milestones in international climate change negotiations leading to the genesis of the Kyoto Protocol and its entry into force

Year/event	Objectives/remarks
1985: Vienna Convention for the Protection of the Ozone Layer	To protect human health and environment by promoting research on the effects of ozone layer changes.
1987: Montreal Protocol	To phase out CFCs and other ozone-depleting substances.
1988: Establishment of Intergovernmental Panel on Climate Change (IPCC)	To look into issues related to the causes of and preventive measures for global climate change.
May 1992: International negotiators agree in New York on the United Nations Framework Convention on Climate Change (UNFCCC) June 1992: UNFCCC signed at the Earth Summit at Rio de Janeiro March 1994: UNFCCC enters into force	Aims at 'stabilization of greenhouse gas concentration in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate'.
1997: CoP-3 adopts the Kyoto Protocol	Providing legally binding GHG emission reduction targets for rich industrialized countries and exempting the developing and the least developed countries from any emission reduction targets.
November1998: CoP-4 adopts the Buenos Aires Plan of Action (BAPA)	To strengthen UNFCCC and prepare for Kyoto Protocol's entry into force.
November 2000: CoP-6, The Hague	Conference suspended due to serious disagreements over a range of issues, especially between the EU and the US.
March 2001	US pulls out the Kyoto Protocol. Future of the climate pact in doubt.
May 2001	EU asserts at the highest political level its intention to ratify the Protocol with or without the US.
July 2001: Suspended CoP-6 reconvenes at Bonn	Arrives at a political agreement on the core issues of BAPA. The Bonn agreement favourably considered, including sink enhancement activities under the CDM.
October/November 2001: CoP-7, Marrakesh (Morocco) adopts the Marakkesh Accords	Adopted the document required to make the CDM operational and set the framework for approval of methodologies for CDM projects. No specific mention about sink projects.
April 2002: EU ratifies Kyoto Protocol September 2002: Poland and Russia declare their intentions to ratify the Protocol at the Johannesburg World Summit on Sustainable Development	Gave new hope of the Protocol surviving. But with the US out of the treaty, ratification by Russia inevitable.
October/November 2002: CoP-8, New Delhi	No specific mention about sink projects.
December 2003: CoP-9 Milan	Afforestation/reforestation projects (sink projects) brought under the CDM. The CDM Executive Board asked to prepare the methodologies for afforestation/reforestation projects for the CDM.
October 2004: Russia ratifies Kyoto Protocol	The critical mass required for the climate pact to enter into force achieved.
18 November 2004: Russian instrument of ratification reaches the UN	The Protocol will come into force 90 days from 18 November 2004.
16 February 2005: Kyoto Protocol comes into force	QELRCs and the market mechanisms under the Kyoto Protocol become legally binding on all countries that have ratified the Protocol. USA, the single largest CO_2 emitter stays outside the Kyoto Protocol, reducing the impact of the Protocol and the demand for tradable carbon credits.

an important step that reflected the concerns of the international community for global climate change. The aim of the IPCC is to look into the issues related to the causes and preventive measures for global climate change. In May

1992, international climate change negotiators agreed to the United Nations Framework Convention on Climate Change (UNFCCC)[12], which was signed at the Earth Summit held at Rio de Janeiro in June 1992. The Convention entered into force with its ratification by the 50th country in March 1994. The objective of the Convention as outlined in Article 2 of the UNFCCC is 'stabilization of greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system'. The Convention has about 190 countries as its signatories, including India. The industrialized countries and economies in transition to open market listed in the Annex I to the UNFCCC (called Annex I countries) agreed, albeit non legally, to reduce their respective GHG emissions to their 1990 levels by 2000; but this never happened.

Three years after adopting the Convention, at the 3rd Conference of Parties (CoP-3) to the UNFCCC held during 1997 in Kyoto, Japan, a Protocol to the UNFCCC was approved. This has been a landmark achievement in the international climate change negotiations. Unlike the UNFCCC, the Kyoto Protocol fixes (Article 3) legally binding quantified emissions limitation and reduction commitments (QELRCs) for GHG emissions by the developed countries (Annex I countries) between 2008 and 2012, the first commitment period of the Protocol. Under the Kyoto Protocol, the Annex I countries are required to reduce their collective CO_2 emissions to at least 5.2% below their 1990 emission levels by 2012. Recognizing the need for the developing and the least developed countries (called non Annex I countries) to have more industries for their development, the Protocol does not bind these countries by any emission reduction targets during the first commitment period.

The emission reduction targets of the Annex I countries which ratified the Protocol have become legally binding on them when the Kyoto Protocol entered into force earlier this year. The Kyoto Protocol could only enter into force when it was ratified by 55 parties of the UNFCCC, including sufficient number of countries from the Annex I block, whose combined emission of CO_2 exceeded 55% of the total emission of CO_2 by the entire Annex I parties as of 1990. As of September 2004, 127 countries accounting for 44.2% CO_2 emission of Annex I countries had ratified the Protocol. With Russia ratifying the Protocol in October 2004, this went up to 128 countries and 61.6% crossing the critical mass of 55% of the Annex I GHG emission. Thus the Protocol entered into force on 16 February 2005, but without the US, the single largest emitter of CO_2.

From a scientific, environmental, political, legal and economic perspective, the negotiation of the Kyoto Protocol is certainly a landmark international treaty. The science of climate change has been appreciated by almost the entire international political community, whose concerns for the environment have been translated into a legally binding international treaty that binds the developed countries, but not the developing and the least developed countries with GHG emission reduction targets. But there has been too much politics that has impaired the Protocol's effective entry into force.

The politics of global climate change negotiation

The UNFCCC signed in 1992 came into force during 1994. Three years later, a Protocol to the UNFCCC was adopted at Kyoto in 1997. It took another seven long years, involving protracted negotiations, for the Protocol to come into force and that again with the largest CO_2 emitter deciding to stay out of it. These facts speak for themselves. Almost all the major nations have ratified the Kyoto Protocol; but not the US and Australia – the latter is only a minor CO_2 emitter. As in the case with many other international issues, world opinion had little effect on the US actions and attitudes with respect to Kyoto.

Between its adoption in 1997 and the recent Russian ratification, the Kyoto Protocol has gone through some rough waters threatening its very survival. During CoP-4 held in Buenos Aires in November 1998, a plan of action called the Buenos Aires Plan of Action (BAPA) was adopted to strengthen the implementation of the UNFCCC and prepare for the Protocol's entry into force. BAPA fixed CoP-6 as the deadline to sort out the issues in the way of the Kyoto Protocol entering into force. But CoP-6 held in The Hague during November 2000, had to be suspended due to serious disagreements among the countries over the Protocol, especially between the EU and the US. Bilateral consultations followed to sort out the issues, but the US pulled out of the Kyoto Protocol during March 2001 soon after George Bush, the new US President took over. However, the rest of the world led by the EU countries, Japan and others made a consorted effort to proceed even without the US participation. The suspended CoP-6 was reconvened in July 2001 in Bonn, Germany and a political agreement on most of the core issues of BAPA was achieved, with the US keeping out of the Kyoto process.

As far as the US is concerned, the Bush administration will not ratify the Kyoto Protocol, which was originally negotiated by the Clinton administration, that had a more pro-green image. UNFCCC takes the position that 'where there are threats of serious or irreversible damage (to the world's climate), lack of full scientific certainty should not be used as a reason for postponing such measures (to reduce the concentration of GHGs in the atmosphere)'. However Bush is of the view that emission targets established by the Kyoto Protocol 'were arbitrary and not based on science' and that 'no one can say with any certainty what constitutes a dangerous level of warming and therefore what level must be avoided'. According to the current US administration, the Kyoto Protocol is 'fatally flawed in fundamental ways'. The world expected a much more environmentally sensitive approach from the President of the

most powerful and the richest country, which is also the largest CO_2 emitter in the world. With about 4% of the world population living in the US, it contributes more than 20% of the world CO_2 emission. Bush argues that CO_2 is not a 'pollutant' under the US Clean Air Act. According to an August 2004 report to the US Congress, the US federal research indicates that emissions of carbon dioxide and other GHGs are the only likely explanation for global warming over the last three decades. Bush is opposed to the developing and the least developed world getting exemption from any emission restrictions and not prepared to share the burden of compliance, arguing that such a compliance would adversely affect the US economy. The views and position of the present US administration on climate change in general and Kyoto Protocol in particular, are contrary to the accepted wisdom of most nations in the entire world. Although the Federal Government in the US has a different view on this matter, several states in the US have unilaterally adopted their own measures to restrict GHG emission. However, none of these efforts will come under the purview of the market mechanisms under the Kyoto Protocol, since the US is not party to the Protocol.

With the US pulling out of the Kyoto mechanism and Russia not ratifying it until October 2004, there were serious doubts about the future of the Kyoto Protocol. With a CO_2 emission that accounted for 36.1 and 17.4% among the Annex I block by the US and Russia respectively (Table 1), ratification by at least one of these two countries was needed to reach the required 55% CO_2 emission mark set for the Protocol to enter into force. With the US already out of the Protocol, ratification by Russia was inevitable for the Protocol to survive. Moscow has been under tremendous international pressure to ratify it. With a large coal-based economy in Russia, President Putin had been reluctant to ratify the Kyoto Protocol. Earlier this year, Andrei Illarionov, the Russian President's economic advisor, called the Kyoto Protocol an 'undeclared (economic) war against Russia'. There have been reports that the EU was putting pressure on Russia to ratify the Kyoto Protocol before Russia could join the WTO. According to a Reuters report, around the middle of 2004, Putin had said that Moscow would move to ratify the Kyoto Protocol after an agreement with the EU on Russia's entry into the WTO. A Russian research group called 'Russia and Kyoto Protocol' went on record that Russia can benefit from the Kyoto Protocol only if it was guaranteed sales of 100–130 million tonnes of CO_2 at a price of not less than US$ 40 per tonne in the international emission trading (IET) market. The current head of the UN Environmental Program, Klaus Toepfer, a former Minister of Environment from Germany, who has been in the forefront of global climate change negotiations, expressed the view earlier last year that that there were clear indications that Russia was serious about the ratification. Clearly, Moscow was under pressure from the EU and others to ratify the Protocol.

In the last week of September 2004, the Russian Cabinet decided to initiate action to send the Kyoto Protocol to the Duma for ratification. Illarionov then commented that Russia would ratify the Kyoto Protocol as a 'gesture towards EU', but denied that this had anything to do with Russia's entry into the WTO, but was only to boost Russia's 'image abroad'. The Duma, the lower house of the Russian Parliament, approved the ratification of the Kyoto Protocol by a huge majority (334/73) during the fourth week of October 2004. The UN Secretary General received on 18 November 2004, the Russian Federation's instrument of ratification and 90 days later, on 16 February 2005, the Protocol entered into force, with the US staying out of it.

Several questions arise out of the latest sudden decision of Russia to ratify the Kyoto Protocol and its timing. Has there been any deal made between Russia and the EU on Russia's entry into the WTO, before Russia decided to ratify the Protocol? If so, what is the nature of that deal? Has any behind-the-scene understanding been arrived at about selling Certified Emission Reductions (CERs) from Russia in the IET market at a prefixed price? If so, how will this affect the CDM market? Is the timing of the somewhat sudden Russian decision to ratify the Kyoto Protocol – as a 'gesture towards EU' and to boost its 'image abroad', presumably under coercion by the EU, which was not keen to see Bush coming back to the White House for a second term – so close to the US Presidential election aimed at making the US look more 'isolated' among the international community? Answers to these intriguing questions will be difficult to come to light. In any case, climate-related issues did not figure significantly in the 2004 US Presidential election, although the Democratic contestant, Senator John Kerry tried to bring the issue to focus during the election campaign. With Bush's reelection, it is certain that the US will continue to remain outside the purview of international climate change negotiations under the auspices of the Kyoto Protocol.

Market mechanisms under the Kyoto Protocol

The Kyoto Protocol has established policies and mechanisms to reduce GHG emission, including phasing out subsidy in energy-intensive technologies, encouraging adoption of alternative environment-friendly technologies, taxing emission, etc. Obviously, there will be considerable financial and political cost in meeting the emission reduction targets of the Annex I countries' set by the Kyoto Protocol. From the developed countries point of view, attempts to reduce GHG emission within their own national boundaries will be expensive and this may also have a negative impact on the high standard of living of their citizens.

The Protocol established three major market mechanisms to help the Annex I countries meet their GHG emission reduction targets cost-effectively[13]. They are International Emission Trading (IET, Article 17), Joint Implementation

of emission reduction projects (JI, Article 6) and the Clean Development Mechanism (CDM, Article 12). An Annex I country can purchase assigned amount units (AAUs) on the basis of IET or emission reduction units (ERUs) on the basis of JI projects from another Annex I country. Thus the first two mechanisms can be operated only among the Annex I countries.

In the third mechanism, the CDM encourages projects by Annex I countries (i.e. industrialized countries) in non Annex I countries (i.e. the developing and the least developed counties) that do not have GHG emission restrictions under the Protocol. The CDM aims at bringing funding from Annex I countries for environment-friendly projects in the non-Annex I countries in the tropics and subtropics, that will earn the Annex I countries what is called Certified Emission Reduction (CER) credits. This can be used by the investing Annex I country to partially offset its Kyoto targets (Article 12.3(a)). One CER is taken as one tonne of CO_2 (or its equivalent in the case of the other GHGs) that is prevented from being released into the atmosphere (emission reduction) or removed from the atmosphere (sequestration) as a result of the CDM project over and above (additionality) the emission reduction/sequestration that would have occurred in the absence of the project (business-as-usual scenario). Several analyses show that given the small marginal costs of projects implemented in developing countries under the CDM, this will be the preferred market instrument unlike JI or IET, which can be operated only between developed Annex I countries[14].

The CDM is a unique mechanism to address global climate change at the marketplace. Some of the salient features and criteria for the CDM are given in Table 3. [Obviously, the CDM makes good economic as well as environment sense.] For the developed countries, it will be more economical to invest in a developing country and obtain CERs rather than limit their own GHG emission within their national boundaries, which can be more expensive and politically less palatable than buying CERs from a non Annex I country. The developing countries are exempted from GHG emission reduction during the first commitment period of the Protocol and thus the Kyoto Protocol does not hinder further industrialization of developing countries. Thus the CDM addresses global environmental concerns by providing an economic opportunity for the developing countries to attract funds for climate-friendly projects, and the developed countries an opportunity to meet their Kyoto compliance cost-effectively. The short-term developmental needs of the non Annex I country and the short-term Kyoto compliance requirement of the Annex I country are simultaneously addressed by the CDM.

The CDM has received several criticisms as well. The most poignant among them is that it gives the rich industrialized countries a cheap option to buy GHG emission rights from the poorer countries. Thus such countries can continue with their current domestic GHG emissions or even increase emissions in lieu of procuring more CERs from a cheap CDM market in the non Annex I countries[15]. But it may be noted that Articles 17, 6.1(d) and 12.3(b) of the Protocol fix restrictions on the extent of use of the flexible market mechanisms to meet Annex I QELRCs. CERs can be used only in part to meet the QELRCs and supplementary to domestic actions by the Annex I countries to meet their Kyoto compliance (supplementarity).

The social, economic and environmental benefits of the CDM far outweigh its deficiencies. Some of the earlier apprehensions about the IPCC strategies being unfair to the south[16–18] are effectively addressed in the CDM philosophy (Table 3). The Kyoto Protocol has been fair to the developing and the least developed countries by not fixing GHG emission reduction targets, which was sternly opposed by the US. The potential financial benefits that the CDM projects can bring into the non Annex I countries (North–South flow of funds) for implementing GHG mitigation projects could be significant. Without them, many non Annex I countries would not be in a position to implement such climate-friendly projects[19], which are also in tune with the sustainable developmental needs of the non Annex I countries. The significance this holds for non Annex I countries such as India, China, Brazil, etc. that have a huge population and are fast developing economies – and therefore, by default, would emit huge amounts of GHGs – cannot be overlooked. Attracting some of the CDM funds into agriculture, commercial plantation and forestry sectors in these countries would help in strengthening their rural economies, while limiting their own net GHG emissions.

CDM and commercial plantation and forestry sectors

Deforestation, the second major cause of GHG accumulation in the atmosphere, next to fossil fuel combustion, has been responsible for 20–25% of global anthropogenic GHG emissions[20] during the 1990s. Recognizing the importance of carbon sequestration in combating global climate change[7,21–25], sink activities such as afforestation and reforestation projects were included in the Kyoto Protocol as a means of meeting the GHG emission reduction targets by the Annex I countries. Removal by sinks (Article 3.3), including agricultural soils, land-use change and forestry (Articles 3.4 and 3.7) have been identified in the Kyoto Protocol as potential mitigation options. Sinks are various forms of stocks of carbon in aquatic or terrestrial ecosystems, such as undersea coral reefs, terrestrial and aquatic living organisms, soil, etc. These stocks of carbon, unlike the inorganic CO_2 gas in the atmosphere, do not have any adverse effect on climate. Net removal of atmospheric CO_2 by sinks through 'land-use, land use change and forestry' (LULUCF) activities, including 'aforestation, reforestration and deforestation' initiated since 1990, which are 'direct human induced' are eligible sink enhancement activities for JI (Article 6.1(b)). But there is no explicit reference in the Protocol to sink projects for the CDM. There are several issues about

Table 3. Some salient features and socio economic criteria for CDM projects[52–54]

The CDM creates a global market for GHG emission rights based on voluntary co-operation between Annex I and non Annex I countries and project participants.
Enables flow of funds in the North-South direction (i.e. from the industrialized Annex I countries to less developed non Annex I countries).
Addressing environmental concerns through the marketplace, the CDM is a unique international market mechanism that reduces cost of Kyoto compliance by Annex I countries, and brings into non Annex I countries, financial resources for climate-friendly projects.
The only international market mechanism established under the Kyoto Protocol by which the developing and the least developed countries can benefit.
Creates a platform for public and private parties to implement GHG mitigation provisions of the Kyoto Protocol.
Helps developing countries in achieving sustainable development and thus contributing to the objectives of UNFCCC.
The CDM project should result in a real, measurable and long-term benefit to the community and environment.
Maximum project duration of a CDM project is 21 years.
The principal authority over the CDM is vested with the Conference of Parties to UNFCCC and Meeting of Parties to the Kyoto Protocol.
Designated Operational Entities validate the projects, verify the emission reductions and give certification of the GHG reduction to the CDM Executive Board.
The CDM Executive Board supervises the project, approves the methodology, establishes CERs and issues CERs.
The CERs obtained through the CDM project should be a measure of GHG emission reduction that is additional to any that would occur in the absence of the project (business-as-usual scenario).
Designated National Authority of the participating countries issues letters of approval on behalf of participating parties.
Buyer and seller of CERs should be party to the Kyoto Protocol or participants in countries that are party to the Kyoto Protocol.
The CDM project should not result in gender, social, environmental, economic or land-use conflicts in the host country.

sink projects, especially biomass projects (e.g. permanence, methodology, additionality, leakages, etc.) that still remain unclear. An analysis of various sink activities to meet the Kyoto commitments, and the advantages of including sink projects under the CDM and the practical difficulties in carbon accounting in international carbon sequestration projects are discussed elsewhere[26–28].

The Bonn agreement favourably considered including sink enhancement activities under the CDM under Articles 3.3 and 3.4 of the Protocol. The Marrakech Accords set the framework for approving modalities and methodologies for the CDM projects. These included only GHG emission reduction projects and not carbon sequestration/sink projects. CoP-9 to the UNFCCC held in Milan during December 2003, has agreed to include afforestation/reforestation projects under the CDM. The CDM Executive Board is currently finalizing the rules and modalities (Article 5.2) for including carbon sinks from afforestation/reforestation activities under the CDM of the Kyoto Protocol. Clearly, this has profound implications for the forestry and other commercial plantation sectors in India. Although farm forestry/plantation activities have not been directly mentioned in the decisions of CoP-9, they are eligible for CDM funding, if they meet the general requirements as applicable to the afforestation and reforestation projects and other conditions stipulated for CDM, such as sustainable development objectives in the host country in the Annex I block. While the CDM in itself will be economically a more attractive Kyoto compliance option than either JI or IET, afforestation/reforestation sink projects would create cheaper CERs than other CDM projects.

Studies conducted at the Rubber Research Institute of India, and other rubber-growing countries show that the carbon sequestration capacity of the natural rubber plantations is very high[29–31]. The carbon sequestration capacity of various native forest ecosystems has been well studied, including those of tropical Amazon[23,32–37], northern latitude ecosystems such as temperate and boreal forests[38–43], savannas[44–46], arctic tundras[47], etc. But only scanty data are currently available on the carbon sequestration rates of commercial plantation species such as *Eucalyptus*, teak, sal, etc. in the non Annex I countries.

Between June 2003 and January 2004 the price of CER in the EU Emission Trading Scheme, a parallel carbon market for the EU which is expected to be linked to the Kyoto mechanism, increased from about 7 to 13 Euro/T CO_2. But in the CDM market the price was notably low, around US$ 5/T CO_2. Even at this modest price, rubber plantations have a potential worth US$ 120–170/ha/yr in the CDM market[30]. It has been estimated that from the total area of 0.5 mha of natural rubber cultivated in India, there will be enough CERs to meet just under 10% of the combined demand by Japan and the EU to meet their Kyoto targets. Just like any tradable commodity, virtual trading of CERs is also open to

market forces. If more and more buyers of CERs come to the market, the price of CERs will go up. Now that the Kyoto Protocol has come into force with Russia ratifying the pact, it is expected that the price of CERs will substantially increase as the first commitment period of the Protocol (2008–2012) approaches, when the demand for CERs would also go up.

Without the US with as much as 36% of the total Annex I GHG emission (Table 1), the scope of the market mechanisms established under the Protocol will remain rather small. Various models have predicted that the non ratification of the Kyoto Protocol by the US would reduce the demand for GHG emission reduction in the carbon market by 60–74% and accordingly, the price of emission credits will also be small[14].

The CDM market potential of CERs from the forestry/farm forestry/commercial plantations can be realized only if the National CDM Authority (NCA) in the Annex I countries include specific forestry/plantation projects under the CDM. In the case of India, the NCA is headed by the Ministry of Environment and Forests. The CDM is as much about economics and environment (and, unfortunately politics too), as it is about livelihood means and sustainable socio-economic development in the developing and the least developed countries in the non Annex I block. The immediate and direct beneficiaries of many commercial plantations and farm/forestry projects in the country are mostly poor peasants who are scattered in the remote landscapes of India. Therefore, any carbon abatement project in the farm/forestry/commercial plantations sector under the CDM, will be compatible with the socio-economic and ecological criteria set out under the CDM for sustainable development in the non-Annex I countries in the tropics and subtropics (Article 12.2).

Processing and product manufacturing sectors

Any activity that results in a reduction in the emission of GHGs into the atmosphere is eligible for CDM funding, subject to certain conditions. Many activities related to primary processing of plantation produces and product manufacturing can qualify for funding under the CDM. Production of biogas from processing effluents from commercial plantations (e.g. natural rubber processing effluents), production of bio-diesel from seeds of species such as jatropha, natural rubber, etc.; use of biomass-based gasifiers and solar thermal system for generating energy are eligible for CDM funding. Among the renewable energy sources such as solar, wind and hydel projects, biomass energy is gaining more importance, given the advances made in the gasification technology[48]. Growing energy plantations in degraded ecosystems for the purpose of producing biomass for gasifier-based power generation in rural areas[49], as successfully demonstrated in Karnataka[50], is an excellent opportunity to tap CDM funds. There are several non Annex I countries like India with vast areas of wasteland and large sections of the rural population that do not have access to assured power supply. In such countries, wastelands could be converted into energy plantations for the production of biomass for gasifiers or vegetable oil from plants such as jatropha that can yield bio-diesel. Both the production of biomass and generation of energy using biomass gasification are inherently climate-friendly technologies that can attract CDM funding.

Use of alternative/renewable energy (e.g. biomass gasifiers, biogas, bio-diesel, etc.) in the rural agriculture sector (e.g. for pumping irrigation water, operating agricultural machinery, running flourmills, etc.) displaces fossil-based fuels, which amounts to indirect sequestration of CO_2 and therefore qualifies for CDM funding. It may be noted that fossil carbon is perhaps the best form in which atmospheric CO_2 can be sequestered and put away permanently without interfering with the world's climate system. But it is unrealistic to expect to achieve this in reasonable time. Hence leaving the fossil stock untouched is the best strategy and therefore, any project that will utilize energy or a product from a renewable, non-fossil carbon source such as energy plantations instead of fossil fuel, is eligible for CDM funding.

Any technological innovation in primary processing and product manufacturing in commercial plantations and forestry sectors that improves the energy use efficiency over the existing level is eligible for CDM funding. The small amounts of CERs from the various plantation and forestry-related processing and industrial units in the country, can be pooled (bundling) and traded in the international CDM market. Use of plantation wood in place of various forest timbers also may qualify for CDM funding. Opportunities may be present in the case of commercial plantations such as rubber, cocoa, coffee, tea, cardamom, etc. and forestry plantations such as eucalyptus, sal, teak, etc. for obtaining CERs through the efficient use of fossil energy and use of renewable energy for the primary processing or value addition of these commodities.

Conclusion

This article attempts to reveal the scientific, political and economic contents of the Kyoto Protocol with special emphasis on carbon sink projects. There are many uncertainties and hurdles still existing in attracting CDM funds for afforestation/reforestation projects under the Kyoto Protocol. Developing appropriate methodologies for estimating CER from sink projects and their adoption by the CDM Executive Board are crucial. The Indian NCA (headed by the Ministry of Environment and Forests, Government of India) keeps an open mind in this regard, but it is up to those working in the areas of forestry and commercial plantations to come forward to capitalize on the potential CDM opportunities. Working out the carbon sequestration rates of various Indian forestry and commercial plantation species is the first step in this direction.

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