The IMRE Journal Volume 1 (1) 2006
2006. TU Bergakademie Freiberg
http://www.wiwi.tu-freiberg.de/~urm/imre/journal/index.htm

Carbon Sequestration through Afforestation and Reforestation in a Developing Country

Lina Lau, Jan C. Bongaerts

Technische Universität Bergakademie Freiberg

Correspondence:
Professor Dr. Jan C. Bongaerts
TU Bergakademie Freiberg
Lessingstraße 45,
09596 Freiberg,
Germany
e-mail: J-C.Bongaerts@ioez.tu-freiberg.de

Revised: 01.11.2006
Online publication date: 21.11.2006

Abstract

Since the ratification of the Kyoto Protocol by 84 countries in 1999, the efforts of the international community to combat climate change have entered into a new phase. Within the European Union (EU), comprehensive medium and long term strategies have been developed and implemented to reduce its greenhouse gas[1] emissions to the target of minus eight percent by the end of 2012, based on the emissions level of the EU in 1990. Meanwhile, the international character of the system, which has been confirmed from the beginning of its design, is now in place. Member States of the EU are in a position to allow the operators of installations coming under the trading scheme to take part in activities under the Clean Development Mechanism in order to achieve their CO_2 emissions targets under the national allocation plan of their Member State of residence[2]. Another issue is the rapid development of specific financial instruments for the marketing of CO_2 certificates. Investment bankers are currently cooperating with brokers in order to generate dedicated financial products for the benefit of operators of installation covered by the trading scheme. The combination of these elements such as emissions trading, financial instruments and the CDM projects may lead to the involvement of forestry as a potential sink for CO_2 emissions. Therefore the purpose of this paper is to investigate the trading scheme with a specific focus on the purchase of CO_2 certificates generated through forestry. The outline of the paper is as follows. First, an introduction with a specific focus on Joint Implementation and the Clean Development Mechanism and their link with emissions trading is given. The next section briefly deals with some of the causes of climate change. This is followed by a discussion of the implementation of the Kyoto Protocol Mechanisms in the EU. An international link between the Emissions Trading Scheme of the EU with other Kyoto Protocol Instrument, notably the Clean Development Mechanism, is illustrative of changing land-uses in so-called Annex I Party B countries. This is discussed at length and a special case study on Malaysia is given to explore this matter in more detail.

Keywords: greenhouse gases, Kyoto Protocol, clean development mechanism

Introduction

Since January 1, 2005 Member States of the EU have introduced the first trading period for greenhouse gases (GHG). Initially, about 12000 industrial installations[3] are requested by law to take part in the first trading period, which is limited to CO_2 and which is to run until 2007. After that, the second trading period will be started in 2008 and close in 2012. At present, the European Commission is already considering a review of the trading scheme for the time after 2012, taking into account other gases of the Kyoto Protocol and expanding trade to other sectors, such as aviation and maritime[4]. This is because transportation is responsible for 21 percent of EU GHG emissions. Under the Kyoto Protocol, three mechanisms to lower emissions have been adopted with the intention to also achieve cost effective solutions. These three mechanisms are referred to as joint implementation (JI), clean development mechanism (CDM) and emissions trading (ET).

Through JI, an Annex I Party[5] to the Kyoto Protocol may invest in or implement a project that reduces emissions or removes carbon from the atmosphere in another Annex I Party. A JI project must lead to emission reductions that are additional to any that would have occurred without the project. In return, the Annex I Party receives emission reduction units (ERUs) from that Annex I Party (UNFCCC, n.d.).The ERUs generated by JI projects can be used by this Annex I Party towards meeting its emissions targets under the Protocol [1]. Figure 1 shows the process of emissions reduction through the JI mechanism.

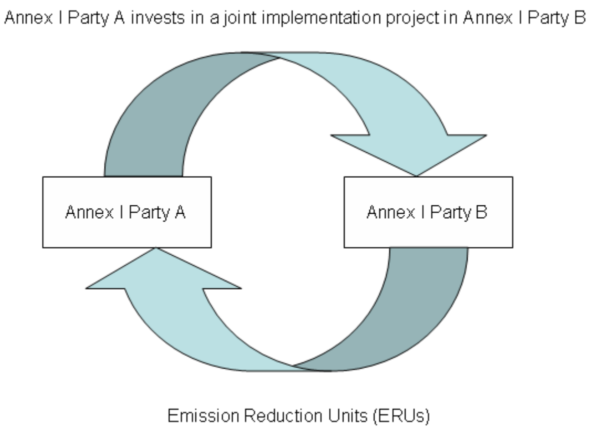

Figure 1: An Example of Emissions Reduction through the Joint Implementation Mechanism. Source: Prepared by the authors

The CDM allows Annex I Parties to implement projects in non-Annex I Parties[6] that reduce emissions and use the resulting certified emission reductions (CERs) to help meet their own targets (UNFCCC, n.d.). For example, a company in Germany is allowed to invest in natural sink[7] projects of afforestation and reforestation in developing countries such as Brazil and Malaysia. A CDM project can also include an investment in a rural electrification project using solar panels or the installation of a more energy efficient plant (UNFCCC, n.d.). The amount of greenhouse gases reduced from the atmosphere through the sink project, known as removed units (RMUs)[8], can be used by Germany to meet its own emissions target. Figure 2 illustrates the mechanism of clean development where Annex I Party A invests in a CDM project in non-Annex I Party B and receives the resulting CERs. The RMUs of emissions from the atmosphere will be used by Annex I Party A to help meet its own emissions t

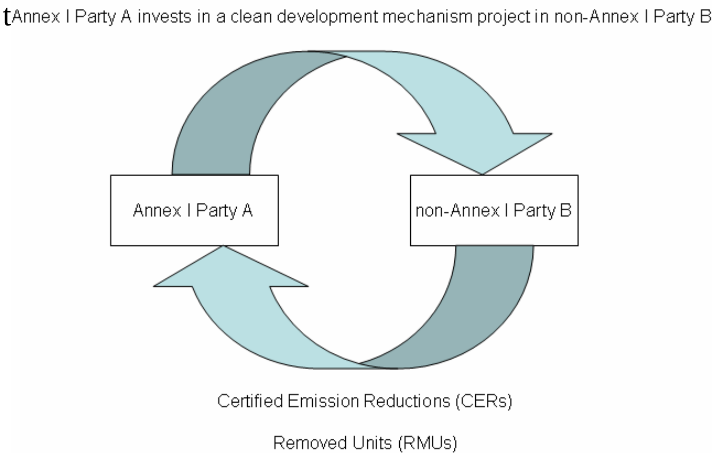

Figure 2: An Example of Emissions Reduction through the Clean Development Mechanism. Source: Prepared by the authors

Since non-Annex I Parties are receiving projects, the CDM also aims to help them achieve sustainable development and contribute to the ultimate objective of the Kyoto Protocol (UNFCCC, n.d.). It should be noted that only certain activities in land use, land-use change and forestry (LULUCF) sector are eligible to be used by Annex I Parties to offset their emissions. Under the Kyoto Protocol, the eligible activities within LULUCF sector are afforestation, reforestation and deforestation (ARD) (UNFCCC, n.d.) After a review of the Kyoto Protocol, the so-called Marrakesh Accords identified and provided common definitions for four additional LULUCF activities that can be accounted for to help meet emission targets (UNFCCC, n.d.). These activities are forest management, cropland management, grazing land management and re-vegetation (UNFCCC, n.d.).

Participation in the emissions trading mechanism is only eligible for Annex I Parties of the Kyoto Protocol who explicitly made commitments to reduce their emissions by setting targets under the Protocol. Under the emissions trading mechanism, a company of an Annex I Party may choose either to reduce its emissions or else "source out" the reduction to another company in the same Annex I Party. The actual decision of this company will depend on the relative costs of both alternatives. The Protocol also allows the use of the emissions trading mechanism between Annex I Parties. In such a case, an Annex I Party which finds it relatively easy to reduce emissions may transfer emissions under its assigned amount known as assigned amount units (AAUs), to another Annex I Party that finds it relatively more difficult to meet its emissions target land management and re-vegetation (UNFCCC, n.d.). Within the emissions trading mechanism, any Annex I Party can transfer its CERs, RMUs and ERUs which it acquires through JI, CDM or sink activities in the same way land management and re-vegetation (UNFCCC, n.d.). Each unit of AAUs, RMUs, ERUs and CERs is equal to one metric tonne of emissions (in CO_2-equivalent terms). In order to prevent the Annex I Parties to over-sell their emissions allowance which might prevent them to meet their own emission targets, the Protocol rulebook requires Annex I Parties to hold a minimum level of AAUs, CERs, ERUs and/or RMUs in a commitment period reserve that cannot be traded land management and re-vegetation (UNFCCC, n.d.).

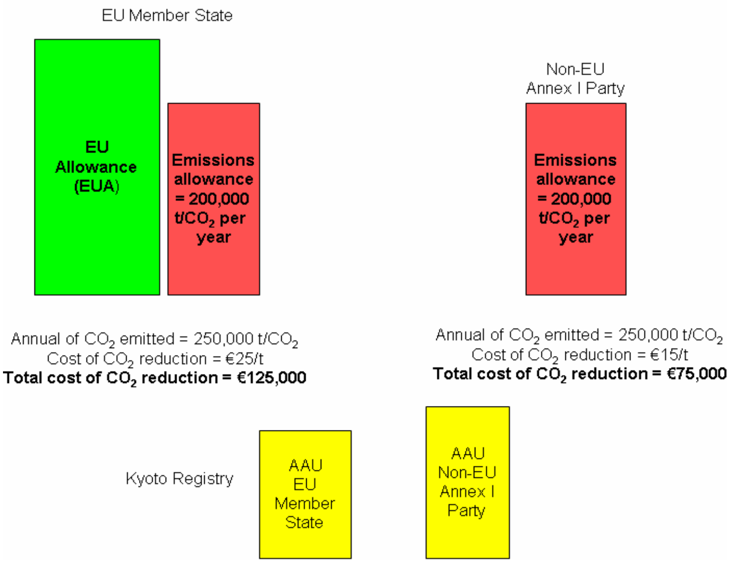

Figure 3: Situation before Emissions Trading between an EU Member State and a non-EU Annex I Party. Source: Prepared by the authors

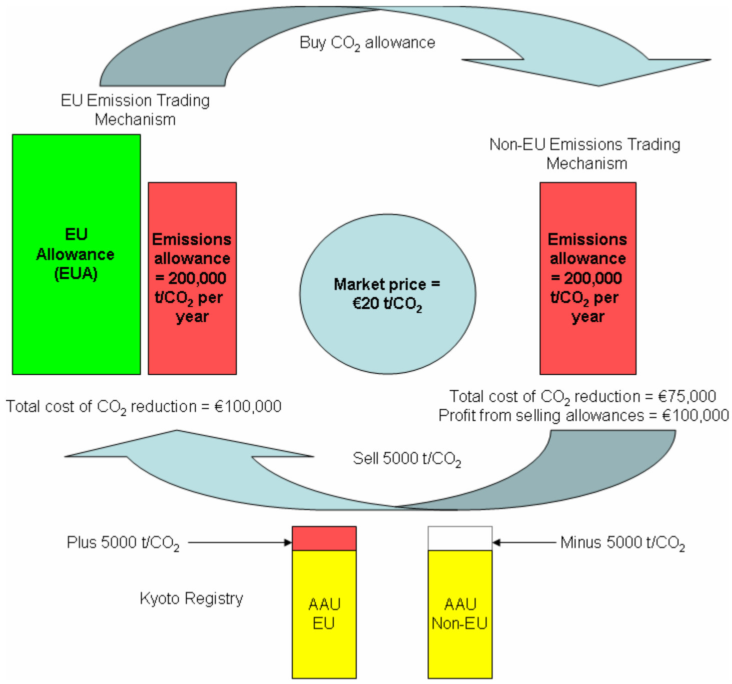

Figure 4: Emissions Trading Mechanism. Source: Prepared by the authors.

Figures 3 and 4 illustrate the functioning of the emissions trading mechanism between a Member State of the EU, which is an Annex I Party, and another non-EU Annex I Party. The EU trading scheme is selected because it is the only one which is organised by a legal instrument, i.e. Directive 2003/87/EC of the European Parliament and of the Council of 13 October 2003[9]. In Figure 3, the situation before trade is shown. For the EU as a whole, a target for emissions reduction is set. The resulting amount of emissions which must not be exceeded is known as the EU Allowance (EUA). For each Member State of the EU, an individual target is set according to a burden sharing agreement[10]. In Figure 3, Annex I Party and the non-EU State emitted 250,000 tonnes of CO_2 per year. Both parties are given an emission allowance of 200,000 per year. One allowance represents the right to emit 1 tonne of CO_2. This mean both parties are unable to fulfil their emissions target. If we assume that the cost of emissions reduction for the Annex I Party is €25 and €15 for the non-EU State, then, without the emissions trading mechanism, the total costs of emissions reduction for each party are €125,000 and €75,000 respectively, for reducing 5,000 tonnes of CO_2 each. Both parties can also choose to invest in JI, CDM or other sink projects in order to gain AAUs, RMUs, ERUs and CERs which can be used to meet their emissions target.

Let us presume that the emissions trading mechanism is taking place and the present market price to buy one tonne of CO_2 allowance is €20. In order to meet the emissions target, Annex I Party and the non-EU State can choose to reduce their CO_2 emissions by 5,000 tonnes or they can purchase the allowances in the market to emit 5,000 tonnes of CO_2. The non-EU State starts to reduce its emissions as it is cheaper than buying the allowances in the market. Meanwhile, Annex I Party chooses to buy allowances in the market as the price of one tonne CO_2 allowance is €5 lower that the unit cost of reducing emissions by itself. The non-EU State reduces its emissions by 10,000 tonnes per year and chooses to sell 5,000 tonnes of CO_2 allowance to Annex I Party. The total cost of reduction for the non-EU Member State is €75,000 at a unit cost of €15 of CO_2. The non-EU State receives €100,000 for selling 5,000 tonnes of CO_2 allowances to Annex I Party. Both parties receive benefits from the emissions trading mechanism. The situation after this trade is illustrated in Figure 4.

All three mechanisms described above are based on the Kyoto Protocol's system for the accounting of targets to reduce emissions of the group of Annex I Parties over the five year commitment period, i.e. the trading period starting in 2008. By the end of this commitment period, the check to ensure that Annex I Parties are in compliance with their emissions targets will take place by comparing each Party's emissions during the commitment period with their holdings of AAUs, RMUs, ERUs and CERs (UNFCCC, n.d.).

Three components are used to track and record the amount of emissions for the Parties. First, a national registry, already referred to in Figure 3, is established and maintained by each Annex I Party for keeping accounts of its AAUs, RMUs, ERUs and CERs. Second, the CDM registry is kept at the international level by the Executive Board of the CDM. It contains the CER accounts of non-Annex I Parties participating in the CDM (UNFCCC, n.d.). The third component, a transaction log, which is also managed by the Secretariat of Kyoto Protocol, is used to verify transactions of AAUs, RMUs, ERUs and CERs as they are proposed, including their issuance, transfer and acquisition between registries, cancellation and retirement (UNFCCC, n.d.).

If a Party fails to meet its emissions target by the end of the first commitment period from 2008 to 2012, the Party must make up the difference in the second plus 30 percent commitment period (UNFCCC, n.d.). A penalty of will be added to the target of emissions reduction at the second period. Besides this, the Party must develop a compliance action plan, and its eligibility to "sell" under emissions trading will be suspended (UNFCCC, n.d.).

Global Climate Change and its causes

The atmosphere of the Earth is divided into four layers with distinct temperature profiles. These four layers are troposphere, stratosphere, mesosphere and thermosphere. Each layer is separated by thermal boundaries called pauses. The troposphere, which contains most of the greenhouse gases[11] acts as a protective layer to absorb radiation emitted by the Earth. 70 percent of incoming solar radiation is absorbed by the ocean, atmosphere, land and biosphere. Virtually all absorbed radiation becomes heat (thermal energy) within the materials that absorb it. Eventually, all of this energy is re-radiated in the form of long-wavelength infrared radiation from the Earth back into outer space. Some of the outgoing radiated energy encounters the greenhouse gases that slow down its escape. As a result, the heat energy is retained a little longer in the lower atmosphere, causing the temperature at the surface of Earth to be higher. This effect is called the natural greenhouse effect. Without this effect, the temperature of Earth surface is estimated to be around minus 15 degree, which is not suitable for any living substance to live.

The increased human-induced emissions of greenhouse gases such as CO_2 and CH_4, and other chemical mainly from combustions of fossil fuels (e.g. oil, gas and coal) and change of land-use (e.g. deforestation and agricultural practice) since the Industrial Revolution in the mid 18th century are changing the concentrations of greenhouse gases in the atmosphere. This result is known as the anthropogenic greenhouse effect. The increased concentrations of greenhouse gases in the atmosphere tend to retain more heat energy and therefore cause the increase of temperature at the surface of Earth. Figure 5 shows the magnitude of annual global carbon dioxide (CO_2), methane (NH_4), nitrous oxide (N_2O) and sulphate aerosols (SO_4) releases to the atmosphere from human activities since the industrial evolution.

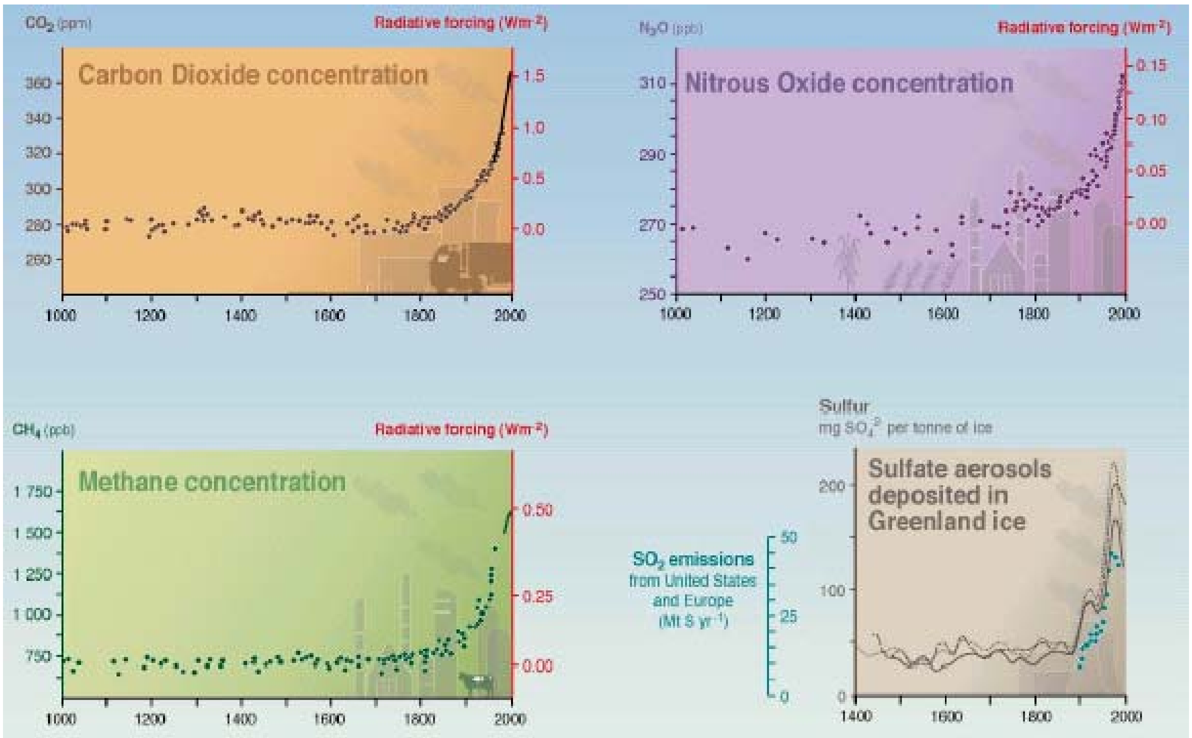

Figure 5: Indicators of Industrial Evolution Anthropogenic Influence on the Atmosphere. Source: Cosmann,N., Gray M. et al (2005). Forestry Projects under the Kyoto Protocol's Clean Development Mechanism: One Response to the Threat of Global Climate Change.

The graphs in Figure 5 show that the atmospheric concentrations of the anthropogenic greenhouse gases were rather constant over hundreds of years before 1800. The observed increases in the atmospheric concentrations of greenhouse gases started during the early 1800s. The CO_2 increased by nearly 30 percent since the pre-industrial times to 2000, CH_4 by more than a factor of two and N_2O by about 15 percent (Watson, 2000). Similarly, the atmospheric concentrations of SO_4 started to increase in the late 1800s due to the combustion of coal (Watson, 2000).

The main reasons for the rapid increase of fossil fuel combustion since the industrial evolution are due to population and economic growth, the energy intensity of equipment and vehicles, energy production and consumption patterns. These changes are in turn influenced by the changes in human lifestyle toward luxurious and comfort, energy and technology costs, settlement and infrastructure patterns, technical progress and overall economic situations (Cosmann & Gray, 2005). During the period of intense industrialization from 1850 to 1998, an estimated 13,000 exajoules of fossil fuel were burned, releasing around 270 (± 30) gigatons (Gt) of carbon into the atmosphere (Watson & Noble, 2000). Along with changes of land-use, fossil fuels have caused atmospheric concentrations of carbon to rise by more than 28 percent for over the past 150 years (Watson & Noble, 2000).

The direct effects of land use and land-use change and the response of terrestrial ecosystems to CO_2 fertilization, nutrient deposition, climatic variation and disturbance (e.g. fires and major draughts) have increased the adverse effects of anthropogenic CO_2 emissions (Cosmann & Gray, 2005). During the period 1850 to 1998, net cumulative of global CO_2 emissions from land-use change are estimated to be 136 (± 55) Gt carbon, assuming that the relative uncertainty of land-use change emissions is the same as the estimate for the 1980s (Watson & Noble, 2000). Of these emissions, about 87 percent were from forest areas and about 13 percent from cultivation of mid-latitude grasslands (Watson & Noble, 2000).

Scientific evidence from the Intergovernmental Panel on Climate Change (IPCC) confirms that climate change is already taking place and that most of the warming observed during the last 50 years is attributable to human activities (Commission of European Communities, 2003). Scientists further project that the rate of change will be more rapid than previously expected due to the rapid economic and demographic growth of developing countries such as China and India where China is now the second biggest

CO_2 emitter after the United States (Commission of European Communities, 2003).

Through the implementation of the Kyoto Protocol mechanisms and the participations of countries in the mechanisms, it is hoped that the amount of greenhouse gases in the atmosphere will maintain at the increase of 2^{o}C per year. On the basis of the second Assessment Report of the IPPC, the EU Council of Ministers stated in 1996 that they "believe that global average temperature should not exceed 2^{o}C above the pre-industrial level[12] in order to slowdown the climate change (Commission of European Communities, 2005). The present concentration of greenhouse gases is already over 440 ppmv[13] and is rising at an average rate of 0.5 percent per year (Commission of European Communities, 2005). To maintain the increase of temperature below 2^{o}C, the concentration of greenhouse gases must be limited around 550 ppmv for coming years (Commission of European Communities, 2005). This would require a significant reduction of greenhouse gases concentration in the atmosphere.

The Implementation of Kyoto Protocol Mechanisms within the European Union

Since January 1, 2005, the Member States of the EU have introduced the first emissions trading period for GHG and specific industrial installations in the EU-25 are requested by law to take part in the first trading period, which is limited to CO_2 and which is to run until 2007. Meanwhile, the international character of the system, which has been confirmed from the beginning of its design, is now in place. Member States are in a position to allow the operators of installations coming under the trading scheme to take part in activities under the JI and CDM in order to achieve their CO_2 emissions targets under the national allocation plan of their Member State of residence. In Germany, the German government has developed a national allocation plan and Germany is committed to reduce its GHG emissions by 21 percent compared to 1990 levels in the first commitment period from 2008 to 2012. Meanwhile, al 25 Member States have their National Allocation Plans adopted and put to practice. At the time of writing, the second round of setting up National Allocation plans is under way and progress can be monitored at the web site of the European Commission[14].

Another issue is the rapid development of specific financial instruments for the marketing of CO_2 certificates. Investment bankers are currently cooperating with brokers in the emissions trading market in order to generate dedicated finance products for the benefit of operators of installation covered by the trading scheme. Complex deals are the outcome, in which the operators, their banks, the investment bankers and the brokers are interrelated.

The combination of all three elements i.e. trading, financial instruments and the CDM mechanism may lead to the involvement of forestry as a potential sink for CO_2 emissions, and, hence as a generator of CO_2 certificates as their equivalents which are able to enter the European Union trading scheme. In that sense, operators of installations coming under the trading scheme may opt for:

1. Reduction of CO_2 emissions at their own site;
2. The purchase of CO_2 emissions certificates generated within the EU; and/or
3. The purchase of CO_2 certificates generated through forestry, also in countries outside the EU.

Consequences the emissions trading scheme for forestry in tropical countries

Background information

The purpose of this section is to discuss some elements of the trading scheme with a specific focus on the third option – the purchase of CO_2 certificates generated by a developing country through forestry under a CDM project. As mentioned in the introduction, CDM is negotiated as a compromise between the different interests of developed and developing countries (Cosmann & Gray, 2005). CDM offers developed countries a chance to lower their GHG emissions at lowest cost through investment in emissions reduction projects or activities in developing countries. In return, the developing countries will be able to achieve sustainable development and contribute to the ultimate objective of the Kyoto Protocol.

One of the reasons for the selection of the third option is that, in many developing countries, where emissions from industry are relatively low, deforestation and forest harvesting are likely to represent a key source of GHG reported under the UNFCCC (FAO, 2005). For example, in Africa, land-use change – essentially deforestation – contributes approximately 70 percent of HG emissions within the region (FAO, 2005). This might due to the fact that the Gross Domestic Product (GDP) of most developing countries depends heavily on agricultural products and natural resources such as

Domain	Natural forest					Forest plantations			Total forest
	Losses			**Gains**	**Net change**	**Gains**		**Net change**	**Net change**
	Deforestation (to other land use)	**Conversion to forest plantations**	**Total loss**	**Natural expansion**		**Conversion from natural forest (reforestation)**	**Affore-station**		
Tropical	-14.2	-1.0	-15.2	+1	-14.2	+1	+0.9	+1.9	**-12.3**
Non-tropical	-0.4	-0.5	-0.9	+2.6	+1.7	+0.5	+0.7	+1.2	**+2.9**
Global	**-14.6**	**-1.5**	**-16.1**	**+3.6**	**-12.5**	**+1.5**	**+1.6**	**+3.1**	**-9.4**

Table 1: Forest Area Changes from 1990 to 2000 in Tropical and Non-Tropical Areas (million hectares per year). Source: FAO (2001). Global Forest Resources Assessment 2000.

wood and other forest products. According to the Food and Agriculture Organization of the United Nations (FAO, 2001), the world's forests covered in 2000 was 3,869 hectares, about 30 percent of the world's land area (FAO, 2001). The net change in forest area was minus 9.4 million hectares per year, representing the difference between a deforestation rate of 14.6 million hectares per year of natural forests and an expansion of 5.2 million hectares per year of natural forests and forest plantations which is shown in Table 1 (FAO, 2001).

Table 1 shows that most of the forest losses were occurred in the tropics where the total loss of natural forest in the tropics is 15.2 million hectares per year compared to 0.9 million hectares per year in non-tropic regions. In addition, a total of 1.5 million hectares per year of natural forests worldwide were converted to forest plantations. As there are many activities been carried out to reduce the dependency on fossil fuels toward renewable energy resources, the possibility of using forests as a carbon sequestration instrument should be exploited as the change of land-use is the second largest contributor to the anthropogenic GHG concentrations in the atmosphere. Besides this, forests produce wood and biomass which are one of the resources of renewable energy.

Forestry projects under the CDM would harness a natural process – the carbon cycle – to reduce the anthropogenic CO_2 in the atmosphere (Cosmann & Gray, 2005). Terrestrial ecological systems, in which carbon is retained in live biomass, decomposing organic matter, and soil, play an important role in the global carbon cycle (IPCC, 2000). Carbon is exchanged between these systems and the atmosphere through photosynthesis, respiration, decomposition and combustion (IPCC, 2000). Photosynthesis is the primary activity that drives the carbon cycle and thus the carbon sequestration in ecosystems (Watson & Noble, 2000). Photosynthesis, also known as primary production, occurs primarily in plants leaves when the green pigments of plants, known as chlorophyll, in the presence of sunlight use water and CO_2 from the atmosphere to produce carbohydrates[15]. Through this process, the CO_2 in the atmosphere is captured and sequestrated, or incorporated into green plants (Watson & Noble, 2000). The total amount of CO_2 that is sequestrated from the atmosphere during photosynthesis in term of carbohydrates (or organic carbons) is known as gross primary production (GPP). Terrestrial GPP has been estimated to be around 120 gigatons per year (Houghton & Ding, 2001).

Presently, several climate mitigation projects have been carried out throughout the world under the LULUCF sector. These include four afforestation and five reforestation projects initiated under the pilot phase for activities implemented jointly, two initiated under the World Bank's Prototype Carbon Fund (PCF), as well as several CDM-type projects (OECD IEA, 2003). Table 2 shows the key characteristics of afforestation and reforestation components of selected LULUCF project activities.

Table 2 shows that most of the afforestation and/or reforestation projects are occurred in potential CDM host countries, in particular in Latin America which consists of high tropical forest cover. Most of the projects are taking place in tropical forests due to the growth rate and regeneration rate in tropical forests are much higher than in temperate and boreal forests. Moreover, vegetation in tropical forests is the biggest carbon stocks in the world. Table 3 shows the global carbon stocks in vegetation and soil carbon pools where tropical forests are the biggest carbon stocks for vegetation while boreal forests are the biggest carbon stocks for soils.

Project name, location and type	To apply for GHG credits?	Size (ha)	Many sites	Expected benefits (kt CO_2)	Project characteristics (A/R components only)	Is harvest expected? Who benefits?
Guaraqueçaba (Brazil)	Yes	713	Yes	852	Reforestation with native species, enhancement of secondary forests, agroforestry (and other components)	Partial (sustainable forest management)
Kilombero (Tanzania)	Yes	12121	No	9365#	Re/afforestation (unclear in project documentation) with 75% pines, 25% eucalyptus	Yes (project developers/operators)
Klinki (Costa Rica), AIJ	Not clear	6000	Yes	7216	Reforestation of margin farmland and pasture to commercial tree plantations (mainly with 1 species)	Partial (for use in long-lived wood products)
Peugeot (Brazil)	No	10000	No	7320	Re/afforestation (unclear in project documentation) of purchased farmland with 30 native species	No
Plantar (Brazil), PCF	Yes	23578	No	4545.4	Reforestation with monoculture plantations (98% of area), assisted regeneration (2% of area)	Yes (100%). Project operator
PROFAFOR (Ecuador), AIJ	Not clear	23102	Yes	2490#	Reforestation of grasslands to create “natural forests” (30% native species), and plantations (maximum 50% of area)	Partial (with replanting planned)
Romania, PCF	Yes	6728	Yes	1900#	Afforestation of degraded agricultural land: 51% monoculture plantations, 41% plantations with two species, remainder reforestation	Yes on some sites – others to remain unharvested
SaskPower (Canada), GERT	Yes	3300	No	191.2	Reforestation with monoculture plantations on lands harvested 1965-1990	Yes (after end of project life)
Scolel Té (Mexico), AIJ	Not clear	3588	Yes	588.1	Reforestation (through planting of pine, cipres and oak) and assisted regeneration (fencing of areas) of currently degraded open pine forest	Yes. Local farmers
SIF, (Chile), AIJ	Not clear	3100	n/a	625.6	Afforestation with monoculture plantations (both pine and eucalyptus) on degraded agriculture land (pasture)	N/a
Sumitomo Forestry, Indonesia	Yes	10000	n/a	3746	Reforestation of degraded forest with six species to create sustainable industrial forest plantations, regeneration of degraded forests	Partial
V&M (Brazil) (potential CDM)	Yes	n/a	No	31400#	Restocking plantations as they are harvested to generate “large areas of sustainably managed plantations”. Credits are generated by using plantation harvest as energy source instead of a fossil fuel (coke)	Yes (100%) – project operator
Viet Nam /Australia, AIJ	Not clear	5	No	646.6	Afforestation to increase availability of genetically improved planting stock. Benefits assume all seed successfully planted in additional A/R activities (but no plans funding for this included in AIJ project activity)	No (seed trees), assumed not for remainder
Virilla (Costa Rica), AIJ	Not clear	1000	Not clear	274.7	Reforestation of pasture with native species to create tree plantations	Yes

The number of credits generated by the project is lower than the expected benefits of the project
* Over the project lifetime

Table 2: Key Characteristics of Afforestation and/or Reforestation Components of Selected LULUCF Project Activities Source: OECD IEA (2003). Forestry Projects: Lessons Learned and Implications for CDM Modalities.

Biome	Area (10^9 ha)	Global Carbon Stocks (Gt C) Vegetation	Soil	Total
Tropical forests	1.76	212	216	428
Temperate forests	1.04	59	100	159
Boreal forests	1.37	88	471	559
Tropical savannas	2.25	66	264	330
Temperate grasslands	1.25	9	295	304
Deserts and semideserts	4.55	8	191	199
Tundra	0.95	6	121	127
Wetlands	0.35	15	225	240
Croplands	1.60	3	128	131
Total	15.12	466	2 011	2 477

Note: There is considerable uncertainty in the numbers given, because of ambiguity of definitions of biomes, but the table still provides an overview of the magnitude of carbon stocks in terrestrial systems.

Table 3: Global Carbon Stocks in Vegetation and Soil Carbon Pools down to a Depth of 1 Meter. Source: IPCC (2000). IPCC Special Report – Land Use, Land-Use Change, and Forestry. Summary for Policymakers.

Table 3 also shows that the current global carbon stocks are much larger in the soils than in vegetation, particularly in non-forested ecosystems in middle and high latitudes (IPCC, 2000).

Although seven out of fourteenth projects listed in Table 2 are eligible to apply for GHG credits under the Kyoto Protocol, none of the projects have yet seek to do so. This shows that even if the carbon sequestration through forestry under a CDM project may lead to more cost effective outcomes in the sense of the generation of a tonne of CO_2, it may not necessarily become (financially) interesting, if the other characteristics are unclear. One example is the transformation of such relatively cheap sequestration techniques into marketable products, in particular in view of the demand for CO_2 certificates by operators of installations in the future. These operators do not necessarily wish to speculate on the price of CO_2 certificates but, instead, require a stable price which will enable them to accurately budget and plan any their climate change strategies. For them, carbon, if it has to have a price at all, should have a predictable price in the future.

This means that techniques for the sequestration of carbon must lead to the creation of financial instruments which can be sold in markets under the emission trading scheme. In that way, forests, in particular in developing countries, may become valuable as assets for the sequestration of CO_2 emissions and the generation of subsequent CO_2 certificates. This may help governments in such countries to redress their forestry policies in the direction of sustainability because through the sale of CO_2 certificates to operators of installations in the EU emissions trading scheme, they dispose of financial incentives. Hence, it is of interest to investigate which steps need to be taken for this policy view to become successful.

Case study on Malaysia

Malaysia can be selected as a case study where she has a better and more systematic forest management system compared to neighbourhood countries in Southeast Asia, such as Indonesia, Cambodia and the Philippines. Malaysia is a federation of 13 states and two federal territories. The country is divided into two sub-regions: Peninsular Malaysia and Sabah and Sarawak which are located on the Borneo Island. Currently, Peninsular Malaysia is using the Selective Management System (SMS) in its logging activities whereas Sabah has adopted a modification of the monocyclic Malayan Uniform System (MUS) (FAO, 2001). Sarawak employs a polycyclic system based on selective logging (FAO, 2001).

With a land mass of 32.855 million hectares, a total of 20.89 million hectares or equivalent to 63.6 percent of the total land mass of Malaysia is still covered with forests (FAO, 2005). The climate of Malaysia is typically humid tropical and is characterized by year round high temperatures and seasonal heavy rain (FAO, 2005). As a result of these climate conditions, the predominant natural vegetation is tropical rain forest, the main forest types being species-rich lowland

Country / Area	Forest[16]							Other wooded land[17]		
	Area			Annual change rate				Area		
	1990	2000	2005	1990-2000		2000-2005		1990	2000	2005
	1000 ha	1000 ha	1000 ha	1000 ha/yr	%	1000 ha/yr	%	1000 ha	1000 ha	1000 ha
Brunei Darussalam	313	288	278	-2	-0.8	-2	-0.7	142	155	160
Cambodia	12,946	11,541	10,447	-140	-1.1	-219	-2.0	335	298	270
Indonesia	116,567	97,852	88,495	-1,872	-1.7	-1,871	-2.0	-	-	-
Lao People's Democratic Republic	17,314	16,532	16,142	-78	-0.5	-78	-0.5	2,875	4,053	4,643
Malaysia	**22,376**	**21,591**	**20,890**	**-78**	**-0.4**	**-140**	**-0.7**	**-**	**-**	**-**
Myanmar	39,219	34,554	32,222	-466	-1.3	-466	-1.4	10,219	10,629	10,834
Philippines	10,574	7,949	7,162	-262	-2.8	-157	-2.1	2,230	3,292	3,611
Singapore	2	2	2	0	0	0	0	0	0	0
Thailand	15,965	14,814	14,520	-115	-0.7	-59	-0.4	-	-	-
Timor-Leste	966	854	798	-11	-1.2	-11	-1.3	-	-	-
Viet Nam	9,363	11,725	12,931	236	2.3	241	2.0	0	1,816	2,259
Total South-east Asia	**245,605**	**217,702**	**203,887**	**-2,788**	**-1.2**	**-2,762**	**-1.4**			
Total World	**4,077,498**	**3,988,649**	**3,952,063**	**-8,885**	**-0.2**	**-7,317**	**-0.2**			

Table 4: Change in the Extent of Forest and other Wooded Land of Countries in Southeast Asia from 1990 to 2005. Source: FAO (2005). Global Forest Resources Assessment 2005.

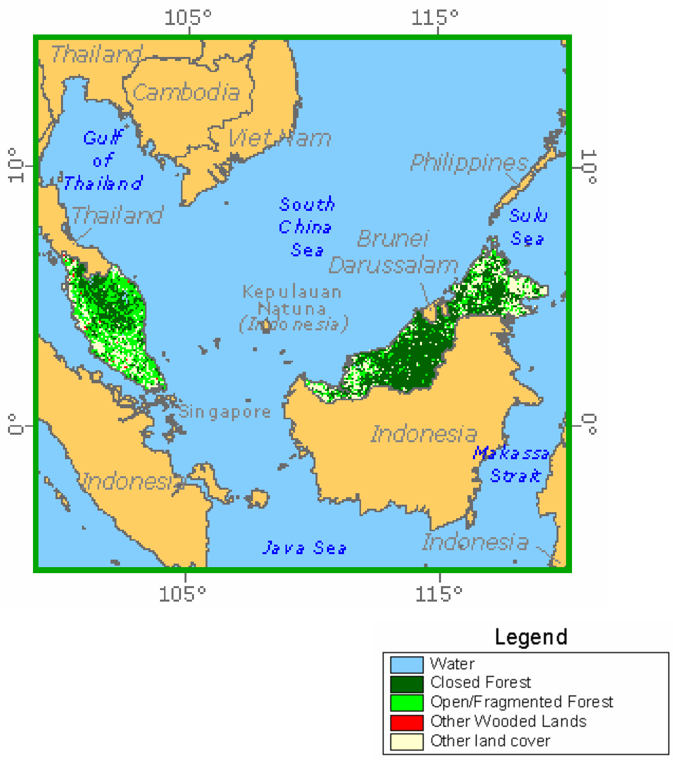

***Figure 6: Forest Cover of Malaysia in 2005** Source: FAO (2005). Forest Cover – Natural Woody Vegetation.*

and hill dipterocarp forest, peat swamp forest, freshwater swamp forest and mangrove (FAO, 2005). Figure 6 shows the geographic location of Malaysia and the area of forest cover which is mainly closed forest, open and/or fragmented forest.Although more than 60 percent of the land mass in Malaysia is still covered with forests, the FAO has estimated that Malaysia lost about 700,000 hectares of forest from 2000 to 2005. Table 4 shows the statistics of change in the extent of forest and other wooded land of the countries in Southeast Asia from 1990 to 2005.

Table 4 shows that the deforestation rate in Malaysia has increased from 0.4 percent per year in 1990-2000 to 0.7 percent in 2005 and the total forest lost is increasing from 78,000 hectares per year to 140,000 hectares per year since 2000. Although the deforestation rate in Malaysia is relatively low compared to most countries in the region i.e. Indonesia and Cambodia have around 2 percent of deforestation rate per year, this rate is still relative high compared to the total world deforestation rate which is 0.2 percent per year from 1990 to 2005.

The change of forest cover in Malaysia has also an effect on the biomass stock in forest. The total biomass stock in forest in Malaysia has decreased by 1.2 percent from 2000 to 2005. Table 5 shows the biomass stock in Malaysian forest from 1990 to 2005.

FRA 2005 categories	Biomass[18] (million metric tonnes oven-dry weight)		
	1990	2000	2005
Above-ground biomass	5,683	5,729	5,661
Below-ground biomass	1,364	1,375	1,359
Total living biomass	**7,047**	**7,104**	**7,020**
Dead wood	1,057	1,066	1,053
Total	**8,104**	**8,170**	**8,073**

Table 5: Biomass Stock in Forest in Malaysia from 1990 to 2005. Source: FAO (2005). Global Forest Resources Assessment 2005.

Despite of the high deforestation rate, the current terrestrial ecosystem in Malaysia still acts as a global sink for carbon. This is shown in Table 6.

FRA 2005 categories	Carbon (million metric tones)		
	1990	2000	2005
Carbon in above-ground biomass	2,842	2,864	2,831
Carbon in below-ground biomass	682	687	679
Carbon in living biomass	**3,524**	**3,551**	**3,510**
Carbon in dead wood	529	533	526
Carbon in litter	-	-	-
Carbon in dead wood and litter	**529**	**533**	**526**
Soil carbon	-	-	-
Total	**4,053**	**4,084**	**4,036**

Table 6: Current Carbon Stock in the Forest in Malaysia from 1990 to 2005. Source: FAO (2005). Global Forest Resources Assessment 2005.

Table 6 shows that the above-ground biomass stores the highest carbons in forests in Malaysia. The forests in Malaysia were acting as a sink from 1990 to 2000 by sequestrating on average 3 million metric tonnes of carbon per year. This is rather strange by comparing the amount of carbon storage from 1990 to 2000 to the amount of deforestation rate in Malaysia, which averaging 0.4 percent per year. From 2000 to 2005, a total of 48 million metric tonnes of carbon has been released into the atmosphere with an annual deforestation rate of 0.7 percent. This shows a rapid increase of 9.6 million tonnes per year of carbon released compared to an average of 3 million tonnes of carbon sink from 1990 to 2000.

The other reason for the selection of Malaysia as an interesting research area is that the opportunity cost of afforestation and/or reforestation in Malaysia is much lower compared to EU Member States. It is well known that, within the EU, the Common Agricultural Policy (CAP) provides for large subsidies to encourage farmers in the EU to conduct agricultural activities. Hence, farmers converting agricultural land into forest land face a loss of subsidy income which is mostly for ever because afforestation is a non-reversible decision. Since agricultural subsidies do not exist in Malaysia it can be expected that it is more economic for Malaysian land users to carry out afforestation and/or reforestation than for farmers in EU Member States.

Land uses in the context of CDM

According to the Kyoto Protocol, forestry projects under the CDM must lead to real, additional and long-term emission reductions. Through this mechanism, the forestry projects must contribute to sustainable development in the developing countries where the projects are being carrying out. Article 3.3 of the Kyoto Protocol describes those LULUCF activities compensating for GHG emissions by sources and removals by sinks resulting from direct human-induced activities to be accounted for by Annex I Parties in the first commitment period (Watson & Noble, 2000). These activities are restricted to afforestation, reforestation, and deforestation (ARD) which have occurred since 1990 (Watson & Noble, 2000).

The Marrakech Accords allows only two kinds of forestry projects under the CDM:

1. **reforestation**, defined as the planting of forests on lands which have, historically, previously contained forests but which have been converted to some other use; and
2. **afforestation**, or defined as the establishment of forest on land that has been without forest for a period of time (e.g. 20 to 50 years or more) and was previously under a different land use (Watson & Noble, 2000).

It should be noted that the Marrakech Accords specify also the limit of the total amount of CERs that can be generated via LULUCF CDM project activities. CERs generated from such LULUCF CDM forestry projects may only be used to help meet emission targets up to one percent of each Annex I Party baseline for each year of the commitment year (UNFCCC, n.d.). This means that each Annex I Party can only use CERs generated by CDM forestry projects to help meet targets up to five percent of the total committed baseline within five years of the commitment period from 2008 to 2012. This limit means that the current Annex I Parties are allowed by the Marrakech Accords to use up to 424.1 million tonnes of CO_2 of credits from CDM A/R activities to offset domestic emissions (OECD IEA, 2003).

In addition, the Tenth Conference of the Parties held in Buenos Aires in December 2004, has provided additional guidelines for CDM forestry projects as agreement has been reached on many definitions of LULUCF issues stated in the Kyoto Protocol (Cosmann & Gray, 2005). For instance, a “forest” under the CDM was defined according to minimum size (0.1 to 1 hectare), minimum crown cover (10 to 30 percent) and minimum height of trees (2 to 5 metres) (Cosmann & Gray, 2005). Therefore, the measurement of sequestration occurs in CDM forestry projects will be facilitated by such definitions (Cosmann & Gray, 2005).

The impacts of CDM forestry projects on the socio-economic of wood industry sector in Malaysia

As mentioned in Section 3.2, Malaysia faces a deforestation rate of 0.7 percent from 2000 to 2005. One of the reasons of the deforestation in Malaysia is that forests are the source of timber and wood products, which play a major role in the socio-economic development in the country. The export earnings of the industry were increasing by 18.9 percent from 2003 to RM 19.8 billion (equivalent to 4.4 billion Euro[19]) in 2004(Malaysian-German Chamber of Commerce, 2006). The forestry and timber sector employs 3.6 of the percent workforce in the country and accounts around for 3.4 percent of GDP and for 4.4 percent of total merchandise export earnings in 2003 (Malaysian-German Chamber of Commerce, 2006). The major products exported from Malaysia were plywood (RM 5.6 billion), furniture (RM 5.5 billion), builders’ carpentry and joinery (RM 1.1 billion) and fibreboard (RM 1 billion) (Malaysian-German Chamber of Commerce, 2006). Under the Ninth Malaysian Plan from 2006 to 2010, it is stated that around 26 million m^3 of forestry and timber products was produced in 2005, with around 9 million m^3 been exported to other countries (Utusan Melayu, n.d.). This shows that the forestry and wood industry is a high resource demanding industry. Presently, it is facing a number of challenges including the need to seek for an adequate supply of raw material to sustain its growth.

The wood industry in Malaysia is predominately owned by local companies (Malaysian-German Chamber of Commerce, 2006). It is estimated that 80 percent of timber-based companies are small and medium-size, while for the furniture industry, 90 percent are small and medium-sized (Malaysian-German Chamber of Commerce, 2006). Most timber-based companies are also forest developers who supply themselves with raw material. Not all timber-based companies are harvesting their forests using sustainable harvesting method and most of them are reluctant to replant the area after harvesting due to high plantation cost and long waiting term in term of profit return. By participating in the CDM project, it gives the timber-based companies in Malaysia temporary income to sustain the waiting period (15 years on average) for trees to reach its maturity.

Since the Kyoto Mechanisms are now allowed and must be used, CDM and JI projects are now also allowed. The EU Directive states that Member States must specify a percentage of the “cap” for which operators of ETS installations may hold CERs, instead of, for example, buying EUA, or, certificates. For example, under the new German National Allocation Plan (NAP) for trading period of 2008 to 2012, the German Government has established that the industrial installations taking part in the emission trading scheme (ETS) will have a limit (the “cap”) of 482 million tonnes of CO_2 equivalents per year. The NAP states that, for each year from 2008 to 2012, this percentage is set at 12 percent which is equivalent to 60 million tons per year.

This means that operators of ETS installations may choose to have several options in respect of achieving their obligations. They may actively reduce their CO_2 emissions, they may trade EUAs and the may participate in the CDM projects. But by 2012 the operators must be able to show that they:

1. have no more emissions that those allocated to them in the Microplan. This means that they have an amount of EUA plus an amount of allocated to them in the Microplan;
2. have more emissions than those allocated to them in the Microplan. The excess is held as EUAs purchased on the market; and
3. have less emissions than those allocated to them in the Microplan. They may possess some EUA or CERs in addition.

If for example, in situation (2), some day before the deadline, if the share of CERs held is higher than 12 percent, the operator of the installation will have to sell CERs in exchange for EUAs in order to achieve the 12 percent status. This means that CERs will be traded also within the EU ETS. Assume, by way of example, that 5 percent of the 60 million tons would be offset by CDM forestry projects in Malaysia each year for 5 years. This means that 15 million tons of CO_2 will be offset through CDM forestry projects in Malaysia. Assume again that one CER is equivalent to 5 to 6 Euro in over the second trading period, than the total income for the forestry sector in Malaysia will be around 65 to 90 million Euro, which is equivalent to 290 million to 400 million Ringgit[20] per annual. This represents around 1.5 to 2.0 percent of the total export earning of the forestry and timber sector in 2004.

By making this assumption, it can be concluded that the CDM qualifying afforestation and reforestation projects might be interesting for CDM project developers in a developing country like Malaysia. The project developers in the country will be more eager to conduct afforestation and reforestation in order to benefit from selling CERs to countries in the Annex I Parties under Kyoto Protocol, for example, Germany. This may set an incentive to Malaysia to develop a policy on CDM and participation in the global mechanism of transfer CO_2 allowances to other countries. Besides this, the financial advantages through the CDM qualifying afforestation and reforestation projects may help the Malaysian government to redress its forestry policies in the direction of sustainability.

Therefore, it can be concluded that the trading scheme with a specific focus on the purchase of CO_2 certificates generated through afforestation and reforestation can benefit both developing and developed countries. Operators of installations in developed countries will be able to meet the target set for EU Member States while project developers in developing countries will receive income to conduct the CDM qualifying afforestation and reforestation projects. The results of the trading scheme meet the aim of the CDM projects to help developing countries to achieve sustainable development and contribute to the ultimate objective of the Kyoto Protocol.

Notes

1. The six greenhouse gases listed under the Kyoto Protocol are carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs) and sulphur hexafluoride (SF_6).
2. See, e.g. Directive 2004/101/EC of the European Parliament and of the Council of 27 October 2004 amending Directive 2003/87/EC establishing a scheme for greenhouse gas emission allowance trading within the Community, in respect of the Kyoto Protocol's project mechanisms. O.J. 13.1.2004, L 338/18 ff.
3. The industrial installations that are involved in the emissions trading are combustion plants, oil refineries, coke ovens, iron and steel plants, and factories making cement, glass, lime, brick, ceramics, pulp and paper.
4. So far, these issues are only being debated. At present, work is concentrating on the new national allocation plans for the trading period of 2008 to 2012. See European Commission: Communication from the Commission. Further guidance on allocation plans for the 2008 to 2012 trading period of the EU Emission Trading Scheme. COM (2005), 703 final, 12.12.2005.
5. The list of Annex I Parties can be found under the following website of UNFCCC http://unfccc.int/parties_and_observers/parties/annex_i/items/2774.php
6. The list of non-Annex I Parties can be found under the following website of UNFCCC. http://unfccc.int/parties_and_observers/parties/non_annex_i/items/2833.php
7. The reduction of carbon through land-use change and forestry sector is also referred as “sink”.

8. Removed Units (RMUs) are issued on the basis of land use, land use change and forestry (LULUCF) activities which are often referred as "sinks" activities.
9. Directive 2003/87/EC of the European Parliament and of the Council of 13 October 2003 establishing a scheme for greenhouse gas emission allowance trading within the Community and amending Council Directive 96/61/EC, O. J. 25.10.2005, L 275/32 ff.
10. Council Decision 2002/358/EC of 25 April 2002 concerning the approval, on behalf of the European Community, of the Kyoto Protocol to the United Nations Framework Convention on Climate Change and the joint fulfillment of commitments thereunder, O. J. 15.05.2002, L 130.
11. The greenhouse gases in the atmosphere are carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), ozone (O_3), chlorofluorocarbons (CFCs), hydrogenated halocarbons (HFCs and HCFCs) and water vapour (H2O).
12. 1939th Council Meeting, Luxembourg, 25 June 1996.
13. „ppmv" means part per million
14. See http://ec.europa.eu/environment/climat/2nd_phase_ep.htm
15. The chemical reaction involved in photosynthesis is: $6CO_2 + 6H_2O$ (+ sunlight) → $C_6H_{12}O_6 + 6O_2$. $C_6H_{12}O_6$ is known as carbohydrate or sugar.
16. According to Forest Research Assessment (FRA, 2005), forest is defined as land spanning more than 0.5 hectares with trees higher than 5 meters and a canopy cover of more than 10 percent, or trees able to reach these thresholds in situ. The term "forest" does not include land that is predominantly under agricultural or urban land use.
17. Other wooded land has been defined as land that is not classified as forest, spanning more than 0.5 hectares; with trees higher than 5 meters and a canopy cover of 5 to 10 percent, or trees able to reach these thresholds in situ; or with a combined cover of shrubs, bushes and trees above 10 percent. Other wooded land does not include land that is predominantly under agricultural or urban land use.
18. According to FRA (2005), biomass is defined as organic material both above-ground and below-ground, and both living and dead, for examples trees, crops, grasses, tree litter, roots and others.
19. Based on exchange rate of 1 Euro to RM4.50
20. Based on the exchange rate of 1 Euro to RM4.50

References

Commission of European Communities. (2003). *Extended Impact Assessment on the Directive of the European Parliament and of the Council Amending Directive establishing a Scheme for Greenhouse Gas Emission Allowance Trading within the Community, in Respect of the Kyoto Protocol's Project Based Mechanisms.* COM(2003)403 Final

Commission of European Communities. (2005). *Communication from the Commission to the Council, the European Parliament, the European Economic and Social Committee and the Committee of the Regions – Winning the Battle Against Global Climate Change.* COM(2005)35 Final.

Cosmann, N., Gray M. et al. (2005). *Forestry Projects under the Kyoto Protocol's Clean Development Mechanism: One Response to the Threat of Global Climate Change*. Retrieved October 21, 2005 from http://www.columbia.edu/cu/mpaenvironment/ pages/projects/sum2005/Kyoto%20Final%20Report%20Sum2005.pdf

Food and Agriculture Organization of the United Nations (FAO). (2001). *Global Forest Resources Assessment 2000.* Retrieved October 18, 2005 from http://ww.fao.org/forestry/site/fra2000report/en

Food and Agriculture Organization of the United Nations (FAO). (2005). *Introduction*. Retrieved November 18, 2005 from http://www.fao.org/forestry/site/5966/en/mys

Food and Agriculture Organization of the United Nations (FAO). (2005). *State of the World's Forest 2005*. Retrieved October 26, 2005 from ftp://ftp.fao.org/docrep/fao/007/y5574e/y5574e00.pdf

Forestry Department, Food and Agriculture Organization of the United Nations (FAO). (2004). *Global Forest Resources Assessment Update 2005*. *Terms and Definitions*. Retrieved November 15, 2005 from ftp://ftp.fao.org/ docrep/ fao/007/AE156E/AE156E00.pdf

Houghton, J.T., Ding, Y. et al (2001). *Climate Change 2001: The Scientific Basic*. Retrieved November 1, 2005 from http://www.grida.no/climate/ ipcc_tar/wg1/index.htm

Intergovernmental Panel on Climate Change (IPCC). (2000). *Land Use, Land-Use Change, and Forestry*. *Summary for Policymakers*. Retrieved October 25, 2005 from http://www.grida.no/ climate/ipcc/spmpdf/srl-e.pdf

Malaysian-German Chamber of Commerce (2006). *Market Watch 2005 – Sector Timber in Malaysia*. Retrieved October 16, 2006 from http://www.ihk-nordwestfalen.de/marktkontakt/ bindata/AHKStudieTimber2005.pdf

Organization for Economic Co-operation and Development (OECD) Environment Directorate and International Energy Agency (IEA). (2003). *Forestry Projects: Lessons Learned and Implications for CDM Modalities.* COM/ENV/EPOC/IEA/SLT(2003)1.

Schlamadinger, B. & Marland, G. (2000). *Land Use and Global Climate Change – Forest, Land Management and the Kyoto Protocol.* Retrieved August 9, 2005 from http://www.pewclimate.org/ docUploads/land%5Fuse%2Epdf

United Nation Framework Convention on Climate Change (UNFCCC). (n.d.). *Kyoto Protocol*. Retrieved June 28, 2005 from http://unfccc.int/ essential_background/kyoto_protocol/ items/3145.php

United Nation Framework Convention on Climate Change (UNFCCC). (n.d.). *Land Use, Land-Use Change and Forestry (LULUCF)*. Retrieved June 28, 2005 from http://unfccc.int/ methods_and_science/lulucf/items/3063.php

United Nation Framework Convention on Climate Change (UNFCCC). (n.d.). *Registry Systems*. Retrieved June 28, 2005 from http://unfccc.int/ kyoto_mechanisms/registry_systems/items/2723. php

United Nation Framework Convention on Climate Change (UNFCCC). (n.d.). *The Kyoto Mechanisms: Joint Implementation Projects.* Retrieved June 28, 2005 from http://unfccc.int/kyoto_mechanisms/ji/items/ 1674.php

Utusan Melayu. (n.d.). *The Ninth Malaysia Plan, 2006-2010*. Retrieved October 13, 2006 from http://www.utusan.com.my/utusan/SpecialCover age/RMK9/bahasa/Bab3.pdf

Watson, R., Noble, I. R. et al (2000). *IPCC Special Report on Land Use, Land-Use Change and Forestry*. Retrieved October 27, 2005 from http://www.grida.no/climate/ipcc/land_use/

Watson, R. (2000). *Intergovernmental Panel on Climate Change (IPCC) at the Sixth Conference of Parties to the United Nations Framework Convention on Climate Change (UNFCCC).* Retrieved October 29,2005 from http://www.ipcc.ch/press/sp-cop6.htm