Agroforestry Practice as Adaptation Tools to Climate Change Hazards in Itu Lga, Akwa Ibom State,Nigeria

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Abstract

Agriculture is the human enterprise that is most vulnerable to climate change. Tropical agriculture, particularly subsistence agriculture is particularly vulnerable, as smallholder farmers do not have adequate resources to adapt to climate change. While agroforestry may play a significant role in mitigating the atmospheric accumulation of greenhouse gases (GHG), it also has a role to play in helping smallholder farmers to adapt to climate change. A combination of participatory approaches including structured questionnaire, household survey, focus group discussions and field survey was conducted in Itu Local Government Area, Akwa Ibom State Nigeria. Climatic elements of rainfall, relative humidity and temperature were collected from Uyo Meteorological Station, Akwa Ibom for 30 years. The study was aimed at ascertaining changes in climate pattern and contribution of agroforestry to the adaptation in the study area. Rainfall shows a decreasing trend of -1.32mm/year. Temperature and relative humidity showed increasing trend of 0.6430C/ year and 0.13 percent year respectively. Major causes of climate change in the area are deforestation ,fossil fuel burning, land use system, pollution, population, military activities, and economic pressure that had (28

Index terms— Agroforestry, climate change, adaptation measures, rural farmers.

threatening biota and human livelihoods. Yet, even as climate changes, food and fiber production, environmental services and rural livelihoods must improve, and not just be maintained. The degradation in the developing world cannot be allowed to persist. Developing countries are faced with urgent needs for development, to improve food security, reduce poverty and provide an adequate standard of living for growing populations.

Large percentages of the populations of developing countries depend on rainfed agriculture for their livelihoods. Climate change is already affecting agriculture and other sources of livelihood in these countries and this situation is likely to worsen. Recent debates within the UNFCCC process on the relation between global adaptation and mitigation measures lack substance due to lack of pertinent experience on the ground. Discussions are often treated in a much generalized manner and are not specifically related to distinct sectors such as agriculture or forestry **??**IPCC, 2001). A practical understanding of the link between adaptation and mitigation measures does not yet exist. However, for some decades now agricultural research has been focusing on the questions of increasing the resilience (against drought, flood, erosion, fertility loss, etc.) and productivity of agricultural systems. Increasing system resilience is directly related to increasing the adaptive capacity of farmers. Agroforestry provides a particular example of a set of innovative practices that are designed to enhance productivity in a way that often contributes to climate change mitigation through enhanced carbon sequestration, and that can also strengthen the system"s ability to adapt to adverse impacts of changing climate conditions. This study looks into ascertaining the changes in some climatic regimes within Itu Local Government Area, Akwa Ibom State and explores sustainable agroforestry potentials that will enhance resilience and thereby reduce vulnerability of smallholder farmers in the study area Itu Local Government Area, Akwa Ibom State is one of the Niger Delta states of Nigeria. The area is living in a low lying coastal region that is vulnerable to climate change impact. Climate-related hazards make agricultural activities of the area highly susceptible to climate -related extreme events such as floods, salinity intrusion from Atlantic Ocean, severe wind storms, soil erosion, river bank erosion and excessive rise in temperature. In recent times, the frequency of these events has become alarming ??IPCC,2007). The livelihoods of the rural poor farmers are at high risk due to the extreme climatic induced events.

In the Niger Delta region of Nigeria, agriculture and fishing are the major occupations of the inhabitants. There have been reports of changes in the onset and cessation of annual rainfall in the area. Also prolong rainfall and temperatures are also noted to have increased over the years. The changes in the pattern and quantity of rainfall as well as other climate parameters such as temperature, wind storm and relative humidity will no doubt impact on the lives of farmers and other vulnerable groups in the area. This makes the zone vulnerable to inter-annual climate variability and climate change. Also the degradation of the area as a result of oil exploration, exploitation and gas flaring has been known to lowering crop yields in this zone ??IPCC,2001). Given the fundamental role of agriculture in this zone, concern has been expressed nationally and locally by scientists and government about the effect of climate change on crop production. Interest in this issue has motivated the need for this study in the Niger Delta zone of Nigeria.

Therefore the study is expected to unveil the pattern of changes in climatic parameters and the importance of agroforestry system in adapting to effect of climate change in the area.

The study used both primary and secondary data. The primary data were obtained using In-depth Interview, Focus Group Discussion and Questionnaire administered to the farmers in the study area on the used of agroforestry as adapting tools to climate change hazards. Information on the communities and climatic conditions in the area were obtained from heads of communities, community chiefs, women leaders, elders and other opinion leaders that have been living in the place for the past 30 years. The questionnaires were structured to elicit much information as possible on the climate-related extreme events; these included previous studies on all possible impacts of climate change, identifying particularly vulnerable area and capacity building which may be taken to prepare for adaptation to climatic hazards in the area. The existing meteorological data were collected for 30 years on daily temperature (maximum and minimum), relative humidity, and daily rainfall. The data were analyzed to ascertain the pattern of these parameters over the years.

The parameters most affected by the impact on climate change were assessed. i.e. key climatic hazards in the area, the past and present status of season of planting, type of crops, time of flooding, income generation, chemical input, method of cropping, yield of crop per unit area, change in cropping system, changes in disease pattern affecting crops, changes in the number of farmers over years, income from farming, labour availability and alternative occupations Adaptation in this study involves a process of adjusting in relation to the impact of climate change which includes ecological, social and economic adjustments in anticipation or actual changes in climatic conditions. The method used to assess adaptation measures in the area were structured questionnaires, in depth interviews and focus group discussion with the inhabitants of the area. The indices used in this assessment included identifying the alternative options that sustained their livelihood during climate disasters, coping measures to climate change events, and new technologies that can be introduced to remedy the situation.

Descriptive statistical presentations of the data (Seepersad and Henerson, 1984; Shepherd and Roger, 1991) were used to analyze data from questionnaires. Correlation analysis and analysis of variance (ANOVA) were used according to Steel and Torrie, (1980). a) Pattern of climate change in the study area.

Statistical record of rainfall obtained in Uyo, Akwa Ibom State from 1979-2010 shows a decreasing trend with the highest amount of rainfall in 1979 and the lowest amount of rainfall in 1983 (Fig. 1). The value of the highest volume of rainfall recorded in 1979 was 3373.7mm while the lowest recorded in 1983 was 1619.4mm. The mean and standard deviation of rainfall data in the area from 1979-2010 were 1876.475mm and 250.34mm respectively (Table ??1). The trend coefficient was -1.32mm/year and implies that there is negative relationship in the amount rainfall from year to year. Also the value of coefficient correlation was 0.0587 which shows that there is positive relationship between amount of rainfall and time in the study area. The irregular pattern of the graph (Fig. 1) shows the uncertainties in the onset and the amount of rain in each year, also due to changes in rainfall characteristic in which early rains may not be sustained, crops planted at that time may

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become smothered by heat waves resulted to loss of income to the farmers. NEST, (2000) predicted that climate change will pose serious threat to food security. This is because agriculture in the study area is highly dependent on rain and irrigation is seldom practiced. Changes in rainfall pattern will greatly affect agriculture in area, because the area is in a low lying coastal region, which that is vulnerable to climate -related hazards such as floods, salinity intrusion from Atlantic Ocean, severe wind storms, river bank erosion and excessive rise in temperature.

Data on temperature from 1979-2010 shows increasing trend with the maximum temperature (31.2 0 C) recorded in 2006 and minimum temperature (25.9 0 C) recorded in 1994 (Fig. ??). The mean value of temperature and its standard deviation over the period were 27.58 0 C and 0.36 0 C respectively. The trend coefficient was 0.119 0 C/year, implying that there increase in the value of temperature from year to year. The coefficient correlation was 0.643 implying that there is positive relationship between temperature and time in the study area (Table 2).

The effects of high temperature on crop yield is poor, spread of diseases and pest, increase in evapotranspiration and reduces productivity of the farms resulted in low income.

Relative humidity data from 1980-2010 showed an increasing trend with its highest value for the period (84.4 %) recorded in 2006 and lowest value (71.3%) recorded in 1998 (Fig. **??**) The mean and standard deviation values of relative humidity over the period are 72.8 and 2.87 percent implying that relative humidity has a narrow variability with time. The trend coefficient is 0.1308 percent per year confirming an increasing trend of relative humidity and is statistically significant. The coefficient of correlation has a value of 0.201 showing a strong relationship between relative humidity and time. The high relative humidity (RH) directly influences the water relations of plant and indirectly affects leaf growth, photosynthesis, pollination, occurrence of diseases and finally economic yield. The dryness of the atmosphere reduces dry matter production through stomatal control and leaf water potential. Smith, (2004) reported that turgor pressure is high under RH due to less transpiration. Thus high relative humidity enhance leaf enlargement. Also, incidence of insect pests and diseases is high under high humidity conditions, and high relative humidity favours easy germination of fungal spores on plant leaves. Ekpo, (2004) observed that the blight diseases of potato and tea spread more rapidly under humid conditions, and several insects such as aphids and jassids thrive better under moist conditions. However, effect of high values of relative humidity : results reduced evapotranspiration; increased heat load of plants; stomatal closure ; reduced CO 2 uptake and reduced transpiration which influences translocation of food materials and nutrients Flooding had the highest percentage of 53.2 percent and was rated as the most prevalent climate change hazards in the communities within the study area by the respondents.(Fig. 4). Soil erosion and river bank erosion was 48.4 and 42 .1 percent respectively. Severe wind storm and rise in temperature had 33.2 and 27.4 percent respectively. Also salinity intrusion into fresh water from Atlantic Ocean was recorded 20,2 percent. Analysis of rainfall pattern of the study area over a period of 30 years indicated a higher intensity of rainfall particularly within the wet months (May-October). Ebong (2000) had reported incidents of heavy flooding in Itu community between the years of 1991-2000. Respondents during IDI exercise complained the flooding has become annual occurrences which affect the livelihood of the people. The Third Assessment Report of the Intergovernmental Panel on Climate Change (IPCC) reported that increasing greenhouse gas concentrations have a detectable effect on earth"s climate system, including increase in global-mean sea level **??**IPCC, 2007). An increase in temperatures would raise sea level by expanding ocean water and melting glaciers. Sea level rise is increasing the susceptibility of communities in Itu and their ecosystems through the permanent inundation of the area. Ultimately, this may lead to the displacement of millions of people, significant damage to property and infrastructure, and a considerable loss of coastal ecosystems in the study area. Agroforestry options may provide a means for diversifying production systems and increasing the sustainability of smallholder farming systems in Itu Local Government Area of Akwa Ibom State, Nigeria. The most worrisome component of climate change in the study area is increased interannual variability of rainfall and temperature. Agroforestry systems have some advantages for maintaining production during wetter and drier years. First, their deep root systems are able to explore a larger soil volume for water and nutrients, which will help during dry season. Second, increased soil porosity, reduced runoff and increased soil cover lead to increased water infiltration and retention in the soil profile which can reduce moisture stress during low rainfall years. Third, agroforestry systems have higher evapotranspiration rates than row crops or pastures and can thus maintain aerated soil conditions by pumping excess water out of the soil profile more rapidly than other production systems (Dhillon et al., 2009(Dhillon et al., , 2010)).

Finally, agroforestry systems often produce crops of higher value. Thus, diversifying the livelihood activities of farmers to include tree component which may buffer against income risks during extreme weather events.

The contribution of agroforestry in buffering against climate variability in a degraded land has been

2 b) improve soil nutrient

Agroforestry practice improve soil nutrient that have been washed by erosion or flooding in the area. This is because nutrient deficiency is one of the major characteristics that affect farm yield. Climate-related hazards can either improve the nutrient status or increase the degradation of the soil fertility (Scherer, 1999). Young (1986) observed that sustainable agroforestry practice in any farming community will increase or at least maintain the organic content matter levels of the soil. Tree components of any agroforestry species perform one major function in controlling erosion; the trees may act as barriers or as cover (Gupta et al., 2006). The barrier function is the conventional approach to erosion control by checking runoff of water and suspended sediment. The cover function involves reducing raindrop impact and runoff by increasing soil cover, with living or dead plant materials. Therefore, agroforestry systems have a significant influence on soil erosion in the study area. This agree with the work of Akpan (2000) who reported that crown cover of some forest trees reduced the intensity of rain water in the soil thereby, reducing the impact of washing the organic matter in the forest soil.

Also tree canopy shade alters soil conditions to promote microbial activity and the rate of soil mineralization **??**

3 c) Source of food and vitamin

With the increasing awareness among nutrition experts that the fruits and vegetable improved vitamin A status. Agroforestry system provides the poor farmers with fruits and vegetable in the study area. Also agrosilvopastoral practices that include the incorporation of a wide range of livestock in the area may reduce the vulnerability to climate change hazards in the area. This system produces substantial amounts of meat and related income per year ??Asare,2000). Generally, agroforestry system in the study area incorporate sheep, goat, rabbit and chickens. However, the incorporation of animals in the agroforestry system is a clear indication of the vital role the livestock play in the rural household economy and will enhance the livelihoods of poor farmers during extreme related climate events in Akwa Ibom State.

Agroforestry is believed to be dependable source of improved nutrition and provide additional income to households. Mitchell and Hanstad (2004) stated that income from agroforestry significantly improves the family financial status in many parts of the world; justifying the revenue generating potential of agroforestry. Okeke (1999) asserted that it is a common misconception that agroforestry is exclusively subsistence-oriented, whereas, it provide households with cash crops as well as food crops. Marsh (1998) also noted that economic returns to land and labour are often higher for agroforestry practices than any other system of agriculture. Incomes from agroforestry could be generated in several ways. Households may sell products in their farm including fruits, vegetables, animal products and other valuable materials such as bamboo and wood for construction or fuel. According to Okigbo (1990), livestock and tree crops produced in agroforestry in Southern Nigeria accounted for 60% of family cash income.

4 d) Soil and land management

Climate change adaptation for agricultural cropping systems requires a higher resilience against both excess of water (due to high intensity rainfall) and lack of water (due to extended drought periods). A key element to respond to both problems is soil organic matter, which improves and stabilizes the soil structure so that the soils can absorb higher amounts of water without causing surface run-off, which could result in soil erosion. Soil organic matter also improves the water absorption capacity of the soil during extended drought. FAO (2000) promotes low tillage and maintenance of permanent soil cover that can increase soil organic matter and reduce impacts from flooding, erosion, drought, heavy rain and winds. Intensive soil tillage reduces soil organic matter through aerobic mineralization, low tillage and the maintenance of a permanent soil cover (through crop residues or cover crops and the introduction of diversified crop rotations) increases soil organic matter ??Young, 1986). A no-or low-tilled soil conserves the structure of soil for fauna and related macrospores (earthworms, termites and root channels) to serve as drainage channels for excess water. Udofia (2010), observed that surface mulch cover protects soil from excess temperatures and evaporation losses and can reduce crop water requirements by 30 percent. With the increasing trend of temperature from the result (Figure ??) the trees leaves will protects the crops from high temperature and also prevent evaporation loss.

Rainfall variability is a major cause of vulnerability in many areas of the tropics, especially in the Niger Delta of Nigeria. However, its effects are often exacerbated by local environmental degradation and oil exploration and exploitation. In reality, vulnerability in many of these fragile ecosystems is often the result of a degenerative process due a combination of factors (deforestation, continuous cropping and changing in land use system), which, when associated with extreme climate, represents a major setback for agricultural and economic development. Therefore, curbing land degradation can play an important role in mitigating the negative impacts of climate change/variability, and that is where agroforestry can be a relevant. A successful and well-managed integration of trees on farms and in agricultural landscapes inevitably results in diversified and sustainable crop production, in addition to providing a wide range of environmental benefits. Systems such as hedgerow intercropping and boundary plantings are effective in protecting soils from erosion and restoring some fertility in degraded lands. In western Kenya, the World Agroforestry Centre, in collaboration with the Institute Recherche pour le Développement (IRD) and Kenyan National Agricultural Research Services, has tested the potential of improved fallow for controlling soil erosion, using fast growing shrubs such as Crotalaria grahamiana and Tephrosia spp. These species showed great promise in reducing soil losses (Singh, 2001).

Improved infiltration of water, while reducing runoff and transportation of sediments, also has a direct effect on water storage in the soil. Studies on water dynamics in a maize field in Northern Nigeria showed that, after a rainfall event, soil moisture accumulates much faster under improved fallow than under maize crop and natural fallow. In addition, the improvement of the soil structure and the soil organic matter allows the water to be stored much longer in the improved systems than in the continuous maize during a dry period. The implication is tremendous from an agronomic point of view. If rainfall is scarce, then crops that follow an improved fallow are likely to have a better water supply than those which follow another crop. Therefore, optimizing the use of increasingly scarce rainwater through agroforestry practices such as improved fallow could be one effective way of improving the adaptive capacity of systems to climate change.

Pests, diseases and weeds already stand as major obstacles to crop production in many tropical agro-ecosystems and there are strong reasons to believe that their prevalence and their deleterious effects on crops may increase with a warmer climate. It is strongly believed, yet not sufficiently tested, that enhancing plant biodiversity and mixing tree and herbaceous species in agricultural landscapes can produce positive interactions that could contribute to controlling pest and disease outbreak. Weeds are one of the most serious limiting factors to tropical agriculture and their control has been beyond the capacities of many smallholder farmers (Akobundu, 1991;Akobundu, 1993). Following climate change scenarios weed pressure can be expected to become more serious in most parts of Africa. The most obvious mechanism of weed control through trees in agricultural systems is through competition for light (shading effect), water and nutrients (Impala, 2001). But there are other specific processes such as allelopathy, which have also been described in some of fallow trees (Gallagher et al., 1999). In addition, some agroforestry trees are known to act as trap crops triggering the germination of the weed seeds without being suitable hosts. For example, Sesbania sesban, and Leucaena diversifolia have shown good potential in controlling Striga hermonthica, a parasitic weed that plague many cereal production systems in Africa (Oswald et al., 1996).

Agroforestry system serves as the immediate and nearest source of food during hungry periods. Fruits, nuts and root crops from farm areas produced during the main crop off-season add to the household"s nutrition. Animals raised in the backyard provide the meat requirement of the family. Agroforestry is an essential part of the effort to feed the hungry people in the rural area Home gardens in Kerala, India are best examples for meeting the multifarious requirements of the farmers through integrated system (Kumar, 2006). While agroforestry efforts cannot substantially alter the social, economic and political factors that cause food supply inequalities, they can help build up the household food security. Also, agroforestry can contribute to increasing the resilience of tropical farming systems and reduce climate change hazards. Thus, agroforestry has the potential to contribute to adaptation to climate change and climate variability in the area.

Potential impacts of agroforestry to the farmers include:

The effects of different agroforestry techniques in enhancing the resilience of agricultural systems against adverse impacts of rainfall variability, shifting weather patterns, reduced water availability, soil erosion as well as pests, diseases and weeds has been well tested. Much of this knowledge is relevant for mainstreaming adaptation measures to climate change into the agricultural sector. The role of agroforestry in reducing the vulnerability of agricultural systems and improve the livelihood of rural communities to climate change or climate variability is strongly emphasized (Akpan, 2000).

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Figure 1: Figure 1 :

[1] [2] [3]

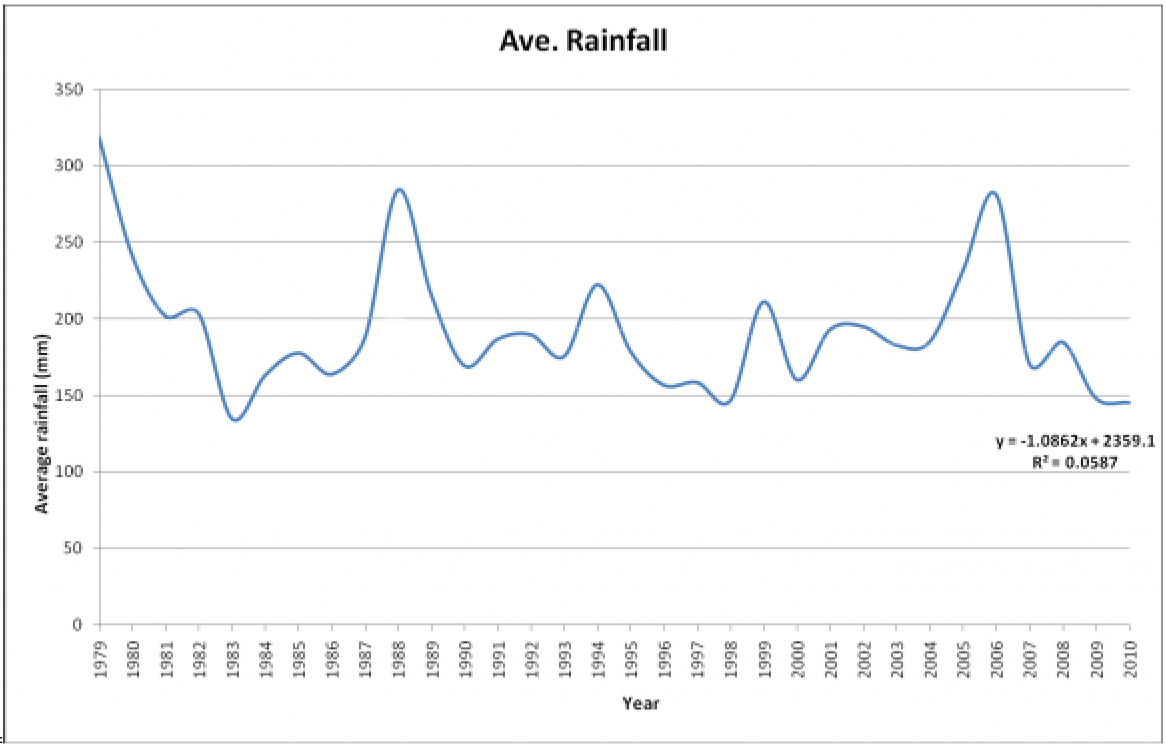
4 

Figure 2: Fig. 4

1

Rainfall	Value
Mean (mm)	1876.475
Standard deviation (mm)	250.34
Maximum rainfall (mm)	3815.1
Minimum rainfall (mm)	1619.4
Trend (mm/year)	-1.0862
Correlation	0.0587

[Note: Figure 2 : Trend of temperature data in Uyo, Akwa Ibom State of Nigeria from 1979-2010]

Figure 3: Table 1 :

2

Source : Department of Meteorological Services, Station Number 050705B, Nigeria. Computer S

Volume XII Issue XI Version I	Temperature	35 30 0 5 10 15 20 25	1979 1980 1981 1982 1983 1984 1985 1986 1987 1988 1989 1990 1991	Average temperatu
D D D D) b (Global Journal of Human Social Science	Temperature Mean (0 C) Standard deviation Maximum Temperature (0 C) Minimum Tempera			

Figure 4: Table 2 :

3

Relative humidity	Value
Mean (%)	72.81
Standard deviation	2.87
Maximum Relative humidity (%)	84.4
Minimum Relative humidity (%)	71.3
Trend (%/year)	0.1308 xxx
Correlation	0.201 xxx
xxx Significant at 0.05% level	

Figure 5: Table 3 :

4

Consequences of climate change hazards on farmers	Percentage of respondents affected
Longer distance to access water	36.80
Longer distance to access fuel wood	29.40
Reduction in farming and other economic activities	37.50
Low output from farming and other economic activities	40.50
Low income from sales of farm produce and other economic activities	42.70
Malnutrition	51.30
Drop outs from school as a result of school fees and other cost of children	27.10
Homeless	32.30
Loss of farm land	34.20
Increasing unemployment	36.70
Migration	13.40
Difficulty in collecting forest foods	23.50
Food security	48.30
Erosion	35.50
a) Importance of agroforestry in combating climate change hazards	

Figure 6: Table 4 :

Figure 7:

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