

## Chapter 2

### Literature Review

In the last few years, quite a few seminal studies have been published on carbon market, emission trading and related themes. This reflects the growing concern of the society world over about the serious threat which climate change is posing before the humanity. Academicians and researchers are coming up with new ideas backed by economic analysis for policy interventions in mitigating the climate change. This chapter presents brief review of selected studies on the themes relevant to this study. The review has been broadly categorized in to two headings.

#### **2.1 Climate Change: Market, Economics & Policies**

**2.1.1** The Economics of Climate Change: The Stern Review (2006) by Nicholas Stern is a comprehensive document giving detailed analysis of the threat posed by climate change and how the global community should respond to it. The review presents economic analysis of treating the climate change which is a global externality. It proves that tackling climate change is a pro growth strategy and the economic benefits of strong early action easily outweigh the costs. The review estimates that 'if we don't act, the overall costs and risks of climate change will be equivalent to losing at least 5% of global GDP each year, now and forever. If a wider range of risks and impacts is taken into account, the estimates of damage could rise to 20% of GDP or more.' Market based mechanism 'cap-and-trade' and its advantages in generating the required capital for mitigation measures have been very effectively explained in the document. The review highlights that land use based options of mitigation particularly forest related activities of

climate change mitigation are the cheapest ways of reducing greenhouse gases in the atmosphere. Wider practice of reducing deforestation and sequestration of CO<sub>2</sub> by raising tree plantations and improved forest management may lead to saving of capital to achieve higher level reduction of GHG concentration. The review enlists four key elements of future international frameworks i.e. (i) emission trading, (ii) technology cooperation, (iii) action to reduce deforestation and (iv) adaptation.

**2.1.2 Domestic Emission Trading Systems in Developing Countries – State of Play and Future Prospects (2011)** by Wolfgang Sterk and Florian Mersmann highlights the importance of domestic emission trading schemes in driving low-carbon investments and achieving global mitigation objectives in a cost efficient manner. The paper also gives an overview of the design factors which need to be taken into account while developing a national domestic emission trading system. This paper aims to give an overview of the current status in key developing countries where a minimum of specific information on emission trading discussions was available. These are Brazil, China, India, Kazakhstan, Mexico, and South Korea. The paper also mentions about the World Bank's initiative in market readiness capacity building in several countries (World Bank's Partnership for Market Readiness). First set of countries viz Chile, China, Columbia, Costa Rica, Indonesia, Mexico, Thailand and Turkey have received 350.000 USD each for capacity building in domestic carbon markets in the year 2012.

**2.1.3 Trends in Global CO<sub>2</sub> Emissions 2013 Report**, PBL Netherlands Environmental Assessment Agency, Institute for Environment and Sustainability (IES) of the European Commission's Joint Research Centre (JRC) (2013)- gives the latest statistics on the emission level from different countries and analyses the trend of emissions for the

countries with high emissions including India. The report also presents a brief account of the status of the emission trading schemes and carbon market in different countries. The report gives reason for little optimism when it mentions that 'actual global emissions increased by 1.4% over 2011, reaching a total of 34.5 billion tonnes in 2012. After a correction for the leap year 2012, this increase was reduced to only 1.1%, compared with an average annual increase of 2.9% since 2000. The CO<sub>2</sub> emission trend mainly reflects energy-related human activities which, over the past decade, were determined by economic growth, particularly in emerging countries. In 2012, a 'decoupling' of the increase in CO<sub>2</sub> emissions from global economic growth (in GDP) took place, which points to a shift towards less fossil-fuel intensive activities, more use of renewable energy and increased energy saving.'

**2.1.4 Transaction Costs of CDM Projects in India – An Empirical Survey, Matthias Krey (2004),** is a study on transaction cost of few CDM projects taken as sample for survey which were under implementation in the year 2004. The report gives a detailed analysis of transaction cost and its different components with reference to CDM projects. The report also includes an economist's perspective on transaction cost and discusses the same in the context of Coase's theorem. As per the report, the lowest transaction cost among the projects surveyed in the study was 57,193 USD. High transaction cost in converting the GHG abatement activity into certified emission reductions (CERs) or carbon credits is a major barrier in large scale propagation of land use change and forestry abatement activities.

**2.1.5** 'Covering New Ground: State of the Forest Carbon Markets, 2013', Forest Trends' Ecosystem Marketplace, authored by Molly Peters-Stanley, Gloria Gonzalez, and Daphne Yin is an annual report series presenting status of forest carbon in the whole world. This is the only report of its kind dedicated to the forest carbon market and is considered an authentic reference on forest carbon. The report presents figures such as of annual quantum of forest carbon credits transacted, its distribution in different standards, in compliance and voluntary market segments, geographical distribution of the forestry offset projects, average price of forestry offsets, profile of buyers and sellers etc. According to the report the total volume of the forestry carbon offsets transacted during the year 2012 was 28 MtCO<sub>2</sub>e and the average price of the forestry offsets were \$7.8/tCO<sub>2</sub>e. The overall market value of forest carbon offset demand reached \$216 million in 2012, 90% of the offsets were purchased by the voluntary buyers. It is reported that 26.5 million ha area is under forest carbon projects and in the year 2012 alone 11.3 million ha new area was brought under such projects, this indicates growing acceptance of forest carbon projects. Main motivation for buying forest carbon offsets according to the report is to demonstrate climate leadership by the big corporate houses; many buyers are also attracted to forest carbon offsets because of the ecological and socio-economic co-benefits which these projects offer. The report also mentions about the growing share of forest carbon offsets in the domestic markets. In the annexure section of the report A.1.4, brief description of the China's Panda Standard has been given. Panda Standard of China is also for a domestic carbon market, somewhat similar to the one being proposed in this dissertation. It mentions 'Panda Standard as the first voluntary carbon standard designed specifically for China,

in order to support the nascent Chinese carbon market and encourage investment into the domestic rural economy. Governed by the Panda Standard Association, the Panda Standard focuses on promoting Agriculture, Forestry, and Other Land-Use offset projects with poverty alleviation benefits.'

**2.1.6** Carbon markets, transaction costs and bio-energy (2008) by Oscar Cacho first, gives an overview of the carbon market, it further argues that payment for carbon sequestration by farm forestry or agroforestry may provide incentive to the farmers to adopt sustainable agriculture practices. However, a project involving contracts with farmers may face high transaction costs in showing that net emission reductions are real and attributable to the project. The paper defines project feasible frontier (PFF) which gives the minimum feasible farm size with a given price of carbon credit. PFF can also be used to analyse how the design of a carbon market affects feasibility of a project.

**2.1.7** In 'Trading Forest Carbon: A Panacea or Pipe Dream to Address Climate Change?' Brandon Scarborough (2007) takes a critical view of trade in forest carbon towards ultimate objective of climate change mitigation. He argues that 'a policy to address climate change that promotes the planting of forests and sustainable forestry practices is politically and environmentally attractive'. In this paper he explains the Carbon Cycle, Sequestration Role of Forests, Emissions Trading and Forest Carbon and about Costs of Commodifying Forest Carbon. He finally draws conclusions about merits and demerits of forest carbon trading. The author comments that 'forests provide a long list of social, economic, and environmental amenities and have the capacity to remove and store significant amounts of carbon from the atmosphere over time.

However, tradable forest credits are not created by simply planting trees or altering management practices in existing forests. Commodification of forest carbon would require accurate measurement, monitoring, and long-term enforcement of carbon stores not only to account for changes (including losses) in carbon stores but to ensure that actual reductions in net emissions will occur. To landowners, and potentially taxpayers, this process introduces significant costs. As these costs increase, they reduce the incentive to grow new forests and diminish the likelihood of a viable market'.

## **2.2 Agroforestry and Carbon Sequestration**

**2.2.1** In 'Smallholder Agroforestry Projects: Potential for Carbon Sequestration and Poverty Alleviation' (2003), , ESA Working Paper No. 03-06 Agriculture and Economic Development Analysis Division, FAO, Oscar J. Cacho, Graham R. Marshall and Mary Milne present an assessment of potential and possibilities of generating certified emission reduction (CER) credits by carbon sequestration from the small holder agro forestry projects. The paper builds argument in favour of small holder agroforestry projects by highlighting biological mitigation of carbon. It mentions 'Biological mitigation can occur through three strategies: (i) conservation of existing carbon pools; (ii) sequestration by increasing the size of existing pools; and (iii) substitution of sustainably produced biological products, such as using wood instead of energy-intensive construction materials, or using biomass to replace energy production from fossil fuels. Options (i) and (ii) result in higher carbon stocks but can lead to higher carbon emissions in the future (e.g., through fires or land clearing for agriculture), whereas (iii) can continue indefinitely (IPCC 2001)'. The paper gives an in-depth analysis of transaction cost as a significant factor in influencing the economic viability of

agroforestry projects for generating carbon credits. It also analyses abatement and transaction costs for drawing policy implications for design of the CER market for the agroforestry based projects from small holdings. Finally paper suggests ways for creating institutional framework to enable the small holder agroforestry projects for carbon credits to function and sustain.

**2.2.2** 'Investing in Forest Carbon: Lessons from the First 20 Years' (2011), Report prepared by the Katoomba Group, Ecosystem Marketplace and Forest Trends with input and support from Bio-Logical Capital provides an overview of the experience of investment in forest carbon in the last 20 years under various mechanisms and markets. The report enlists the challenges which forest carbon market has faced in the last 20 years. According to the report, uncertainty whether compliance markets will include various types of forest carbon projects or not has been the most significant challenge. Despite these challenges forest carbon market has continued to grow world over, mainly in the voluntary market, not so much in the compliance segment.

**2.2.3** In the paper 'Carbon Sequestration Potential of Agroforestry Systems in India' by Indu K Murthy, Mohini Gupta, Sonam Tomar, Madhushree Munsri, Rakesh Tiwari, GT Hegde and Ravindranath NH, *Centre for Sustainable Technologies, Indian Institute of Science, Bangalore, India*, (published in *Journal of Earth Sci Climate Change* 2013, 4:1) the authors have highlighted importance of agroforestry practice in climate change mitigation. Agroforestry meets the twin objectives of mitigation and adaptation to climate change. Quoting IPCC report the paper mentions that there is potential of mitigating 1.1 to 2.2 Giga ton of carbon in terrestrial ecosystem (1 Giga ton =  $10^9$  ton). Additionally 630 mha of unproductive croplands and grass land can be converted to sequester

391000 MtCO<sub>2</sub>e/yr. The paper gives sequestration potential from agroforestry for different regions of India along with suitable systems and species. While enlisting diverse benefits of agro forestry from enhancing agricultural productivity to aesthetics, soil and moisture conservation, livelihood generation etc, the paper suggests that to harness the full potential of agroforestry, technical, institutional and financial barriers need to be identified and should be systematically addressed. The paper also emphasizes on the need for strong research support on various technical issues of agroforestry extension in different regions of the country.

**2.2.4** In Agroforestry and Carbon Sequestration: A Global Scenario by I.A Khan and O.P. Chaturvedi, Journal of Tropical Forestry, July-Dec, 2007, Vol 23 (III & IV), authors have highlighted the potential of agroforestry in sequestering carbon as a major global strategy for climate change mitigation. The authors quote in the paper that the carbon sink capacity of the world's agricultural and degraded soils is 50 to 66% of the historic carbon loss of 42-78 gigatons of carbon (Lal,2004). Agroforestry systems prevent wind erosion and soil erosion, increase farm income and maintain above ground and below ground biodiversity and play an important role in regulating water hydrology. The paper mentions that agroforestry if used for energy production has an additional benefit in terms of carbon sequestration if it substitutes fossil fuels in energy production. Because wood fuels, unlike fossil fuels are considered to be 'carbon neutral', the assumption being that the resulting emissions will be compensated for by the absorption of an equivalent amount of carbon in the regrowth of the fuel wood on sustainably managed woodlands.

**2.2.5** 'In Carbon sequestration: An Underexploited Environmental Benefit of Agroforestry Systems by F. Montagnini and P. K. R. Nair, published in *Agroforestry Systems* 61: 281–295, 2004, the authors mention that 'Agroforestry has importance as a carbon sequestration strategy because of carbon storage potential in its multiple plant species and soil as well as its applicability in agricultural lands and in reforestation. The potential seems to be substantial; but it has not been even adequately recognized, let alone exploited.' The authors quote IPCC Report (Watson et al. 2000) which estimates the area currently under agroforestry worldwide as 400 million ha with an estimated carbon sequestration potential  $0.7\text{tCO}_2\text{e ha}^{-1} \text{ y r}^{-1}$ , with potential for sequestering  $26 \text{ MtCO}_2\text{e yr}^{-1}$  by 2010 and  $45 \text{ MtCO}_2\text{e yr}^{-1}$  by 2040 (1 Tg =  $10^{12}$  g or 1 million tons). That report also estimates that 630 million hectares of unproductive cropland and grasslands could be converted to agroforestry worldwide, with the potential to sequester  $\text{MtCO}_2\text{e yr}^{-1}$  by 2010 and  $586 \text{ MtCO}_2\text{e yr}^{-1}$  by 2040. The report further argues that agroforestry can sequester carbon at time-averaged rates of 0.2 to  $3.1 \text{ tCO}_2\text{e yr}^{-1}$ . The paper also illustrates an example of payment of ecosystem service in Costa Rica which is relevant to the study of my dissertation In Costa Rica, in 1997, \$14 million was invested for the Payment for Environmental Services (PES), which resulted in the reforestation of 6 500 ha area, the sustainable management of 10 000 ha of natural forests, and the preservation of 79 000 ha of private natural forests. Eighty percent of this funding originated nationally from a tax on fossil fuels; the other 20% came from the international sale of carbon from public protected areas and contributed with \$2 million. Recently, the world Bank provided a \$32.6 million loan to Costa Rica to fund the PES through a Project called 'Ecomarkets'. It came along with a grant from the Global

Environment Facility (GEF) of approximately \$8 million. These schemes only considered reforestation or forest conservation. Starting in 2003, PES in Costa Rica also includes agroforestry systems, with payments calculated based on the number of individual trees present in the farm.

**2.2.6 Carbon Sequestration Potential of Agroforestry Systems: Opportunities and Challenges** by B. Mohan Kumar and P.K. Ramachandran Nair (Editors) (2011) is a book containing peer reviewed articles by the authors from different countries on the theme. The book presents an international perspective on the subject. The book could be a single source to give adequate information on various aspects of agroforestry systems in the context of carbon sequestration. The chapters Methodological Challenges in Estimating Carbon Sequestration Potential of Agroforestry Systems, Linking Carbon, Biodiversity and Livelihoods Near Forest Margins: The Role of Agroforestry, The Socioeconomic Context of Carbon Sequestration in Agroforestry: A Case Study from Home Gardens of Kerala, India were found very useful for the dissertation work.