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Review of the Role of Plant in Carbondioxide Sequestration Globally using Chlorophy II or Leaf Index

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Abstract
The terrestrial biosphere plays a prominent role in the global carbon cycle. Although a net source of Carbon, some terrestrial ecosystems are currently accumulating Carbon and it appears feasible to manage existing terrestrial (forest, agronomic, desert) ecosystems to maintain or increase Carbon storage.Forest ecosystems can be managed to sequester and store globally significant amounts of Carbon. Agro-ecosystems and arid lands could be managed to conserve existing terrestrial Carbon but **Carbon dioxide** sequestration rates by vegetation in these systems is relatively low. Biomass from forest agro-ecosystems has the potential to be used as an energy source and trees could be used to conserve energy in urban environments. Some ecosystem management practices that result in Carbon sequestration and conservation provide ancillary benefits.We also reviewed studied soil carbon sequestration as affected by three land use types in Nigeria Area. Random soil sampling was used in field studies. Routine soil analyses were conducted on soil properties after soil sample preparations. Soil data were analyzed statistically using analysis of variance (ANOVA) to estimate variability while relationships between soil carbon sequestration and soil properties were obtained by simple correlation. All these were tested at 5% level of significance.Results showed significant ($P=0.05$) differences in soil moisture and soil temperature. There were significant ($P=0.05$) differences between soil carbon sequestration among cassava-dominated, pineapple and fallow soils. Fallow soils sequestered (1468 to 1688 mM) of total soil organic carbon, followed by pineapple orchard (1178 to 1526 mM) and cassava-dominated (1065 to 1373 mM) in the study. Soil temperature, soil moisture and soil clay had strong correlation with r-values of -0.96, 0.90 and 0.70, respectively with soil carbon sequestration.
Keywords: Soil Carbon, Land use, Sequestration, Tropical soils, Photosynthesis, Bio-reactor, Plant.

INTRODUCTION

What is carbon sequestration?

The term "carbon sequestration" is used to describe both natural and deliberate processes by which CO2 is either removed from the atmosphere or diverted from emission sources and stored in the ocean, terrestrial environments (vegetation, soils, and sediments), and geologic formations. Before human-caused CO2 emissions began, the natural processes that make up the global "carbon cycle" maintained a near balance between the uptake of CO2 and its release back to the atmosphere.

However, existing CO2 uptake mechanisms (sometimes called CO2 or carbon "sinks") are insufficient to offset the accelerating pace of emissions related to human activities. Annual carbon emissions from burning fossil fuels in the United States are about 1.6 gigatons (billion metric tons), whereas annual uptake amounts are only about 0.5 gigatons, resulting in a net release of about 1.1 gigatons per year.

Aims and Objectives

Carbon sequestration is a term you will increasingly hear over the coming years. This article provides a basic explanation of what it is some of the suggestions of how humans may go about artificial sequestration and some of the unknown and dangers involved.

Natural carbon sequestration

Natural carbon sequestration is a cycle that's been happening on this planet for billions of years. It's simply the process by which nature has achieved a balance of carbon dioxide in our atmosphere suitable for sustaining life. Animals expel carbon dioxide, as do plants during the night; forest fires belch carbon dioxide into the atmosphere, volcanic eruptions and magma reservoirs deep beneath the ground also play their part. With all this carbon dioxide being pumped into the atmosphere, there needed to be a way of removing it otherwise the surface of the planet would rapidly overheat. Nature provided trees, the oceans, earth and the animals themselves as carbon sinks, or sponges. All organic life on this planet is carbon based and when plants and animals die, much of the carbon goes back into the ground where it has little impact on contributing to global warming. Nature's fine handling of carbon dioxide in our atmosphere has served the planet very well. up until man's industrial revolution that has now thrown the earth's carbon dioxide sinks out of balance. For example, our oceans have absorbed so much carbon dioxide; they are becoming saturated and acidic.(schlensinger 1999)

Many tree planting programs have been initiated over the years; originally to assist with preventing erosion, loss of biodiversity and desertification, but increasingly the benefits of these programs are focused around their carbon dioxide sequestration benefits. The problem is, we've removed so many trees from this planet over the last couple of hundred years; it is going to take some time before the millions of trees planted in the last couple of years mature enough to provide sequestration benefits. Still, it's great to see the added impetus on tree planting.

Artificial carbon sequestration

Humans are odd creatures - we like to dig stuff up, make it causes havoc and then tries to bury it again - out of sight is out of mind. Coal and oil are great examples. We rip up the earth to get to these resources and then burn them which causes massive amounts of carbon dioxide to be released, causing global warming.

Dangers of artificial carbon sequestration

We know that trees remove carbon dioxide from the atmosphere and can do it very well. They also provide us, animals, insects, food and shelter. It's all the more reason for us to preserve the forests we have left and to restore ones we've destroyed. We'd be simply replacing what we have taken in an effort to restore balance. To enhance those efforts, renewable energy sources such as solar and wind power should be ramped up and everyone needs to also reduce their consumption. It's pretty simple really - consume less + more trees + renewable energy sources = less carbon dioxide = less warming.

Artificial carbon sequestration on the other hand is costly, energy intensive, relatively untested and has no other side benefits. Not enough research has been done on the above mentioned artificial processes to determine any dangers in disposing of carbon dioxide in this way.

Instead of rapidly discontinuing the use of what we know is heating our planet, researchers are trying to find other ways of defeating Nature to allow us to continue our lifestyles; or helping it deal with the excess carbon dioxide we produce - how you view the situation is up to you. Artificial carbon sequestration refers to a number of processes whereby carbon emissions are captured at the point of product and then, well, buried. One proposed method is ocean sequestration whereby carbon dioxide is injected deep into the ocean, forming lakes of CO2. In theory, the carbon dioxide will stay down deep due to the pressure and temperature of the surrounding water; gradually dissolving into that water over time. Another method is geological sequestration where the carbon dioxide is pumped into underground chambers such as old oil reservoirs, aquifers and coal seams that are unable to be mined.

Mineral sequestration is also being considered. In this method, carbon dioxide is injected into areas rich in Magnesium or Calcium. The carbon dioxide will react with those elements and combine to form calcium carbonate (limestone) and magnesium carbonate (magnesite).

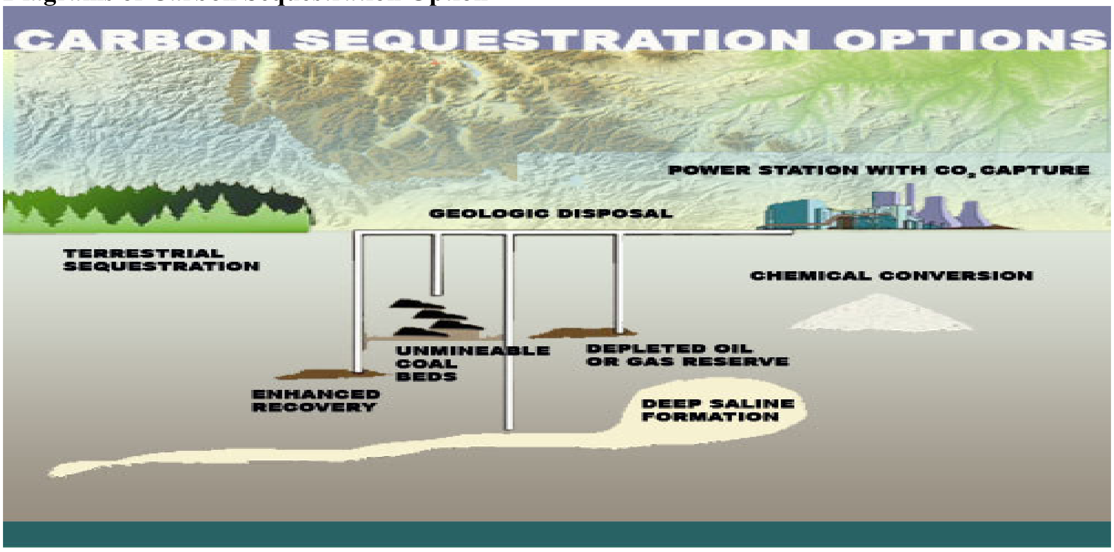
Carbon assimilation

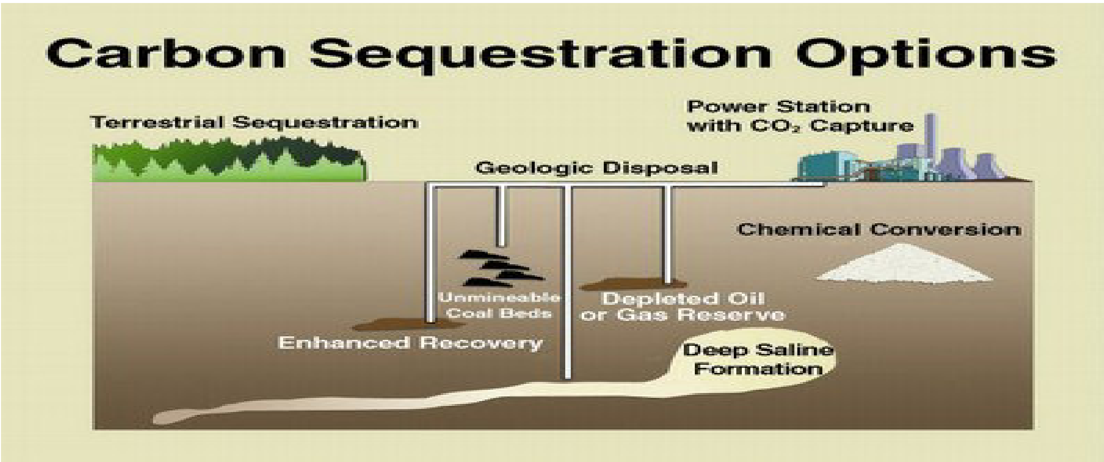
Photosynthesis is the process by which light energy is absorbed by green plants and used to produce carbohydrates from carbon dioxide (CO_2) and water (H_2O). The overall chemical reaction is

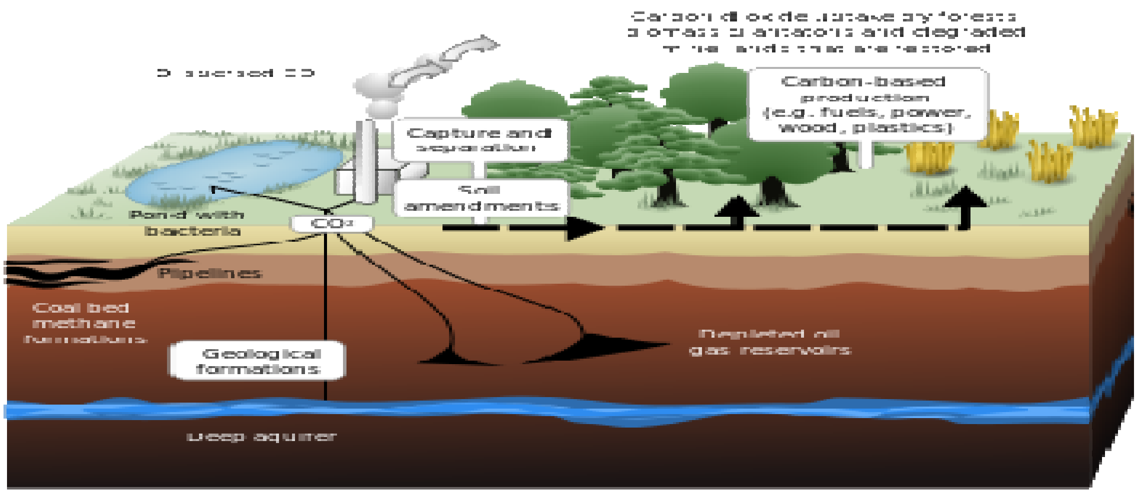
$$nCO2+2nH2O=(CH2O)n+nO2+nH2O$$

where n is the number of molecules of CO_2 that combine with water to form the carbohydrate $(CH_2O)_n$, releasing n molecules of oxygen (O_2) to the atmosphere. The compound $(CH_2O)_n$ is not real but rather represents the general structure of a carbohydrate. Carbohydrates are sugars, starches and other related.

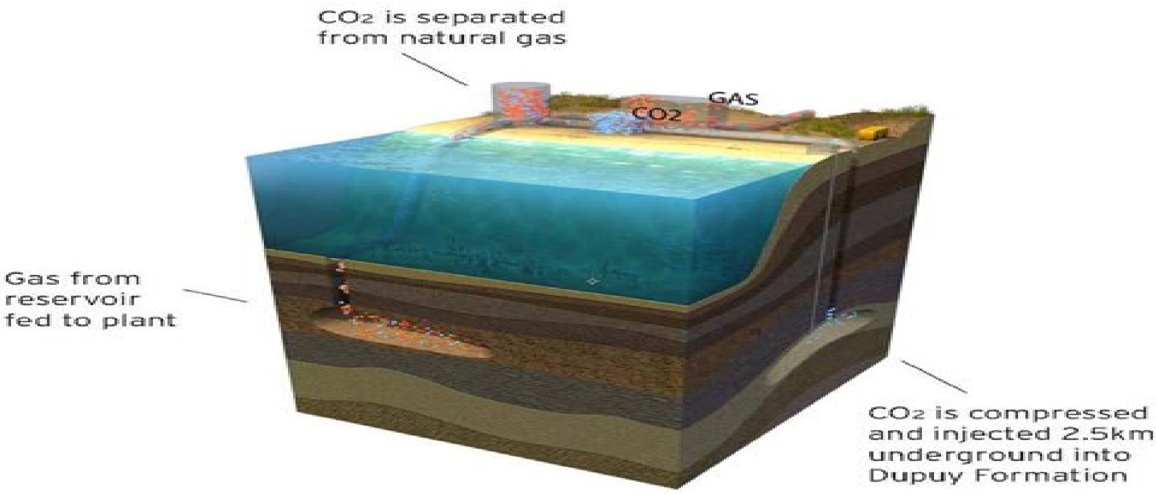
Diagrams of Carbon Sequestration Option







Largest carbon sequestration plant 2 pump 3.3M tons of CO2

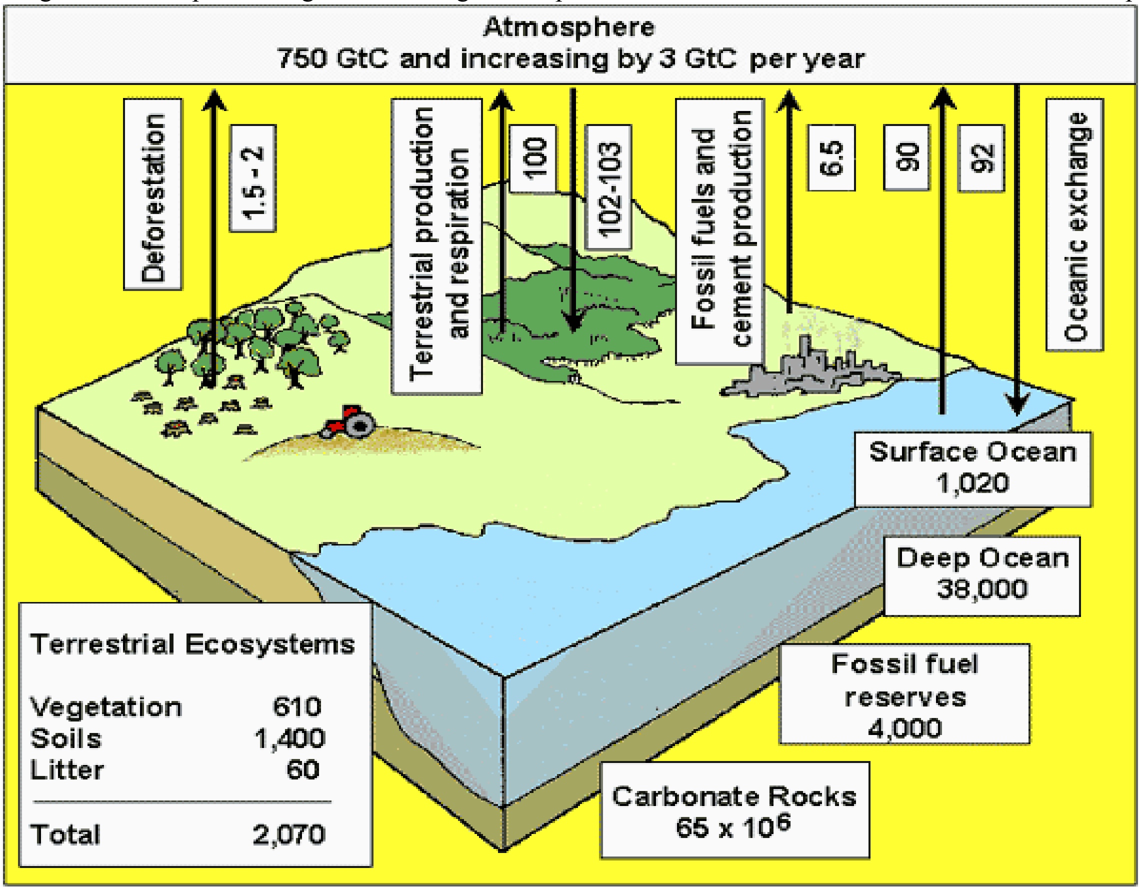


Forests and climate change

Carbon and the greenhouse effect

The scientific community essentially agrees on the phenomenon of global change (IPCC, 2001). The main cause of climate change is the anthropogenic increase in greenhouse gas concentrations in the earth's atmosphere. Carbon dioxide (CO_2) is the principal greenhouse gas. Its concentration in the atmosphere is the result of a cycle between different carbon pools: $CO_2$is the product of the oxidation of carbon from these pools. The carbon cycle at the earth level is presented in the following diagram.

Diagram 1: A simplified diagram indicating carbon pools and CO_2fluxes between the earth and the atmosphere



Source:*Edinburgh Centre for Carbon Management*(http://www.eccm.uk.com/climate.htm)

CO_2concentration in the atmosphere has increased by 31% since the beginning of the industrial era, from 280 to 360 ppm (IPCC, 2001). Anthropogenic emissions of CO_2originate primarily from the burning of fossil fuels and deforestation in tropical regions. Some of these emissions (on the order of 6 GtC/year) are reabsorbed by the terrestrial and oceanic ecosystems. The net atmospheric increase (on the order of 3 GtC/year) is small compared to the size of the carbon pools. However, this flow, that began more than a century ago with the Industrial Revolution, continues to grow, and is sufficient to explain global warming and the resulting imbalance in the climate system.

Definitions

Carbon pool:A reservoir of carbon. A system which has the capacity to accumulate or release carbon.

Carbon stock:The absolute quantity of carbon held within a pool at a specified time. The units of measurement are mass.

Carbon flux:Transfer of carbon from one carbon pool to another in units of measurement of mass per unit area and time (e.g., t C ha -1 yr-1)

Carbon sink:Any process or mechanism which removes a greenhouse gas, an aerosol or a precursor of a greenhouse gas from the atmosphere. A given pool (reservoir) can be a sink for atmospheric carbon if, during a given time interval, more carbon is flowing into it than is flowing out.

Sequestration (uptake):The process of increasing the carbon content of a carbon pool other than the atmosphere.

(IPCC, 2000).

The role of forests in climate change

Forests are important carbon pools which continuously exchange $CO_2$with the atmosphere, due to both natural processes and human action. Understanding forests' participation in the greenhouse effect requires a better understanding of the carbon cycle at the forest level. Organic matter contains carbon susceptible to be oxidized and returned to the atmosphere in the form of CO_2. Carbon is found in several pools in the forest:

· The vegetation: living plant biomass consisting of wood and non-wood materials. Although the exposed part of the plant is the most visible, the below-ground biomass (the root system) must also be considered. The amount of carbon in the biomass varies from between 35 to 65 percent of the dry weight (50 percent is often taken as a default value).

· Dead wood and litter: dead plant biomass, made up of plant debris. Litter in particular is an important source of nutrients for plant growth.

· Soil: organic matter, the humus. Humus originates from litter decomposition. Organic soil carbon represents an extremely important pool.

At the global level, 19 percent of the carbon in the earth's biosphere is stored in plants, and 81 percent in the soil. In all forests, tropical, temperate and boreal together, approximately 31 percent of the carbon is stored in the biomass and 69 percent in the soil. In tropical forests, approximately 50 percent of the carbon is stored in the biomass and 50 percent in the soil (IPCC, 2000).

· Wood products derived from harvested timber are also significant carbon pools. Their longevity depends upon their use: lifetimes may range from less than one year for fuel wood, to several decades or centuries for lumber.

The oxidation of carbon found in organic matter and the subsequent emissions of CO_2result from the following processes:

· Respiration of living biomass,

· Decomposition of organic matter by other living organisms (also called heterotrophic respiration),

· Combustion (fires).

The process of photosynthesis[2] explains why forests function as CO_2sinks, removing $CO_2$from the atmosphere. Atmospheric $CO_2$is fixed in the plant's chlorophyll parts and the carbon is integrated to complex organic molecules which are then used by the whole plant.

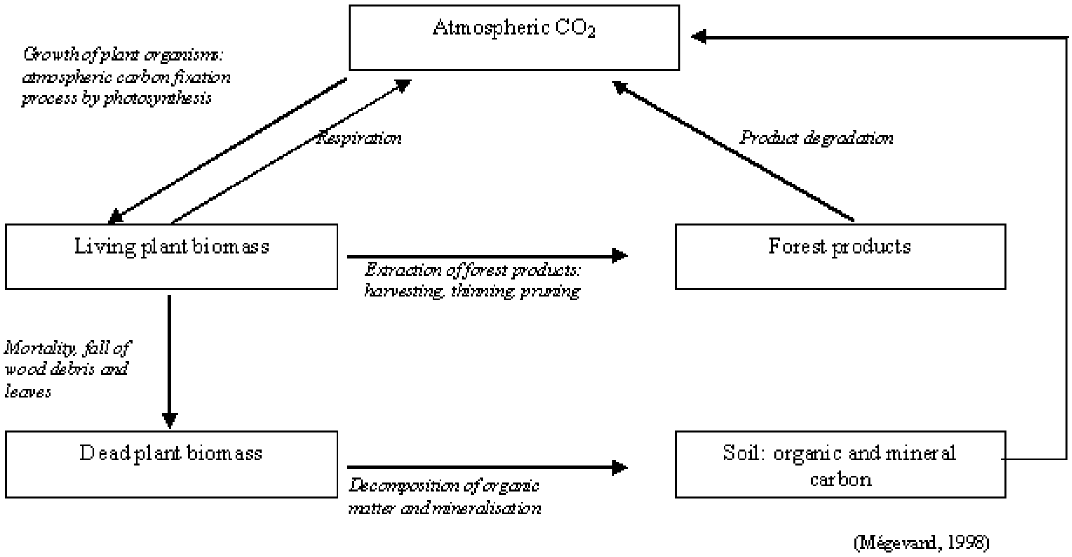


Diagram 2: The carbon cycle in the forest

The participation of forests in climate change is thus three-fold:
• They are carbon pools
• They become sources of $CO_2$when they burn, or, in general, when they are disturbed by natural or human actio
• They are CO_2 sinks when they grow biomass or extend their area.

The earth's biosphere constitutes a carbon sink that absorbs approximately 2.3 GtC annually. This represents nearly 30 percent of all fossil fuel emissions (totaling from 6.3 to 6.5 GtC/year) and is comparable to the CO_2emissions resulting from deforestation (1.6 and 2 GtC/year).

The carbon cycle (photosynthesis, plant respiration and the degradation of organic matter) in a given forest is influenced by climatic conditions and atmospheric concentrations of CO_2. The distinction between natural and human factors influencing plant growth is thus sometimes very difficult to make. The increase of CO_2in the atmosphere has a "fertilizing effect" on photosynthesis and thus, plant growth. There are varying estimates of this effect: + 33 percent, + 25 percent, and + 60 percent for trees, + 14% for pastures and crops (IPCC, 2001). This explains present regional tendencies of enhanced forest growth and causes an increase in carbon absorption by plants. This also influences the potential size of the forests carbon pool.

There are still questions regarding the long-term future of the biospheric carbon pool. Several bio-climatic models indicate that the ecosystems' absorption capacity is approaching its upper limit and should diminish in the future, possibly even reversing direction within 50 to 150 years, with forests becoming a net source of CO_2. Indeed, global warming could cause an increase in heterotrophic respiration and the decomposition of organic matter, and a simultaneous decrease of the sink effectiveness, thereby transforming the forestry ecosystems into a net source of CO_2(Ellert,etal 2001).

Economic instruments for developing countries and a potential for African forestry

The climate change negotiations have produced different economic instruments for developing countries. Some of them are already operational, some are still being developed, and others depend on the ratification of the Kyoto Protocol. Their potential for forestry is summarized in table 2 and presented in detail below.

Type	*Instrument*	*Potential for forestry*
Funds provided by the Convention or the Protocol	GEF climate change focal area	Biomass production and use Carbon sequestration
	GEF Multifocal area OP 12 Integrated ecosystems management	Projects addressing climate, biodiversity and land degradation issues E.g. Rehabilitation and improved management of forested watersheds (sustainable forest management)
	Special climate change fund of the Convention	Adaptation, technology transfer, forestry. Details to be determined
	Least developed countries fund of the Convention	Capacity building and adaptation priorities identification
	Adaptation Fund of the Kyoto Protocol	Conservation projects in vulnerable zones where forests constitute an adaptation measure
	French fund for the global environment	Carbon sequestration in forests and soils
Mechanisms to foster North/ South private and public investment flows	CDM for GHG sinks	Afforestation and reforestation projects, to be defined more specifically by COP9
	CDM for GHG sources	Substitution projects of fossil fuels by biomass
	AIJ pilot phase	All forestry activities, as a learning experience for the CDM

Table 2: Economic instruments towards developing countries and their potential for forestry

Tables

Table 2.1. *Maximum net photosynthesis with natural CO_2 availability, saturated light intensity, optimal temperature, and adequate water*

Plant type	CO_2 uptake (µmol m^{-2} s^{-1})
Herbaceous	
C_3	
Grasses	5-15
Crops	20-40
C_4	30-60
CAM	5-10
Tree	
Tropical broadleaf evergreen	
Sunlit leaves	10-16
Shaded leaves	5-7
Broadleaf deciduous	
Sunlit leaves	10-15
Shaded leaves	3-6
Needleleaf evergreen	3-6
Needleleaf deciduous	8-10

Table 2.2. *Photosynthetic characteristics of C_3, C_4, and CAM plants*

Characteristic	C_3 plants	C_4 plants	CAM plants
Carboxylating enzyme	Rubisco	PEP carboxylase and rubisco	Dark: PEP carboxylase Light: rubisco
First product of photosynthesis	3-carbon acid (PGA)	4-carbon acids (oxaloacetate, malate, aspartate)	Dark: malate Light: PGA
CO_2:ATP:NADPH	1:3:2	1:5:2	1:6.5:2
Location of processes	Mesophyll cells	Mesophyll cells then bundle-sheath cells	Mesophyll cells
Stomatal behavior	Open during day, close at night	Open during day, close at night	Close during day, open at night
Photorespiration	High	Low	Low
Photosynthesis inhibited by 21% O_2	Yes	No	Yes
Photosynthetic capacity	Low to high	High to very high	Medium
Light saturation	Intermediate intensity	No saturation	Intermediate to high intensity
Water use efficiency	1-5 g kg^{-1} H_2O	3-5 g kg^{-1} H_2O	6-15 g kg^{-1} H_2O
Optimum temperature for photosynthesis	15-25 °C	30-45 °C	30-35 °C
CO_2 compensation point	30-50 ppm	0-10 ppm	0-5 ppm

Table 2.3. *Physiological and life history characteristics of early and late successional plants*

	Early succession	Late succession
Seeds		
Number	Many	Few
Size	Small	Large
Dispersal	Wind, birds	Gravity, mammals
Dormancy	Long	Short
Germination	Enhanced by light	Not enhanced by light
Photosynthesis		
Light saturation intensity	High	Low
Light compensation point	High	Low
Efficiency at low light	Low	High
Maximum rate	High	Low
Respiration rate	High	Low
Transpiration rate	High	Low
Stomatal resistance	Low	High
Resource acquisition	High	Low
Morphology		
Root-to-shoot ratio	Low	High
Size at maturity	Small	Large
Structural strength	Low	High
Lifespan	Short	Long

Conclusion

Introducing conservation tillage practices may reduce the loss of soil carbon stocks associated with land conversion. However, the positive effect of conservation tillage is not comparable to the negative effect of land conversion, and may not result in significant accumulation of carbon in southeastern Nigeria soils. The results of this study have shown that different management systems impact on the ability of the soil to sequester carbon. In tropical hot climates as those found in the study area, natural undisturbed forests, artificial forests and grasslands store between 7906-9510 gC m^{-2} within the first 0-30 cm soil layer, whereas cultivated and continuously-cropped lands sequester about 1978-3604 gC m^{-2} depending on the management system adopted. In other words, the large-scale conversion of forests to croplands in the southeastern Nigeria may lead to 50-75% loss in the regional soil carbon stock.

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