Impact of Climate Change on Soil Fertility Status in Agbarho, Delta State, Nigeria

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Abstract
Climate change which is undisputedly the most important environmental issue of our time poses important opportunities and challenges to soil and plant sciences. Soils are crucial in the production of biofuels and changing climate has considerable effects on the soils and the food it produces. This research therefore addressed the issue of effect of climate change on soil fertility status in Agbarho with the aim of arresting its impact on the environment. Five soil samples each were collected from the five zones and from the uncultivated plots to test the variation in the soil properties. From the analyses, it was discovered that variation exists in the soil parameters examined in both the cultivated and uncultivated plots of land in the area. The paper therefore recommends sustainable soil management practices to decrease greenhouse gas emission in the area.

Introduction

Climate change and soil are interrelated processes that occur on a global scale. Global warming is projected to have a significant impact on conditions affecting agriculture, including temperature, precipitation and humidity. These conditions determine the carrying capacity of the biosphere to produce enough food for the human population and domesticated animals. Rising carbon dioxide levels would also have effects, both detrimentally and beneficially on crop yields. The overall effect of climate change on soil will depend on the balance of these effects. Assessment of the impacts of global climate change on soil might help to properly anticipate and adapt farming to maximize agricultural production.

Soil, through the process of crop cultivation, has been shown to produce significant effects on climate change, primarily through the production and release of greenhouse gases, such as carbon dioxide, methane and nitrous oxide, but also by altering the earth's land cover, which can change its ability to absorb heat and reflect light, thus contributing to radiative forcing (Burke, 2008). Land use changes, such as deforestation and desertification, together with the use of fossil fuels, are the major anthropogenic sources of carbon dioxide. Agriculture itself is the major contributor to increasing methane and nitrous oxide concentrations in earth's atmosphere (UN Report, 2007).

Causes of Climate Change

The agricultural sector is a driving force in the gas emission and land use effects thought to cause climate change. In addition to being a significant user of land and consumer of fossil fuel, agriculture contributes directly to greenhouse gas emissions through practices such as rice production and the raising of livestock (Food and Agricultural Organization, 2007). According to the Intergovernmental Panel on Climate Change (IPCC), the three main causes of the increase in greenhouse gases observed over the past 250 years have been fossil fuels, land use and agriculture (IPCC, 2003).

Agriculture contributes to greenhouse gas increases through land use in the release of carbon-dioxide linked to deforestation, methane from rice cultivation, methane from enteric fermentation in cattle and nitrous oxide released from fertilizer application. Together, these agricultural processes comprise 54 percent of methane emissions, roughly 80 percent of nitrous oxide emissions and virtually all carbon oxide emissions tied to land use (IPCC, 2003).

The Earth's major changes to land cover since 1750 have resulted from deforestation in temperature and tropical regions. When forests and woodlands are cleared to make room for fields and pastures, the albedo capacity of the affected area increases, which can result in either warming or cooling effects, depending on local conditions (IPCC, 2003). Deforestation also affects regional carbon reuptake which can result in increased concentrations of carbon-dioxide, the dominant greenhouse gas. Land clearing methods such as slash and burn practiced extensively in Africa compound these effects by burning biomatter, which directly releases greenhouse gases and particulate matter such as soot in the air.

Livestock and livestock related activities such as deforestation due to over-grazing and increasingly fuel-intensive farming practices are responsible for over 18 percent of human-made greenhouse gas emission, including 9 percent of global carbon dioxide emissions, 35-40 percent of global methane emissions and 64 percent of global nitrous oxide emissions (FAO, 2007).

Livestock activities also contribute disproportionately to land use effects, since crops such as maize and alfalfa are cultivated in order to feed the animals. Worldwide livestock production occupies 70 percent of all land used for agriculture or 30 percent of the land surface of the Earth (FAO, 2007).

Climate Change and Crop Production

The duration of crop growth is related to temperature, precipitation and humidity. An increase in temperature will speed up crop development. In the case of an annual crop, the duration between sowing and harvesting will shorten. The shortening of such a cycle could have an adverse effect on productivity because senescence would occur sooner.

Carbon dioxide is essential for plant growth. Rising carbon dioxide in the atmosphere can have both positive and negative consequences. Increased carbon-dioxide is expected to have positive physiological effects by increasing the rate of photosynthesis. Currently, the amount of carbon dioxide in the atmosphere is 380 parts per million; while the amount of oxygen is 210,000 parts per million. This means that often plants may be starved of carbon dioxide, being outnumbered by the photosynthesis pollutant oxygen. The effects of an increase in carbon dioxide would be higher in wheat than in maize, because the former is more susceptible to carbon dioxide shortage. Under optimum conditions of temperature and humidity, the yield increase could reach 36 percent, if the levels of carbon dioxide are doubled.

Climate change has effect on the quality of grains produced. According to the Intergovernmental Panel on Climate Change (2003), the importance of climate change impacts on grain and forage quality emerges from new research. For rice, the amylose content of the grain – a major determinant of cooking quality – is increased under elevated carbon dioxide (Conroy, 1994). Cooked rice grain from plants grown in high carbon dioxide environments would be firmer than that from today's plants. However, concentrations of iron and zinc, which are important for human nutrition, would be lower (Seneweera and Conroy, 1997). Moreover, the protein content of the grain decreases under combined increases of temperature and carbon dioxide (Ziska, 1997). Studies have shown that higher carbon dioxide levels lead to reduced plant uptake of nitrogen resulting in crops with lower nutritional value (Grist, 2005).

Prevailing Trends

Despite technological advances, such as improved varieties, genetically modified organisms and irrigation systems, weather is still a key factor in agricultural productivity, as well as soil properties and natural communities. The effect of climate on agriculture is related to variabilities in local climates rather than in global climate patterns.

In the 2001 Intergovernmental Panel on Climate Change Third Assessment Report, it concluded that the poorest countries would be worst hit with reductions in crop yields in most tropical and sub-tropical regions due to decreased water availability. In Africa and Latin America many rainfed crops are near their maximum temperature tolerance, so that yields are likely to fall sharply for even small climate changes.

Climate change induced by increasing greenhouse gases is likely to affect crops differently from region to region. More favourable effects on yield tend to depend to a large extent on realization of the potentially beneficial effects of carbon dioxide on crop growth and increase of efficiency in water use. Decrease in potential yields is likely to be caused by shortening of the growing period, decrease in water availability and poor vernalization.

In the long run, climate change could affect agriculture in terms of productivity, agricultural practices, environmental effects and rural space. Thus, there are large uncertainties to uncover, particularly because there is lack of information on many specific local regions and include the uncertainties on magnitude of climate change, the effects of technological changes on productivity, global food demands and the numerous possibilities of adaptation. Most plant scientists believe that agricultural production will be mostly affected by the severity and pace of climate change, not so much by gradual trends in climate. If change is gradual, there may be enough time for biota adjustment. Rapid climate change, however could harm agriculture in many countries, especially in the developing countries of Africa and Nigeria in particular that are already suffering from rather poor soil and climate conditions, because there is less time for optimum natural selection and adaptation.

Study Area

Agbarho lies between latitude 5°31 North to 5°39 North of the Equator and longitude 5°51 East to 5°57 East of the Greenwich Meridian. Agbarho has a land area of about 79 square km, and is located in Ughelli North Local Government Area of Delta State. Agbarho is bounded in the North by Okpe Local Government Area, in the West by Uvwie Local Government Area, in the South by Ughelli South Local Government Area and in the East by Ethiope East Local Government Area.

Climate

The climate of the area is characterized by high but uniform temperatures. The mean daily maximum temperature is about 32°C all year round and a minimum of about 23°C (Ajayi, 2003).

Humidity is also relatively high during the wet season resulting in damp conditions. A situation which is ideal for disease proliferation. Rainfall intensities range between 3000mm to 3500mm (Ajayi, 2003). This high annual rainfall, high water table and low relief are responsible for the poor soil formation in the area.

Soil

According to Aweto (1994), soil classification in the area is based on slope distribution and superficial deposits. Hence, the soil can be classified into four groups: upper soil, middle slope soil, lower slope soil and valley slope soil. This classification is based on the catena concept which relates soil morphological properties to differences in the gradient locations along the topography.

The upper slope soils are often well drained; while the middle slope soils are moderately well drained. The lower slope soils are often poorly drained; while the valley bottom soils are basically flood plains. They are usually waterlogged during the rainy season and almost all year round.

Methodology

This study is an empirical research. It involves data collection and laboratory analysis of soil samples collected from different agricultural land uses in the area.

Sources of Data Collection

The data for this study were derived from two main sources:

(a) Primary sources include soil samples collected from different agricultural land uses of cultivated plots of cassava + maize, oil palm, plantain, rubber and from uncultivated plots. To have a proper coverage of the study area, the area was stratified into five zones based on existing quarters as; Ikweghwu-Erhwerhe, Ughwrughelli-Ophori, Orhokpokpor – Ekrerhavwe, Oguname – Ohrerhe, Uvwiama – Uvwiamuge. The essence is to ensure proper representation of the population under investigation. The systematic random sampling technique was adopted to select the five farm plots within each zone under the different crops. Five soil samples each were collected under the different crops. This implies that 25 soil samples each from the four cultivated plots, making a total of 100 soil sample sites and another 25 soil samples from the uncultivated plots – which will serve as control – were collected for analyses. Soil samples were collected with an auger from 0 – 20cm depth in each sampling point. It was done at an equidistant point of 12.5 metres using scale ruler to measure the sample depth. The soil samples were collected into labeled polythene bags and taken immediately to the laboratory for analyses (Atorhe, 2009).

The materials and equipment used for the analyses and assessment were based on the analytical equipment recommended and validated by the Food and Agricultural Organization of the United Nations Organization.

(b) Secondary sources were derived from journals, research abstracts, periodicals, reports and magazines.

Laboratory Analysis of Soil Properties

At the laboratory, the soil samples were air-dried under room temperatures. The soil samples were then crushed with mortar and sieved. The major elements that were analyzed include sand, clay and silt content, bulk density, organic matter (carbon), nitrogen, phosphorus and soil pH were tested. With the exception of samples collected for bulk density determination, all the other soil samples were air-dried at room temperature, passed through a 2mm sieve and analysed for:

i. Organic carbon by chronic acid digestion of Walkley and Black method (1934).
ii. Nitrogen by regular micro-kjedahl digestion method (Bremmar and Mulvaney, 1982).
iii. Soil pH, determined potentiometrically in distilled water using a soil to water ration of 1:1 (Bates, 1964).
iv. Phosphorus by Brays P1 solution of Bray and Kurtz (1945) and determined in accordance with Murphy and Eily (1962) procedure.

These listed elements have been proved to be physiologically and metabolically essential for plant growth (Aduayi, 1985). In a biological heterogeneous environment, such as the soil, there are complex factors such as particle size composition, organic carbon, nitrogen, soil pH and phosphorus which give indication of a nutritionally firm plant. These physical and chemical properties of the soil provide all the essential mineral elements of the soil and maintain soil fertility.

The Coconut

According to Gilman (2001), when crops are planted on the soil, the crops make a great demand on the soil through the process of nutrient immobilization and there is bound to be changes in the nutrient status of the soil of that same unit. Since it is evident that crop cultivation makes a great demand on soil nutrient, there is the need to determine the status of these elements in the laboratory to assess the fertility level of the soil and to ascertain if these nutrients have been influenced by climate change.

Discussions and Findings

Impact of Climate Change on: Organic Carbon of the Soil

Organic carbon consists of an accumulation of undercomposed or partly decomposed roots, stems and leaves of higher plants and residues of worms, anthropoids, bacteria, algae and fungi. The dead remains of these materials added to the soil are converted dark coloured complexes known as humus (Aduayi, 1985). The humus is slowly oxidized to carbonates, water and nitrates and other simple substances, which serve as food for plants.

Organic carbon is an essential constituent of the soil. It exerts a profound influence on almost every facet of the soil. It provides nutrients for plant growth as well as influences the physical properties of the soil.

Table 1, below shows that the total mean value of organic carbon for the different cultivated crops such as cassava + maize is 3.03%, oil palm, 2.25%, plantain, 3.85% and rubber, 2.79% while the uncultivated soil is 3.53%. Except for plantain with (3.85%), the variation in organic carbon under cassava + maize (1.6), oil palm (1.5), plantain (1.8) and rubber (1.6). These changes in soil organic carbon content have effects on the carbon dioxide concentration in the atmosphere, thus leading to increases in greenhouse gas emission.

Soil pH

This is a measure of hydrogen ion concentration in the soil. Soil pH is a very important soil property as it controls the amount of nutrients available to plants. It tends to correlate with other soil properties.

Table 1: Range, Mean and Standard Deviation of soil properties under the uncultivated and cultivated plots in Agbarha.

	Uncultivated			Cassava + Maize			Oil Palm			Plantain			Rubber		
Soil Properties	**Range**	$\bar{X}$	**S.D**	**Range**	$\bar{X}$	**S.D**	**Range**	$\bar{X}$	**S.D**	**Range**	$\bar{X}$	**S.D**	**Range**	$\bar{X}$	**S.D**
Sand %	92.7-83.4	91.26	1.99	95.3-88.2	88.94	3.3	96.4-84.1	88.96	3.4	97.2-69.3	88.28	7.4	94.6-82.0	88.92	4.3
Silt %	9.2-2.3	4.74	2.4	7.4-3.1	5.54	1.5	7.1-3.1	4.88	1.5	13.2- 2.28	7.56	3.5	7.8-3.1	4.86	1.6
Clay %	12.4-2.8	6.34	3.4	12.0- 9.8	5.52	3.3	10.4-2.4	6.16	3.1	10.1-2.4	6.16	3.1	6.4-3.2	4.44	1.0
Bulk Density	1.46-1.09	1.38	0.1	1.50-1.28	1.40	0.02	1.49-1.08	1.59	0.4	1.89-0.73	1.34	0.3	2.41-1.28	1.36	0.2
Total Porosity	65.68-61.18	63.50	1.0	66.90-59.0	62.30	2.3	66.64-58.98	62.32	2.4	70.05-50.21	60.43	5.8	66.42-57.86	62.08	2.7
Soil pH	5.67-4.12	5.21	0.35	5.60-4.21	4.68	0.3	5.34-4.21	4.96	0.2	5.84-4.25	4.98	0.5	5.42-4.20	4.98	0.4
Organic Carbon	6.24-0.01	3.53	2.1	4.51-1.09	3.03	1.6	43.81-1.04	2.25	1.5	4.81-0.22	2.85	1.8	5.42-0.59	2.79	1.8
Nitrogen %	0.66-0.05	0.36	0.22	0.64-0.07	0.26	0.2	0.44-0.08	0.27	0.1	0.70-0.11	0.30	0.097	0.49-0.22	0.36	0.09
Phosphorus (uglg)	11.54-6.48	8.94	1.6	7.01-4.21	5.55	0.10	7.72-5.69	6.89	0.6	4.41-1.21	2.84	0.9	11.40-4.26	7.06	3.1
CEC (me/g)	4.07-2.72	3.40	0.5	4.20-0.96	2.91	1.2	3.98-2.49	2.96	0.4	1.26-0.50	0.84	0.3	3.14-2.05	2.63	0.2
Magnesium (me/g)	3.13-1.92	2.47	0.5	3.50-2.06	2.89	0.5	3.78-1.97	3.16	0.6	3.40-0.78	1.53	0.87	3.57-1.19	2.21	0.89
Potassium (me/g)	0.67-0.30	0.47	0.10	0.29-0.06	0.15	0.08	0.19-0.07	0.11	0.04	0.41-0.12	0.32	0.1	0.71-0.26	0.43	1.14
Sodium (me/g)	0.41-0.02	0.2	0.17	0.23-0.01	0.11	0.09	0.36-0.11	0.26	0.1	0.47-0.02	0.22	0.14	0.44-0.02	0.11	0.15
0.08	1.08-0.19	0.33	0.40	0.22-0.10	0.16	0.04	1.10-0.12	0.36	0.3	0.35-0.4	0.14	0.10	0.30-0.07	0.14	

$\bar{X}$ = Mean; SD = Standard Deviation

Source: Atorhe, 2009

As shown in table 1, the total mean value of pH in uncultivated plot is 5.21%, while the mean value of soil pH under the different cultivated crops of cassava + maize is 4.68%, oil palm 4.96%, plantain 4.98% and rubber 4.98%. The variation in pH content under cassava + maize is (0.3), oil palm (0.2), plantain (0.5) and rubber (0.4). The pH value observed in the uncultivated plots suggest that the different crops make a great demand on soil nutrients such as calcium and magnesium than the uncultivated plots (Atorhe, 2009).

Generally speaking, both cultivated and uncultivated soils of the study area are acidic, because they are within 4-5pH values. This acidic nature is attributed to heavy annual rainfall resulting in depletion of the cations which is an outcome of climate change.

Soil Nitrogen

Nitrogen is one of the elements that is of primary importance in the determination of crop yield and quality. It is required in comparatively large amount and is likely to be deficient in soil unless the best management practice is used.

In table 1, the total mean value for nitrogen in the uncultivated plot is 0.36%. This value is greater than the recorded values for the cultivated crops such as cassava + maize (0.26%), oil palm (0.27%), plantain (0.30%) and rubber (0.36%). The variation in the nitrogen content under cassava + maize is (0.26), oil palm (0.1), plantain (0.097) and rubber (0.09). The reasons for this phenomenon could be attributed to the fact that the uncultivated plots consist of varied leguminous plant species that fix nitrogen to the soil. Also, organic matter is a major source and store house of nitrogen component. Therefore nitrogen responds to the level of organic carbon content in the soil and contributes to greenhouse gas emission.

Bulk Density

As shown in table 1, the total mean value of bulk density is 1.38g/cm^3 under the uncultivated plots while those under the different cultivated plots of cassava + maize (1.40g/cm^3), oil palm (1.36g/cm^3), plantain (1.44g/cm^3) and rubber (1.56g/cm^3) respectively (Atorhe, 2009). The variation in bulk density under cassava + maize is (0.02), oil palm (0.4), plantain (0.3) and rubber (0.2). The lower bulk density obtained in soils of the uncultivated plot may be attributed to the modification of some forest soils structural properties by its higher organic matter content, compared to the values obtained from the different cultivated cropped soil (Ekanade, 1999).

Effect of Agricultural Land uses and soil properties from model summary in tables 2-7 below, the correlation between y – uncultivated plot and the predictors, cassava + maize.

Table 2:Regression Analysis of the Effects of the Different Agricultural Land Uses on the Soil Properties.

Descriptive Statistics

Land use	Mean	Std. Deviation	N
Uncultivated	13.6887	26.7337	14
Cassava + maize	13.1227	26.4226	14

Oil palm	13.2164	26.2933	14
Plantain	12.7169	26.1980	14
Rubber	13.0514	26.3524	14

Table 3: Correlation

	Uncultivated	**Cassava + maize**	**Oil palm**	**Plantain**	**Rubber**
Uncultivated	1.000	0.997	0.998	0.993	0.996
Cassava + Maize	0.997	1.000	0.999	0.995	0.998
Oil palm	0.998	0.999	1.000	0.995	0.995
Plantain	0.993	0.995	0.995	1.000	1.000
Rubber	0.996	0.998	0.998	0.995	000
Sig (1-tailed) uncultivated	000	000	000	000	000
Cassava + maize	000	000	000	000	000
Oil palm	000	000	000	000	000
Plantain	000	000	000	000	000
Rubber	000	000	000	000	000
N Uncultivated	14	14	14	14	14
Cassava + maize	14	14	14	14	14
Oil palm	14	14	14	14	14
Plantain	14	14	14	14	14
Rubber	14	14	14	14	14

Table 4: Model Summary [b]

Model	**R**	**R Squares**	**Adjusted R Square**	**Std Error of the Estimate**
1	0.998	0.996	0.996	1.7748

Table 5: ANOVA [b]

Model	**Sum of Squares**	**Df**	**Mean of Square**	**F**	**Sig**
1 Regression	49108.822	4	12277.205	2897.739	000[a]
Residual	204.739	9	3.150		
Total	49313.561	12			

a. Predictors: (Constant (Rubber, Plantain, Cassava + Maize, Oil palm)
b. Dependent Variable Uncultivated

Model	Unstandarized Coefficients	Standard Coefficient		T	Sig
	B	Std error	Beta		
1 Constant	312	240			
Cassava + Maize	164	157	162	1.045	300
Oil palm	792	175	779	4.514	000
Plantain	1.32E-03	087	.001	.015	.988
Rubber	5.667E-02	.142	.056	.398	692

Table 6: Coefficients [a]

Model	95% Confidence Interval for B		Correlation		
	Lower Bound	Upper Bound	Zero-Order	Partial	Part
1 (Constant)	-168	791			
Cassava + Maize	-150	478	0.999	129	008
Oil palm	.442	1.142	0.998	489	036
Plantain	-173	.176	0.993	002	000
Rubber	-227	.341	0.996	.049	.003

Table 8:Analysis of Variance of Soil Parameters

Parameters used for comparison	Calculated ANOVA value	Table of ANOVA at 5% level
Sand	21625.1	3.07
Silt	17.9	,,
Clay	302.5	,,
Bulk density	1849.2	,,
Soil pH	19278.5	,,
Organic carbon	1125.53	,,
Nitrogen	173.5	,,
Phosphorus	369.5	,,
Cation Exchange Capacity	710.7	,,

Magnesium	756.4	,,
Potassium	394.1	,,
Sodium	133.3	,,
Calcium	87.8	,,

Source: Atorhe, 2009.

oil palm, plantain and rubber is 0.996, which shows that there is a high positive relationship between the uncultivated plots and the different cultivated crops vis-à-vis their impact on the environment. This indicates a 99% contribution to the soil fertility depletion in the study area.

$R^2 = 0.996$

Also, the coefficient of determination

$R = (0.996)^2 X 100$

$R = 0.992010 X 100$

$R = 99.2\%$

The value of R2 = 0.0996 is the same as 99.2% when converted to percentage. This shows that about 99 percent of total variation in Y explained by X, which is to say that about 99 percent of total variations occur in the soil nutrient under the uncultivated plot.

The ANOVA table (table 5) is a measure of the overall significance of independent variable (X) in explaining dependent variable (Y). The calculated values were tested with regression analysis using the statistical package for social sciences (SPSS). The F – calculated is 3897.793, df, is the degree of freedom given by K – 1 (5-1 = 4) and df, given by N – K (14 – 5 = 9).

The value of F – tabulated at 0.05% level of significance is 3.63 using a one tailed test. This is because the value of F – calculated (3897.739) is greater than the value of the F – tabulated. Thus, the cultivated crops in the study area have significant effect on the soil; hence on climate change (see table 8).

Conclusion

With climate change, soil degradation is more likely to occur and soil fertility would probably be affected by global warming. However, because the ratio of carbon to nitrogen is a constant, a doubling of carbon is likely to imply a higher storage of nitrogen in soils as nitrates as depicted by the cultivated and uncultivated plots in the study area. Thus, the average needs for nitrogen could decrease and give the opportunity of changing often costly fertilisation strategies. However, due to extremes of climate, increased precipitation in the study area resulted in greater risk of leaching and erosion, whilst at the same time providing soil with better hydration, according to the intensity of the rain. Organic matter in the soil was highly contestable, while increase in temperature induced greater rate in the production of minerals, lessening the soil organic matter content. The atmospheric carbon-dioxide concentration led to an increase in the greenhouse gas emission in the study area.

Recommendations

In line with the laboratory results of the soil samples analysed, the researcher recommends:

- Adoption of climate adapted species of crops such as vernalization need and heat or cold resistance plants for the soil.
- The application of irrigation during the dry season and use of fertilizer to enrich the soil in order to check climate variability.
- A reduction in greenhouse gas emission and speeding the transition to a low carbon economy.
- An understanding of the soil biology and soil chemistry of soils should be carried out in order to maintain soil fertility and check climate change effects on soils and plant growth.

References

Aduayi, E.A (1985). Making the soil nutritious to plants, An inaugural lecture delivered at the Obafemi Awolowo University, Ile-Ife on Tuesday, December 10.

Ajayi, O. (2003). *Comprehensive Geography,* Lagos, Johnson Publishers.

Atorhe, O.I (2009). A comparison of soil fertility status under different crops in Agbarho, Delta State, Unpublished M.Sc dissertation.

Aweto, A. (1994). Effect of an oil palm plantation on a tropical forest in South Western Nigeria, *The Indonesian Journal of Geography,* 26, 51-59.

Bates, R.C. (1964). *Determination of pH: Theory and Practice,* New York, John Wiley and sons.

Bray, R.H & Kurtz, L.T. (1945). Determination of total organic and available forms of phosphorus in soils, *Science,* 59;39-45.

Bremmer, J.M & Mulvaney, C.S. (1982). Nitrogen Total,' in methods of soil analysis, part 2, A.L.R.H. Miller and D.R. Keeny (eds). *American Society of Agron, 9, 595-622.*

Burke, M.B. (2008). Prioritizing climate change adaptation needs for food security in 2030" *science* 319(5863): 607-610.

The Coconut

Conroy, S.O. (1994) . Land use and soil management". *Outlook in Agriculture* 1(1):40-43.

Ekanade, O. (1999). The nature of soil properties under mature forest and plantains of fruiting and exotic trees in tropical rain forest fringes of South Western Nigeria. *Journal of World Forest Resources Management*, 10(2):101 – 114.

Food and Agricultural Organization (2007) http://www. Virtualcentre.org/en/library/key-pub/longshad/A0701E00.pdf. Retrieved on 25 June, 2009.

Gilman, R. (2001) *Plants and Environment. A textbook of Plant Autecology*. New Delhi, W.E.P. Limited.

Grist, G. (2005) "The Good, the Bad and the Ugly". http://www/grist.org/news/maindish/ 2005/07/12/schereplantchem/. Retrieved on 25 June, 2009.

Intergovernmental Panel on Climate Change (2003) "Special Report on Emission Scenarios. http://www.grida.no/climate/ipcc/emission/076.htm. Retrieved on 15 May, 2009.

Seneweera, O. & Conrey, S.O. (1997) "Climate Change and Agriculture". *Science* 14(5): 201-210.

UN Report (2007). Climate change http://www/ipcc.ch/SPM2feb07.pdf. Retrieved on June 25.2009.

Walkey, A. & Black, A. (1934). Determination of organic carbon in Soil. *Soil Science* 37:29-38.

Ziska, G. (1997) . Climate change and agricultural vulnerability. *Science* 319(2345) 105-112