Forests, Agriculture, and Climate: Economics and Policy Issues

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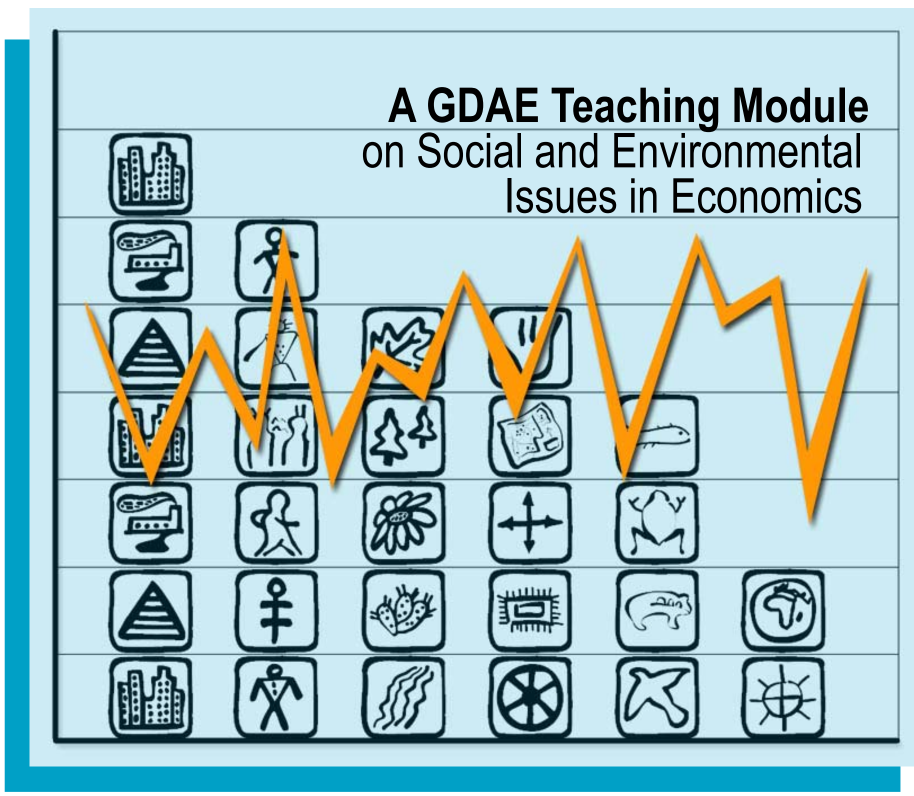

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CONTENTS

1. THE ROLE OF FORESTS AND AGRICULTURE IN CLIMATE CHANGE 3
   Importance of forests in the carbon cycle 5
   Scale of world forest coverage and forest loss 9
   What causes deforestation? 12
2. REDUCING EMISSIONS FROM DEFORESTATION AND DEGRADATION 15
   The structure of REDD 15
   Potential of REDD mechanisms for carbon reduction 16
3. THE ECONOMICS OF REDD 19
   REDD Costs 19
   Establishing a baseline 20
   Permanence 21
   Leakage 21
   Estimating emissions from deforestation 23
4. AGRICULTURE AND CLIMATE CHANGE 24
   The significance of agriculture 24
   Potential for greenhouse gas mitigation in agriculture 26
   The impact of biofuels 27
   Biofuels, food supply, and forests 32
5. CONCLUSION: NEW INSTITUTIONS FOR FORESTRY AND AGRICULTURE 33
   REDD and development 34

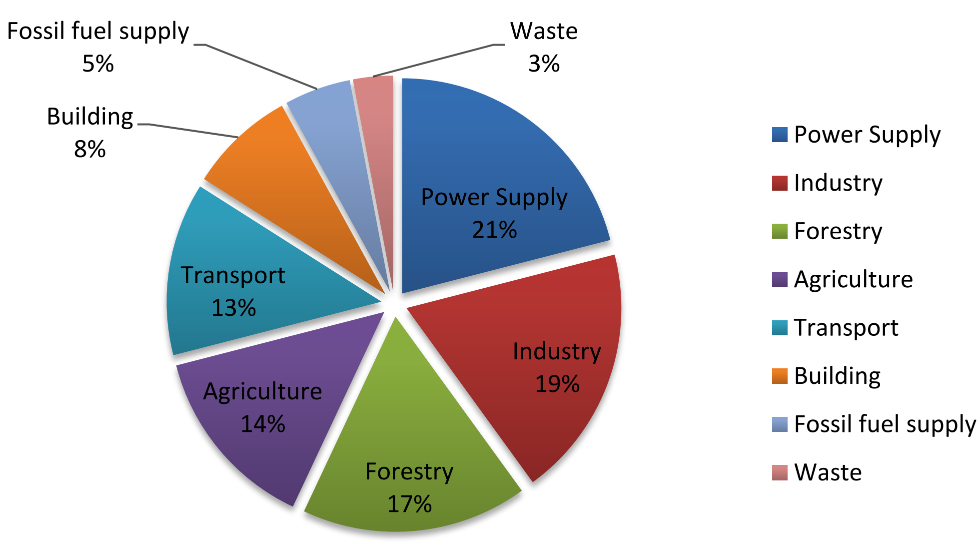
KEY TERMS AND CONCEPTS 36
REFERENCES 38
DISCUSSION QUESTIONS 41
WEB LINKS 42

1. THE ROLE OF FORESTS AND AGRICULTURE IN CLIMATE CHANGE

The problem of global climate change has occurred because the balance of the world's carbon cycle has been upset. Atmospheric carbon emissions by humans, together with other greenhouse gases such as methane, exceed the earth's capacity to store carbon in forests, oceans and living and dead biomass. The solution to the problem must lie in reducing human-created carbon emissions, increasing carbon absorption capacity, or both. The focus of most climate policy discussions has been on reducing industrial emissions, and with good reason -- industrial emissions account for about 70% of total greenhouse gases (GHG's), and it is virtually impossible to imagine ways to absorb and store this much excess carbon. But it is also true that non-industrial areas including land use, forestry, and agriculture account for about 30% of emissions. Agriculture and forestry hold significant potential for storing excess carbon – not enough to solve the problem, but certainly enough to be a significant contribution to any systematic policy solution. For this reason, attention has started to focus on the issues of land use, forestry and agriculture – sometimes referred to as REDD (reduction of emissions from deforestation and degradation) or, more broadly as LULUCF (Land Use, Land Use Change, and Forestry).

The world's forests store more than 650 billion tons of carbon: 44 percent in biomass, 11 percent in dead wood and litter, and 45 percent in soil. According to the Intergovernmental Panel on Climate Change (IPCC) 2007 report, deforestation accounts for about 17%-18% of global anthropogenic GHG emissions, the biggest contributor after energy supply (power and fossil fuel), which accounts for about 26 percent of emissions (IPCC 2007) (Figure 1).

Figure 1. Forestry and Agriculture as a Percent of Total Greenhouse Gas Emissions



Source: Figure adapted from UN Framework Convention on Climate Change (UNFCCC 2007).

As shown in Figure 2, deforestation and timber harvest together contribute 20.8% of GHG emissions, offset by 2% carbon absorption from **afforestation** (increase in forest area) and **reforestation** (regrowth in harvested areas) Most of the emissions from deforestation are in the form of CO_2, while emissions from agriculture, primarily methane (CH_4) and nitrous oxide (NO_2), amount to 13.5% of global GHG emissions.

These figures indicate that reduction of emissions from deforestation and agriculture could be a significant part of global efforts to combat climate change and reduce GHG emissions. The possibility of mitigating climate change by reducing carbon emissions caused by deforestation and forest degradation, and by increasing carbon uptake through afforestation and sustainable forest management, has become a significant feature of global discussions on responses to climate change.

Figure 2. Sources and Flows of Greenhouse Gases

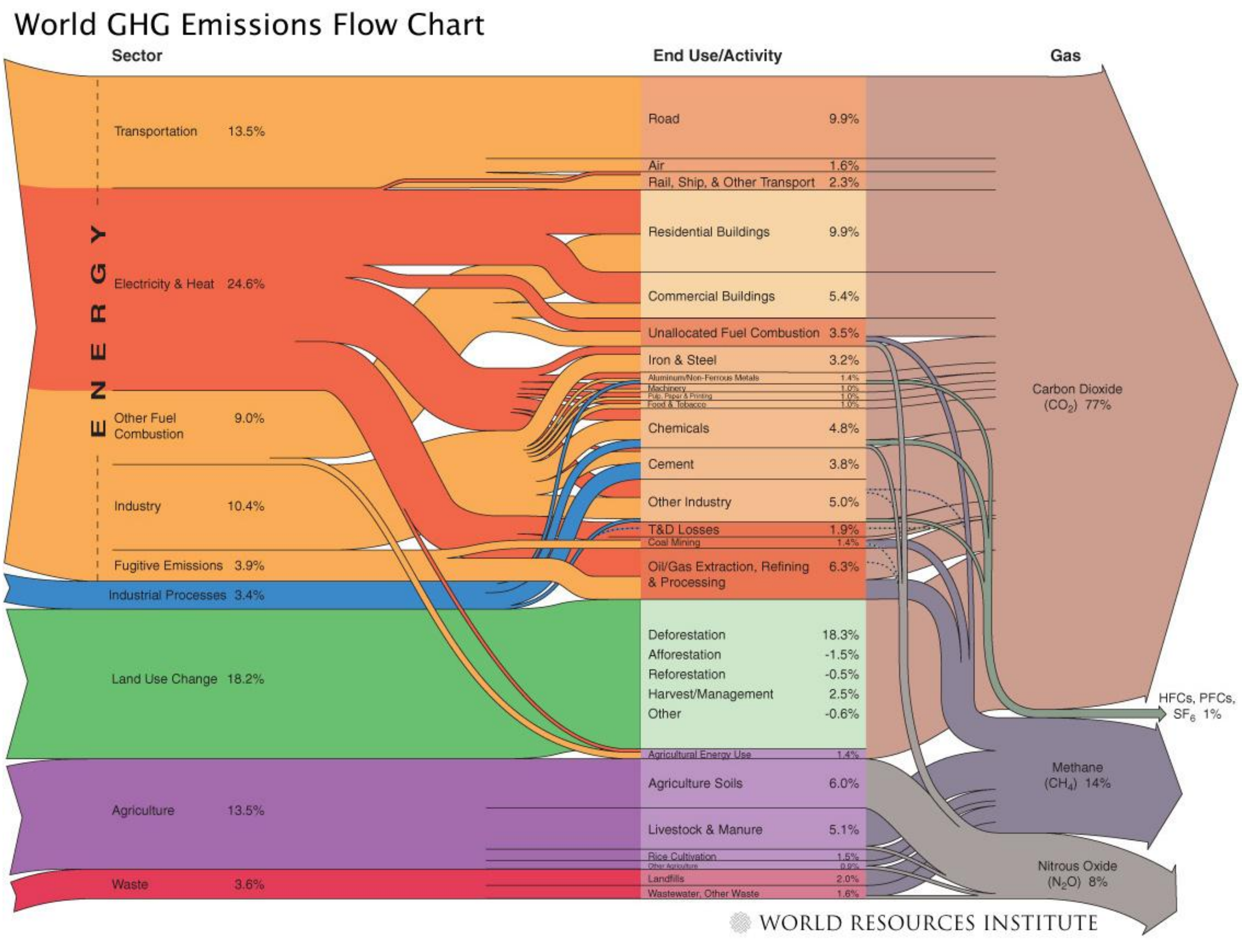
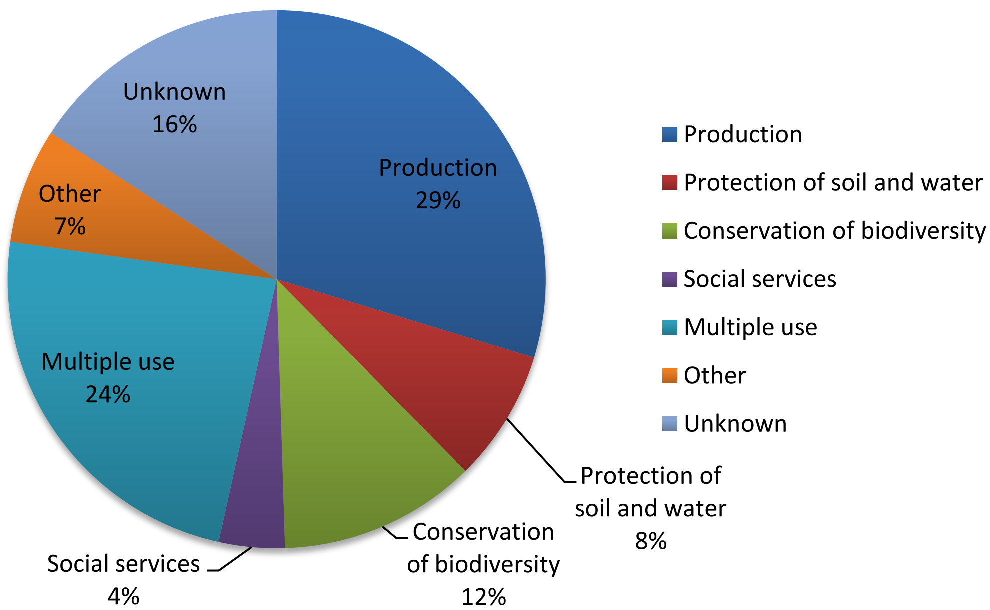


Figure source: World Resource Institute (WRI)[1], accessed 2011.

[1] Chart can be accessed at http://cait.wri.org/figures.php?page=/World-FlowChart

Forests are increasingly being conserved and managed for multiple uses and values – often in combination (Figure 3). Around 949 million hectares, or 24 percent of all forests, are designated for multiple uses, i.e. managed for a combination of the production of goods, protection of soil and water, conservation of biodiversity and provision of social services (see Box 1 on p. 7). Agricultural lands are primarily used for production of food and other agricultural products, but can also serve functions of soil and water protection and carbon storage, depending on agricultural techniques. In this module, we will focus on the potential of forests and agricultural lands to help solve the problem of climate change, and examine some of the policy initiatives that have begun to take advantage of this potential.

Figure 3. Designated functions of forests, 2010



Source: *Global Forest Resources Assessment*, by Food and Agriculture Organization of the United Nations, 2010 (FAO 2010)

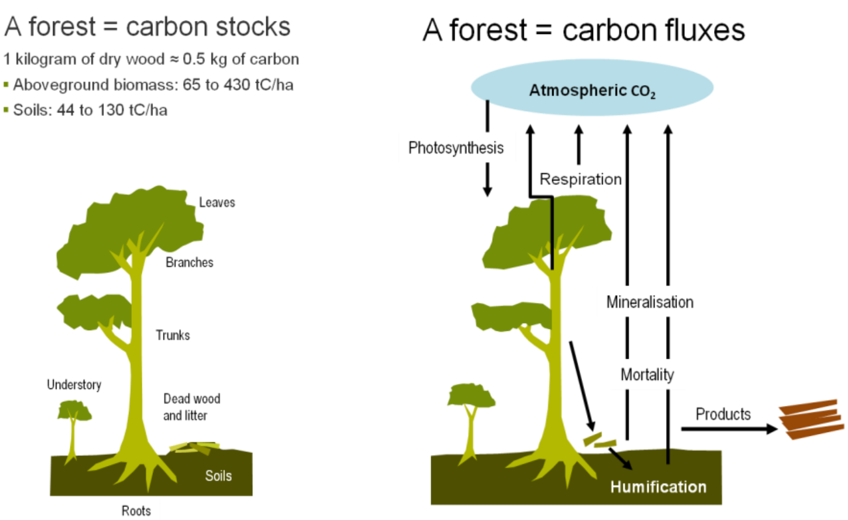
Importance of forests in the carbon cycle

Let’s have a closer look at the linkages between forestry and climate change and clarify some related definitions in order to better understand the role of forests in combating climate change. Forests can affect the global carbon cycle in two different ways:

- Forests as **carbon stocks**: a forest, like any other ecosystem, accumulates carbon from the atmosphere by breaking down carbon dioxide into carbon and oxygen. The carbon thus generated is stored in tree trunks, branches, leaves, and other parts of plants, as well as in soils as living and dead biomass. The dry biomass of a tree is about 2 tons, which can contain around 1 ton of carbon. A tropical wet forest can store up to 430 tons of carbon per hectare in aboveground biomass (CIFOR 2009).

- Forests as **carbon fluxes**: The second way through which forests can affect the carbon cycle is carbon fluxes they generate. Through the process of photosynthesis and using sunlight, leaves absorb CO_2 from atmosphere (inbound flux). This stored up carbon will be distributed to the plant and transferred to soil when leaves and branches fall down and decompose. Also, part of this CO_2 will be returned to the atmosphere through respiration and soil mineralization (outbound flux). The **net absorption flux** is the difference between the inbound and outbound (CIFOR 2009). This concept is represented in Figure 4.

Figure 4. Forests as carbon stocks and carbon fluxes



Source: CIFOR 2009

As a forest grows, the net flux is an inbound flux, meaning that CO_2 is removed from the atmosphere. This process is called **carbon fixation**, absorption or removal and the ecosystem is called a **carbon sink**. On the other hand, if the stock decreases (in a decaying or burning forest), an outbound flux will increase atmospheric greenhouse gas emissions concentrations and increase climate change. The process is called carbon emission and the ecosystem is called a **carbon source** (CIFOR 2009).

Depending on whether forest cover is expanding or contracting, large regions of the world can be net carbon sources (contributing to climate change) or net carbon sinks (reducing climate change. Figure 5a shows how forested areas in South and Central America, Africa, and South and South East Asia have become major sources of atmospheric carbon due to forest loss and degradation during the twentieth and early twenty-first centuries. Figure 5b shows that forests in Europe, the former USSR, China, and the United States are no longer major carbon sources, and in the case of the U.S., Europe, and China have become net carbon sinks. China's transition to a carbon sink is mainly due to afforestation projects developed in the past decade as a result of serious environmental damage, including massive flooding, that resulted from earlier forest degradation (See Box 2 on p. 10 for more information on China's forest policy)

Figure 5a. Annual Net Flux of Carbon to the Atmosphere from Land Use Change, South America, Africa, and Asia: 1850-2005

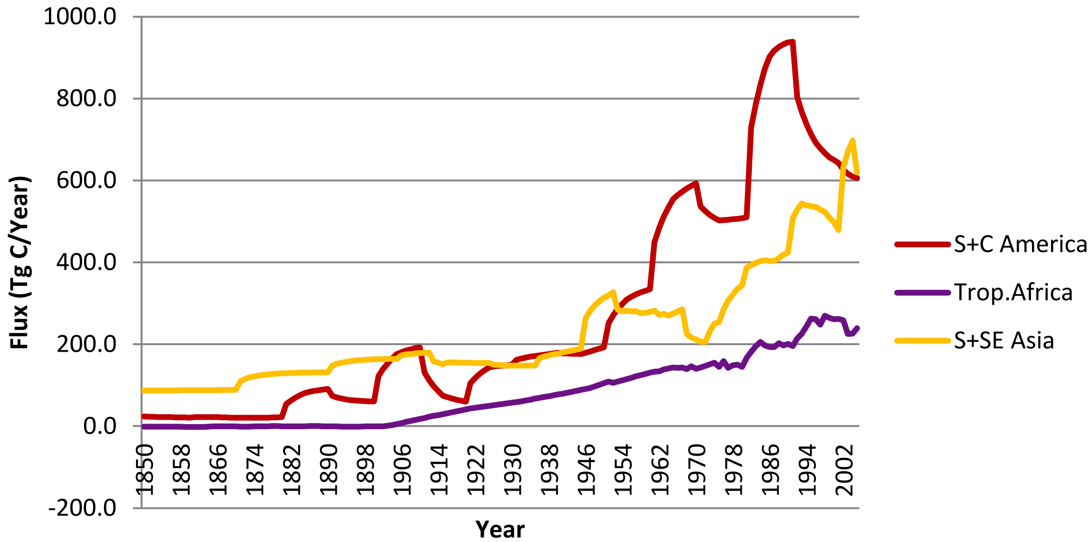


Figure 5b. Annual Net Flux of Carbon to the atmosphere from land use change, Europe, China, Former USSR, and USA: 1850-2005

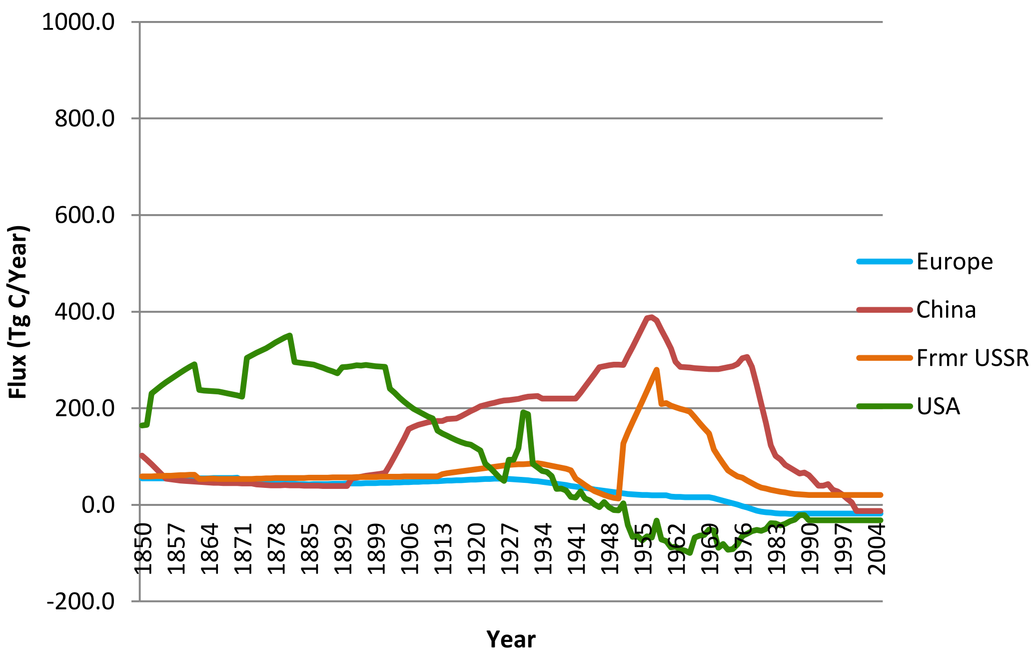


Figure source: Houghton 2008[2].

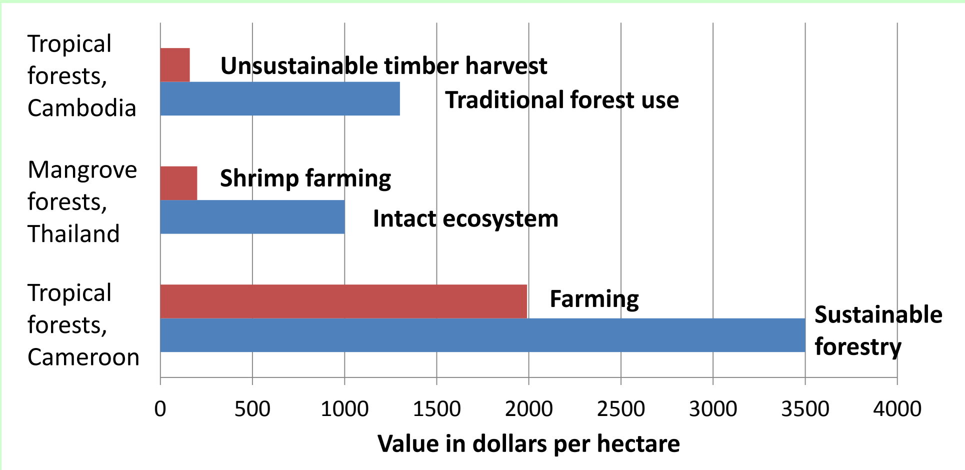
[2] Data are accessible at http://cdiac.ornl.gov/trends/landuse/houghton/houghton.html

Box 1 - Social and ecological functions of forests

"Forests are more than just carbon, they are home to local communities and they provide essential ecosystem services beyond carbon storage. Forest resources directly support the livelihoods of 90% of the 1.2 billion people living in extreme poverty and are home to nearly 90% of the world's terrestrial biodiversity. Indigenous and forest-dependent peoples are stewards of their forests, providing the rest of humanity with vital ecosystem services (ES). Also, forests provide ecosystem services such as watershed protection, water flow regulation, nutrient recycling, rainfall generation and disease regulation that all will be negatively affected by the recent global deforestation and forest degradation trends." (Parker et al. 2008).

The total economic value of forests includes all these services, as well as other benefits such as recreation opportunities and the existence value of simply knowing that pristine forests are preserved. Some economists have attempted to measure the total economic value of intact forest ecosystems. While converting all these benefits to monetary units is subject to both methodological and ethical concerns, policy makers can potentially use this information to determine optimal forest policies. In particular, the economic value of preserving forests can be compared to extractive uses such as timber or agricultural development.

The results of several studies suggest that the benefits of preserving forests often exceed the benefits of extractive uses. For example, a study of Mediterranean forests found that in some countries nonmarket benefits, including carbon storage, watershed protection, and recreation, are greater than the combined economic values from timber, fuelwood, and grazing. Other research (see figure below) has found that the benefits of intact or sustainably managed forest ecosystems exceed the value of unsustainable uses in Cambodia, Thailand, and Cameroon (Millenium ecosystem assessment 2005).

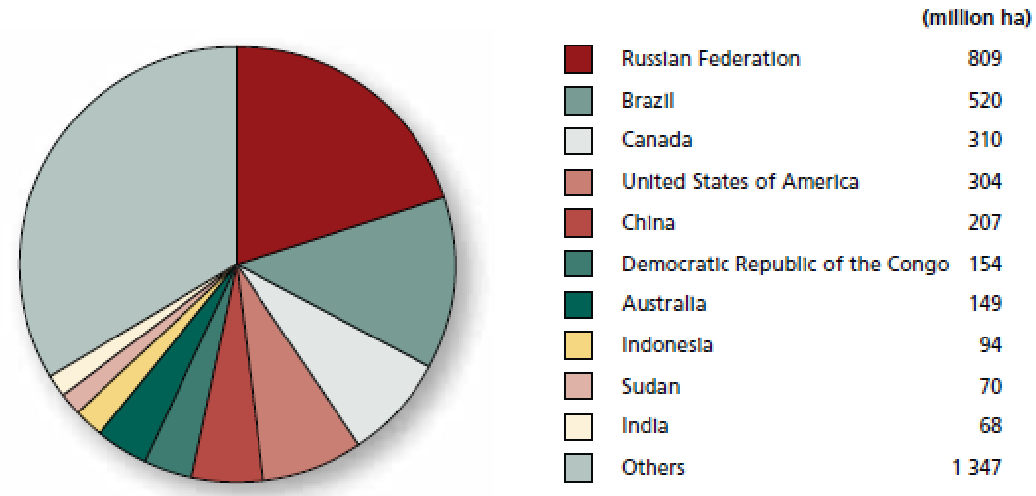


An attempt to estimate the economic value of the world's forest ecosystems found that forests provide about $5 trillion in total annual value to humanity, with only about 20% of these benefits derived from extractive uses. Economic benefits from forests includes the ecosystem services provided to us without cost, such as nutrient cycling, erosion control, climate regulation and waste treatment (Costanza et al. 1997, 253-260).

Scale of world forest coverage and forest loss

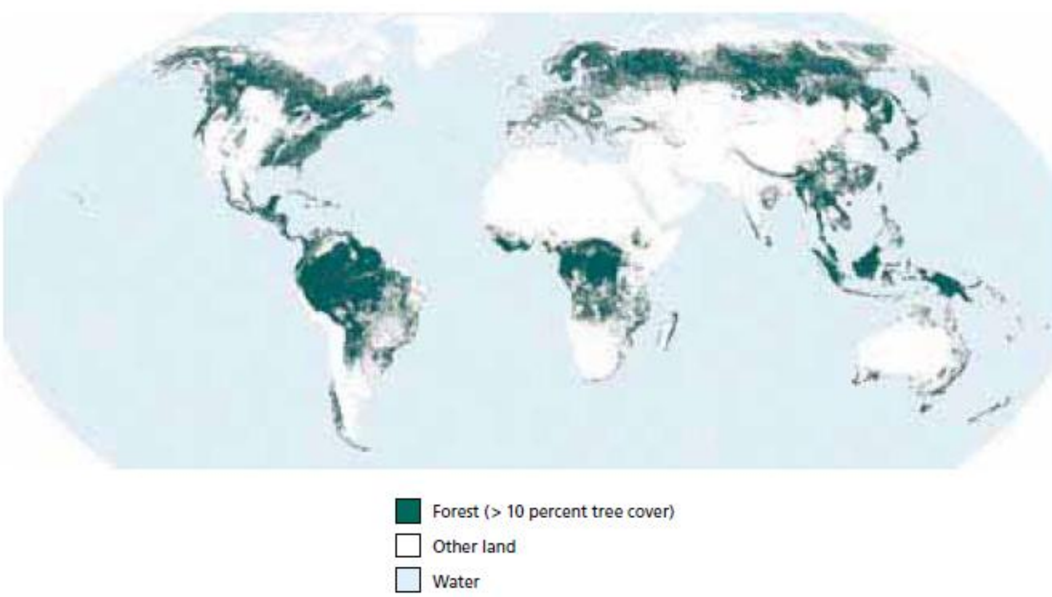
Forests cover 31 percent of the total land area of the planet (Figure 6). The largest forest areas are located in the Russian Federation and Brazil. Canada, the Eastern U.S., Central Africa, and South-East Asia also have large forested areas (Figure 7).

Figure 6. Top countries with the largest forest area



Source: Global Forest Resources Assessment, by Food and Agriculture Organization of the United Nations, 2010, (FAO 2010)

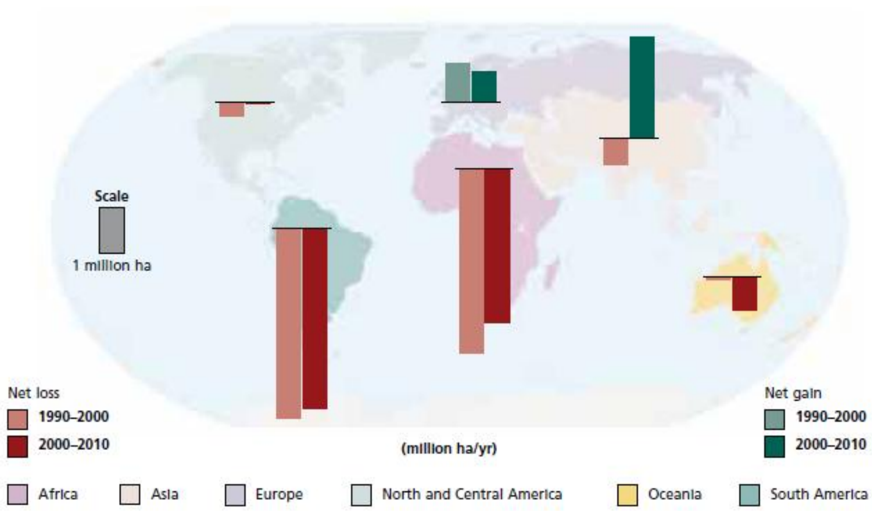
Figure 7. The world's forest coverage



Source: Global Forest Resources Assessment, by Food and Agriculture Organization of the United Nations, 2010, (FAO 2010)

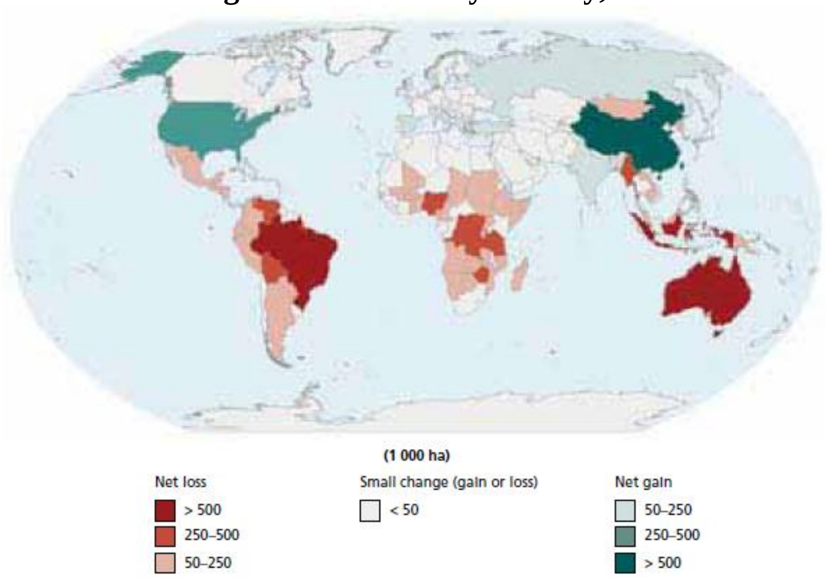
At a regional level, South America suffered the largest net loss of forests between 2000 and 2010 – about 4.0 million hectares per year – followed by Africa, which lost 3.4 million hectares annually (Figs. 8 & 9) (FAO 2010). Asia, which saw a net loss of some 0.6 million ha/yr in the 1990s, reported an average net gain of more than 2.2 ha/yr between 2000 and 2010, due to large-scale afforestation in China (see Box 2) and a reduction in the rate of deforestation in some countries, including Indonesia.

Figure 8. Annual change in forest area by region, 1990-2010



Source: Global Forest Resources Assessment, by Food and Agriculture Organization of the United Nations, 2010, (FAO 2010)

Figure 9. Annual change in forest area by country, 2005- 2010



Source: Global Forest Resources Assessment, by Food and Agriculture Organization of the United Nations, 2010, (FAO 2010)

Box 2 - Afforestation and Reforestation in China

China has long suffered from severe problems of soil erosion and flooding due to loss of forest cover. An estimated 2 to 4 billion tons of silt flows into the Yangtze and Yellow Rivers annually, and periodic floods cause hundreds of deaths and huge economic losses. This has motivated the Chinese government to undertake the largest reforestation project in the world.

China's Sloping Lands Conversion Program (SLCP), initiated in 1999, has the goal of converting 14.67 million hectares of cropland to forests by 2010 and afforesting a roughly equal area of wasteland by 2010. In the past two decades, volunteers participating in the national tree-planting movement throughout the country have planted over 35 billion trees. As a result, forest coverage in China has increased to 16.5 percent. In the 1950s and 60s, China had one of the highest net forest carbon emission rates in world (see Figure 5b) – this rate has now fallen to zero and could become negative (net carbon storage) in the near future.

The program involves tens of millions of rural households who receive payments for forest conservation from a total government budget of RMB 337 billion (over US $40 billion). This makes it the largest program of Payment for Environmental Services (PES) worldwide. Analyses of the program find that its net effect on farm family income has been positive. Although China's motivation for this reforestation program is not directly related to global climate change, it could provide a model for forest conservation programs throughout the developing world.

Erosion on the Yellow River plateau (Source: cnr.cn)

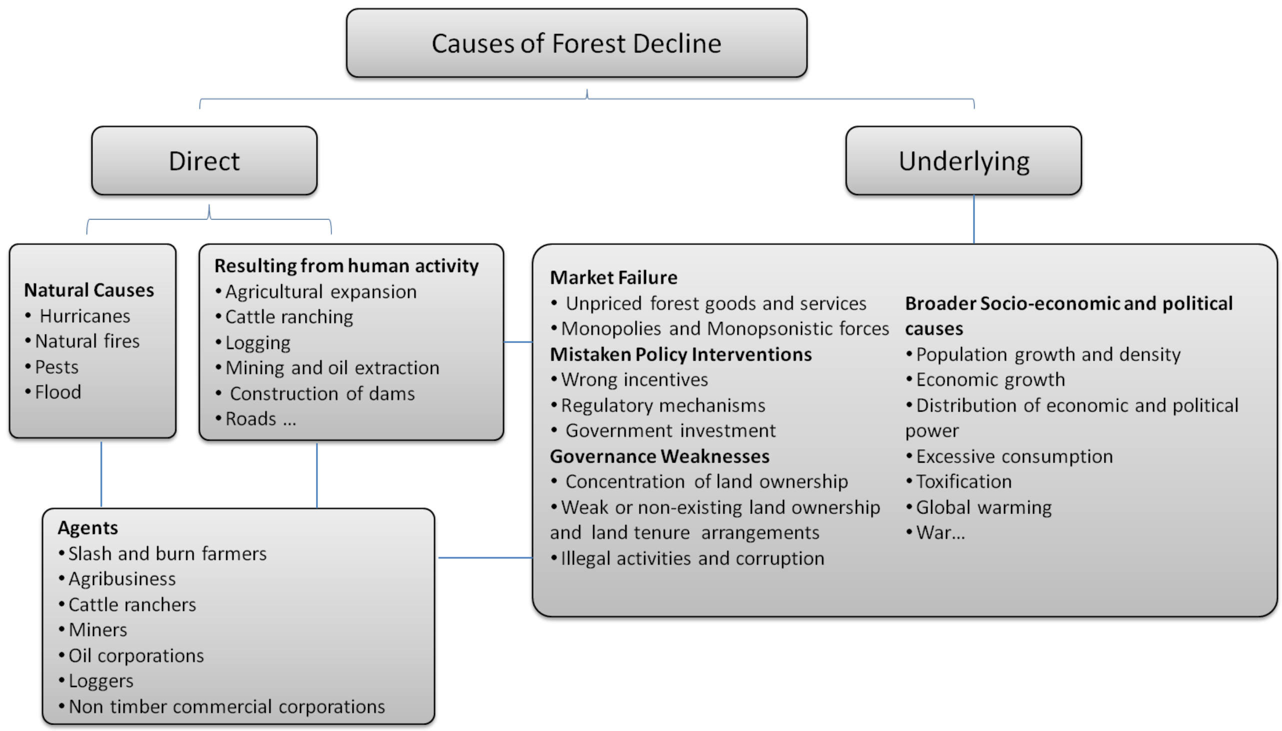
Sources: J. Lie M. Feldman, S. Li, and G. Daily, "Rural household income and inequality under the Sloping Land Conversion Program in western China" Proceedings of the National Academy of Sciences, April 25, 2011 http://www.pnas.org/content/early/2011/04/20/1101018108.short

Kelly, P., "Effects of China's Sloping Land Conversion Program on Nonfarm Labor Market Participation" http://bss.sfsu.edu/economics/newsevents/pacdev/Papers/Kelly.pdf
China Through a Lens, http://www.china.org.cn/english/features/38276.htm

What causes deforestation?

There are multiple causes for deforestation. Despite public perception that the main culprit is logging, the major reason for deforestation is agricultural activities. These include expansion of both subsistence and intensive agricultural operations and cattle ranching. The economic incentives for forest destruction may arise from markets for timber and agricultural products, but they may also be a result of **market failures** and destructive **government policies** such as subsidies for logging, road-building, and agricultural exports. The complex patterns which lead to forest loss are shown in Figure 10.

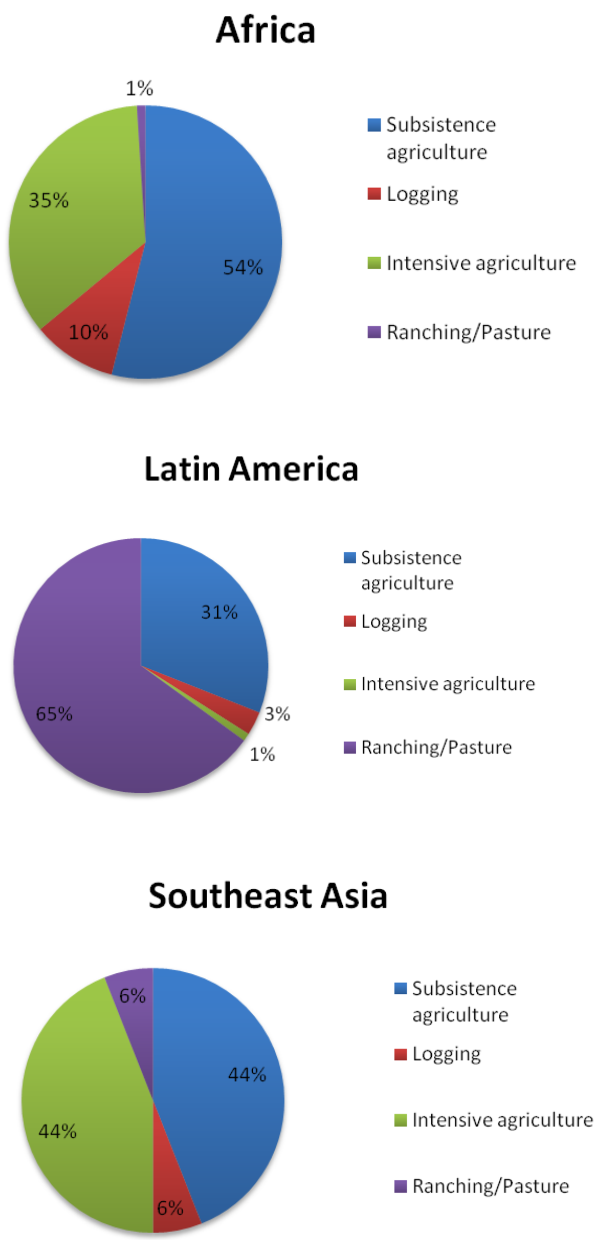
Figure 10. Causes of Forest Decline



Source: Contreras-Hermosilla 2000.

Figure 11 shows a regional breakdown of the drivers of deforestation. In Latin America, the main driver is conversion of forest land for ranching or pasture, while in Southeast Asia and Africa it is agriculture, with intensive agriculture being more significant in Southeast Asia and subsistence agriculture the main driver in Africa.

Figure 11. Regional breakdown of drivers of deforestation



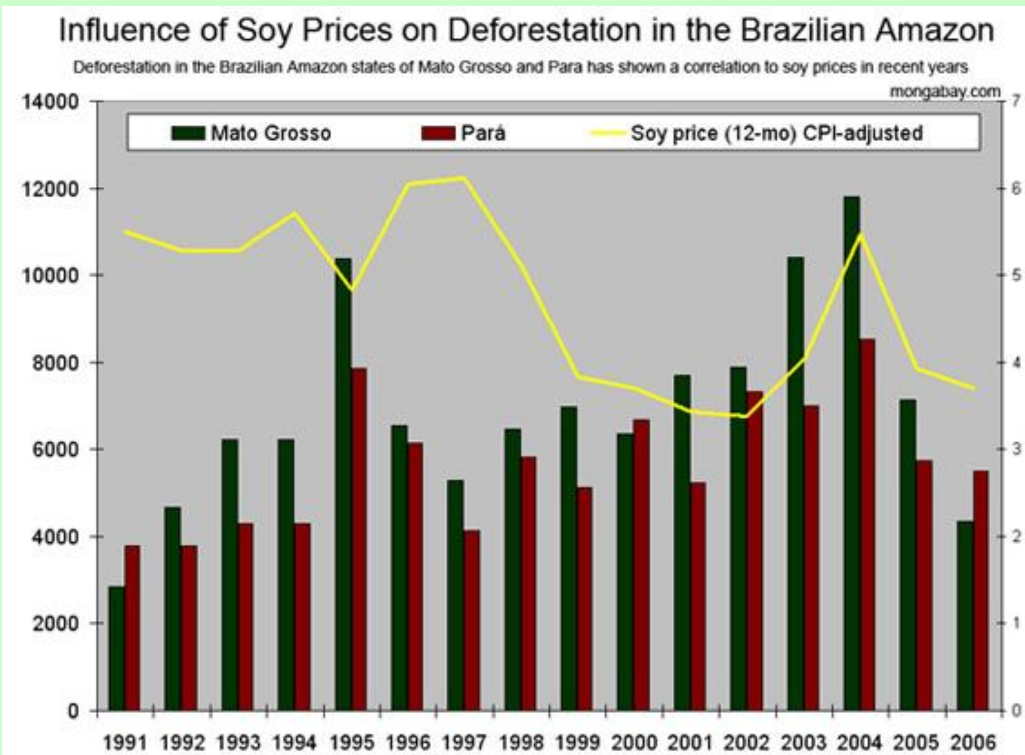
Source: Project Catalyst, 2009[3]

[3] Project Catalyst 2009 Towards the inclusion of forest-based mitigation in a global climate agreement (Working Draft), http://www.project-catalyst.info/Publications/Working%20Group%20papers/Towards%20the%20inclusion%20of%20forest-based%20mitigation%20in%20a%20global%20climate%20agreement%2014%20May%2009..pdf

Box 3 - Deforestation in Brazil

Agriculture is linked to deforestation in developing countries both directly through expansion and indirectly through infrastructure development. Clearing forest land for cattle pasture is the largest driver of deforestation in the Amazon, accounting for more than two-thirds of annual forest clearing in many years. Brazil is now the world's largest beef-exporting country by volume, due in part to Brazil's ready availability of land resources. In areas suitable for soy cultivation, forest lands are typically cleared for cattle ranching then sold to soy producers some two to three years later. As ranchers move further into frontier areas, the pattern of deforestation and expansion continues.

The graph below shows the influence of soy prices (CPI-adjusted, 12-month moving average) on deforestation in the Brazilian Amazon. Deforestation in the states of Mato Grosso and Para has shown a particularly strong correlation to soy prices in recent years.



Graph Source: Rhett A. Butler / mongabay.com, http://www.mongabay.com/

Sources: REDD and Agriculture, a report by Agricultural Carbon Market Working Group, available at: http://www.agcarbonmarkets.com/documents/TCG%20White%20Paper_Agriculture%20and%20Deforestation_FINAL.pdf; Elizabeth Barona, Navin Ramankutty, Glenn Hyman and Oliver Coomes. The role of pasture and soybean in deforestation of the Brazilian Amazon. Environ. Res. Lett. 5 (April-June 2010); Robert Walker, Ruth DeFries, Maria del Carmen Vera-Diaz, Yosio Shimabukuro, and Adriano Venturieri "The Expansion of Intensive Agriculture and Ranching in Brazilian Amazonia," by, in *Amazonia and Global Change*, Geophysical Monograph Series, Volume *186*, 2010; "The Environmental Impacts of Soybean Expansion and Infrastructure Development in Brazil's Amazon Basin," by Maria del Carmen Vera-Diaz, Robert K. Kaufmann, and Daniel C. Nepstad, GDAE Working Paper No. 09-05, June 2009.

2. REDUCING EMISSIONS FROM DEFORESTATION AND DEGRADATION

<u>The structure of REDD</u>

International negotiations as part of the Kyoto process following the original Kyoto accords on climate change in 1997 have led to the adoption of a program known as REDD (Reduction of Emissions from Deforestation and Degradation). The Copenhagen Accord (2010) acknowledged the need to act on reducing emissions from deforestation and forest degradation and established a mechanism known as REDD-plus. The Accord emphasizes funding for developing countries to enable action on mitigation, including substantial finance for REDD-plus, adaption, technology development and transfer and capacity building.

According to the United Nations REDD program, http://www.un-redd.org/:

> Deforestation and forest degradation, through agricultural expansion, conversion to pastureland, infrastructure development, destructive logging, fires etc., account for nearly 20% of global greenhouse gas emissions, more than the entire global transportation sector and second only to the energy sector. It is now clear that in order to constrain the impacts of climate change within limits that society will reasonably be able to tolerate, the global average temperatures must be stabilized within two degrees Celsius. This will be practically impossible to achieve without reducing emissions from the forest sector, in addition to other mitigation actions.
>
> Reducing Emissions from Deforestation and Forest Degradation (REDD) is an effort to create a financial value for the carbon stored in forests, offering incentives for developing countries to reduce emissions from forested lands and invest in low-carbon paths to sustainable development. “REDD+” goes beyond deforestation and forest degradation, and includes the role of conservation, sustainable management of forests and enhancement of forest carbon stocks.
>
> It is predicted that financial flows for greenhouse gas emission reductions from REDD+ could reach up to US$30 billion a year. This significant North-South flow of funds could reward a meaningful reduction of carbon emissions and could also support new, pro-poor development, help conserve biodiversity and secure vital ecosystem services.

The REDD+ program thus involves several possible strategies for reducing carbon emissions:

- Preventing deforestation. Reduced deforestation and degradation is the forest mitigation option with the largest and most immediate carbon stock impact in the short term per ha and per year globally. Each hectare (1 hectare = 2.47 acres) of forest lost will release 350-900 tons of CO_2 to the atmosphere, and this large emission can be prevented by preserving the forest. Effective programs to prevent deforestation thus have the potential to deliver large cuts in carbon emissions at a low cost, within a short time span.

- Afforestation and reforestation -- planting forests in areas that previously were not forested, or have lost forest. This strategy leads to long-term carbon-storage benefits as the new forests grow, but also involves up-front costs.

REDD promotes both forest preservation and afforestation/reforestation by linking financial incentives for conservation with the carbon stored in forests. Forest owners or managers would receive credits for 'avoided deforestation' or reforestation; credits would be tradable in international carbon markets or through other mechanisms that effectively convert the credit to cash. In March 2009, a United Nations program aimed at reducing greenhouse gas emissions from forests and boosting livelihoods in tropical nations approved $18 million in support of five pilot countries in Africa, Asia and Latin America. Since then, a total of $55.4 million has been approved for projects in Bolivia, Cambodia, Democratic Republic of the Congo (DRC), Ecuador, Indonesia, Panama, Papua New Guinea, Paraguay, the Philippines, Solomon Islands, Tanzania, Viet Nam and Zambia**.**

Although the concept and initial funding is encouraging, many issues remain for REDD implementation, including its economic foundations, financial mechanisms and political debates, which will be further discussed in the following sections.

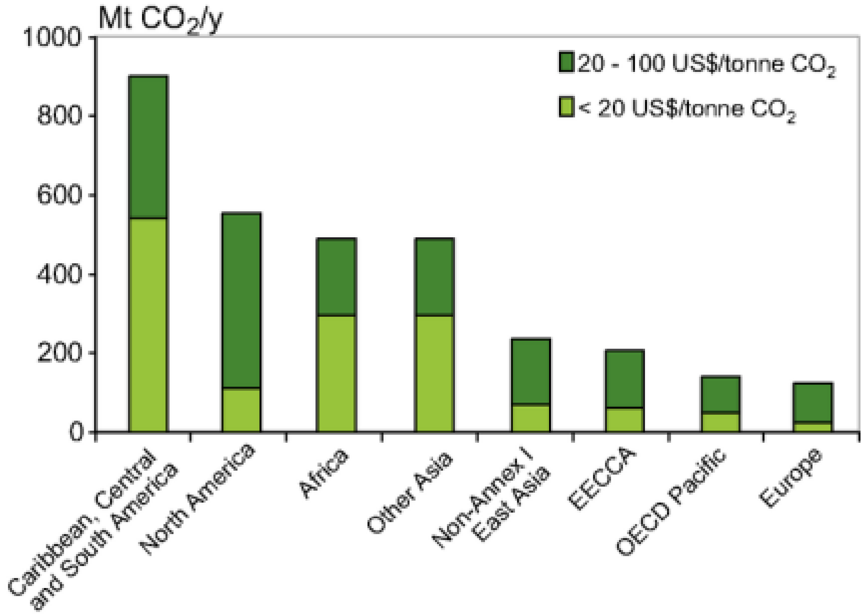
Potential of REDD mechanisms for carbon reduction

How much carbon reduction could be achieved through REDD? From an economic point of view, answering this question requires a consideration of the costs of REDD. Different methods of carbon reduction have different costs (and some may have economic benefits apart from emissions reduction). It turns out that a substantial amount of forestry-related carbon reductions could be achieved at fairly low cost.

According to the Intergovernmental Panel on Climate Change (IPCC) Fourth Assessment Report, forestry mitigation options have the potential to contribute between 1270 and 4230 $MtCO_2$/yr in 2030, and about 50% of the this amount is achievable at a cost under 20 US$/$tCO_2$ (Metz et al. 2007a) (Figure 12). 20 US$/$tCO_2$ represents a low carbon cost – for comparison, the price of a ton of carbon in the European Union's carbon trading scheme has varied around $20 per ton, and some analysts recommend a much higher carbon price (Ackerman and Stanton 2011).

The greatest forestry mitigation potential is in the tropics. For tropical areas as a whole, mitigation estimates for lower price ranges (<20 US$/$tCO_2$) are around 1100 $MtCO_2$/yr in 2040, about half of this potential is located in Central and South America (Sathaye et al. 2006), (Soares-Filho et al. 2006, 520-523), (Sohngen and Sedjo 2006, 109-126) and (Metz et al. 2007a). For each of the regions Africa and Southeast Asia, this mitigation potential is estimated at 300 $MtCO_2$/yr in 2040. In the high range of price scenarios (< 100 US$/$tCO_2$), the mitigation estimates are in the range of 3000 to 4000$MtCO_2$/yr in 2040 (Metz et al. 2007a) (Table 1).

Figure 12. Annual REDD economic mitigation potential, 2030



Source: IPCC Fourth Assessment Report: Climate Change 2007[4]

Table 1: Potential for Carbon Emissions Reduction in Forested Lands

	Economic potential in 2040 ($MtCO_2$/yr) low	Economic potential in 2040 ($MtCO_2$/yr) high	Fraction of total (technical) potential in cost class <20 US$/$tCO_2$
North America	400	820	0.2
Europe	90	180	0.2
Russian Federation	150	300	0.3
Africa	300	875	0.6
OECD Pacific	85	255	0.35
Caribbean, Central and South America	500	1750	0.6
Non Annex I East Asia	150	400	0.3
Non Annex I South Asia	300	875	0.6
Total	**1,975**	**5,455**	

Source: (Metz et al. 2007a)[5]

[4] Accessible at http://www.ipcc.ch/publications_and_data/ar4/wg3/en/ch9s9-4-4.html

[5] Also available at http://www.ipcc.ch/publications_and_data/ar4/wg3/en/ch9s9-4-4.html#table-9-6

Box 4 - Deforestation and Conservation Scenarios for the Amazon Basin

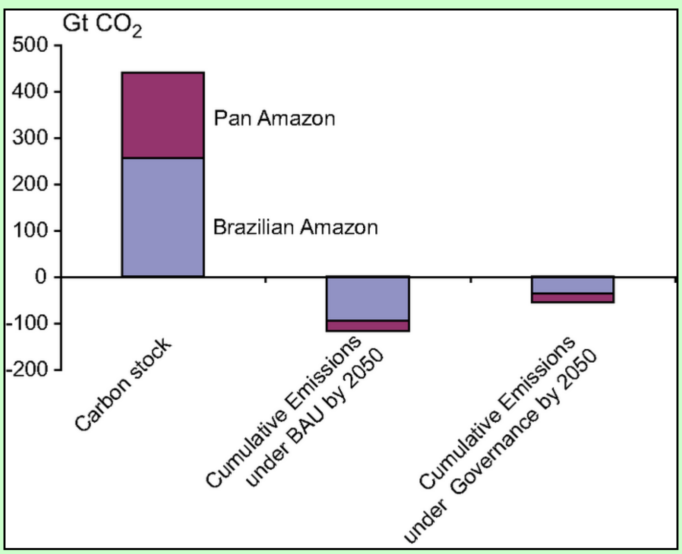
Assumptions of future deforestation rates are key factors in estimates of GHG emissions from forest lands and of mitigation benefits, and vary significantly across studies. In all the studies, however, future deforestation is estimated to remain high in the tropics in the short and medium term. Sathaye *et al.* (2006) estimate that deforestation rates continue in all regions, particularly at high rates in Africa and South America, for a total of just under 600 million ha lost cumulatively by 2050.

An empirically based, policy-sensitive simulation model of deforestation for the Pan-Amazon basin has been developed (Soares-Filho et al. 2006, 520-523). Model output for the worst-case scenario (business-as-usual) shows that, by 2050, projected deforestation trends will eliminate 40% of the current 5.4 million km^2 of Amazon forests, releasing approximately 117,000 $MtCO_2$ cumulatively by 2050.

Conversely, under the best-case governance scenario, 4.5 million km^2 of forest would remain in 2050, which is 83% of the current extent or only 17% deforested, reducing cumulative carbon emissions by 2050 to only 55,000 $MtCO_2$. The difference between the two scenarios represents an amount equivalent to eight times the carbon emission reduction to be achieved during the first commitment period of the Kyoto Protocol.

Current experiments in forest conservation on private properties, markets for ecosystem services, and agro-ecological zoning must be refined and implemented to achieve comprehensive conservation. Part of the financial resources needed for these conservation initiatives could come in the form of carbon credits resulting from the avoidance of 62,000 $MtCO_2$ emissions over 50 years.

Current carbon stocks for the Pan-Amazon and Brazilian Amazon (left bar); estimates of cumulative emission by 2050 under BAU (business-as-usual) and governance scenarios.



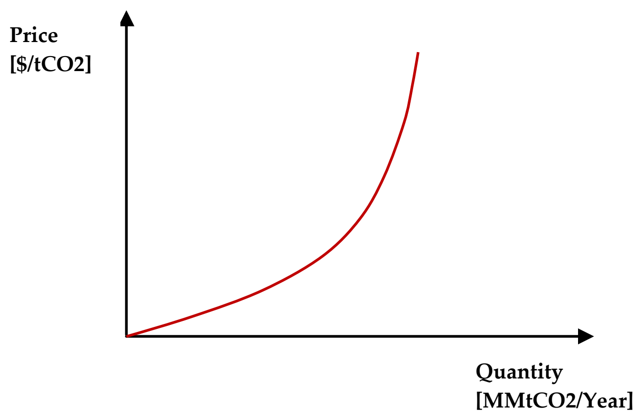
Sources: Sathaye et al. 2006; Soares-Filho et al. 2006, 520-523; *IPCC Fourth Assessment Report: Climate Change 2007, accessible at* http://www.ipcc.ch/publications_and_data/ar4/wg3/en/ch9s9-4-3-1.html

3. THE ECONOMICS OF REDD

<u>REDD Costs</u>

What are the costs of reducing carbon emissions through REDD? These will vary depending on the amount reduced and the locations and strategies for reduction. The structure of costs is extremely important in determining whether investments in REDD are worthwhile, and where the greatest benefit in terms of reduced emissions can be obtained. In some case, emissions can be reduced at relatively low cost, but other options will require a higher price per ton of CO_2 reduced (Wertz-Kanounnikoff 2008). At some point, the costs of further reduction will become very high, when the best opportunities have already been exploited. This results in a supply curve for emissions reduction with an upward-curving shape, as shown in Figure 13.

Figure 13. REDD supply curve



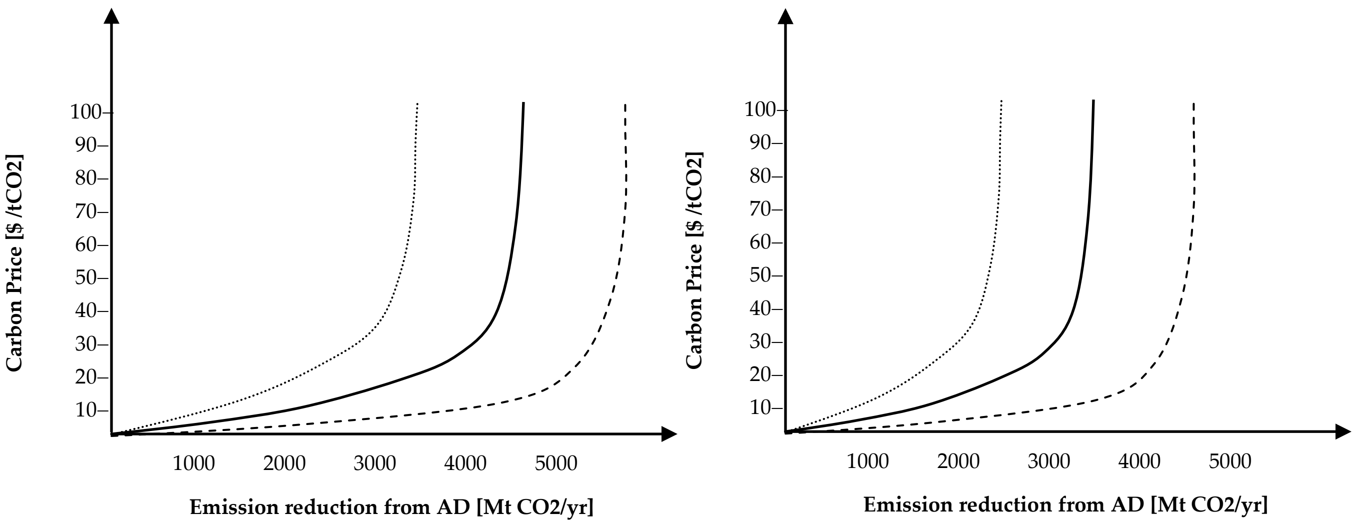
Source: Adapted from *Estimating the Costs of Reducing Forest Emissions* (Wertz-Kanounnikoff 2008).

The costs of REDD include **opportunity costs**, (the forgone profits from alternative land uses such as cash, food crops, or timber); and **transaction costs**, which include costs borne by the government to establish and administer the scheme, and costs to individual landowners to participate in the program. In addition, there will be costs for reforestation and afforestation including planting and labor and capital costs to maintain newly forested areas.

Supply curves can be estimated based on local studies, and these costs can be extrapolated to global models taking into account the total supply of forested land in various regions, and the differing opportunity costs for forest preservation. Figure 14 shows the results of global models of emissions reduction costs. Note that there is considerable variation among these models, but the general shape of the supply curve is the same.

As depicted in Figure 14, **marginal costs** tend to rise over time because the lowest-cost opportunities are adopted first, usually involving land of lower productivity. Although model projections vary, it appears that up to 2-3 billion tons of CO_2 reduction per year can be obtained at relatively low cost per ton. The higher costs projected for 2030 assume that some of the lower-cost opportunities have already been exploited by that time (Kindermann et al. 2008)

Figure 14. Supply curves from global models



Supply curves in 2010
REDD cost: $20/tCO2 can abate on average 3000 Mt CO2/Yr

Supply curves in 2030
REDD becomes more expensive: $20/tCO2 can abate on average 2200 Mt CO2/Yr

Source: Adapted from Kindermann et al. 2008 *and* Wertz-Kanounnikoff 2008

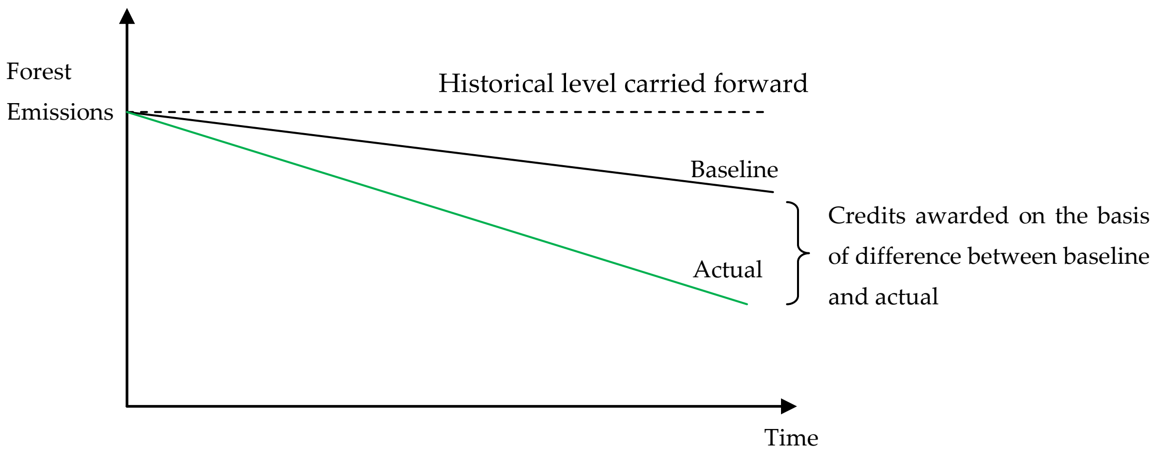
These supply cost estimates indicate that there is very significant potential for carbon reductions through REDD. But in order to take advantage of this potential, REDD mechanisms must be designed to be effective in overcoming a number of obstacles. Since carbon stored in forests is not a traditional economic good, it is necessary to create a market for forest carbon in a way that accurately represents actual carbon storage and is not open to manipulation or abuse. A number of issues arise in designing effective mechanisms.

Establishing a baseline

An important issue is the establishment of a **baseline** for emissions reduction. The point of REDD is to increase carbon storage, so credit should not be given for emissions reduction that would have occurred anyway. Analysis of a country's historical emissions rate, as well as current conditions and policies, can indicate what this baseline should be. Credits can then be awarded based on reductions below this baseline (Figure 15).

Establishing a credible baseline helps to deal with the problem of **additionality**. Any reductions that earn credits should be additional to reductions that would have occurred in the absence of active policy. As well as comparing overall national projects to a baseline, evaluating individual projects will be important to establish additionality.

Figure 15. Illustration of baseline credit system



Source: Adapted from Eliasch 2008.

Permanence

Global climate change is a long-term problem, so it is important that the gains achieved under a REDD program are lasting. What happens if forests preserved or expanded under REDD are later destroyed or converted to other uses? To avoid this problem, it is necessary to structure incentives for continuous preservation. Countries that receive REDD funds may need to be held liable if projects to preserve forests are later abandoned, or forest conversion for agriculture or other uses is allowed (Angelsen 2008).

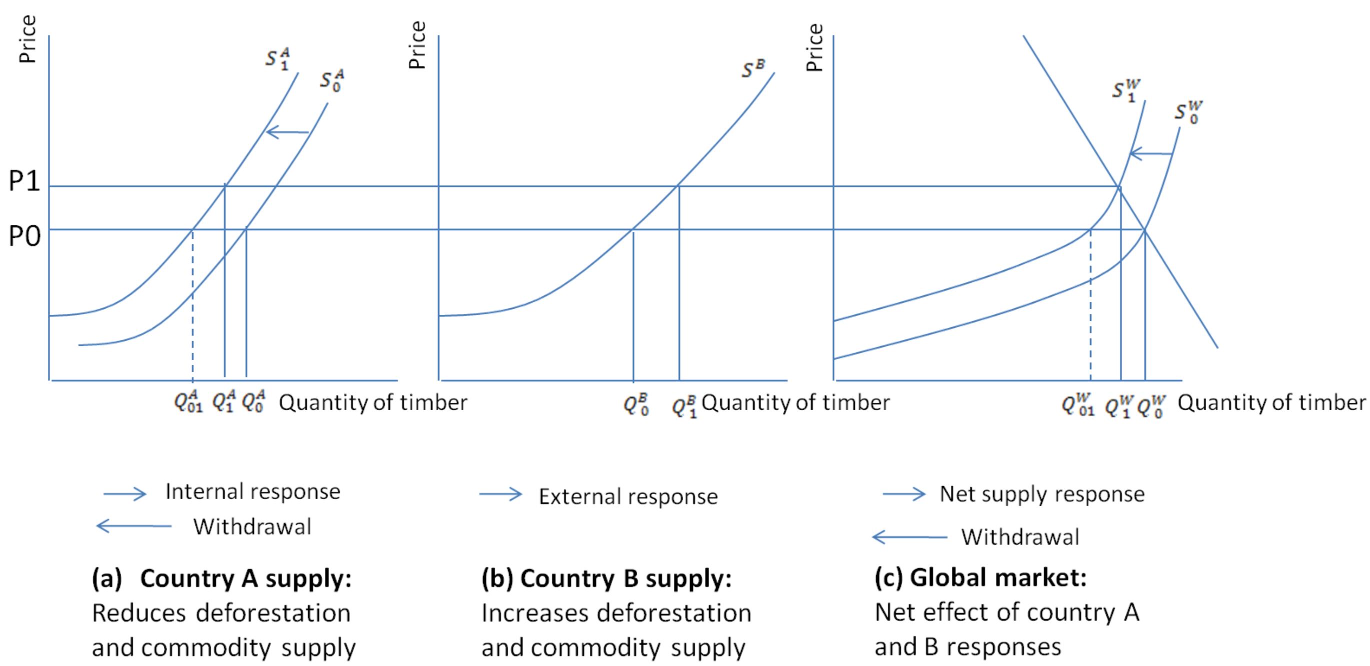
Leakage

Suppose a country accepts REDD credits to preserve a large tract of forest. The forest is placed off limits to logging, and its preservation is certified by independent authorities. That sounds like a success. But the removal of one area of forest from logging may increase logging pressures in other areas. So even though a large amount of forest – say, 10,000 acres – is preserved, another 5,000 acres elsewhere may be logged. This is **leakage.** The original forest preservation plan may have been partly effective, but the net amount of avoided forest loss is only 5,000 acres, not 10,000. It is of course possible that the increased logging elsewhere would amount to 10,000 acres, and in that case no net benefit would have been achieved. But even if the new logging is less than 10,000 acres, it still reduces the effectiveness of the original effort by a certain percentage. It is important to take account of the possible effects of leakage in evaluating any forest conservation program (Murray 2008).

Leakage can occur at various scales: farm-level, local/regional, national or international. An international example of market processes leading to leakage is shown in Figure 16.

When the supply of timber is reduced through a REDD program in Country A from S^A_0 to S^A_1, this leads to a price increase that is reflected on international markets. As a result of the price increase, timber production becomes more profitable, leading to increases in production both in Country A and Country B. The increase in country A, which is similar to the example described above, may be accounted for by project authorities, but they are less likely to consider the effects on Country B. The net effect on the global market (in this simple example, the world market consists of just these two countries) is a reduction in timber supply from Q^W_0 to Q^W_1, which is less than the reduction from Q^W_0 to Q^W_{01} that would have been expected if there were no leakage effects (Murray 2008).

Figure 16. Market phenomenon causing leakage



Source: Murray 2008

Estimating emissions from deforestation

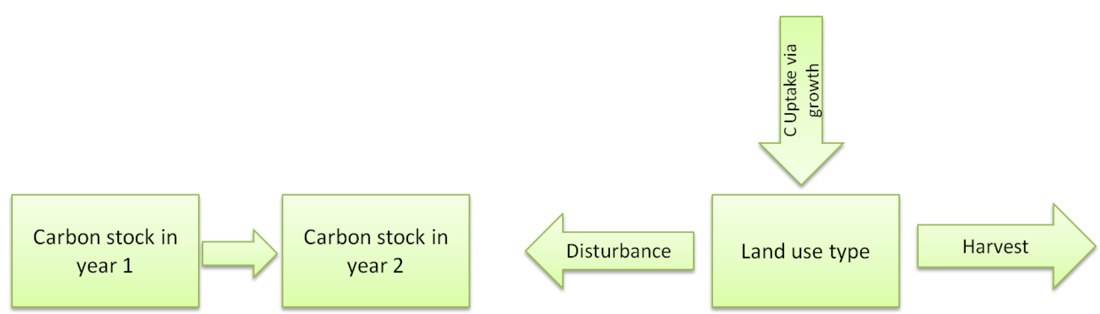
In estimating emissions reduction, it is important to take into account both the type of forest involved and the potential alternative uses of the land. For example, converting tropical forest to soybean, maize or rice potentially produces 60% more emissions than conversion to oil palm. The updated IPCC greenhouse gas (GHG) accounting method IPCC 2006[6] includes two approaches to estimating carbon stock changes : (i) the stock-based or stock-difference approach; and (ii) the process-based or gain-loss approach (Wertz-Kanounnikoff 2008).

Stock-difference approach: This method estimates the difference in carbon stocks in a particular pool at two moments in time. It can be used when carbon stocks in relevant pools have been measured and estimated over time, such as in national forest inventories. This approach is suitable for estimating emissions caused by both deforestation and degradation, and it can be applied to all carbon pools.

Gain-loss approach: This approach estimates the net balance of additions to and removals from a carbon pool. In the REDD context, depending on how ecosystem rehabilitation is treated, gains result from growth and carbon transfer between pools (e.g. biomass pool to a dead organic matter pool due to disturbance). Hence, losses result from carbon transfer to another pool and emissions due to harvesting, decomposition or burning (Wertz-Kanounnikoff et al. 2008, 87-98).

1. Stock- difference approach

2. Gain- loss approach



$$\Delta C = \frac{C_{t2} - C_{t1}}{t_2 - t_1}$$

$$\Delta C = \Delta C_{gain} - \Delta C_{loss}$$

$\Delta C = Annual\ carbon\ stock\ change\ in\ pool$

$C_{t1} = Carbon\ stock\ in\ pool\ at\ time\ t1$

$C_{t2} = Carbon\ stock\ in\ pool\ at\ time\ t2$

$\Delta C = Annual\ carbon\ stock\ change\ in\ pool$

$\Delta C_{gain} = Annual\ gain\ in\ carbon$

$\Delta C_{loss} = Annual\ loss\ in\ carbon$

Source: Adapted from Wertz-Kanounnikoff et al. 2008, 87-98.

[6] 2006 IPCC Guideline for National Greenhouse Gas Inventories, Vol. 4, Agriculture, Forestry and other Land Use, accessible at http://www.ipcc-nggip.iges.or.jp/public/2006gl/vol4.html

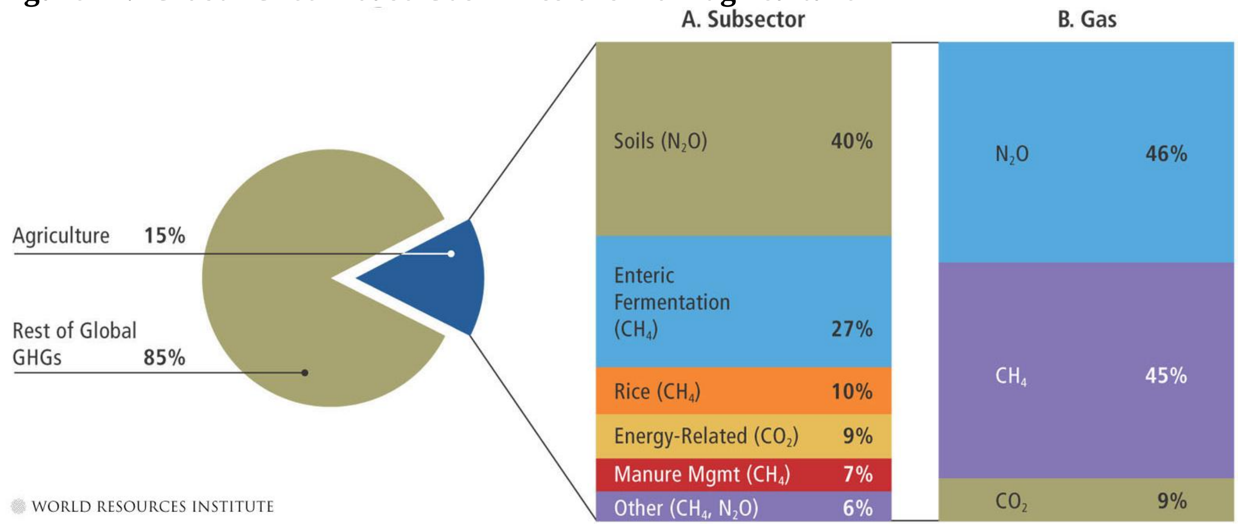
4. AGRICULTURE AND CLIMATE CHANGE

The significance of agriculture

Agriculture plays a very important role in climate change for a number of reasons. As we have seen (Figure 1), agriculture currently accounts for about 13-15% of greenhouse gas emissions. Some of these emissions are from fertilizer and energy use in agriculture, and some from livestock. A large portion of methane emission, a particularly potent source of global warming, comes from agriculture (Figures 2 and 17). Agricultural nitrous oxide (N_2O) emissions are projected to increase by 35-60% up to 2030 due to increased nitrogen fertilizer use and increased animal manure production (FAO 2003). Also, as discussed above, conversion of forested land to agriculture is a major cause of deforestation.

But agriculture can also play a very positive role. Certain agricultural practices, in particular organic agriculture, are effective in storing carbon in soils. Agroforestry (intercropping trees with row crops), perennial crops, minimal tillage, rotational grazing systems, and other techniques can reduce carbon emissions and store carbon in soils. Reduced fertilizer use can cut nitrous oxide emissions, and manure management and biogas systems can lower methane emissions. In addition, adding biochar (partly burned biomass) to soils has the potential both to enhance productivity and store large quantities of carbon (Scher and Sthapit 2009).

Figure 17. Global Greenhouse Gas Emissions from agriculture

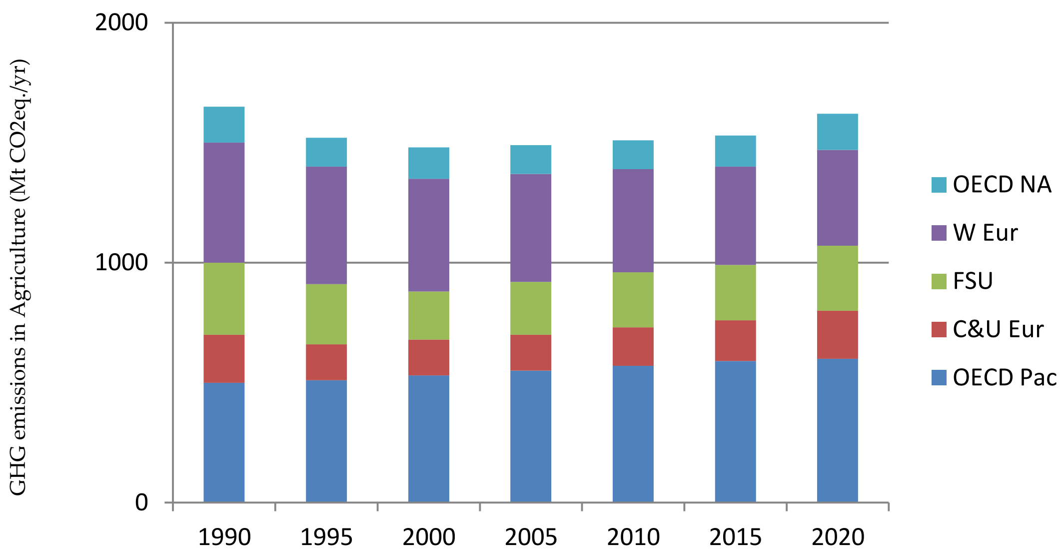


Source: World Resource Institute (WRI), accessed 2011

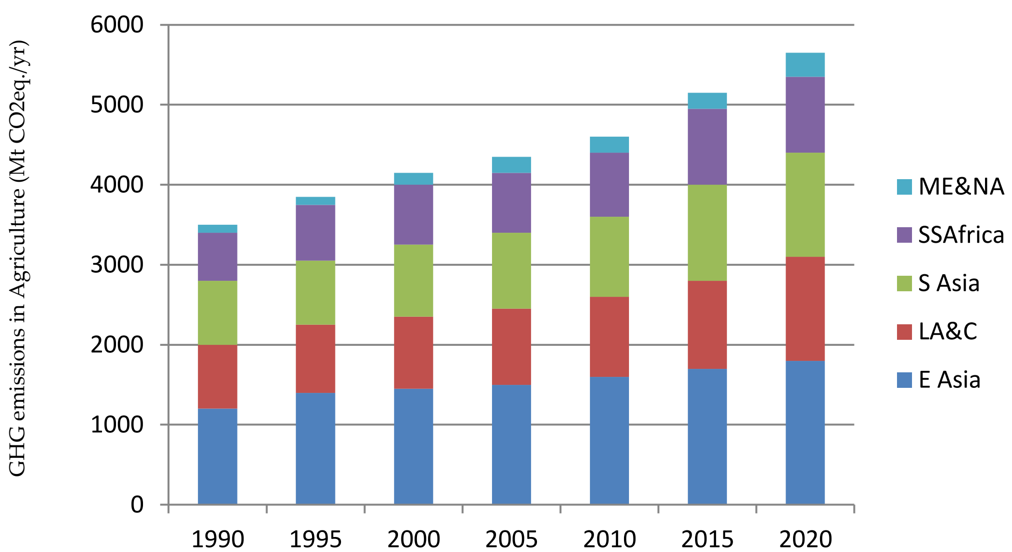
Developing countries have the largest share of global agricultural greenhouse gas emissions, and also the largest expected rates of increase in emissions, as shown in Figure 18 (FAO 2003). This implies that the agricultural patterns and techniques used in the developing world can play a huge role in either increasing or decreasing global greenhouse gas emissions. Current projections for increased emissions are not an inevitable outcome – but it will take significant investment in agricultural techniques for emissions reduction and carbon storage to put agriculture on a different path

Figure 18. Agricultural Greenhouse Gas Emissions by Region, Projected to 2020

Developed nations:



Developing nations:



Source: Smith et al. 2007, 6-28

Note: ME&NA: Middle East and North Africa; SS Africa: Sub-Saharan Africa; S. Asia: developing countries of South Asia; LA&C: Latin America and The Caribbean; E Asia: developing countries of East Asia; OECD Pac: OECD countries of the Pacific Region; C&E Eur: Central and Eastern Europe; FSU: Former Soviet Union; W Eur: Western Europe; OECD NA, OECD countries of North America

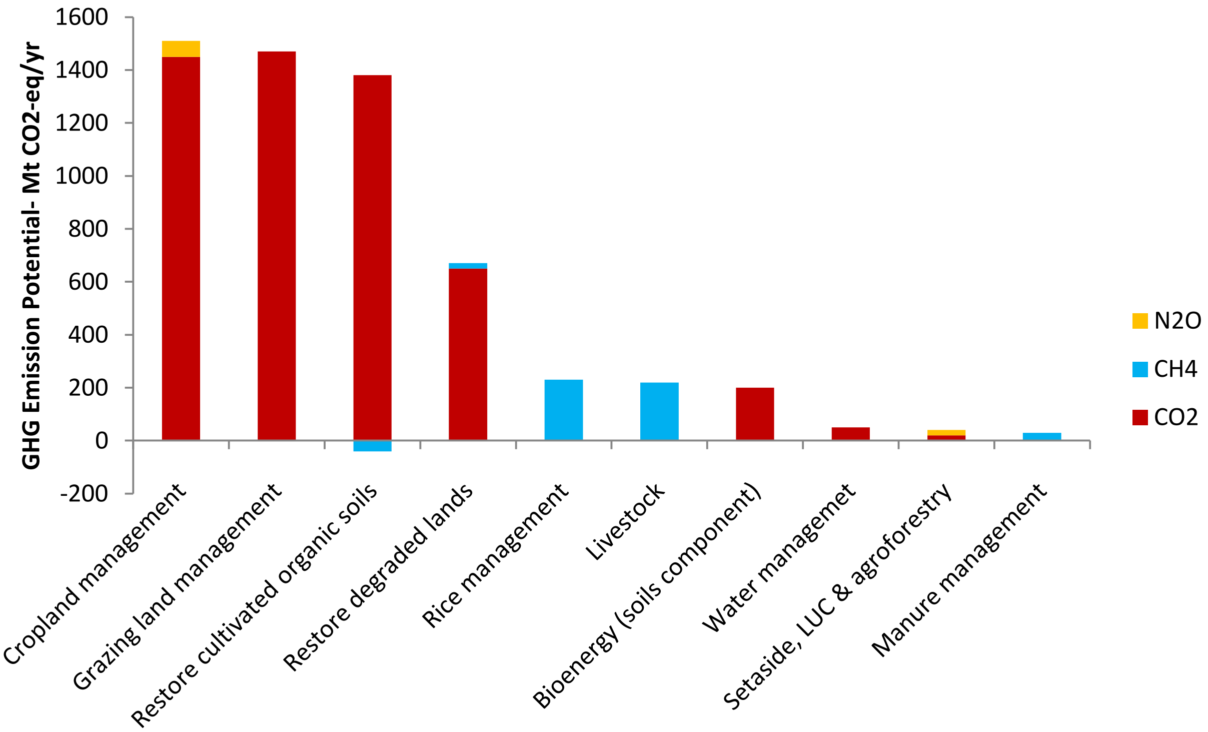
Potential for greenhouse gas mitigation in agriculture

According to the IPCC's 4th Assessment report (Metz et al. 2007a)[7] opportunities for mitigating GHGs in agriculture fall into three broad categories, based on the underlying mechanism:

- Reducing emissions by more efficient management of carbon and nitrogen flows in agricultural ecosystems.
- Enhancing removals by sequestering carbon in soils or plant material.
- Replacing fossil fuels: Crops and residues from agricultural lands can be used as a source of fuel, either directly or after conversion to fuels such as ethanol or diesel. These bio-energy feedstocks still release CO_2 upon combustion, but now the carbon is of recent atmospheric origin (Metz et al. 2007b) and (Metz et al. 2007a).

The global technical mitigation potential from agriculture by 2030, considering all gases, is estimated to be approximately 5500–6000 Mt CO_2-eq. yr^{-1}, with cumulative economic potentials of 1500–1600, 2500–2700 and 4000–4300 Mt CO_2-eq. yr^{-1} at carbon prices of up to 20, up to 50 and up to 100 US$/t CO_2-eq (Figure 19).

Figure 19. Global GHG mitigation potential from agriculture



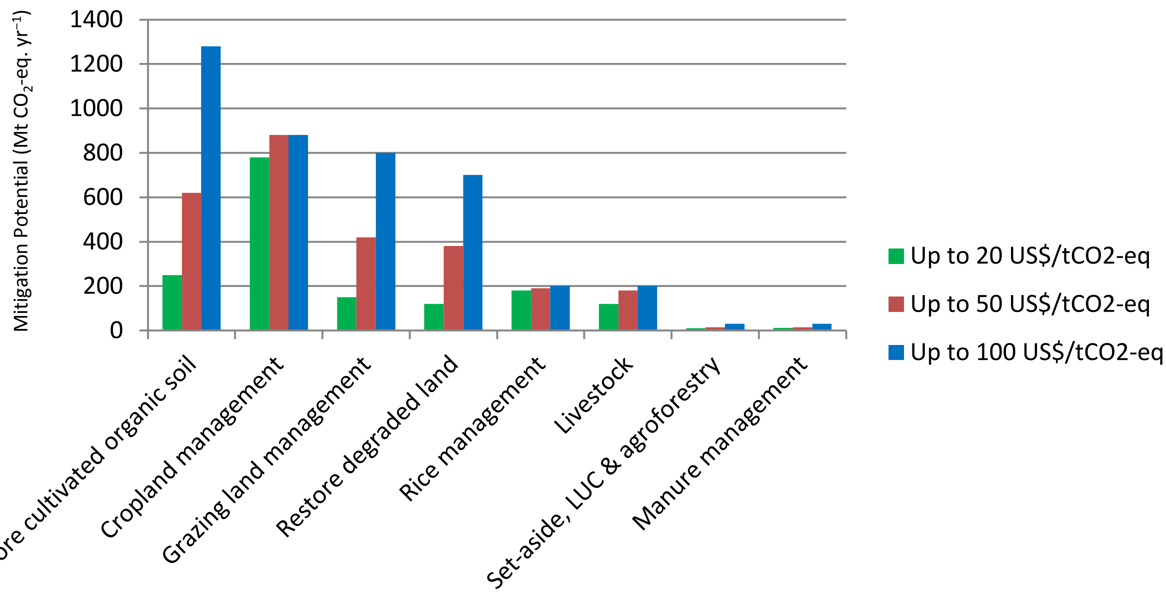
Source: Adapted from Metz et al. 2007a[8] and Smith et al. 2008

[7] Also available at http://www.ipcc.ch/publications_and_data/ar4/wg3/en/ch8s8-4.html

[8] Also available at http://www.ipcc.ch/graphics/ar4-wg3/jpg/fig-8-4.jpg

Of these total mitigation potentials, approximately 89% is from reduced soil emissions of CO_2, approximately 9% from mitigation of methane and approximately 2% from mitigation of soil N2O emissions (Smith et al. 2008) (Figure 19). Figure 20 illustrates global biophysical mitigation potential (Mt CO_2-eq. yr^{-1}) by 2030 of each agricultural management practice showing the impacts of each practice on each GHG stacked to give the total for all GHGs combined (Smith et al. 2008)[9].

Figure 20: Global mitigation potential from agriculture by CO2 price



Source: Adapted from Metz et al. 2007a[10] and Smith et al. 2008

The impact of biofuels

Biofuels, which are combustible materials derived from plants, animals, micro-organisms, and organic wastes, can substitute for fossil fuels. This substitution can reduce carbon emissions if the carbon that is burned in biofuels is newly removed from the atmosphere, and so does not constitute a net addition to atmospheric carbon. But there are potential drawbacks to biofuels.

Some biofuels themselves require large energy inputs to produce, meaning that the net carbon reduction may be small or even negative. Biofuels can also compete for scarce land and water resources, possibly increasing deforestation. There are also potential negative social effects since biofuels can create an additional demand either for food crops (such as ethanol produced from corn) or for land used to produce food crops. In either case, expansion of biofuel production will

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9 Also available at http://rstb.royalsocietypublishing.org/content/363/1492/789.long

10 Also available at http://www.ipcc.ch/graphics/ar4-wg3/jpg/fig-8-9.jpg

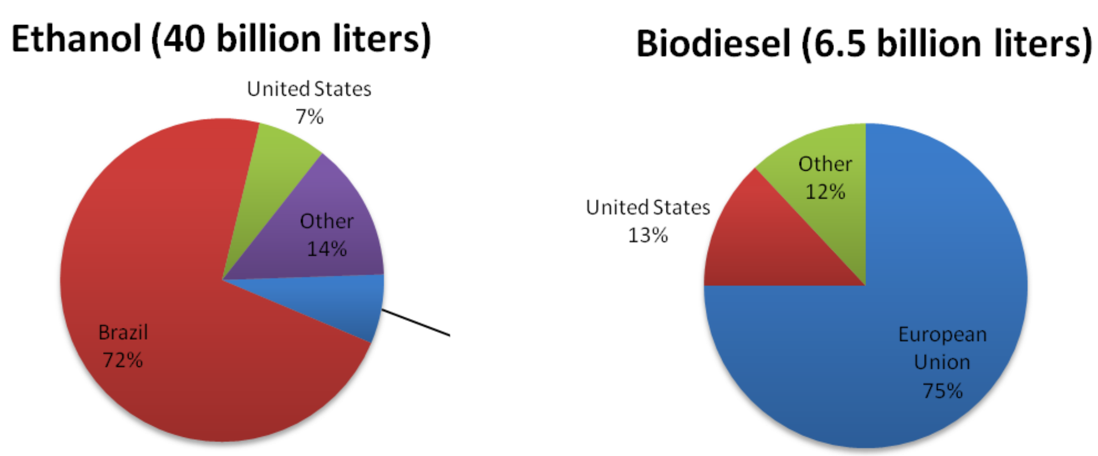
tend to drive up food prices. Thus the use of biofuels, and particularly their subsidization by governments, must be carefully weighed against the possible negative consequences.

There are three main types of biofuels:

- First-generation fuels are biofuels made from sugar, starch, vegetable oil, or animal fats using conventional technology.
- Second generation biofuels are made from a variety of non-food crops, including waste biomass, the stalks of wheat, corn, wood, and special-energy or biomass crops using biomass-to-liquid technology..
- Third generation biofuels are made from algae, sometimes known as oilgae[11].

Current production is almost entirely first generation biofuels, primarily ethanol and biodiesel. According to the World Bank's 2008 World Development Report, "global production of ethanol as fuel in 2006 was around 40 billion liters. Of that amount, nearly 90 percent was produced in Brazil and the United States. In addition, about 6.5 billion liters of biodiesel were produced in 2006, of which 75 percent was produced in the European Union (Figure 21). Brazil is the most competitive producer and has the longest history of ethanol production." [12]

Figure 21: Global biofuel production



Source: World Bank, World Development Report 2008[13]

[11] Adapted from forest and climate change toolbox, Center For International Forestry Research, available at http://www.cifor.org/fctoolbox/)

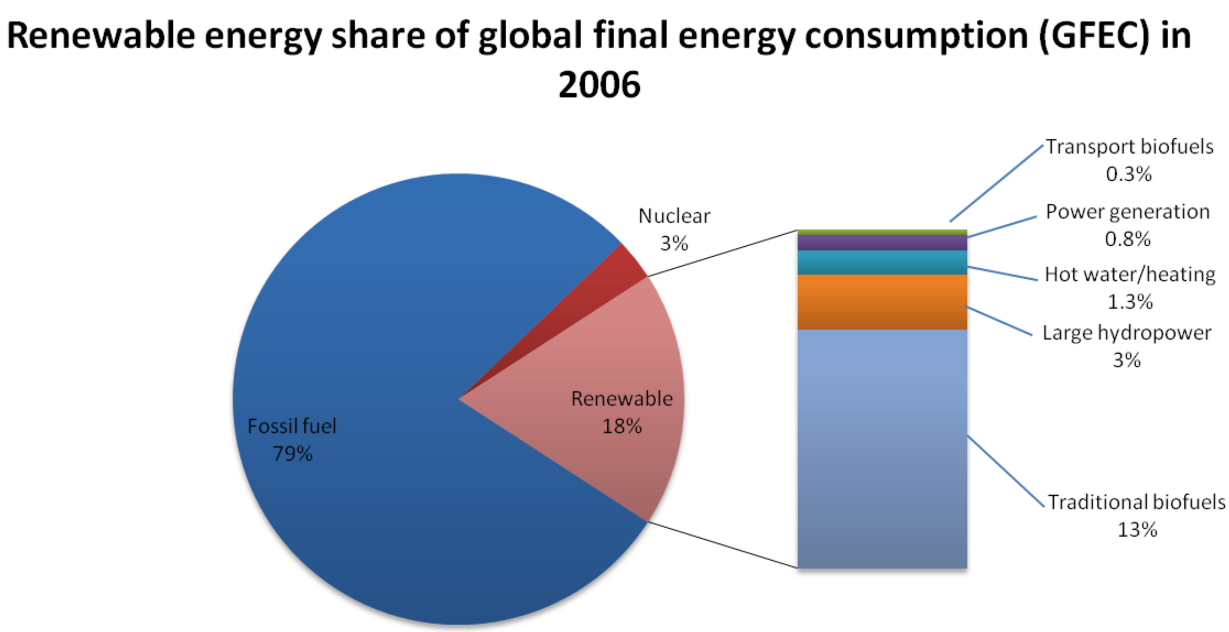
[12] World Bank, World Development Report 2008, Biofuels: the promise and the risks, available at http://siteresources.worldbank.org/INTWDR2008/Resources/2795087-1191440805557/4249101-1191956789635/Brief_BiofuelPrmsRisk_web.pdf

[13] Same source as above

So far, “modern” biomass use constitutes only a negligible share of total global energy consumption. But traditional biomass accounted for about 13% of global final energy demand in 2006, the largest contribution to all renewable energies, which together accounted for 18% of total world energy demand (Figure 22).

In use of biofuel for transportation, “world ethanol production for transport fuel tripled between 2000 and 2007 from 17 billion to more than 52 billion liters, while biodiesel expanded eleven-fold from less than 1 billion to almost 11 billion liters (Figure 23). Altogether biofuels provided 1.8% of the world’s transport fuel. Recent estimates indicate a continued high growth. From 2007 to 2008, the share of ethanol in global gasoline type fuel use was estimated to increase from 3.78% to 5.46%, and the share of biodiesel in global diesel type fuel use from 0.93% to 1.5%” (UNEP 2009)[14]

Figure 22: Renewable energy and traditional biomass



Source: WorldWatch Institute 2007 and UNEP 2009.

[14] Also available at http://hqweb.unep.org/pdf/biofuels/Assessing_Biofuels_Full_Report.pdf

Box 5 - Biofuel subsidies

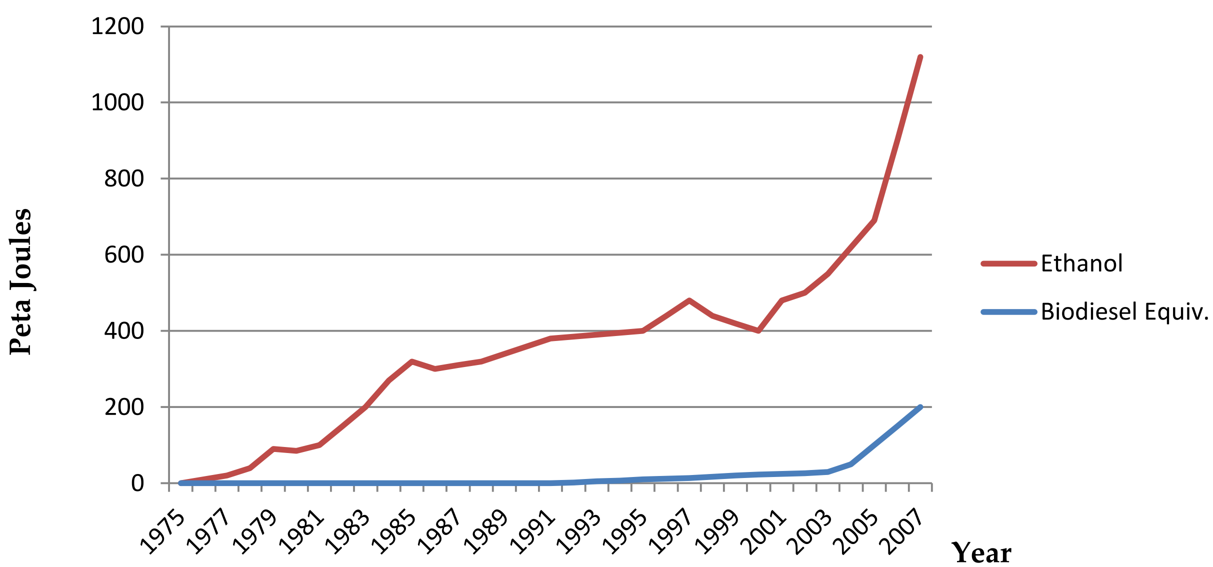
Governments often provide substantial support to biofuels so that they can compete with gasoline and conventional diesel. Such support includes consumption incentives (fuel tax reductions); production incentives (tax incentives, loan guarantees, and direct subsidy payments); and mandatory consumption requirements. This can push up feedstock prices.

The clearest example is maize, whose price rose by over 60 percent from 2005 to 2007, largely because of the U.S. ethanol program combined with reduced stocks in major exporting countries. In recent years rising agricultural crop prices caused by demand for biofuels have come to the forefront in the debate about a potential conflict between food and fuel.

The grain required to fill the tank of a sports utility vehicle with ethanol (240 kilograms of maize for 100 liters of ethanol) could feed one person for a year; this shows how food and fuel compete. Rising prices of staple crops can cause significant welfare losses for the poor, most of whom are net buyers of staple crops. But other poor producers, who are net sellers of these crops, will benefit from higher prices.

Source: World Bank *World Development Report 2008*, "Biofuels: The Promise and the Risks" http://siteresources.worldbank.org/INTWDR2008/Resources/2795087-1191440805557/4249101-1191956789635/Brief_BiofuelPrmsRisk_web.pdf)

Figure 23. Trends in biofuel production, 1975-2007



Source: Adapted from UNEP 2009 and SCOPE International Biofuels Project 2009[15]

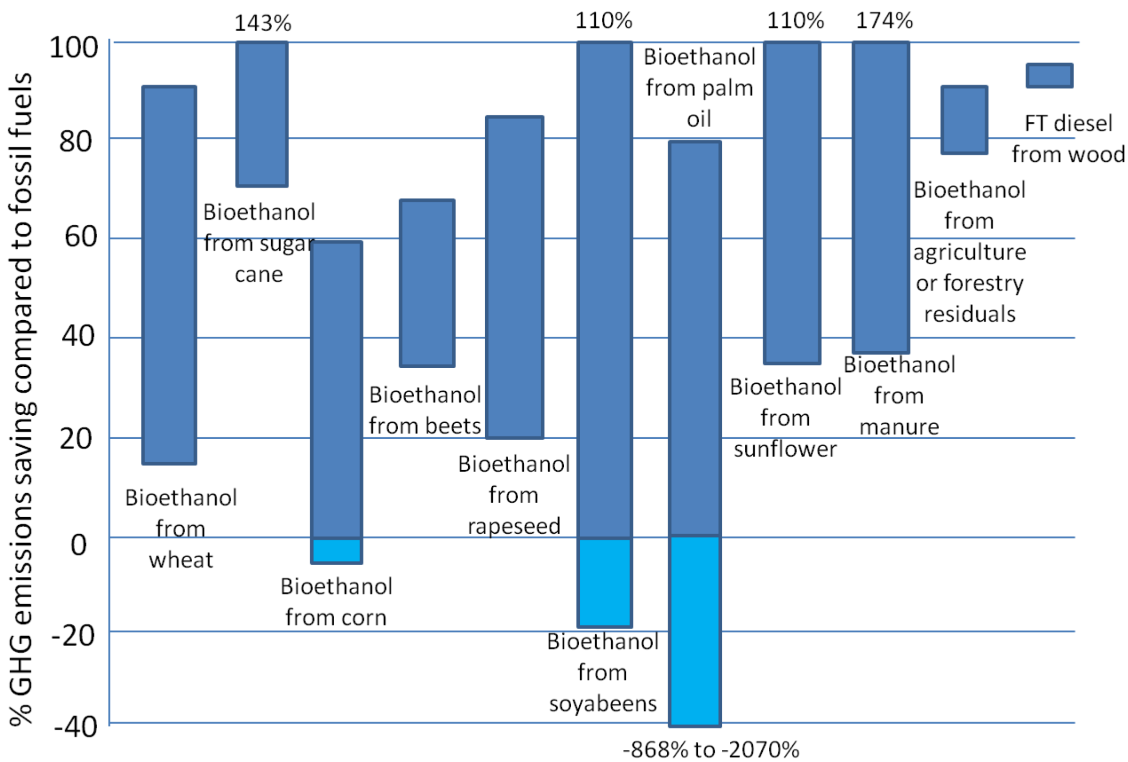
[15] SCOPE International Biofuels Project, http://www.eeb.cornell.edu/howarth/SCOPEBiofuels_home.html

How effective are biofuels in terms of net greenhouse gas (GHG) reduction? Ideally, biofuels would replace fossil fuels while emitting less or even no net carbon. The actual impact of biofuels, however, varies widely (Figure 24).

In the case of ethanol, the impact depends on the crop source. Bioethanol from sugar cane is highly efficient, reducing GHG emissions by at least 70% and in some cases more than 100% (i.e. achieving net carbon storage). Bioethanol from corn is less effective, achieving at best 60% net reduction, but possibly even increasing GHG emissions if the corn is intensively cultivated and fertilized. Biodiesel can have impacts ranging from a 110% reduction to a 2070% *increase* in emissions in the case of biodiesel from palm oil. This dramatic increase in emissions occurs when palm oil plantations replaced natural forest. In that case, the savings from using biofuel are far exceeded by the carbon emitted when the forest is cleared.

Other types of biofuel, such as biomethane from manure and bioethanol from agriculture and forestry wastes, are more environmentally beneficial, with net GHG savings ranging from 35% to 174%. Biomethane from manure and agricultural wastes is an especially useful source of fuel in rural areas of developing nations, since it can be decentralized and provide a locally-available low-cost fuel.

Figure 24. Greenhouse Gas Savings of Biofuels Compared to Fossil Fuels



Source: UNEP 2009.

Biofuels, food supply, and forests

Many biofuels are also food crops. Thus increased demand for biofuels competes with food crops for land, driving up food prices. Currently global land use for fuel crops is about 2% of global cropland (UNEP 2009). But as biofuel demand increases, the conflict with expanding global food needs will intensify. There can also be indirect effects on forests, as agricultural production is displaced from current croplands to forested areas. Box 6 summarizes some of the global impacts of expanding biofuel production.

Clearly, biofuels have varying impacts. They can be an additional tool to reduce carbon emissions, but their effectiveness depends on the type of biofuel and production methods. Uncontrolled expansion of biofuels is likely to do more harm than good. But discriminating use of biofuels can result in net greenhouse gas reduction without destructive ecological and social impacts.

Box 6 - Impacts of increased biofuel demand on agriculture and forests

The extension of cropland for biofuel production is continuing, in particular in tropical countries where natural conditions favor high yields. In Brazil, the planted area of sugar cane comprised 9 million hectares in 2008 (up 27% since 2007). Currently, the total arable land of Brazil covers about 60 Mha. The total cropping area for soybeans, which is increasingly being used for biodiesel, could potentially be increased from 23 Mha in 2005 to about 100 Mha. Most of the expansion is expected to occur on pasture land and in the savannah.

In Southeast Asia, palm oil expansion – for food and non-food purposes – is regarded as one of the leading causes of rainforest destruction. In Indonesia, a further extension of 20 Mha for palm oil trees is planned, compared with the existing stock of at least 6 Mha. Two-thirds of the current expansion of palm oil cultivation in Indonesia is based on the conversion of rainforests, while one third is based on previously cultivated or to-date fallow land. Of the converted rainforest areas, one quarter contained peat soil with a high carbon content - resulting in particularly high GHG emissions when drained for oil palms. By 2030, a share of 50% from peat soils is expected. If current trends continue, in 2030 the total rainforest area of Indonesia will have been reduced by 29% as compared to 2005, and would only cover about 49% of its original area from 1990.

A special concern is consequences for **biodiversity**. Increased biofuel production is expected to have large impacts on biological diversity in the coming decades, mostly as a result of habitat loss, increased invasive species and nutrient pollution. Habitat loss will mainly result from cropland expansion. Species and genotypes of grasses suggested as future feedstocks of biofuels may become critical as invaders. Nutrient emissions to water and air resulting from intensive fuel cropping will impact species composition in aquatic and terrestrial systems.

Source: http://hqweb.unep.org/pdf/biofuels/Assessing_Biofuels_Full_Report.pdf

5. CONCLUSION: NEW INSTITUTIONS FOR FORESTRY AND AGRICULTURE

Financing Carbon Reduction

We have seen that there is a very large potential for carbon storage through forestry and agriculture. Unfortunately, the institutions for promoting the development of this potential are not strongly developed. What is required is a system of economic incentives for managers of forests, farmers, and other land owners to preserve forests, reduce carbon emissions, and expand carbon-storing agricultural methods.

There are a number of ways to provide financing for carbon reduction. One is for individual countries to set up funds that can be used to pay landowners who reduce emissions or create **carbon sinks**. These funds could be derived from **carbon taxes** levied on fossil fuels, or provide from general revenues. Bilateral and multilateral funds may be used especially to finance institutional reforms needed to set up carbon payment systems, and also to fund pilot projects (see Box 7) (Eliasch, 2008).

To provide a reliable long-term source of financing, however, payments for carbon storage through forests and agriculture need to be integrated into a wider scheme of **carbon trading.** Under a national or international carbon trading scheme, firms that emit carbon must purchase permits to do so. Farmers or forest managers who implement plans to reduce emissions or store carbon can be granted permits through a process of **certification**, and can then sell these permits to firms. This has the effect of providing an **offset** to carbon emissions in one location by reducing or storing carbon in another.

The major existing carbon trading schemes, including the European Union Emissions Trading System (ETS) and the Clean Development Mechanism set up under the Kyoto Protocol on Climate Change, allow this kind of offset trading, but in general have not included forestry and agriculture, despite the large potential in these areas. Most of the currently traded offsets involve reduction of industrial emissions or energy efficiency, and only a small percentage come from forestry or agriculture. The goal of the REDD process is to change this, and allow much wider participation of the agriculture and forestry sectors in carbon trading.

One of the reasons for slow progress in this area is the lack of institutional capacity. Important issues include the need for clear definition of land tenure rights and involvement of local and regional governments and social groups in forest management and agricultural reform. Often it is difficult for local communities to access the potential financial benefits of carbon-reducing activities. Schemes such as farmers' and foresters' cooperatives can help to overcome this problem, allowing the distribution of payments for forest preservation or agricultural reform through the cooperative. Community involvement is essential for successful reform that can benefit the poor (Eliasch, 2008).

REDD and development

It is important to integrated the goals of REDD into development strategies. For example, Nair and Rutt (2009)[16] propose that providing employment in forestry activities would have the double advantage of slowing down deforestation and degradation that would have taken place in the absence of employment; and augmenting carbon sequestration through increased tree planting and improved management of forests. Nair and Rutt estimate that "the annual outlay for rebuilding the forest asset base, focusing on the activities indicated above, would be approximately US$36 billion. This could generate about 10 to 16 million jobs, largely depending on local conditions, especially costs of inputs. More jobs can be generated in developing countries where wages are relatively low." There is significant potential for employment generation in the sustainable management of forests.

> **Integrating development and carbon reduction**
>
> Many of the drivers of deforestation are linked to economic interests both inside and outside the forest sector. Therefore, in order to be effective, REDD+ needs to be linked into wider low carbon development strategies, which take into account processes and incentives in other sectors such as agriculture and energy. This could have major implications in terms of how to ensure coordination between sectors and also the equity implications of REDD+, which will need to be understood more broadly to consider impacts not just on those who live in or near forests.
> In some cases, there may be potential opportunities to link REDD+ and broader low carbon development strategies, such as 'green' economic recovery packages that aim to increase employment in the forest sector, slowing down deforestation and degradation that would have taken place in the absence of employment; and augmenting carbon sequestration through increased tree planting and improved management of forests.
>
> See http://redd-net.org/themes/redd-and-low-carbon-development

While richer nations need to reduce carbon below their "business as usual" baselines, poorer nations need funds that they may be able to obtain through expanded carbon trading. Rather than compelling poorer nations to reduce their already relatively low carbon emissions, they should be able to gain credit for forest preservation and carbon storage, provided these can be demonstrated to be **additional** to reductions that would have occurred anyway. For any global emissions reduction scheme to be effective, it must be perceived as an advantage rather than an impediment to the development of poorer countries.

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[16] Nair, C.T.S. and Rutt, R. (2009) "Creating Forestry Jobs to Boost the Economy and Build a Green Future", article developed from background paper "Impacts of Global Economic Turbulence on the Forest Sector" at the nineteenth sessions of the FAO Committee on Forestry, 20 March 2009.

If the political and organizational barriers to effective carbon finance for agriculture and forestry can be overcome, these sectors will play a major role in meeting the enormous challenge of major carbon reductions on a global scale. This has been the focus of continuing discussions including the Durban Climate Change Conference of November/December 2011. (http://unfccc.int/meetings/durban_nov_2011/meeting/6245.php). It remains to be seen whether the world's nations can meet the challenge effectively, but if so the prospects for effective action on climate change will be much brighter.

Box 7 - Multilateral funds to support programs to reduce emissions from deforestation

Global Environment Facility (GEF)

The GEF was established in 1991 to help developing countries fund projects and programs that protect the global environment. GEF grants support to projects related to biodiversity, climate change, international waters, land degradation, the ozone layer and persistent organic pollutants. It has financed forest preservation and sustainable land management projects under its land degradation theme.

UN-REDD

UN-REDD is implementing a program that aims to help prepare countries to access a REDD mechanism through capacity building needs assessment; support to strategy development and capacity for monitoring and measuring, methods and tools for REDD;

Forest Carbon Partnership Facility (FCPF)

The FCPF was launched by the World Bank during the Bali climate talks in December 2007. It is a multi-stakeholder partnership of developing and industrialized countries, NGOs and international financial institutions. The facility's target capitalization is at least $300 million. FCPF includes a Readiness Fund to support the development of measuring and monitoring systems and REDD strategies, and a Carbon Fund intended to 'pump-prime' crediting mechanisms for REDD.

World Bank Strategic Climate Fund (SCF)

The SCF and the Clean Technology Fund (CTF) together make up the World Bank's new Climate Investment Funds (CIF), a source of interim funding through which the Multilateral Development Banks (MDBs) will provide additional grants and concessional financing to developing countries to tackle climate change. A Forest Investment Program (FIP) of investments to reduce emissions from deforestation and forest degradation through sustainable forest management is currently being developed in conjunction with major donors and developing countries.

Source: The Eliasch Review 2008, Climate Change: Financing Global Forests, available at http://www.official-documents.gov.uk/document/other/9780108507632/9780108507632.pdf

KEY TERMS AND CONCEPTS

Additionality: According to the Kyoto Protocol, gas emission reductions generated by Clean Development Mechanism and Joint Implementation project activities must be additional to those that otherwise would occur. Additionality is established when there is a positive difference between the emissions that occur in the baseline scenario, and the emissions that occur in the proposed project[17].

Afforestation: The process of establishing and growing forests on bare or cultivated land, which has not been forested in recent history[18].

Baseline: The emission of greenhouse gases that would occur without the contemplated policy intervention or project activity.

Biodiversity: The total diversity and variability of living things and the systems (e.g., coral reefs), of which they are part[19].

Carbon stocks: The quantity of carbon contained in a "pool", meaning a reservoir or system which has the capacity to accumulate or release carbon. In the context of forests it refers to the amount of carbon stored in the world's forest ecosystem, mainly in living biomass and soil, but to a lesser extent also in dead wood and litter.[20]

Carbon flux: A forest - or any ecosystem - is a set of carbon fluxes. Forests absorb carbon dioxide (CO_2) from the atmosphere and transform it into stored carbon through the process of photosynthesis. Other fluxes are emitting CO_2 back in to the atmosphere through respiration and soil mineralization. Products exported from the ecosystem, such as wood, are also responsible for carbon fluxes.[21]

Carbon fixation: The process through which carbon dioxide is taken up, removed or absorbed from the atmosphere. It is usually driven by photosynthesis whereby carbon dioxide is converted to solid compounds.

Carbon sink: A natural or artificial storage that accumulates and stores carbon dioxide for a long period through physical or biological process.

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[17] Coalition for Rainforest Nations, http://www.rainforestcoalition.org/

[18] Ibid.

[19] World Resource Institute glossary, http://www.wri.org

[20] Based on definition by GreenFacts Glossary and FAO

[21] Forest and Climate Change Toolbox, http://www.cifor.org/fctoolbox/

Carbon source: The ecosystem that emits CO_2 to atmosphere and increases GHG concentration is called carbon sources and the physical or biological process that release CO_2 to the atmosphere is called carbon emission.

Carbon tax: A per-unit tax levied on carbon-based fuels in proportion to the amount of carbon dioxide emitted when the fuel is burned.

Carbon trading: a system that allows firms or institutions to trade permits to emit carbon based on an initial allocation or auction of permits. Permits may also be allocated to firms or institutions that engage in carbon reduction or carbon-storing practices, which they can then sell.

Certification: A process of validation by an independent authority; in the case of carbon permits, a certification that an activity or process reduces carbon by a certain amount, or removes a certain amount of carbon from the atmosphere

Leakage: That portion of cuts in greenhouse-gas emissions by developed countries that may reappear in other areas or countries not bound by carbon limits. For example, multinational corporations may shift factories from developed countries to developing countries to escape restrictions on emissions[22].

Market failures: Situations where the allocation of goods and services by a free market is not efficient due to the breakdown of price mechanism caused by factors such as establishment of monopolies or existence of externalities including environmental costs.

Marginal cost: The change in total cost when the quantity produced is increased by one unit. In other word, is the cost of producing one more unit of output.

Net absorption flux: The difference between inbound (photosynthesis) and outbound fluxes (respiration and mineralization) is the net absorption flux.

Offset: In a carbon trading scheme, a credit issued for a process that reduces carbon emissions or stores carbon. Offsets can be purchased by firms that emit carbon in an equal amount to the carbon they wish to emit, as an alternative to reducing their emissions.

Opportunity cost: The cost of an alternative that must be forgone in order to pursue a certain action. In other word, the benefits could have been received by taking an alternative action.

Reforestation: This process increases the capacity of the land to sequester carbon by replanting forest biomass in areas where forests have been previously harvested[23].

Transaction cost: A cost incurred in making an economic exchange.

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22 UNFCCC Glossary

23 Coalition for Rainforest Nations

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DISCUSSION QUESTIONS

1. How significant are forests and agriculture in global climate change? What roles do they play in the emissions and absorption of carbon dioxide and other greenhouse gases? Why do you think that forests and agriculture have played a relatively small role until recently in policies to combat climate change?

2. What economic principles are important in the formulation of policies to mitigate carbon emissions through forestry and agricultural practices? What important patterns of costs are relevant and what do they indicate about the potential of forests and agriculture to mitigate climate change? What market processes may strengthen or undermine policies for carbon reduction through forestry and agriculture?

3. Are biofuels a positive or a negative factor in climate policy? How would you distinguish the different impacts of different biofuels and what might this imply for policies regarding biofuels, including the use of subsidies?

WEB LINKS

1. http://www.conservation.org/osiris/Pages/overview.aspx
   The Open Source Impacts of REDD+ Incentives Spreadsheet (OSIRIS) is a free, transparent, accessible and open source decision support tool designed by the Collaborative Modeling Initiative on REDD Economics to support UNFCCC negotiations on REDD+. OSIRIS enables a click-of-a-button comparison of global, regional and country-by-country emissions reduction, deforestation and revenue impacts of alternative approaches to providing positive economic incentives for REDD+.

2. http://www.ipcc-data.org/
   The Data Distribution Centre (DDC) of the Intergovernmental Panel on Climate Change (IPCC) provides climate, socio-economic and environmental data, both from the past and also in scenarios projected into the future. Technical guidelines on the selection and use of different types of data and scenarios in research and assessment are also provided. The DDC is designed primarily for climate change researchers, but materials contained on the site may also be of interest to educators, governmental and non-governmental organizations, and the general public.

3. http://www.cifor.org/
   The Center for International Forestry Research is a nonprofit, global facility dedicated to advancing human wellbeing, environmental conservation and equity that conducts research on the use and management of forests in less-developed countries. For quick access to the online library use: http://www.cifor.org/online-library/browse.html

4. http://www.cifor.org/fctoolbox/
   The Forests and Climate Change Toolbox has been developed by CIFOR to build understanding and technical proficiency on issues of climate change and forests including mitigation, adaptation, carbon accounting and markets, and biofuels. This website provides slide presentations on a variety of topics related to forests and climate change and all materials are downloadable and presentations can be viewed in audio format.

5. http://www.theredddesk.org/
   This website provides a collaborative resource collection for REDD. Of special importance on this website are the case studies provided on forest management in different countries and short videos on definition of REDD and related concepts. The Little REDD Book is another resource on this website.

6. http://www.rainforestcoalition.org/Default.aspx
   This website provides an extensive collection of data, papers and reports on UNFCCC documentation, general issues about REDD, policy, science and methods and economic implications of REDD.