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Carbon Markets and Mitigation Strategies for Africa/Ethiopia: Literature Review and the Way Forward

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Carbon Markets and Mitigation Strategies for Africa/Ethiopia: Literature Review and the Way Forward

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Foreword

Currently climate change is a development agenda across the globe. It has become a serious threat to sustainable economic growth and development worldwide and across developing countries in particular. The African region is highly vulnerable to climate change due to its poor economic base, structural rigidity, rain-dependent agriculture, widespread natural resources degradation and depletion, excess livestock population and loss of soil fertility, among others. Ethiopia is one of the countries that have been seriously affected by climate change. In response the country is taking far-reaching initiatives to combat the negative consequences of climate change and build a green economy.

The Ethiopian Development Research Institute (EDRI), School of Economics of Addis Ababa University, and the Environmental Economics Policy Forum for Ethiopia (EEPFE) Project have been engaged in desk review studies on three sub-themes of climate change, viz. "Climate Finance, Climate Conventions, Carbon Markets and Implication for Africa/Ethiopia". The reports are produced in three separate volumes pertaining to each sub-theme. This volume focuses on "***Carbon Markets and Mitigation Strategies for Africa/Ethiopia***". The global carbon market has been in effect since the Kyoto Protocol. The volume/value of carbon transactions has grown to some extent since then. However, it is widely recognized that African countries are not benefiting to the desired level. Based on the available literature and documents, this component of the broader study theme analyzes the challenges and opportunities of the global carbon market and carbon trading from the perspectives of Africa and Ethiopia. The discussion herein is hoped to foster mutual understanding and insights on issues of carbon markets that are at stake for developing countries in general and Africa in particular.

I take this opportunity to thank the researchers, including Zenebe Gebreegziabher, Alemu Mekonnen, Adane Tufa, and Assefa Seyoum. I also would like to acknowledge the support provided by the African Capacity Building Foundation (ACBF) and the Environmental Economics Policy Forum for Ethiopia (EEPFE) Project.

Newai Gebre-ab
Executive Director

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Acronyms

A/R	Afforestation/ Reforestation
AAU	Assigned amount unit
CBO	Community Based Organizations
CDM	Clean Development Mechanism
CERs	Certified Emissions Reduction
DRC	Democratic Republic of Congo
EPA	Environmental Protection Authority/Agency
ERUs	Emissions Reduction Units
EU ETS	European Union Emissions Trading Scheme
FEM	Forest Enterprise Management
GHG	Green House Gases
IET	International Emissions Trading
IMF	International Monetary Fund
IPCC	Inter-governmental Panel on Climate Change
JFM	Joint forest Management
JI	Joint Implementation
LUCF	Land Use Change and Forestry
MAC	Marginal Abatement Cost
NB	Net Social Benefits
OTC	Over The Counter
PCF	Prototype Carbon Fund
REDD	Reducing Emissions from Deforestation and Forest Degradation
UN	United Nations
UNFCCC	United Nations Framework Convention on Climate Change
VERs	Verified Emission Reductions
WB-FCPF	World Bank-Forest Carbon Partnership Facility

Abstract

Climate change is a serious threat to Africa, in general, and sub-Saharan Africa, in particular, as it is expected to have significant economic, social, and environmental impacts. Although the region has the lowest average per capita greenhouse gases (GHG) emission, it is particularly vulnerable to climate change because of its overdependence on rain-fed agriculture, compounded by factors such as widespread poverty and weak capacity to adapt. Climate change is a global issue, and international collective action will be critical in driving effective, efficient, and equitable mitigation and adaptation responses on the scale required. This report explores mitigation strategies for Africa taking the global carbon market(s) as an opportunity. There appears to be a number of mitigation options for Africa/Ethiopia including clean energy, energy efficiency, improved livestock systems, afforestation, avoided deforestation and forest degradation, and improved land management practices—to mention few.

Keywords: climate change; carbon markets; mitigation strategies; Africa;

Executive summary

The climate change challenge

Climate change is a serious threat to Africa, in general, and sub-Saharan Africa, in particular, as it is expected to have significant economic, social, and environmental impacts. Although the region has the lowest average per capita greenhouse gases emission, it is particularly vulnerable to climate change because of its overdependence on rain-fed agriculture, compounded by factors such as widespread poverty and weak capacity to adapt.

Climate change is a global issue, and international collective action will be critical in driving effective, efficient and equitable **mitigation** and **adaptation** responses on the scale required. This report explores mitigation strategies for Africa/Ethiopia taking the global carbon market(s) as an opportunity.

Economics/ Theory

The problem of **climate change** is a **negative externality** problem where emitters of **greenhouse gases** (GHGs) do not face the full cost implications of their actions. The two most common market-based instruments employed to enforce the quantitative limit of emission targets and internalizing the **negative externality** are emissions/carbon taxes and cap and trade. A tax on a negative externality is called a **Pigovian tax** and should equal the **marginal damage costs**. However, cap-and-trade has come to be the most popular ones. In the cap and trade system each country, large-scale emitter, or company, will have a limit on the amount of GHG that it can emit, also known as "emissions permit". These permits set an enforceable limit, or **cap**, on the amount of GHG that the company/country is allowed to emit. Then **trade in emissions could take place as** it will be relatively cheaper or easier for some countries/companies to reduce their emissions beyond what is implied by their permit than others. These more efficient countries/companies, who emit less than their allowance, can sell their extra permits to companies that are not able to make reductions as easily. This creates a system that guarantees a set level of overall reductions, while rewarding the most efficient countries/companies and ensuring that the **cap** can be met at the lowest possible cost to the economy.

Carbon markets and carbon prices

The global carbon market has emerged quite considerably during the last decade and particularly since the **Kyoto Protocol.** The **Protocol** defines several **flexible mechanisms**: **Clean Development Mechanism** (CDM), **Joint Implementation** (JI), and **Emissions Trading,** that are designed to allow **Annex I countries** to meet their emission reduction commitments (caps) with reduced economic impact. The **CDM** and **JI** mechanisms are requirements for projects which create a supply of emission reduction instruments, while **Emissions Trading** allows those instruments to be sold on international markets. Latin America and Asia-Pacific host 95% of the CDM projects with China, India, and Brazil being the countries that benefited most, both in terms of number of projects and volume of related emissions. In terms of sectoral composition of GHG emissions, while emission from the energy sector is the most important one, **non-energy emissions** make up one-third of total GHG emissions. Within **non-energy emissions**, the combined contribution of emissions from deforestation and forest degradation account for about 18% of the global GHG emissions. The World Bank Forest Carbon Partnership Facility (WB-FCPF) and the United Nations REDD (UN REDD) program assist developing countries in their efforts to **r**educe **e**missions from **d**eforestation and forest

degradation—**called REDD**—by providing value to standing forests. Essentially **CDM** and **REDD** are the two carbon market mechanisms where Africa can be involved.

A distinction is also made between **mandatory** (regulated) and **voluntary** markets. The mandatory market mechanisms are meant to reach the goals defined in the **Kyoto Protocol**, with the least economical costs. A well-known mandatory local emissions trading scheme is the **European Union Emissions Trading Scheme** (EU ETS). In contrast to the strict rules set out for the **mandatory market**, the **voluntary market** provides companies with different options to acquire emissions reductions.

A solution, comparable with those developed for the mandatory market, has been developed for the voluntary market.

While some mandatory emission reduction schemes exclude forest projects, these projects flourish in the voluntary markets.

Despite the global economic downturn, the global carbon trading market grew 68 percent in 2009 compared with the previous year. But the value of the market remained virtually unchanged after carbon prices fell. In terms of the size of the market, the global carbon market reached US$136 billion in 2009, up from US$133 billion in 2008 and US$58 billion in 2007.

Carbon markets and mitigation strategies for Africa
Africa currently contributes only about 4% of global GHG emissions. Energy emissions and emissions from agriculture account for about 86 percent of aggregate GHG emissions of the continent. Africa's forest resources are serving as sink for about 25 percent of its emissions. Mitigation actions are necessary not only to enhance sustainable development but also prevent the continent from becoming a major emitter. Mitigation strategies that appear to be of comparative advantage to Africa are listed below.

Clean energy development: Given the untapped renewable energy resources potential—including hydro, solar, and wind—the continent can emphasize on clean energy development and step-by-step replace the fossil-fuel based systems by clean energy both on and off-grid options. This could be in the form of either individual country projects or cross-border cross-country investments.

Mitigating emissions from livestock systems: Agricultural emission related with methane emission from livestock is the second most important emitter in the continent. It accounts for about 96 percent of the aggregate emission for countries like Benin. Therefore, Africa could take adequate care of the emissions from livestock systems. GHG emissions from livestock systems can be reduced significantly through technologies, policies, and the provision of adequate incentives for their implementation.
The most important ways include better feed management, using more productive livestock breeds or shifting species, manure management, and methane capture through biogas.

Avoided deforestation (and forest degradation): Avoided deforestation (and forest degradation) through mechanisms such as REDD could be potentially beneficial for a number of African countries. The Democratic Republic of Congo, Cameroon, Tanzania, and Madagascar can be viewed as priority countries for REDD.

Afforestation/reforestation: The afforestation and reforestation activities undertaken in the continent can be viewed as mitigation options and be linked to CDM with the condition that these activities occur on land that had no forest at the end of 1989.

Bio-energy and energy efficiency: This involves many innovative projects aimed at replacing unsustainable fuelwood use with sustainable biomass or biogas, or reducing unsustainable fuelwood use through more efficient cooking stoves.

Improvements in agricultural and land management practices: These can also have substantial potential as carbon sink, for example, soil carbon sequestration. Massive soil and water conservation activities such as those in Ethiopia can be viewed in this light. Grazing systems can enhance the removal of CO_2 from the environment, hence selected rangeland systems can be linked to carbon finance for their agro-ecosystem services/contribution as a carbon sink and to provide income diversification options for pastoralists.

1. Background

Major international environmental problems include global biodiversity, acid rain, stratospheric ozone depletion, and GHG (greenhouse gases) emissions of which CO_2 is the most important.[1] Economic activities give rise to flows of GHG emissions. All nations are emitters of GHGs and each is affected by the emissions of all others; thus, GHG emissions can be thought of both as a reciprocal spillover problem and as a global public 'bad'. The principal GHG—carbon dioxide—is derived mainly from **fossil-fuel use**, but an important contribution is also made by **deforestation**. **Climate change** is driven by the atmospheric concentration of GHGs, and by the rate of change of those concentrations through time.

Climate change is a real threat to our planet. Most scientists agree that the warming in recent decades has been caused primarily by human activities that have increased the amount of GHGs in the atmosphere. GHGs, such as carbon dioxide, have increased significantly since the Industrial Revolution, mostly from burning of fossil fuels for energy, industrial processes, and transportation as well as from deforestation. Carbon dioxide levels are at their highest in at least 650,000 years and continue to rise (US NAS 2008).

Two key messages that stand out in the climate change discussion are that developed countries must take the lead in combating climate change and that mitigation will be neither effective nor efficient without large efforts by developed countries. And, developing countries must also play their role in combating climate change. At the same time, a third crucial dimension to meet the global climate change challenge is equity. That is, while developing countries have contributed little to the problem historically, their development is jeopardized by climate change. Hence, an equitable approach to limit global emissions of GHGs has to recognize that developing countries have legitimate development needs. Financial flows from developed to developing countries in relation to climate change represent the principal way to reconcile equity with effectiveness and efficiency in dealing with the problem. In this regard, climate finance or funding requirement for mitigation, adaptation, capacity building, as well as technology development and transfer are massive. There are also claims that the newly proliferating multilateral climate funds require improvement and reform. A number of environmental agreements/climate conventions—such as the Kyoto Protocol—have been designed, ratified and implemented by many countries, ever since the recognition that climate change would have adverse consequences on human kind. However, the short-run and long-run implications of these conventions for Africa have not been critically examined. In addition, although the global carbon market has emerged quite substantially during the last decade and particularly since the **Kyoto Protocol**, there is a widespread discontent that Africa has not benefited from the carbon market in general and the Clean Development Mechanism (CDM) in particular. Hence, key questions include: How should Africa use the carbon market? What possible mitigation strategies or options are there for Africa in general and Ethiopia in particular to benefit from this opportunity?

Understanding the opportunities created by the global carbon market and the challenges involved for Africa is important to efficiently utilize this mechanism. By assessing and documenting carbon market issues as it pertains to Africa in general and Ethiopia in particular, the study seeks to enhance better informed decision making and mutual understanding in the climate discussion. More specifically, the objective of the study is assessing and examining

[1] In this paper we use the term **carbon** and **GHGs** interchangeably.

mitigation options for Africa/Ethiopia by taking the global carbon market (and carbon trading) as an opportunity. Finally, the study will draw implications (opportunities/challenges) for Africa/Ethiopia and will suggest the way forward.

The report is organized in seven sections. In the next section we briefly present the climate change challenge. Section three presents the economics/theory underlying determination of optimal level of emissions, emissions trading, and the instruments involved in controlling/reducing emissions. Section four focuses on the Kyoto Protocol and carbon markets while section five presents the determination of carbon prices and price trends. Section six provides carbon markets and mitigation strategies for Africa/Ethiopia. The last section presents summary, conclusions, and the way forward.

2. The climate change challenge

As Lord Stern puts it, climate change is 'the greatest and widest-ranging ever seen market failure' (Stern 2007). Climate change is a serious threat to the world in general and to Africa in particular. It is expected to have significant economic, social, and environmental impacts. Africa's overdependence on rain-fed agriculture, compounded by factors such as widespread poverty and weak capacity make the continent particularly vulnerable to climate change. Hence, climate change is seen as a major threat to sustainable growth and development in Africa, and the achievement of the Millennium Development Goals. The main long-term impacts of climate change in Africa include changing rainfall patterns affecting agriculture and reducing food security; worsening water security; decreasing fish resources in large lakes due to rising temperature; shifting vector-borne diseases; rising sea level affecting low-lying coastal areas with large populations; and rising water stress (APF 2007).

At any point in time, GHG concentrations depend on the levels of emissions at all previous points in time, and on the extent to which sinks have sequestered atmospheric GHGs, or the amounts that have decayed into harmless forms, at all previous points in time. How much global climate change will occur over the next century and beyond also depends on future GHG emissions and actions that affect the size of various carbon sinks.
Climate change is global in its causes and consequences, and international collective action on the scale required will be critical in driving an effective, efficient, and equitable response (Stern 2007).

Emissions of carbon dioxide associated with power, transport, and industry are important contributors to total GHG emissions in the world. Agriculture and land use are also important contributors (Table 2.1).

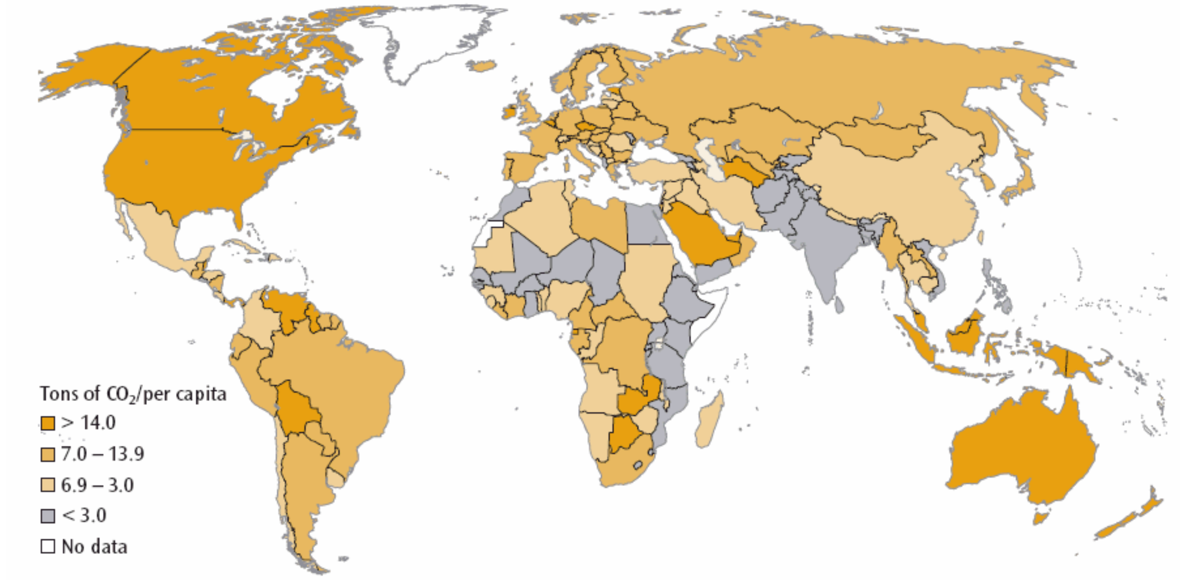
Table 2.1. Greenhouse gas emissions in 2000, by source (Global)

Source	Share in total emissions (%)
Power	24
Transport	14
Buildings	8
Industry	14
Other energy	5
Waste	3
Agriculture	14
Land use	18

Source: Stern (2007)

There are also important differences in emissions across countries. Figure 2.1.below shows per capita GHG emissions of countries in the year 2000.

Figure 2.1. Per capita GHG emissions (including land use change) of countries in 2000.



Source: Burgoo (2007)

According to UNFCCC (2005) the 122 **non-Annex I** parties[2] in total have an average per capita GHG emissions (expressed in tons of CO_2 equivalent, excluding Land Use Change and Forestry(LUCF)) of 2.8 tons. Table 2.2 provides aggregate and per capita emissions (and removals of CO_2, CH_4 and N_2O) in CO_2 equivalent without and with LUCF of selected countries/regions for non-Annex I parties. The African region, in general, has the lowest emissions both in aggregate and per capita terms as compared to the other regions. Its average per capita emissions is 2.4 tons. The Asian and the Pacific region have an average per capita emission of 2.6 tons, with China and India having average per capita emissions of 3.3 and 1.3 tons, respectively. The Latin American and the Caribbean region have average per capita

[2] **Non-Annex I** parties are developing countries or countries that are not listed in **Annex I** of the Kyoto Protocol. (See Appendix Table A.1 for details)

emission of 4.6 tons. Brazil has an average per capita emission of 4.1 tons, which is slightly lower than the average for the region. This is because the LUCF sector is not taken into account and most of Brazil's emissions come from that sector. With an average of 5.1 tons, Eastern Europe and former Soviet Union countries form the region with the highest per capita emissions in Table 2.2.

Table 2.2. Total aggregate and per capita emissions (and removals of CO_2, CH_4 and N_2O) in CO_2 equivalent without and with Land Use Change and Forestry (LUCF) of selected countries/regions (non-Annex I parties)

Country/region	**Total emissions (without LUCF)** (in Gg)[a]	**Total emissions (with LUCF)** (in Gg)[a]	**Per capita emissions (without LUCF)** (tons)
Asia and the Pacific	7,929,690	7,614,072	2.6
Latin America and the Caribbean	2,058,600	2,986,460	4.6
Africa	1,612,904	1,201,794	2.4
Eastern Europe and former Soviet Union	134,244	129,170	5.1
China	4,057,306	3,649,827	3.3
India	1,214,248	1,228,540	1.3
Brazil	658,976	1,477,056	4.1
South Africa	379,837	361,221	9.1
Ethiopia	47,415	33,008	0.7

Source: UNFCCC (2005)
Notes: [a] Gg stands for Gigagrams

3. Economics/Theory

Carbon trading works by setting a quantitative limit on the emissions produced by emitters and then allowing the emitters to trade in emission permits associated with the emission limits. The economics/theory underlying emissions trading is one that has to do with **property rights** (Goldemberg et al. 1996). The problem of **climate change** in particular is a situation where emitters of GHGs do not face the full cost implications of their actions (IMF 2008). That is, there are costs that the emitter does face, for example, the costs of the inputs used, but there are other costs that are not necessarily included in the price of a good or service. This divides into the **private or internal** costs, that is, the costs that are fully internalized by the decision maker, and other costs that the emitter does not face, **uninternalized or external** costs (Halsnaes et al. 2007). These **external** costs may affect the **welfare** of others. In the case of **climate change**, GHG emissions affect the welfare of people today and in the future as well as the natural environment (Stern 2007; Tothet al. 2001). These **external** costs can be estimated and converted into a common (monetary) unit.

The argument for doing so is that these **external** costs can then be added into the private costs that the emitter faces and be **internalized**. In doing this, the emitter faces the full (**social**) costs of his/her actions (IMF 2008).

3.1. Optimal level of emissions

In this section we outline how an optimal level of emissions (emissions targets) is set (determined) using an efficiency criterion. Specifically, we consider what is called a static model of flow pollution—one in which time plays no role—to identify the efficient level of flow pollution (Perman et al. 2003). In this model **emissions** have both **benefits** and **costs.** Following much of the pollution literature, we call the costs of emissions "damages" (negative/adverse externality). Specifically, consider production that entails **joint products**: the intended good or service, and the associated pollution emissions.

As explained earlier damages caused by pollution are not taken into account by agents/firms in their decisions, and so they are considered as externalities.

Moreover, it is also the case that the externality in question is what is called a public bad (as opposed to private bad), in that once it has been generated, no one can be excluded from suffering its adverse effects.

For simplicity, suppose that damage is independent of the time or source of the emissions and that emission have no effect outside the economy being studied. Then, the optimal level of emissions is one that maximizes the net benefits from pollution, where net benefits are pollution benefits minus pollution costs (or damages).

The level of emissions at which net benefits are maximized is equivalent to the outcome that would prevail if **pollution externality** were **fully internalized**.
Given damage (D) is dependent only on the magnitude of the emissions flow (M), so, algebraically, the damage function can be specified as:

$$D=D(M) \qquad (1)$$

If firms were strictly required to produce their intended final output without generating any emissions or pollution, they would incur substantial pollution abatement costs[3]. However, on the other hand, if this requirement is gradually relaxed and as the amount of allowable emissions rises, firms can increasingly avoid the pollution abatement costs that would otherwise be incurred.

Therefore, firms make **cost savings** (and so **profit** increases) if they are allowed to generate emissions in producing their goods. There are additional costs involved with emissions reduction and, equivalently, there are savings (or benefits) associated with emissions increases.
It is these **cost savings** that we regard as the **benefits** of pollution. Hence, we can now, algebraically, represent the benefit function

$$B=B(M) \qquad (2)$$

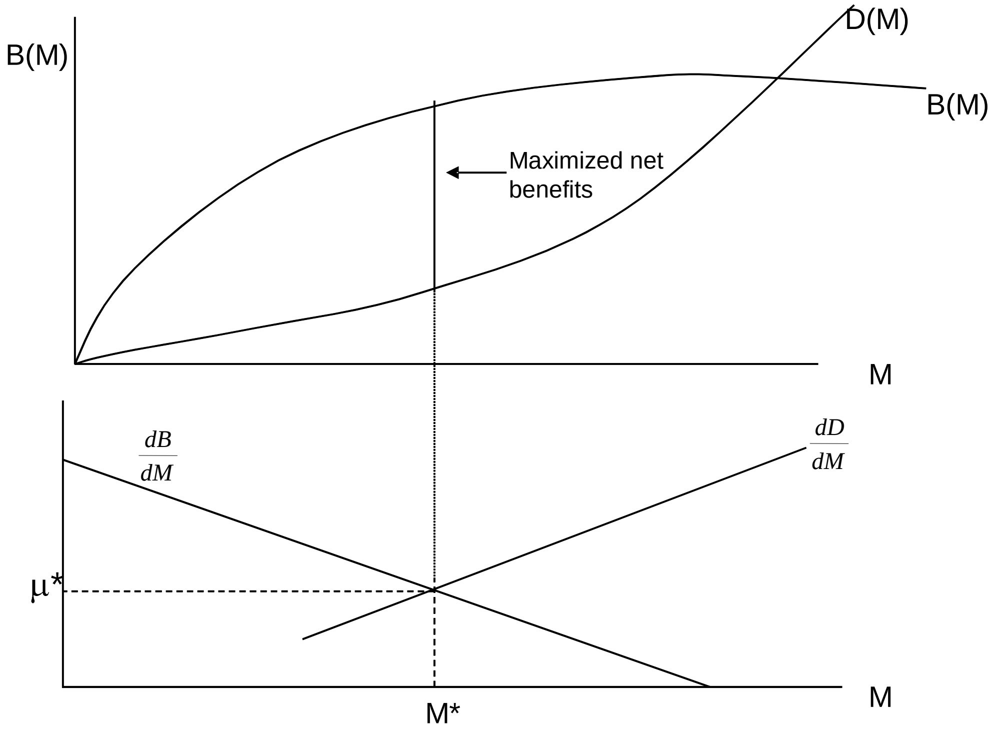
where B denotes the **benefits** from emissions. The **net social benefits** (NB) from a given level of emissions would then be defined as:

$$NB=B(M) - D(M) \qquad (3)$$

[3]Abatement cost: A cost borne by many businesses for the removal and/or reduction of an undesirable item that they have created.

Often, it would be convenient working with marginal, rather than total, functions. So, let dB/dM (or B'(M) in an alternative notation) be the marginal benefit of pollution and dD/dM (or D'(M)) be the marginal damage of pollution. Figure 3.1 below graphically illustrates the general form of the total and marginal damage and benefit functions. As can be seen from the figure, the total damage is thought to rise at an increasing rate with the size of the pollution flow, and so the marginal damage will be increasing in M. In contrast, total benefits will rise at a decreasing rate as emissions increase (because per-unit pollution abatement costs will be more expensive at greater level of emissions reduction), i.e., B'(M) would fall as M rises.

Figure 3.1. Total and marginal damage and benefit functions, and the optimal level of M



Source: Perrman et al. (2003) and Authors' compilation

The net benefits of economic activity are maximized at the point where the emissions flow, M, is chosen in such a way that:

$$\frac{dNB(M)}{dM} = \frac{dB(M)}{d(M)} - \frac{dD(M)}{dM} = 0 \qquad (4a)$$

Or, equivalently, that

$$\frac{dB(M)}{dM} = \frac{dD(M)}{dM} \qquad (4b)$$

Condition (4b) states that the net benefits of pollution can be maximized only where marginal benefits of pollution equal the marginal damage of pollution. Hence, the **optimal level of emissions** is *M**.

If actual emissions are less than *M** the marginal benefits of emitting more are greater than the marginal damage, so more emission will yield additional **net benefits**.

However, conversely, if actual emissions are greater than *M** the marginal benefits of emitting more are less than the marginal damage, so less emission will yield more net benefits. The value of the marginal damage and marginal benefit functions at their intersection is labeled μ^* in Figure 3.1. This can be thought of as the equilibrium 'price' of emission, for example, of a unit of GHG.

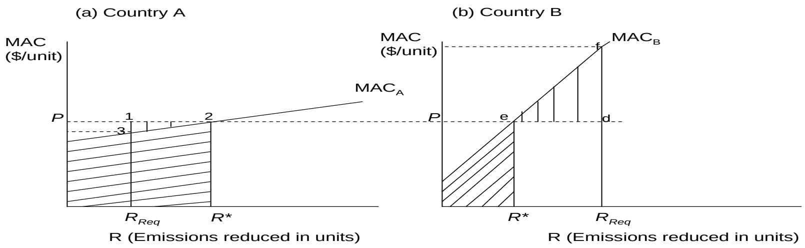
This price has a particular significance in terms of an efficient (optimal) rate of emissions tax or subsidy. However, in a context where there is no market for emissions, μ^* is a hypothetical or shadow price rather than one which is actually revealed in **market** transactions. More specifically, a shadow price emerges as part of the solution to an optimization problem (in this case the problem of choosing *M* to maximize net benefit).

Alternatively, we could also describe μ^* as the shadow price of the pollution externality. If a market was to exist for the pollutant itself (thereby internalizing externality so that firms had to purchase rights to emit units of the polluting GHG (e.g., tradable permits), μ^* would be the optimal market price.

3.2. The case for trading

In this section we elaborate the case for carbon trading. Consider two countries, Country A and Country B, each of whom can either reduce all the required amount of emissions by itself or choose to buy or sell in the market. Assume that Country A can abate its CO_2 at a much cheaper cost than Country B, that is, MAC_B (marginal abatement cost of country B) > MAC_A, and R_{Req} is the total amount of emissions that need to be reduced by the country in question (see Figure 3.2. below).

Figure 3.2. Emissions trading



Source: Authors' compilation

On the left panel of the figure is the MAC curve for Country A. R_{Req} is the amount of required reductions for Country A, but at R_{Req} the MAC_A curve has not intersected the market allowance price of CO_2 (market allowance price = P = μ^*). Thus, given the market price of CO_2 allowances, Country A has the potential to profit if it abates more emissions than required and sell some of its allowances. On the right panel of the figure, that is, panel (b), is the MAC curve for Country B.

R_{Req} is the amount of required reductions for Country B, but the MAC_B curve already intersects the market price of CO_2 allowances before R_{Req} has been reached. Thus, given the market allowance price of CO_2, Country B has the potential to make a cost saving if it abates fewer emissions than required internally, and instead abates them elsewhere.

In this particular example, Country B would abate emissions until its MAC_B intersects with P (at R*), but this would only reduce a fraction of Country B's total required abatement. After that it could buy emissions credits from Country A for the price *P* (per unit). The internal cost of Country B's own abatement, combined with the credits it buys in the market from Country A, add up to generate the total required reductions (R_{Req}) for Country B. Thus Country B can make a saving equivalent to the triangle Δ def from buying credits in the market. This represents the "**Gains from Trade**", the amount of additional expense that Country B would otherwise have to spend if it abated all of its permitted emissions by itself without trading. Country A also made a profit on its additional emissions abatement, above what was required: it met the regulations by abating all of the emissions that was required of it (R_{Req}). Besides, Country A sold its surplus to Country B as credits, and was paid *P* for every unit it abated, while spending less than *P*. Its total revenue is the area of the graph (R_{Req} 1 2 R*), its total abatement cost is area (R_{Req} 3 2 R*), and so its net benefit from selling emission credits is the area of the triangleΔ123), that is the **Gains from Trade**.

The two R* (on both graphs) represent the efficient allocations that arise from trading.

Country A sold (R* - R_{Req}) emission credits to country B at a unit price of *P*.

Country B bought emission credits from Country A at a unit price of *P*. If total cost for achieving *M** level of emissions in the *Command and Control* scenario is *X*, then the **total abatement cost** of achieving this same amount of emissions target would be less in the *Emissions Trading* scenario (that is , would be equal to X - Δ 123 - Δ def).

It has to be noted that the above notion applies not just at the national level. It also applies just as well between two companies in different countries and there could also be trade between two companies in one country, or between two subsidiaries within the same company.

3.3. Emissions control instruments: Taxes versus cap and trade

As explained before, emissions of GHG are externalities, that is, social consequences that are not accounted for by the market. They are market failures because agents do not pay for the current and future costs of their emissions. Therefore, controlling global warming or emissions reduction cannot be achieved without a strong price signal (Duong 2009). That is, high carbon price is a necessary condition for implementing carbon policies. Among the whole set of environmental policy instruments (see Perman et al. 2003), emissions/**carbon taxes** and **cap and trade** are the two most common (market based) instruments employed to enforce the quantitative limit of emissions and internalizing the **negative externality** (Nordhaus 2007b; Keohane 2009). Perhaps the most controversial policy question in the design or mechanism of economic systems to control global warming involves the decision whether to rely primarily on quantity-based or price-based constraints. More specifically, the question concerns the relative advantage of a cap-and-trade system or a carbon tax system.

3.3.1. Taxes

Pollution/carbon taxes have long been argued for internalizing negative externality and correcting market failure. This tax on a negative externality is called a **Pigovian tax** (after Arthur Pigou (Pigou1932), and should equal the **marginal damage costs**. These have been largely used for limiting gasoline or cigarette consumption (Sterner 2003). It is also argued that under certain conditions, Pigovian tax can result in a double dividend: one, reduction of pollution; and, two, recycling of the government revenue from the green tax. Nordhaus (2007b and 2008) outlines the following points:

i. Carbon taxes will lend predictability to energy prices, whereas cap-and-trade systems will aggravate the price volatility that historically has discouraged investments in less carbon-intensive electricity generation, carbon-reducing energy efficiency, and carbon-replacing renewable energy.
ii. Carbon taxes can be implemented much sooner than complex cap-and-trade systems. Because of the urgency of the climate crisis, we do not have the luxury of waiting while the myriad details of a cap-and-trade system are resolved through lengthy negotiations.
iii. Carbon taxes are transparent and easily understandable, making them more likely to elicit the necessary public support than an opaque and difficult to understand cap-and-trade system.
iv. Carbon taxes can be implemented with far less opportunity for manipulation by special interests, while a cap-and-trade system’s complexity opens it to exploitation by special interests and perverse incentives that can undermine public confidence and undercut its effectiveness.
v. Carbon taxes address emissions of carbon from every sector, whereas some cap-and-trade systems discussed to date have only targeted the electricity industry, which accounts for less than 40% of emissions.
vi. Carbon tax revenues would most likely be returned to the public through dividends or progressive tax-shifting, while the costs of cap-and-trade systems are likely to become a hidden tax as dollars flow to market participants, lawyers, and consultants.

3.3.2. Cap and Trade

Cap and trade is a quantity based emissions control instrument. **The cap** is that each country/ large-scale emitter, or company will have a limit on the amount of GHG that it can emit. Note that this largely depends on the amount of GHG emissions reduction the country/firm commits itself to the global/regional climate regime. Then, this transpires into the country/firm having an “emissions permit” for every ton of GHG/carbon dioxide it releases into the atmosphere. These permits, in turn, set an enforceable limit, or **cap**, on the amount of GHG pollution that the company is allowed to emit. As time passes, with more countries/firms joining the regime, the limits eventually become stricter, allowing less and less pollution, until the ultimate reduction goal is met.

The trade is that it will be relatively cheaper or easier for some countries/companies to reduce their emissions below their required limit than others. That is, some are more efficient at reducing emissions whereas others are not. The more efficient countries/companies, those that emit less than their allowance, can sell their extra permits to companies that are not able to make reductions as easily. By rewarding the most efficient countries/companies and ensuring that the **cap** can be met at the lowest possible cost to the economy, this creates a system that guarantees a set level of overall reductions.

The **cap and trade** program was (first) introduced/enacted in the USA by the **Clean Air Act of 1990**, which reduced the sulfur emissions that cause **acid rain**, and it met the goals at a much lower cost than industry or government predicted.

Cap and trade is suggested as a counter-argument to tax. This is largely due to the possible preference that politicians may have for emissions trading compared to taxes (Bashmakovet al. 2001). One of the underlying reasons is that emission permits can be freely distributed to polluting industries rather than the revenues going to the government. Nonetheless, industries may also successfully lobby to exempt themselves from a carbon tax. Therefore, it is argued polluters will have an incentive to cut emissions with emissions trading, but they will have no incentives to cut emissions if they are exempted from a carbon tax (Smith 2008). However, freely distributing emission permits, on the other hand, could potentially lead to corrupt behavior (World Bank 2010).

The popularity of cap-and-trade seems to have declined particularly since the recent financial crisis. Recently, there appears to be an intense debate about the relative merits of cap-and-trade versus carbon taxes in the United States particularly following President Barack Obama's request to House Members "for a legislation that places a market-based cap on carbon pollution" in his February 24, 2009 Speech (Shapiro 2009).

Contrary to the views of Nordhaus (2007b and 2008), Keohane (2009) argues in favor of a cap and trade program around two basic distinctions between emissions taxes and tradable permit systems: (i) how the value of emissions is allocated, and (ii) whether the policy sets the price or the quantity of emissions. Regarding the first distinction, under a tax, as commonly proposed, the government captures the value of emissions in the form of tax revenue. Under most cap and trade systems, in contrast, the government could give away a significant fraction of the value to emitters in the form of free allowances. Keohane, therefore, argues that while raising revenue can reduce deadweight losses (if used to cut marginal taxes), free allocation offers important political advantages, in particular providing legislators with flexibility that is crucial for balancing distribution and efficiency. Keohane also argues that price and quantity instruments frame political debates very differently, and create different incentives for regulated firms concerning the desired scope of the program. In addition, he suggests that cap and trade systems are more easily harmonized across countries without explicit coordination enhancing the cost-effectiveness, scope, and equity of an international climate regime. Although the price of tradable permits can fluctuate in the short run in contrast to a tax, and raises concerns about price volatility, he argues that such fears have been overstated.

4. The Kyoto protocol and carbon markets

4.1. The Kyoto protocol

The Kyoto Protocol is a 1997 international treaty which came into force in 2005. In the treaty, most developed nations agreed to legally binding targets for their emissions of the six major GHGs: carbon dioxide (CO_2); methane (CH_4); nitrous oxide (N_2O); hydrofluorocarbons (HFCs); perfluorocarbons (PFCs); sulphur hexafluoride (SF_6) (UN 1998)

Emission quotas (known as "**Assigned amounts**") were agreed by each participating '**Annex I**' country, with the intention of reducing the overall emissions by 5.2% from their 1990 levels by the end of 2012. The United States is the only **Annex I country** that has not ratified the treaty, and is therefore not bound by it. The Inter-governmental Panel for Climate Change(IPCC) has projected that the financial effect of compliance through trading within the Kyoto commitment period will be limited at between 0.1-1.1% of GDP among trading countries.

The **Protocol** defines several mechanisms ("**flexible mechanisms**") that are designed to allow **Annex I countries** to meet their emission reduction commitments (caps) with reduced economic impact (IPCC 2007a, 2007b, 2007c). Under Article 3.3 of the **Protocol**, **Annex I Parties** may use GHG removals, from afforestation and reforestation (forest sinks) and deforestation (sources) since 1990, to meet their emission reduction commitments. **Annex I Parties** may also use International Emissions Trading (IET).

Under the treaty, for the 5-years compliance period from 2008 until 2012, nations that emit less than their quota will be able to sell **Assigned amount unit** (AAU) to nations that exceed their quota. It is also possible for **Annex I** countries to sponsor **carbon projects** that reduce greenhouse gas emissions in other non-Annex I countries. These projects generate **tradable carbon credits** that can be used by **Annex I** countries to meet their caps.

The project-based Kyoto Mechanisms are the **Clean Development Mechanism** (CDM) and **Joint Implementation** (JI). The CDM covers projects taking place in **non-Annex I countries**, while JI covers projects taking place in **Annex I countries**. CDM projects are supposed to contribute to **sustainable development** in developing countries, and also generate "**real**" and "**additional**" emission savings, that is, savings that only occur thanks to the CDM project in question (Carbon Trust 2009). Whether or not these emission savings are genuine is, however, difficult to prove (World Bank 2010).

4.2. Carbon markets

4.2.1. CDM

The **Clean Development Mechanism** (CDM) is one of the "**flexible mechanisms**" defined in the **Kyoto Protocol** (IPCC 2007a, 2007b, 2007c). It is defined in Article 12 of the **Protocol**, and is intended to meet two objectives:

i. To assist parties not included in Annex I in achieving sustainable development and in contributing to the ultimate objective of the United Nations Framework Convention on Climate Change (UNFCCC), which is to prevent dangerous climate change; and
ii. To assist parties included in Annex I in achieving compliance with their quantified emission limitation and reduction commitments (GHG emission caps).

Annex I parties are those countries that are listed in Annex I of the treaty, and are the industrialized countries. **Non-Annex I** parties are developing countries.

A total of 2967 projects have been registered by the **CDM** Executive Board as **CDM** projects as of 11 April 2011 (UNFCCC 2011). This figure shows 41 percent growth as compared to that of the 2099 projects that were registered as of 23 March 2010. The projects are believed to contribute to reduction in greenhouse gas emissions of more than 220 million tons of CO_2 equivalent per year. There were about 4,000 projects yet to be certified as of 23 March 2010. These projects would also reduce CO_2 emissions by over 2.5 billion tons until the end of 2012. However, the experience so far suggests adoption (approval) rates of only a fraction of these projects which are certified. The largest potential for production of Certified Emissions Reductions (CERs) by 2012, are believed to be in China (52% of total CERs) and India (16%) (World Bank 2010). Latin America and the Caribbean make up about 15% of the potential total CERs produced, with Brazil being the largest producer in the region (7%).

Humbo Ethiopia Afforestation/Reforestation CDM project

Humbo Afforestation/Reforestation project is so far the only CDM project that has been approved for Ethiopia. This project seeks to establish a native forest rich in biodiversity and to support income and employment generation activities through assisted natural regeneration of the Humbo area. The project activities contribute to sustainable development, among others, through:

i. Regeneration of native forest through farmer managed natural regeneration (FMNR) and traditional forest establishment techniques.
ii. Enhancement of GHG removals by sinks in the project area. It includes restoration of approximately 2,728 hectares of natural forest rich in biodiversity in the Humbo woreda, using indigenous and natural species.

Table 4.1 below shows a list of CDM project plans in Ethiopia. There were 16 project plans, including Humbo, that have been submitted to the Environmental Protection Authority (EPA) of Ethiopia.

Table 4.1. List of CDM Project Plans in Ethiopia

No.	Name of Project	Implementation Body
1	Ethanol (biofuel) production project in the Ethiopian sugar industry	Ethiopian Sugar Development Agency
2	Production and marketing of biofuel	Atirf Alternative energy Plc
3	Integrated A/R & biofuel project in some woredas of BGNRS, SNNPRS, and ARS*	Ethan Biofuel Ltd.
4	Methane Gas capture from effluents and solid waste	Ethan Biofuel Ltd.
5	Establishment of distillery plant to produce fuel ethanol and biogas from cane molasses to substitute fossil fuel	Metahara Sugar Factory
6	Ethiopian Millennium initiative of household energy efficiency. Dissemination of efficient household light bulbs project	Ethan Biofuel Ltd.
7	Rehabilitation of degraded land through bamboo planting	Ministry of Agriculture and Rural Development
8	Choke Mountain Afforestation and Reforestation Project	Ethio Horn Plc
9	Hakim Gara Reforestation Project	Harar Brewery
10	A proposal to demonstrate how to operate a highly beneficial clean cooking stove	Makobu Enterprises Plc/ Guia Association
11	Meta Abo Brewery Watershed Development/ Meta Abo brewery	Oromiya BoARD
12	Conservation Agriculture	SG-2000 & Makobu Enterprises Plc
13	Carbon Sequestration and Better Energy Utilization	Bahir Dar University & Amhara EPA
14	Carbon Sequestration by 10 woredas (districts) farming communities of Tigray, Oromia and Amhara Regions	ISD
15	Converting Methane into renewable energy through biogas digester in Mekelle University	ISD
16	Humbo Reforestation Project	World Vision/Humbo community

Source: Embassy of Japan in Ethiopia (2008)
Notes: *BGNRS=Benishangul National Regional State; SNNPRS=Southern Nations and Nationalities and Peoples' Regional State; ARS=Amhara Regional State.

4.2.2. REDD

The World Bank Forest Carbon Partnership Facility (WB-FCPF) and the United Nations REDD (UN REDD) program assist developing countries in their efforts to **r**educe **e**missions from **d**eforestation and forest **d**egradation **called REDD**, by providing value to standing forests. **Non-energy emissions** make up one-third of total GHG emissions and it could be envisaged that action in this area will make an important contribution (see Table 2.1 above). But, more importantly, within **non-energy emissions**, recent evidence shows that the combined contribution of emissions from deforestation and forest degradation accounts for about 18% of the global GHG emissions (Stern 2007; IPCC 2007a, 2007b, 2007c).

It is believed that mitigation of global warming by limiting rise in global temperature to 2 degrees Celsius will not be achieved without the inclusion of forests in an international regime. Evidence also suggests that action to prevent further deforestation would relatively be cheap compared with other types of mitigation, if the right policies and institutional structures are put in place.
It is argued that without **REDD** the climate stabilization goal will not be reached (Angelsen et al. 2009).

The WB-FCPF/UN REDD is designed to set the stage for a large-scale system of incentives for reducing emissions from deforestation and forest degradation providing a fresh source of finance for the sustainable use of forest resources and biodiversity conservation. It targets over 1.2 billion people who depend on forests for their livelihoods to varying degrees and aims at building the capacity of developing countries in tropical and subtropical regions to reduce emissions from deforestation and forest degradation and to tap into any future system of positive incentives for **REDD**.

It also helps to reduce the rate of deforestation and forest degradation by providing an incentive per ton of emissions of carbon dioxide reduced through specific Emission Reductions Programs targeting the drivers of deforestation and forest degradation.

Nowadays, there is also a new mechanism called **REDD plus** that emphasizes on involving local people (Angelsen 2009). Currently, **REDD** mainly involve **REDD** readiness and demonstration activities. Readiness activities include national level readiness activities such as REDD strategy development, policies, and capacity building under multi-lateral or bilateral programmes such as the WB-FCPF or UN REDD programs. Demonstration activities are sub-national level activities aimed at reducing emissions.

Table 4.2 presents distribution of national REDD readiness and demonstration activities. The table reveals that the East Asia and Pacific region appears to host the most demonstration projects (40), while South America's Amazon region hosts the greatest number of national readiness activities (21). As a single country, Indonesia stands out as hosting the largest group of projects (34) and implementing the most national readiness activities (7).

Table 4.2. National readiness and REDD demonstration projects by region(number)

Region	Readiness	Demonstration
East Asia and Pacific	19	40
South America (Amazon)	21	31
Central America and Caribbean	13	12
East Africa	11	8
Central Africa	8	5
West Africa	3	4
South Asia	2	1
South America (non-Amazon)	1	1
South Africa	1	1

Source: Cerbu et al. (2009)

In terms of REDD readiness, Africa plays host to an equal number of multilaterally sanctioned activities at the national level (i.e., within the WB-FCPF and UNREDD programs) as compared to the other continents (Table 4.2).

However, in terms of demonstration activities, the continent seems to be lagging behind with only 18 REDD demonstration projects established. This seems to be a replay of the trend in readiness phases of the Clean Development Mechanism (CDM) which is potentially worrying.

This lack of **REDD** investment in Africa could also be attributed to investor perceptions of poor governance, increasing the risk for **REDD** investments (Cerbu et al. 2009).

Ethiopia has currently prepared its **REDD** readiness plan through the support of the World Bank, that is, WB-FCPF.

Bale Mountain REDD project

An example for Ethiopia is the **Bale Mountain REDD project which is still under development.** The project intends to protect and rehabilitate the natural forests in the Bale Mountain Eco-Region of Ethiopia. The project covers an area of 0.5 million hectares and eventually a national park with an additional area of 0.2 million hectares. It is an initiative of the Oromia State Forestry Agency, with support from the Bale Eco-Region Sustainable Management Program (BERSMP)

Believed to generate emission reductions of approximately 45 to 97 million mtCO_2 over a 20 year period, depending on the project activities considered (avoided deforestation only or combined with forest enhancement activities). The project will develop community based organization (CBO) forest management, joint forest management (JFM), and forest enterprise management (FEM) systems to reduce deforestation and to enhance carbon stocks by adopting sustainable forest management (SFM) practices.

4.3. Mandatory versus voluntary market[4]

4.3.1. Mandatory market mechanisms

The mandatory market mechanisms are meant to reach the goals defined in the **Kyoto Protocol**, with the least economical costs. For this purpose the **Protocol** introduced the following **flexible mechanisms**:

i. Clean Development Mechanism(CDM)
ii. Joint Implementation(JI)
iii. Emissions Trading

The **CDM** and **JI** mechanisms' requirements for projects create a supply of emission reduction instruments, while **Emissions Trading** allows those instruments to be sold on international markets. Projects which are compliant with the requirements of the CDM mechanism generate **Certified Emissions Reductions** (CERs). Projects which are compliant with the requirements of the JI mechanism generate **Emissions Reduction Units** (ERUs). Russia, Ukraine, and Czech Republic are the countries hosting most of the JI projects. Latin America and Asia &Pacific region host 95% of the CDM projects, with China, India, and Brazil being the countries that benefited most, both in terms of number of projects and volume of CERs.

The CERs and ERUs can then be sold through **Emissions Trading**. The demand for the CERs and ERUs being traded is driven by:

i. Shortfalls in national emission reduction obligations under the Kyoto Protocol.
ii. Shortfalls amongst entities obligated under local emissions reduction schemes.

Nations which have failed to deliver their Kyoto emissions reductions obligations can enter **Emissions Trading** to purchase CERs and ERUs to cover their treaty shortfalls.

[4] Carbon markets exist both under compliance schemes and as voluntary programs. *Compliance* or *mandatory* markets are markets created and regulated by mandatory national, regional, or international carbon reduction regimes. The *voluntary* carbon markets function outside of the compliance market. They provide a mechanism for businesses, governments, NGOs, and individuals to offset their emissions by purchasing offsets that were created either through CDM or in the voluntary market.

Nations and groups of nations can also create local emission reduction schemes which place mandatory carbon dioxide emission targets on entities within their national boundaries. If the rules of a scheme allow it, the obligated entities may be able to cover all or some of any reduction shortfalls by purchasing CERs and ERUs through **Emissions Trading**. While local emissions reduction schemes have no status under the **Kyoto Protocol** itself, they play a prominent role in creating the demand for CERs and ERUs, stimulating **Emissions Trading** and setting a **market price** for emissions. The well known mandatory local emissions trading scheme is the **EU Emissions Trading Scheme** (EU ETS).

4.3.2. Voluntary market mechanisms

Transactions in the global voluntary carbon markets have increased 200 percent between2005 and 2006**.**An Ecosystem Marketplace study valued these markets at over US$93 million in 2006 and it is likely that they doubled in size in 2007 (EM & BSR 2008). The prospects for continued growth in carbon markets are strong. In contrast to the strict rules set out for the **mandatory market**, the **voluntary market** provides companies with different options to acquire emission reductions. A solution, comparable with those developed for the mandatory market, has been developed for the voluntary market, the **Verified Emission Reductions** (VERs).

There are voluntary markets in North America, Australia, New Zealand, and Japan.

The voluntary market in North America is divided between members of the **Chicago Climate Exchange** and the **Over the Counter** (OTC) market. The **Chicago Climate Exchange** is a voluntary yet legally binding **cap-and-trade emissions scheme** whereby members commit to the capped emission reductions and must purchase allowances from other members or offset excess emissions. The **OTC** market does not involve a legally binding scheme. A wide array of buyers from the public and private spheres, as well as special events that want to go **carbon neutral** are involved.

There are project developers, wholesalers, brokers, retailers, as well as carbon funds in the voluntary market. Some businesses and nonprofits in the voluntary market encompass more than just one of the activities listed above. The report by Ecosystem Marketplace shows that carbon offset prices increase as it moves along the supply chain-from project developer to retailer. While some mandatory emission reduction schemes exclude forest projects, these projects flourish in the voluntary markets. A major criticism concerns the imprecise nature of GHG sequestration quantification methodologies for forestry projects. However, others note the community co-benefits that **forestry** projects foster.

Among the project types traded in the **voluntary market** are: avoided **deforestation**, **afforestation/reforestation**, industrial gas **sequestration**, increased **energy efficiency**, **fuel switching**, **methane capture** from coal plants and livestock, and even **renewable energy**. Due to additionality[5] concerns, the **Renewable Energy Certificates** (RECs)[6] sold on the **voluntary**

[5] It is also important for any carbon credit (offset) to prove a concept called additionality. The concept of additionality addresses the question of whether the project would have happened anyway, even in the absence of revenue from carbon credits. Only carbon credits from projects that are "additional to" the business-as-usual scenario represent a net environmental benefit. Carbon projects that yield strong financial returns even in the absence of revenue from carbon credits; or that are compelled by regulations; or that represent common practice in an industry are usually not considered additional (http://en.wikipedia.org/wiki/Carbon_credit).

[6] Renewable energy certificates (RECs), also known as renewable energy credits, green certificates, green tags, or tradable renewable certificates, are tradable, non-tangible energy commodities. They serve as proof that 1 megawatt-hour (MWh) of electricity was generated from an eligible renewable energy resource, and represent the environmental attributes of the power

market appear to be quite controversial. Industrial Gas projects are also criticized for only being applied to large industrial plants that already have high fixed costs. Credits generated from industrial gas projects are the cheapest in the voluntary market. Hence, siphoning off industrial gas for sequestration is considered picking the low hanging fruit.

It is difficult to measure the size and activity of the **voluntary carbon market**. The report released by Ecosystem Marketplace and New Carbon Finance in July 2007 appears to be the most comprehensive report on the voluntary carbon markets to date (Hamilton et al. 2007). This measure has the great advantage that the projects/activities are managed according to the quality standards set out for CDM/JI projects but the certificates provided are not registered by the governments of the host countries or the Executive Board of the UNO. As such, high quality VERs can be acquired at lower costs for the same project quality. However, at present VERs cannot be used in the **mandatory market**.

The global carbon market has emerged quite considerably during the last decade and particularly since the **Kyoto Protocol.** The World Bank, with its partners in the Prototype Carbon Fund (PCF), established the first global carbon fund to create a demand for carbon credits and to gain experience with the Kyoto Protocol project-based mechanisms (World Bank 2009). The carbon market grew in value to an estimated US$30 billion in 2006 (€23 billion), three times greater than the previous year (Capoor and Ambrosi 2007). As could be clear from Table 4.3, the global carbon market doubled in value terms between 2007 and 2008.The global carbon trading market also grew in volume terms by 68 percent in 2009 compared with the year 2008, despite a global economic downturn. But the value of the market remained virtually unchanged after carbon prices fell, averaging US$16.40 per ton in 2009. This is 40 percent down from US$27.15 in 2008.

Table 4.3. Carbon market at a glance, volumes and values in 2007–08

	2007		**2008**	
	Volume ($MtCO_2$)	**Value (MUS$)**	**Volume ($MtCO_2$)**	**Value (MUS$)**
Project-based Transactions				
Primary CDM	552	7,433	389	6,519
JI	41	499	20	294
Voluntary Market	43	263	54	397
Sub-total	**636**	**8,195**	**463**	**7,210**
Secondary CDM				
Sub-total	**240**	**5,451**	**1,072**	**26,277**
Allowances Markets				
EU ETS	2,060	49,065	3,093	91,910
New South Wales	25	224	31	183
Chicago Climate Exchange	23	72	69	309
RGGI	na	na	65	246
AAUs	na	na	18	211
Sub-total	**2,108**	**49,361**	**3,276**	**92,859**
Total	**2,984**	**63,007**	**4,811**	**126,345**

Source: World Bank (2009b)
Note: Mt = Megaton = one million tons; MUS$ = million US dollar

produced from renewable energy projects. These certificates are sold separate from commodity electricity. Green Power Network, US Department of Energy, http://apps3.eere.energy.gov/greenpower/markets/certificates.shtml (Retrieved 2012-03-29.

5. Determination of carbon prices and price trend

5.1. Carbon price determinants

EcoSecurities Consulting Ltd. (ECL2009) identifies the following set of variables that determine carbon price and that need to be considered in any attempt to forecast future carbon prices.

i. *Context variables:* These variables include the development of science of climate change, public opinion, and the international political context related to multilateral cooperation. These are also variables that drive the priority and shape the public policy on climate change.

ii. *Mitigation demand variables:* These variables include economic and emissions growth, the impact of voluntary emission reduction programs, the severity of regulatory emission reduction mandates, the timing of mandates, the role of developing countries in global mitigation efforts, the treatment of sinks, and compliance and penalty regimes. These are also variables that determine the demand for GHG credits in a future mitigation market.

iii. *Mitigation supply variables:* They include the fungibility[7] of reductions from different sectors and crediting systems, the technical potential of sectors to deliver emission reductions, additionality and quality standards that limit market participation to “real” reductions, whether credit banking is permitted, treatment of sinks and potentially impermanent reduction options, and expectations regarding the future market. These are variables that influence the supply of emission reductions available to meet compliance mandates. In fact, it turns out that almost any of these variables could dramatically affect the supply of credits under many market scenarios.

iv. *Project-level transaction variables:* These are variables that determine the transaction costs involved with creating credits in the GHG market. These include baseline and other documentation requirements, approval and certification processes, adaptation or other tax levies, guarantee requirements, and costs associated with project monitoring and verification.

v. *Technology variables:* These are variables that change the shape of the supply curve over time, and comprise the factors that influence the evolving cost-effectiveness of different technologies. Generally, these factors include changes in related commodity prices (e.g., natural gas and electricity) and the emergence of new emissions reduction technologies (e.g., long-term geological sequestration). In principle, these variables could factor into creating different carbon prices in different emissions trading systems that operate simultaneously.

[7] A good is fungible if one unit of the good is substantially equivalent to another unit of the *same* good of the same quality at the same time and place (http://en.wikipedia.org/wiki/Fungibility)

5.2. Carbon price trend

Generally speaking, carbon price has been on the rise between 2005 and 2008. For example, the average price for all the markets has increased from 15.30 US$ per ton of CO_2 emitted in 2005 to 26.32 in 2008 (Table 5.1). In addition, except for the project based voluntary market where price has been volatile and falling, carbon prices in the rest of the markets were generally on the rise between 2005 and 2008. A clear distinction could also be witnessed between the various markets (mandatory versus voluntary as well as allowance versus project-based) regarding the carbon price trend. Considering the allowance markets, the carbon price appears to be generally low but rising in the Chicago Climate Exchange whereas it appears to be falling in New South Wales. It also turns out that carbon prices are generally higher in Europe than in the US or Australia and New Zealand.

Table 5.1. Trends in carbon price/average price (in US$ per ton CO_2 emitted), by year 2005–2008

	2005	2006	2007	2008
Allowance[a] Markets				
EU ETS	24.64	22.12	23.82	29.72
New South Wales	9.83	11.25	8.96	5.90
Chicago Climate Exchange	3	3.80	3.13	4.48
RGGI	na	na	na	3.78
Sub-total	**24.30**	**21.77**	**23.42**	**28.44**
Project-based Markets				
Primary CDM	7.09	10.70	13.47	16.76
Secondary CDM	22.10	17.76	22.71	24.51
JI	6.18	8.81	12.17	14.70
Voluntary Market	9.35	4.65	6.12	7.35
Sub-total	**7.57**	**10.78**	**15.58**	**21.81**
Total	**15.30**	**18.36**	**21.11**	**26.32**

Source: Capoor and Ambrosi (2007; 2009)
Note: [a] Allowance is an authorization to emit a certain fixed amount of a GHG.

6. Carbon markets and mitigation strategies for Africa/Ethiopia

6.1. Mitigation options and challenges for Africa

CDM/REDD mechanisms are supposed to contribute to **sustainable development** in developing countries, and also generate "**real**" and "**additional**" emission savings, which is meant to assist parties not included in Annex I in achieving sustainable development and in contributing to the ultimate objective of the UNFCCC, which is to prevent dangerous **climate change.**

For example, while Tanzania is seen to have received justifiable and significant project investments from REDD, some countries and regions, such as the Congo Basin, have not received investments that reflect the technical potential for reducing emissions (Cerbu et al. 2009). In 2004, only two countries across the entire continent were accessing the **CDM**—Morocco and South Africa.

Since 2004 the country with the largest share on **CDM** projects is South Africa with just under 30 registered projects or in the pipeline, followed by Egypt with 12 projects; and Morocco with 9. As of 2006, out of 1376 **CDM** projects in 50 countries, only 34 projects were in Africa, i.e. 2.5%. In December 2006**,** at a conference in Nairobi the then Secretary-General Kofi Annan called for an international effort to extend the **CDM**'s reach to the almost non participating African continent.
The Nairobi Framework was set up subsequently, comprising of three UN agencies and two multilateral development banks. Through the set up of the Framework, assistance is offered to sub-Sahara African countries to identify clear barriers and to develop, submit, and process **CDM** projects. Numbers are showing some improvements and by 2008, many African countries have projects up and running or in the pipeline. However, the results are yet to be seen.

African countries need to have resources and transparency to attract **CDM** investments and to overcome several bureaucratic constraints. This is to be contrasted with China and India that have institutions and a designated national authority (DNA) that are better acquainted with the **CDM**. With regards to **REDD**, Africa hosts a small number of demonstration projects. This is indicative of a duplicate of the inequitable distribution of **CDM** projects.

While countries in other regions are already gaining practical lessons from **REDD** demonstration activities, Africa has few solid local experiences to learn from. In addition, this lack of **REDD** investment in Africa could also be attributed to investors' perceptions of poor governance, increasing the risk for REDD investments. Therefore, there is a need for Africa to enhance credibility in good governance and institutional arrangements.

Africa currently contributes to only 4% of global GHG emissions. Energy emissions and emissions from agriculture account for about 86 percent of the continent's aggregated GHG emissions. Africa's forest resources are serving as a sink for about 25 percent of its emissions. Mitigation actions are necessary not only to enhance sustainable development but also to prevent the continent from becoming a major emitter. Mitigation strategies that appear to be a comparative advantage to Africa are briefly described as follows.

Clean energy development: Given the untapped renewable energy potential, including hydro, solar, and wind, the continent can emphasize on clean energy development and step-by-step replace the fossil-fuel based systems by clean energy both on and off grid. This could be in the form of either individual country projects or cross-border cross-country investments.

Mitigation of emissions from livestock systems: Livestock systems are a significant source of livelihoods globally. Ethiopia has the largest livestock population in Africa. Livestock production systems in countries of the tropics like Ethiopia use large quantities of natural resources and also produce significant amounts of greenhouse gas emissions (GHGs). Agricultural emission related with methane emission from livestock is the second most important emitter in the continent. For example, in Benin it accounts for about 96 percent of the aggregated emissions. Therefore, Africa should take adequate care of the emissions from livestock systems. GHG emissions from livestock systems can be reduced significantly through technologies, policies, and the provision of adequate incentives for their implementation (Herrero and Thornton 2009). The most important ways include better feed management, using more productive livestock breeds (or shifting species), manure management, and methane capture through biogas.

Better feed management

The amount of methane produced per unit of animal (product) can be reduced by feeding better quality diets to ruminants. This increased efficiency could be achieved through improved land-use management with practices such as improved fodder technologies (development of fodder banks, improved pasture species, use of legumes, and others) and supplementation with crop by-products. These practices, which are cost effective and available in developing countries, can increase milk production, improve the efficiency of methane production, and, together with reductions in the number of animals, help mitigate methane emissions from ruminant systems. Other options include manipulation of rumen microflora and use of feed additives, as practiced in some parts of the developed world, although reductions are only likely to be on the order of 10 percent at best.

More productive livestock breeds

Many but low-producing animals is a major problem in the developing world. Therefore, these many low-producing animals could be replaced with fewer but better-fed animals, in order to reduce total emissions while maintaining or increasing the supply of livestock products. However, this will require changing breeds or implementing crossbreeding schemes. A strategy that could yield a higher productivity per animal for the resources available is switching to livestock species that are more suitable for particular environments. Although it could also increase the demand for grains, switching from cows, sheep, and goats to pigs and poultry could also lead to reduced methane emissions. But, understanding the effects of such tradeoffs between species would require conscientious research into the matter.

Manure management

GHG emissions caused by microbial activities during manure decomposition could essentially be minimized through manure management practices. Temperature, oxygen level (aeration), moisture, and nutrient sources are the factors that affect GHG emissions from manure. These factors, in turn, are affected by manure type (livestock type), diet, storage and handling of manure (pile, anaerobic lagoon, etc.), and manure application (injected, incorporated, etc). Because storing manure for long periods can encourage anaerobic decomposition and result in increased methane emissions, applying manure to soil as soon as possible, for instance, is a preferable procedure. Similarly, it is also advisable to avoid manure application when the soil is extremely wet, as this would lead to anaerobic conditions and increased methane emission. Manure handling method (liquid versus solid storage) also has an effect. For example, liquid manure management systems can emit up to 80 percent of manure based methane emissions, while solid manure emits little or no methane.

Methane capture through biogas (Biogas digesters): process animal waste under anaerobic conditions (no oxygen) to produce methane gas (biogas), which can then be used as an alternative energy source for domestic and other purposes. At the same time, the slurry/effluent can be used as fertilizer for soil conditioning. By turning human and animal waste into a mixture of methane and carbon dioxide that can be used for lighting and cooking, biogas helps reduce methane's more damaging global warming effects (Pathak et al. 2009).

In fact, biogas can be viewed as a double-edged sword directly contributing to both climate change mitigation and poverty reduction. Ethiopia currently embarked on the dissemination/construction of about a million biogas plants; making it to include *injera* baking and linking it to CDM/REDD resource opportunities might be important.

Avoided deforestation (and forest degradation): Avoided deforestation (and forest degradation) and preserving Africa's natural forests through REDD is one possible mitigation option for Africa. Indeed, Africa can benefit substantially through emphasizing on other mitigation options and offering its natural forests as a sink to the rest of the world. DRC, Cameroon, Tanzania, and Madagascar can be viewed as priority countries for REDD.

Afforestation/reforestation: The afforestation and reforestation activities undertaken in the continent can be viewed as mitigation options and can be linked to CDM. The condition to be recognized as CDM project is that the afforestation/reforestation activities have to be undertaken on land that had no forest at the end of 1989.

Bio-energy (including energy efficiency): this involves many innovative projects aimed at replacing unsustainable fuelwood use with solar energy, sustainable biomass or biogas, or aimed at reducing unsustainable fuelwood use through more efficient cooking stoves.

Improvements in **agricultural and land management** practices: these can also have substantial potential as carbon sink. For example, soil carbon sequestration[8]. The massive soil and water conservation activities in countries as Ethiopia can be viewed in this light. Grazing systems can enhance the removal of CO_2 from the environment; hence, selected rangeland systems can be linked to carbon finance for their agro-ecosystem services/contribution as a carbon sink and to provide income diversification options for pastoralists.

6.2. Mitigation options for Ethiopia

Little has been done in light of tapping the global opportunities of carbon financing and it can be argued that Ethiopia has not benefited. The country's large livestock population and massive **afforestation** and **reforestation could be examined as possible mitigation options that could attract carbon finance.** However, there are limits to what can be done. For example, eligibility to CDM projects requires that **afforestation** and **reforestation** efforts need to be on land that had no forest at the end of 1989 to be eligible sink projects (Desanker 2005).

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[8] Soil carbon sequestration is a process by which carbon dioxide is transferred from the atmosphere into the soil through crop residues and other organic solids, and in a form that is not immediately reemitted. It is also important to note this sequestering or "transfer" of carbon helps off-set emissions from fossil fuel combustion and other carbon-emitting activities while enhancing soil quality and long-term agronomic productivity. (Sundermeier et al. 2005)

In addition, the high forest areas/regions of the country might have good opportunities for REDD projects. Given the untapped renewable energy resources potential, the country can emphasize on clean energy development and step-by-step replace the fossil-fuel based transport (freight and public) system by a railway system connected to the grid.
These efforts can also be linked to the global carbon finance opportunities. The country's biogas program can be linked to carbon finance opportunities. Improvements in agricultural and land management practices can also have substantial potential as carbon sink. An example is soil carbon sequestration (Ringius 2002).

The massive soil and water conservation activities in the country can be viewed in this light. However, to be eligible for crediting under the CDM, they need to be included in the upcoming commitments and climate negotiations. Grazing systems can enhance the removal of CO_2 from the environment and hence selected rangeland systems can be linked to carbon finance for their agro-ecosystem services/contribution as a carbon sink and to provide income diversification options for pastoralists. However, the tough and complex processes involved all the way through to register the projects for carbon financing are reasons for unnecessary disappointments.

7. Conclusions and the way forward

7.1. Summary and conclusions

Climate change is a major threat to sustainable growth and development in Africa, and the achievement of the Millennium Development Goals. The problem of climate change in particular is one of negative externality problem where emitters of greenhouse gases (GHGs) do not face the full cost implications of their actions. Therefore, enforcing quantitative limits (or cap) or emission targets is one way of making the emitters face the consequences of their actions and internalizing the externality. The two most common market based instruments employed to enforce the quantitative limits or emission targets are emissions/carbon taxes and cap and trade. This tax on a negative externality is called a Pigovian tax and should equal the marginal damage costs. In the cap and trade system each country, large-scale emitter, or company, will have a limit on the amount of GHG that it can emit, also known as "emissions permit or allowances". These permits set an enforceable limit (or cap**)** on the amount of GHG pollution that the company/country is allowed to emit.
The concept of the trade is that it will be relatively cheaper or easier for some countries/companies to reduce their emissions below their required limit than others. These more efficient countries/companies, who emit less than their allowance, can sell their extra permits to companies that are not able to make reductions as easily. This creates a system that guarantees a set level of overall reductions, while rewarding the most efficient countries/companies and ensuring that the cap can be met at the lowest possible cost to the economy. However, the popularity of cap-and-trade seems to be on the decline particularly since the recent financial crisis. Lately, there appears to be an intense debate about the relative merits of cap-and-trade versus carbon taxes, especially in the United States.

The global carbon market has emerged quite considerably during the last decade and particularly since the Kyoto Protocol**.** Essentially, CDM and REDD are the two major carbon market mechanisms where Africa can be involved. A distinction can also be made between mandatory (regulated) and voluntary markets. While some mandatory emission reduction schemes exclude forest projects, these projects flourish in the voluntary markets. In addition, although the global carbon market has emerged quite substantially during the last decade and particularly since the Kyoto Protocol**,** there is a widespread discontent that Africa has not benefited from the carbon market in general and the CDM in particular.

Despite the global economic downturn, the global carbon trading market grew 68 percent in 2009 compared to the previous year. But the value of the market remained virtually unchanged after carbon prices fell, averaging US$16.40 per ton in 2009. This is 40 percent down from US$27.15 in 2008. In terms of total value, the global carbon market reached US$136 billion in 2009, up from US$133 billion in 2008 and US$58 billion in 2007.

There are a number of mitigation options for Africa, including clean energy, energy efficiency, improved livestock systems, afforestation, avoided deforestation and forest degradation, and improved land management practices.

7.2. The way forward

Africa currently contributes only 4 percent of global GHG emissions. Energy emissions and emissions from agriculture account for about 86 percent of aggregated GHG emissions of the continent. Africa's forest resources are serving as a sink for about 25 percent of its emissions. Mitigation actions are necessary not only to enhance sustainable development but also to prevent the continent from becoming a major emitter.

Given the untapped renewable energy resources potential—including hydro, solar, and wind—the continent can emphasize on clean energy development and step-by-step replace the fossil-fuel based systems by clean energy both on and off grid options. This could be in the form of either individual country projects or cross-border cross-country investments.

Agricultural emission related with methane emission from livestock is the second most important emitter in the continent. Therefore, Africa should take adequate care of the emissions from livestock systems. The most important ways include better feed management, using more productive livestock breeds (or shifting species), manure management, and methane capture through biogas.

Africa can benefit substantially through emphasizing on other mitigation options and offering its natural forests as a sink to the rest of the world. DRC, Cameroon, Tanzania, and Madagascar can be viewed as priority countries for REDD. The afforestation and reforestation activities undertaken in the continent can be viewed as mitigation options and be linked to CDM. However, it requires that these **afforestation** and **reforestation** efforts need to be on land that had no forest at the end of 1989 to be eligible sink projects. Bio-energy (including energy efficiency) is yet another option. It involves many innovative projects aimed at replacing unsustainable fuelwood use with sustainable biomass or biogas, or aimed at reducing unsustainable fuelwood use through more efficient cooking stoves.

In Ethiopia, little has been done in light of tapping the global opportunities of carbon finance and it can be argued that Ethiopia has not yet benefited. The country's large livestock population, massive afforestation and reforestation can be considered as important mitigation options. In addition, the high forest areas/regions of the country might have good opportunities for REDD projects. Given the untapped renewable energy resources potential, the country can emphasize on clean energy development and step-by-step replace the fossil-fuel based transport (freight and public) system by a railway system connected to the grid. These efforts as well as the country's biogas program can also be linked to the global carbon finance opportunities. Improvements in agricultural and land management practices can also have a substantial potential as carbon sink. The massive soil and water conservation activities in the country can be viewed in this light. However, to be eligible for crediting under the CDM, they need to be included in the upcoming commitments and climate negotiations.

Grazing systems can enhance the removal of CO_2 from the environment, and hence selected rangeland systems can be linked to carbon finance for their agro-ecosystem services/ contribution as a carbon sink and to provide income diversification options for pastoralists. However, the tough and complex bureaucratic processes involved in registering the projects for carbon financing are reasons for unnecessary disappointments. In addition, mainstreaming (economics of) climate change into relevant sectors as well as institutionalizing (economics of) climate change as a discipline into the curriculum of universities that are granting BSc/MSc degree in Environmental/Resource Economics is another strategy.

A more careful analysis of relevant issues is also called for. Issues for further research include drought/weather index crop insurance for Ethiopia; analyzing historical costs of climate change for Ethiopia; assessing viable CDM opportunities for Ethiopia; and reviewing (revisiting) current carbon emissions rate of Ethiopia. It is also important to carefully examine in a comprehensive way the costs and benefits of various options that are available for African countries before deciding to undertake projects for carbon finance.

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Appendix

Appendix Table A.1. List of Non-Annex I Parties to the Convention

S.N.	Country	S.N.	Country	S.N.	Country	S.N.	Country
1	Afghanistan	26	Central African Republic	51	Gambia	76	Liberia
2	Albania **	27	Chad	52	Georgia	77	Libya
3	Algeria	28	Chile	53	Ghana	78	Madagascar
4	Angola	29	China	54	Grenada	79	Malawi
5	Antigua and Barbuda	30	Colombia	55	Guatemala	80	Malaysia
6	Argentina	31	Comoros	56	Guinea	81	Maldives
7	Armenia **	32	Congo	57	Guinea-Bissau	82	Mali
8	Azerbaijan	33	Cook Islands	58	Guyana	83	Marshall Islands
9	Bahamas	34	Costa Rica	59	Haiti	84	Mauritania
10	Bahrain	35	Cuba	60	Honduras	85	Mauritius
11	Bangladesh	36	Cyprus	61	India	86	Mexico
12	Barbados	37	Côte d'Ivoire	62	Indonesia	87	Micronesia (Federated States of)
13	Belize	38	Democratic People's Rep. of Korea	63	Iran (Islamic Republic of)	88	Mongolia
14	Benin	39	Democratic Rep. of the Congo	64	Iraq	89	Montenegro
15	Bhutan	40	Djibouti	65	Israel	90	Morocco
16	Bolivia	41	Dominica	66	Jamaica	91	Mozambique
17	Bosnia and Herzegovina	42	Dominican Republic	67	Jordan	92	Myanmar
18	Botswana	43	Ecuador	68	Kazakhstan **	93	Namibia
19	Brazil	44	Egypt	69	Kenya	94	Nauru
20	Brunei Darussalam	45	El Salvador	70	Kiribati	95	Nepal
21	Burkina Faso	46	Equatorial Guinea	71	Kuwait	96	Nicaragua
22	Burundi	47	Eritrea	72	Kyrgyzstan	97	Niger
23	Cambodia	48	Ethiopia	73	Lao People's Democratic Republic	98	Nigeria
24	Cameroon	49	Fiji	74	Lebanon	99	Niue
25	Cape Verde	50	Gabon	75	Lesotho	100	Oman

Appendix Table A.1. Continued

S.N.	Country	S.N.	Country	S.N.	Country	S.N.	Country
101	Pakistan	116	Samoa	130	Suriname	144	United Arab Emirates
102	Palau	117	San Marino	131	Syrian Arab Republic	145	United Republic of Tanzania
103	Panama	118	Sao Tome and Principe	132	Swaziland	146	Uruguay
104	Papua New Guinea	119	Saudi Arabia	133	Tajikistan	147	Uzbekistan **
105	Paraguay	120	Senegal	134	Thailand	148	Vanuatu
106	Peru	121	Serbia	135	The former Yugoslav Rep. of Macedonia	149	Venezuela (Bolivarian Rep. of)
107	Philippines	122	Seychelles	136	Timor-Leste	150	Viet Nam
109	Qatar	123	Sierra Leone	137	Togo	151	Yemen
110	Republic of Korea	124	Singapore	138	Tonga	152	Zambia
111	Republic of Moldova **	125	Solomon Islands	139	Trinidad and Tobago	153	Zimbabwe
112	Rwanda	126	Somalia	140	Tunisia		
113	Saint Kitts and Nevis	127	South Africa	141	Turkmenistan **		
114	Saint Lucia	128	Sri Lanka	142	Tuvalu		
115	Saint Vincent and the Grenadines	129	Sudan	143	Uganda		

Source: UNFCCC Website. Retrieved 2012-03-29 (http://unfccc.int/parties_and_observers/parties/non_annex_i/items/2833.php)
Notes: ** Party for which there is a specific COP and/or CMP decision

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