Soil Erosion Menace and the Incidence of Climate Change

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Abstract: **- Soil Erosion still remains one of the major land degradation problems which still challenge the efforts of the government at various levels in the war against hunger and poverty in Abia State. Studies on the impact of climate change on sediment transport suggest that transport enhancement due to increased soil erosion, particularly in areas with increased runoff, soil and vegetation changes in Abia state. This study adopts Geographic Information Systems (GIS) and Remote Sensing techniques as veritable tools to classify areas with soil loss potential in Abia state. The rainfall distribution characteristics and rain days was studied, the frequency analysis was applied using normal distribution log-Pearson type III distribution, with rainfall data recorded for 43 years (between 1972 and 2015). This indicates that the distribution is negatively skewed and with an increase in rainfall variability, implying a change in weather, increased heavy rainfall intensity and extremes and soil loss. The 0.2 and 1% Chance Exceedance rainfall event were used as input into climate factor coupled with soil, DEM and anthropogenic factors as the basic requirement for environmental modeling of soil loss using Universal Soil Loss Equation (*USLE*). Sediment yield was computed and large deposits were found to leave Abia state basin accompanied by nutrients runoff, posing threat to agricultural productivity and land degradation. Results reveal that soil loss and sediment yield is an annual event which needs an Agro-environmental measure to reverse the negative trend towards environmental degradation.**

Keywords: **Soil Erosion, Climate Change, Menace, Rainfall, Abia State, GIS, Remote Sensing.**

I. INTRODUCTION

Climate change refers to long-term modifications to climate, whether due to natural occurrences or human activity (IPCC, 2007a). The global climate is warming, as demonstrated by increases in air and ocean temperatures, increased ice and snow melt and rising average sea levels. The risk of extreme weather events is also rising (Adger et al., 2007); all these trends are expected to continue. Climate change is, in turn, affecting multiple spheres of society. The most immediate impacts are environmental, resulting in increased desertification, drought and floods, shifts in arable land and water stress. The rate of change in climate is faster now than in any period in the last 1000 years. According to the United Nations Intergovernmental Panel on Climate Change, in 90 years, average global temperatures will increase between 1.8^{0}C and 4.0^{0}C and sea level will rise between 18 and 59 cm. Extremes of the hydrologic cycle (e.g., floods and droughts) are also expected to accompany global warming trends. The global rate of tropical deforestation continues at staggering levels, with nearly 2% to 3% of global forests lost each year. Land use change for agriculture represents the largest driver of land cover change across the earth. Together, croplands and pastures have become one of the largest terrestrial biomes on the planet, rivaling forest cover in extent, and occupying 40% of the land surface (Asner et al, 2004; Ramankutty et al, 1999).

All studies on soil erosion show that the expected increase in rainfall intensity would lead to greater rates of erosion. In addition, the shift of winter precipitation from less erosive snow to more erosive rainfall due to increasing winter temperatures enhances erosion, with this leading, for example, to negative water quality impacts in agricultural areas. Further indirect impacts of climate change on erosion are related to soil and vegetation changes caused by climate change and associated adaptation actions. The very few studies on the impact of climate change on sediment transport suggest transport enhancement due to increased erosion, particularly in areas with increased runoff (IPCC, 2007b). Soil erosion is a dynamic geomorphic event operating on the landscape(Ojo et al. 2010).In spite of technological advancement, erosion menace still remains a major problem in Nigeria (especially in South Eastern Nigeria). The yearly heavy rainfall has very adverse impacts altering existing landscape and forms. Such landforms create deep gullies that cut into the soil. The gullies spread and grow until the soil is removed from the sloping ground. Soil erosion when formed expand rapidly coupled with exceptional storm or torrential rain down the stream by head-ward erosion gulping up arable lands, economic trees, homes, lives, and sacking of families and valuable properties that are worth millions of naira (Umudu, 2008). As a matter of fact, there is a direct correlation between development and the effect of soil erosion in Abia State (Nwilo et al, 2011).

Soil Erosion still remains one of the major land degradation problems which still challenge the efforts of the government at various levels in the war against hunger and poverty in Abia State (Kalu et al, 2012). According to Abegunde et al (2006), soil erosion remains the world's biggest environmental problems, threatening sustainability of the existence of both plant and animal in the world. The reason for this is because land and soil resources are greatly threatened by soil erosion. Ozor (2009) in listing the impact climate change on national development of the country stated that variations in climate change have led to devastating consequences and effects in various parts of the country which include flooding, desertification, erosion, drought, sea level rise, heat stress, pests and diseases, erratic rainfall patterns and land degradation, specifically he stated that the South-South geopolitical zone is mainly affected by sea level rise and deforestation-induced changes; the Southwest zone also is affected by sea level rise and deforestation-induced changes; Southeast by erosion, flooding and land degradation; North-central by changes due to de-vegetation and overgrazing; Northeast by drought, desertification and heat stress; and Northwest also by drought an, desertification and heat stress. In view of the fact that stability and sustainability of land as a factor of production in the agricultural and other sectors is the main sure way of eradication poverty and bearing in mind the great threat posed by climate change to the realization of this goal, it becomes very important to give climate change issues serious consideration if the objective of protecting eastern oil palm belt of Abia state will ever be achieved. This paper seeks to provide answers to disturbing issues like; estimating the amount of soil loss; climate change effect on rainfall distribution and trend; and implications of climate change on soil erosion in the eastern palm belt of Nigeria.

II. RESEARCH METHODOLOGY

This research integrates Remote Sensing, GIS and Statistical techniques in studying soil erosion menace and the incidence of climate change in Abia State (in the old Eastern oil Palm belt).The research procedure adopted includes:

2.1 Data Acquired and Source

The data collected for this study include (1.) Field survey entails taking GPS reading and ground trothing of study locations, (2.) ASTER (Advance Space borne Thermal Emission and Reflection Radiometer) DEM (Digital Elevation Model) USGS 30m Resolution, (3.)Administrative maps of the study area obtained from Ministry of Lands, Survey and Urban Planning, Town planning department, Umuahia. (4.) Landsat Multispectral Scanner (MSS), Thematic Mapper (TM), Enhanced Thematic Mapper Plus (ETM^+) and Operational Land Imager (OLI) imagery with a Resolution 30 and 60 meters. (5.) Meteorological variables like Rainfall were acquired from National Root Crop Research Institute, Umudike for the period between 1972 and 2015, and (6.) Population data of the study area, as well as the review of relevant and current literatures. In addition, field survey (GPS reading and ground trothing) was conducted to help understand and get first-hand information about land use type and soil erosion areas throughout the study area which is useful to assess the dynamics of change.

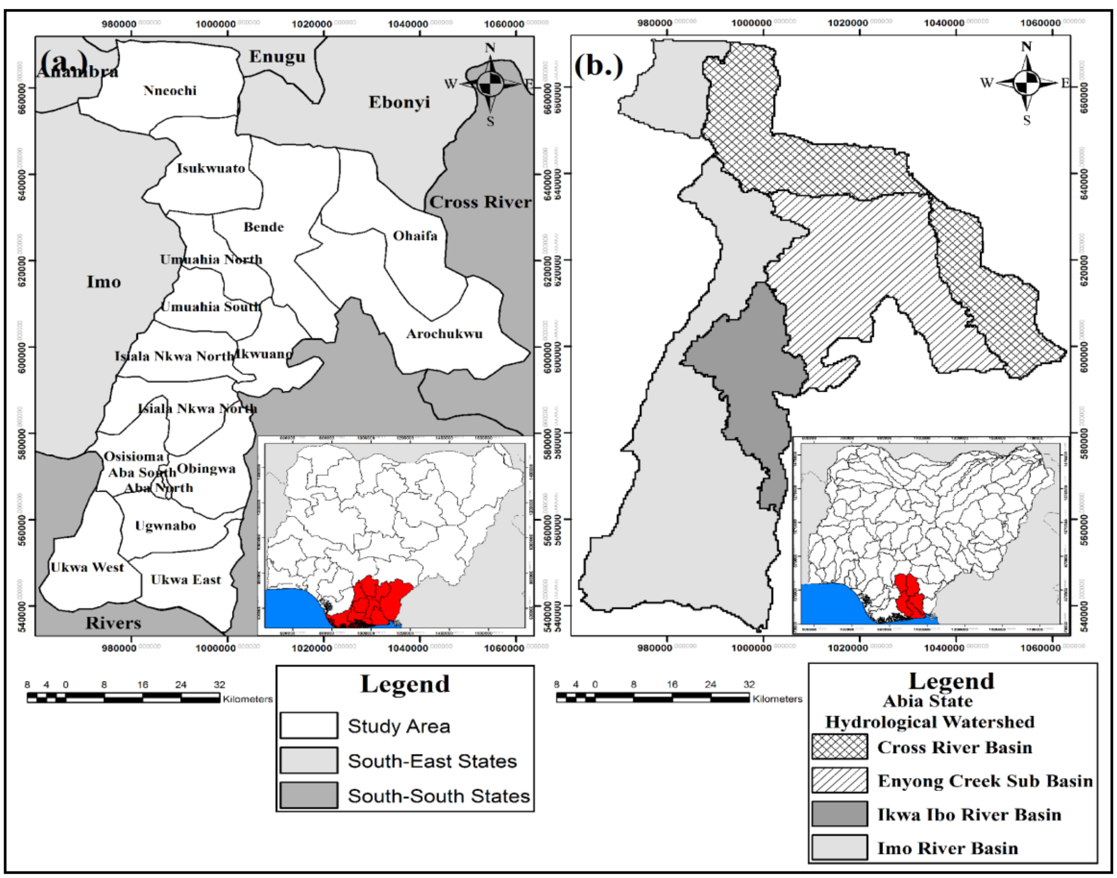

Figure 1: (a.) Map showing Abia state and an inset map of Nigeria indicating the Eastern Oil Palm Belt. (b.) Abia state hydrological watershed and an inset map of drainage basin of Nigeria

The Eastern oil Palm belt is shown in figure1a and the study extent covers Abia state and is located east of Imo State and shares common boundaries with Anambra, Enugu and Ebonyi States to the North West, North and North East respectively (Nwilo et al, 2011) . To the East and South East, it is bounded by Cross River and Akwa Ibom States and by Rivers State to the South. It occupies a landmass of 5,833.77 square kilometers. Abia state comprises of seventeen (17) local government areas. Rainfall data was acquired from National Root Crop Research Institute (**NRCRI**), Umudike. **NRCRI** is Located on 5.483^0 E and 7.549^0N; and elevation high of 122m in Abia state. Rainfall data for Abia state was collected for time period of 43 years.

2.2 GIS Operations and Remote Sensing Techniques

Available maps (sections 2.1) where scanned, converted to digital/raster image. The scanned maps were georeferenced and digitized in ArcGIS 10 software environment, while DEM and elevations were extracted form ASTER DEM. GPS reading and data captured in excel was converted through co-ordinate geometry overlaid to locate and compliment in soil erosion study. Database was created and used for carrying out the necessary GIS analysis/manipulation and operations (tasks—such as spatial query, reprojecting, clipping, raster-based math, and features extraction**)** with a view to produce relevant maps, charts and tables. The bands 4, 5 and 7 of the acquired Landsat OLI, ETM, TM, and MSS imagery were enhanced using histogram equalization and used in the creation of false color composite map. In this research supervised classification was used with Maximum Likelihood Classification (MLC) method to classify the imagery into Agriculture (land use), barren ground, primary and secondary forests, urban (build-up area) and water body using Idrisi software.

2.3 Historical Rainfall Observations and Intensity of Reoccurrence over Eastern Oil Palm Belt of Abia state.

Using rain storm (Bulletin 17B Methods) analysis the reoccurrence rainfall and rain days was computed using data from acquired from National Root Crop Research Institute for a 0.2 and 1**%** Chance Exceedance Rainfall event. The data was fitted into Components of Bulletin 17B (Davie, 2008) which include: (a.) Fit logarithms of daily rainfall to a Pearson Type III distribution using the method of moments to compute mean, standard deviation, and skew of the log-transformed data; (b.) Improve skew estimate by averaging it with a regional skew estimate obtained from Bulletin 17B or other source. Weight station and generalized skew to reflect relative accuracy; (c.)Test to identify high and low outlier limits and screen data against them; and (d.)Adjust for low outliers, zero flows, and below gage base peaks based on conditional probability techniques.

2.4 Soil Erosion estimation using the Universal Soil Loss Equation (USLE) in the Eastern Oil Palm Belt of Abia state.

The Universal Soil Loss Equation *(USLE)* is a mathematical model used to describe soil erosion processes (Wischmeier et al 1960 and 1978). Universal Soil Loss Equation *(USLE)* was used in ArcGIS 10 environment to calculate the soil erosion index for Abia State. *USLE* is an empirical model and its formula is given as:

$$A = R\ L\ S\ K\ C\ P \qquad (1)$$

Where: ***A*** = Average annual soil loss in tons per acre, ***R*** = Rainfall and runoff erosivity factor, ***L*** = Slope length factor, ***S*** = Slope steepness factor, ***K*** = Soil erodibility factor, ***C*** = Cover and Management factor, ***P*** = Supporting and Conservation practices factor. In general, the *USLE* model estimates soil erosion by rain drop impact and surface runoff. ***R*** is the rainfall and runoff erosivity index which is given as:

$$R = EI30/100 \qquad (2)$$

EI for a given rainstorm equals the product: total storm energy (*E*) multiplied by the maximum 30-min intensity (*I30*), *E* is the kinetic Energy in the Rainfall in hundreds of foot-tons per acre and *I30* is in inches per hour. *R* depends on the amount of raindrop energy and rainfall intensity. ***L*** factor is the Slope Length Factor. Slope Length determines the concentration of water. Therefore, the greater the length of slope of a field the greater the concentration of water and run off. A DEM of the study area was used as the source data to computes the flow direction and flow accumulation of the study area. The equation used for computing slope length is:

$$(DEM > Flow\ Direction > Flow\ Accumulation * Cell\ size / 22.13)^{0.4} \qquad (3)$$

S factor is the Slope Steepness Factor. Also, DEM data for Abia State was used to compute the S factor and the equation used to compute the slope steepness is:

$$(DEM > Slope > * 3.14 / 180 > sin\ slope / 0.0869)^{1.3} \qquad (4)$$

Slope Steepness Factor (***S***) was then multiplied with the length factor (*L*) to derive the ***LS*** factor, which is the Topographic factor of Abia State. ***K*** factor is the Soil Erodibility Factor. This is an estimate of the ability of soils to resist erosion, based on the physical characteristics of each soil. It depends on soil structure, texture and composition. In this project, *K* factor is based on values established in literatures. A high *K* factor indicates a lower water infiltration rate thus more prone to erosion. *K* factor was derived from tables provided by Roose(1977). Cover and management factor (***C*** factor) indicates the influence of cropping systems and management variables on soil erosion. This factor depends on 4 sub factors: Prior land use, canopy cover, soil surface cover and surface roughness. The *C* factor for Abia State was obtained from two sources. ***C*** factors for Agriculture (land use), barren ground, primary and secondary forests, urban (build-up area) and water body were obtained from literature review (Roose 1977). Based on the above, ***C*** factor was created for land use/land cover type for 1972 and 2015. ***P*** factor is the Supporting and conservation Practices

Factor. These are the erosion control practices such as contouring, strip cropping, terracing etc. as well as land management practices that reduce soil erosion. The ***P***-factor is the ratio of soil loss under the given condition to soil loss from up-and-down-slope farming as observed in the study area. Therefore it is a value between 0 and 1 for each land use type in Abia State. A field trip to carry out ground trothing revealed that there were no measurable conservation measures in the study area. The potential soil loss was classified based on the results gotten from *USLE* (***R L S K C P***) computation above using Table 1.

Table 1: Soil Loss Tolerance Rates

Soil Erosion Class	Potential Soil Loss (tons/acre/year)
Very Low (tolerable)	<3.00
Low	3.00-5.00
Moderate	5.00-10.00
High	10.00-15.00
Severe	> 15.00

(Source: Stone et al, 2000)

2.5 Implications of Climate Change on Soil and Agricultural Productivity of the Eastern Oil Palm Belt of Nigeria.

USLE (***R L S K C P***) was used as input in Sediment yield computation for each watershed basin for a 0.2 and 1% Chance Exceedance Rainfall Event. The Sediment Delivery Ratio (***SDR***) is determined from the average annual sediment yield. Sediment yield is the amount of soil loss (erosion) that reaches a stream and is transported within the waterway. The ***SDR*** is the ratio between the amount (sediment yield) reaching the stream and the soil loss in the analysis unit (***SY/Soil Loss = SDR***). It calculates an index of the potential of a landscape area to export nutrients to surface water bodies. When combined with agricultural land use data, watershed managers can use the non-point source assessment to determine which sub-basins, because of their characteristic combination of soils and topography, pose the greatest risk of nutrient transport to surface waters and should be targeted for conservation programs. ArcGIS 10- Arc Hydro tool was used to perform drainage analysis on a terrain model. The Arc Hydro tools are used to derive several data sets that collectively describe the drainage patterns of a catchment. Raster analysis is performed to generate data on stream segmentation and watershed delineation. These data are then used to develop a vector representation of catchments and drainage lines. Watershed delineation is of importance to this work. The nutrient loss (such as phosphorus and nitrogen) was calculated the study area per land use and then sums per watershed. It integrates data on pollutant loading (as stated by Reckhow et al (1980)), and the capacity of different land use/cover types to filter pollutants. The Natural Resources Conservation Service (NRCS) has recommended method for estimating time of concentration was used which can be expressed as:

$$Time(t) = L/_{60V} \quad \text{(Units: Hours)} \tag{5}$$

Where, **t** =Time, ***L*** = the overland flow path of distance, and ***V***= the velocity of overland flow in fps or m/s**.** The flow length (Weight raster) is imputed as distances multiplied by ***1/V*** (velocity) to obtain the runoff time. The above data was used to study and estimate sediment discharge in the individual water shed and travel time for contaminants in water from averages nutrient export in Abia state watershed and cost its effect agricultural productivity from sediment loss.

III. RESULTS AND DISCUSSION

3.1 Historical Rainfall observation and Intensity of Reoccurrence over Eastern Palm belt of Abia state.

For the period between 1972 and 2015, the rainfall characteristics such as mean, median, mode, standard deviation, variance, minimum, and maximum was observed for Abia state. The annual mean of 175.03 mm/day, mode of 0mm/day, and median of 167.35 mm/day was recorded for the study area. The variance of 20558.977 mm/day, minimum value of 0 mm/day and maximum of 576 mm/day was recorded for the study area. For rain days annual mean of 12.14 day, mode of 1day, and median of 13day was recorded for the study area. The variance of 70 day, with minimum of 0 day and maximum of 31day was recorded for Abia state. The rainfall and rain days distribution was studied (figure 2) using frequency analysis and log-Pearson type III distribution was applied, with a rainfall data recorded for 43 years (between 1972 and 2015). Results showed that the log-Pearson type III distribution is the best probability distribution, applicable to describe Abia state's rainfall characteristics (table 2). Using the upper confidence limit (0.05%) of the distribution, the station records very high rainfall (or rainfall frequency) over short period between 0.2 and 1% Chance Exceedance rainfall event (958.3 and 886.7 mm/day; 57.8 and 50.2 days) for the study period (Table 2). This has encouraged frequency flooding and soil loss. This indicating that distribution is negatively skewed and an increase in variability was observed, which implies that there is a change in weather, increased heavy rainfall intensity and extremes (such as soil erosion). The standard deviation is positive for the study area this indicates that mean rainfall is sufficient support crop growth and agriculture (Ayoade, 1993) because it can be expected to be equaled or exceeded with 95% probability 0.2 and 1% Chance Exceedance or rainfall event (that is 1-in-5years and 1-in-1year return period) was picked for further analysis and the result reveals that the frequency of heavy precipitation or the proportion of total rainfall from heavy falls has increase in Abia state between 1972 and 2015.

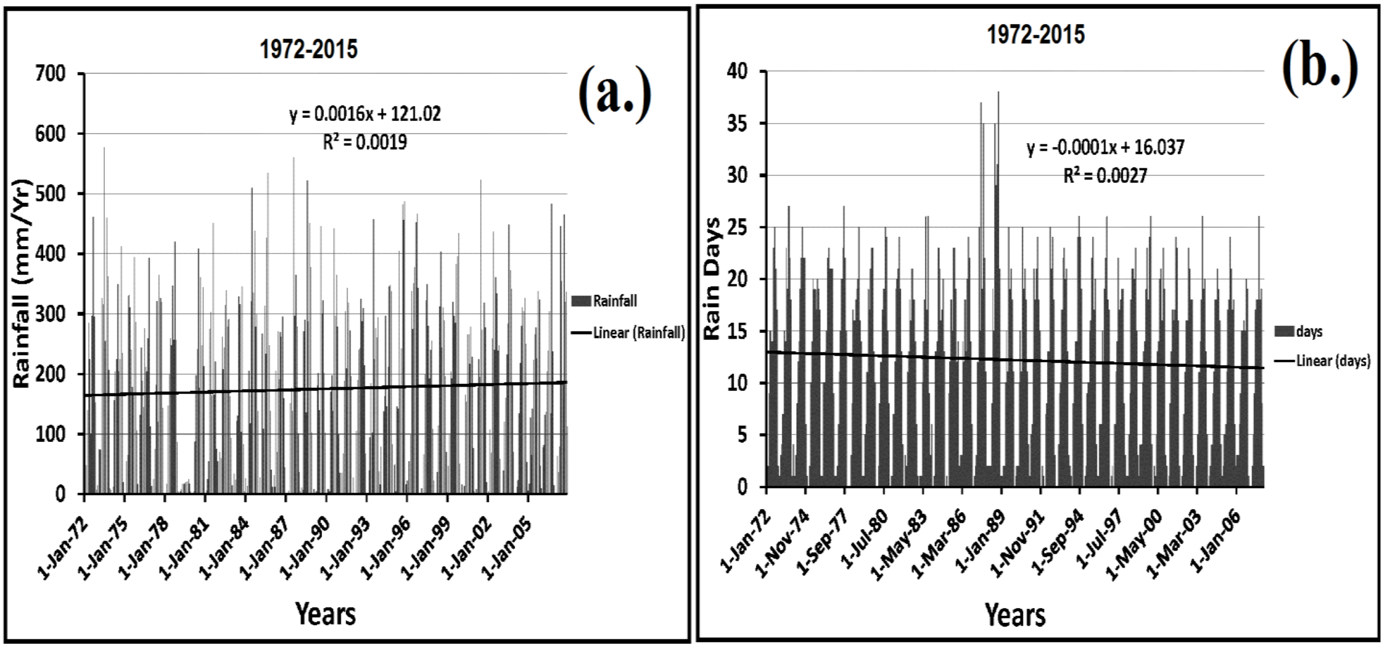

Figure 2: (a.) Rainfall distribution trend and (b.) Rainfall days in Abia state between 1972 and 2015.

Table 2: Probability Distribution for Rain days and Rainfall in Abia State.

	Rainfall Distribution				**Rain days Distribution**			
Percent Chance Exceedance	**Computed Curve**	**Expected Probability**	**Confidence Limits**		**Computed Curve**	**Expected Probability**	**Confidence Limits**	
			0.05	**0.95**			**0.05**	**0.95**
0.2	785	786.1	958.3	652.4	50.4	50.6	57.8	44.8
1	728.6	730	886.7	607.1	44.1	44.2	50.2	39.1
Mean	1.899	**Station Skew**	-1.544		**Mean**	0.963	**Station Skew**	-1.074
Standard Deviation	0.783	**Adopted Skew**	-1.544		**Standard Deviation**	0.443	**Adopted Skew**	-1.074

3.2 Soil Erosion estimation using the Universal Soil Loss Equation (USLE) and in Eastern Palm belt of Abia state.

In the study area the soil erosion estimation and map for 0.2 % and 1 % Chance Exceedance (rainfall event) are shown in figure 3a and 3b. The 0.2 % Chance Exceedance (rainfall event) of soil erosion for Abia state, result reveals that 0.00 and 255.97 tons/acre/year in 1972, between 0.00 and 296.85 tons/acre/year in 1986, between 0.00 and 272.38 tons/acre/year in 2003, between 0.00 and 296.85 tons/acre/year in 2015. And for 1% Chance Exceedance of soil erosion for Abia state 0.00 and 156.15 tons/acre/year in 1972, between 0.00 and 181.09 tons/acre/year in 1986, between 0.00 and 166.16 tons/acre/year in 2003, between 0.00 and 181.09 tons/acre/year in 2015. Soil erosion estimation is more in the northern part of the state this is due to high terrain variability and abrupt changes in slope while south has low terrain. And in the south the terrain are low lying and also discharge velocity is low. For 0.2 % Chance Exceedance, soil erosion values were recorded for some local government with an annual mean value of 1.143 tons/acre/year for Ohaifa, 1.0069 tons/acre/year for Ikwuano, 0.942 ton/acre/year for Nneochi, 0.521 tons/acre/year for Isukwuato in 1972. While the annual mean value of 3.83 tons/acre/year for Ohaifa, 2.195 tons/acre/year for Ikwuano, 4.923 tons/acre/year for Nneochi, Ugwunabo 2.04 tons/acre/year, Ukwa East 2.50 tons/acre/year and 2.62 tons/acre/year for Isukwuato in 1986.

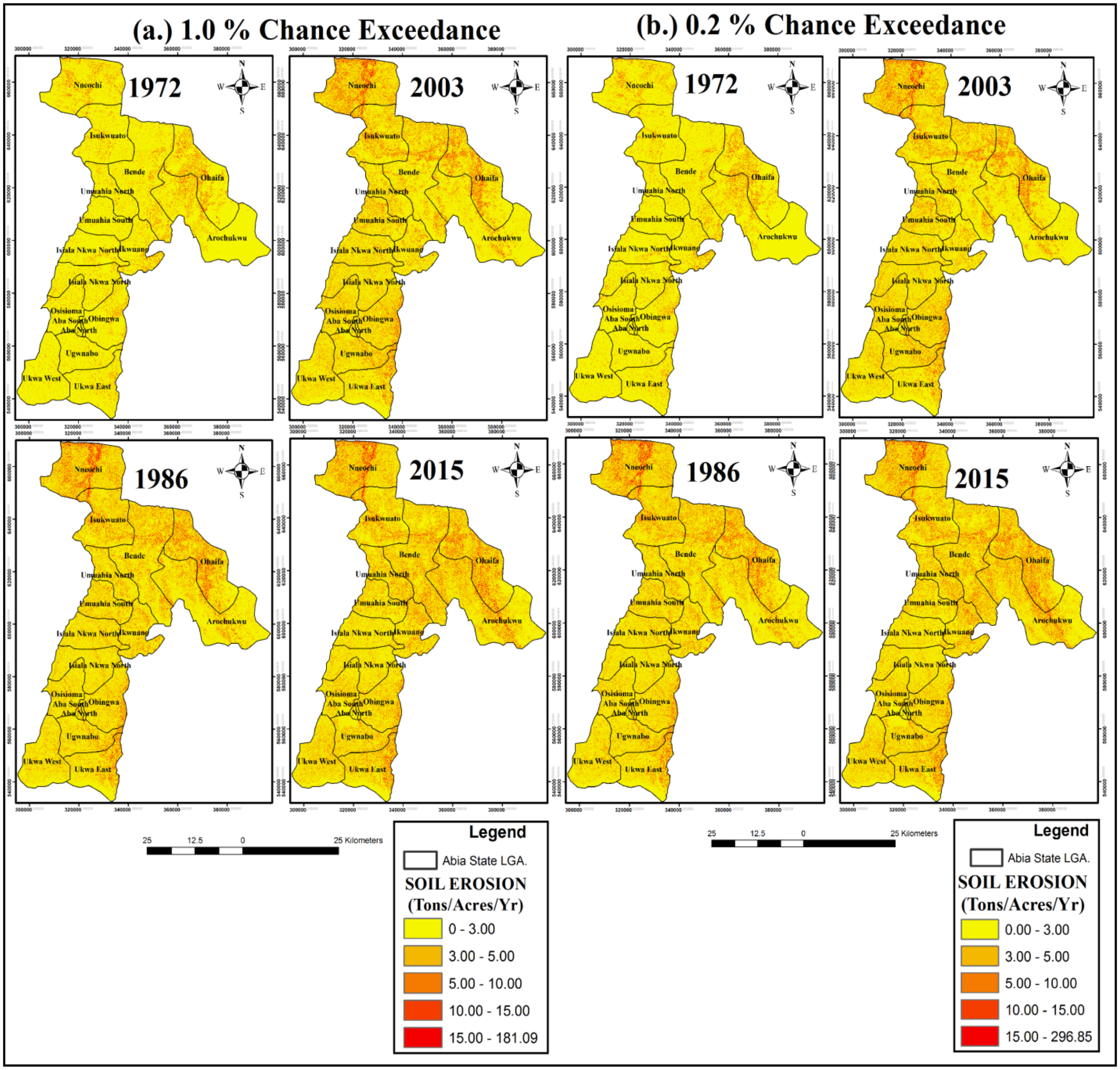

Figure 3: Soil Erosion map for (a.) 1.0 % Chance Exceedance and (b.) 0.2 % Chance Exceedance (Rainfall event) for Abia state between 1972 and 2015.

For 2003, the annual mean value of 3.055 tons/acre/year for Ohaifa, 1.45 ton/acre/year for Ikwuano, 4.30 tons/acre/year for Nneochi, Ugwunabo 1.96 tons/acre/year, Ukwa East 1.82 tons/acre/year and 2.25 tons/acre/year for Isukwuato. And for 2015, the annual mean value of 3.82 tons/acre/year for Ohaifa, 2.5 tons/acre/year for Ikwuano, 3.844 ton/acre/year for Nneochi, Ugwunabo 2.04 tons/acre/year, Ukwa East 2.71 tons/acre/year and 2.29 tons/acre/year for Isukwuato (figure 4a and b). For 1 % Chance Exceedance (rainfall event), soil erosion values were recorded for some local government with an annual mean value of 0.69 tons/acre/year for Ohaifa, 0.614 tons/acre/year for Ikwuano, 0.57 tons/acre/year for Nneochi, 0.318 tons/acre/year for Isukwuato in 1972. While the annual mean value of 2.38 tons/acre/year for Ohaifa, 1.32 tons/acre/year for Ikwuano, 2.99 tons/acre/year for Nneochi, Ugwunabo 1.24 tons/acre/year and 1.59 tons/acre/year for Isukwuato in 1986.

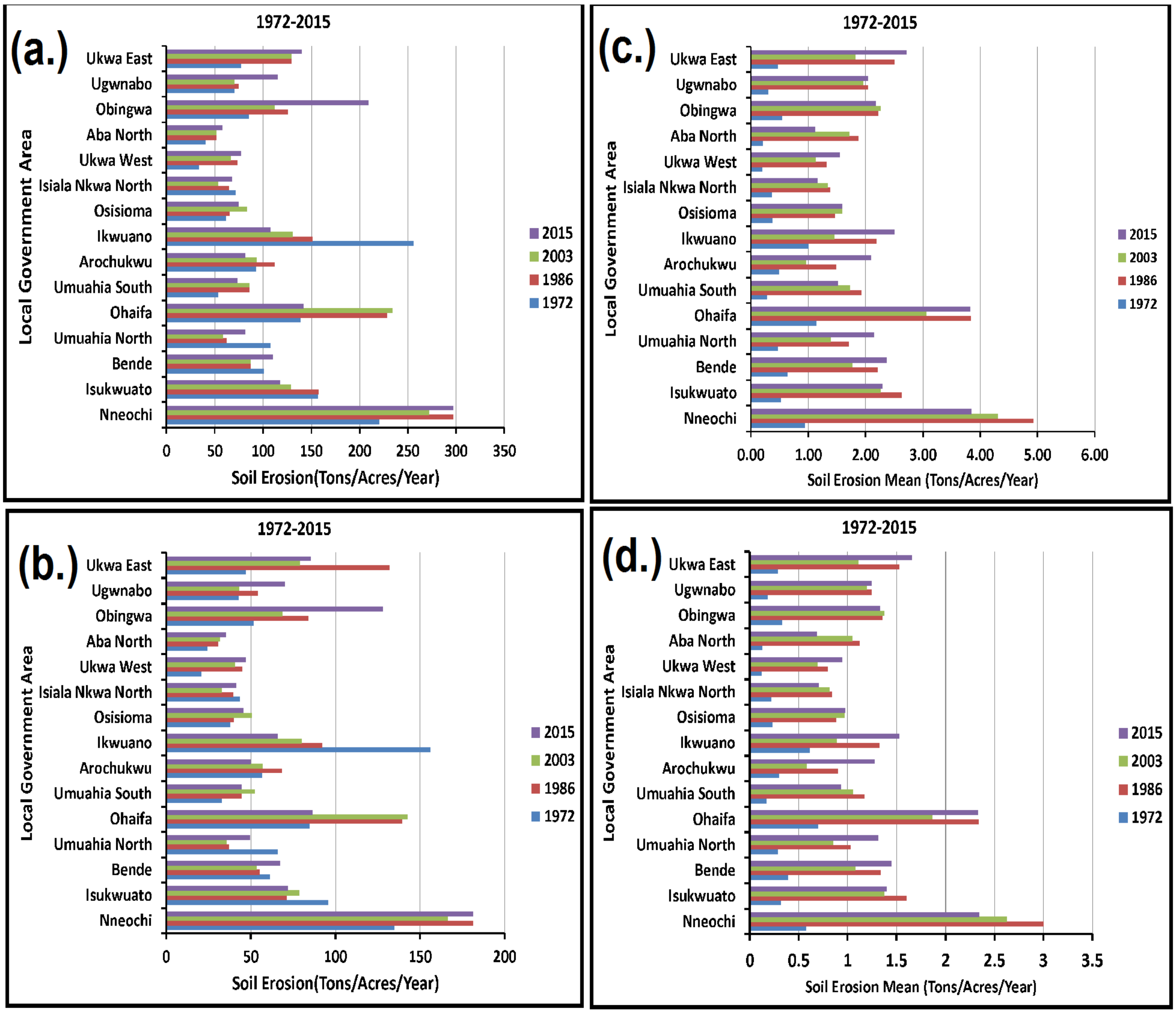

Figure 4: Soil Erosion (a.) Maximum for a 0.2 % Chance Exceedance and (b.) 1% Chance Exceedance (Rainfall Event) between 1972 and 2015 for Abia state. Soil Erosion. (c.) Mean for a 0.2 % Chance Exceedance and (d.) 1 % Chance Exceedance (Rainfall Event) between 1972 and 2015 for Abia state.

For 2003, the annual mean value of 1.86 tons/acre/year for Ohaifa, 0.89 tons/acre/year for Ikwuano, 2.62 ton/acre/year for Nneochi, Ukwa East 1.11 tons/acre/year and 1.377 tons/acre/year for Isukwuato. And for 2015, the annual mean value of 2.33 tons/acre/year for Ohaifa, 1.52 tons/acre/year for Ikwuano, 2.34 ton/acre/year for Nneochi, Ukwa East 1.65 ton/acre/year and 1.4 tons/acre/year for Isukwuato (figure 4c and d).

3.3 Implications of Climate Change on the Soil and Agricultural productivity of the Oil Eastern Palm Belt of Nigeria.

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An increase in the percentage chance exceedance (or return period), increases climate induced-rainfall and extreme events, this will have greater impacts on agriculture on the hydrological river basin (or catchment) scale (figure 2), the result reveals there is high confidence that changes in climate have the potential to seriously affect soil loss leading to high sediment yield (figure 5 and 6) and water management systems, by increasing the incidence or intensity of rainfall and rainfall days.

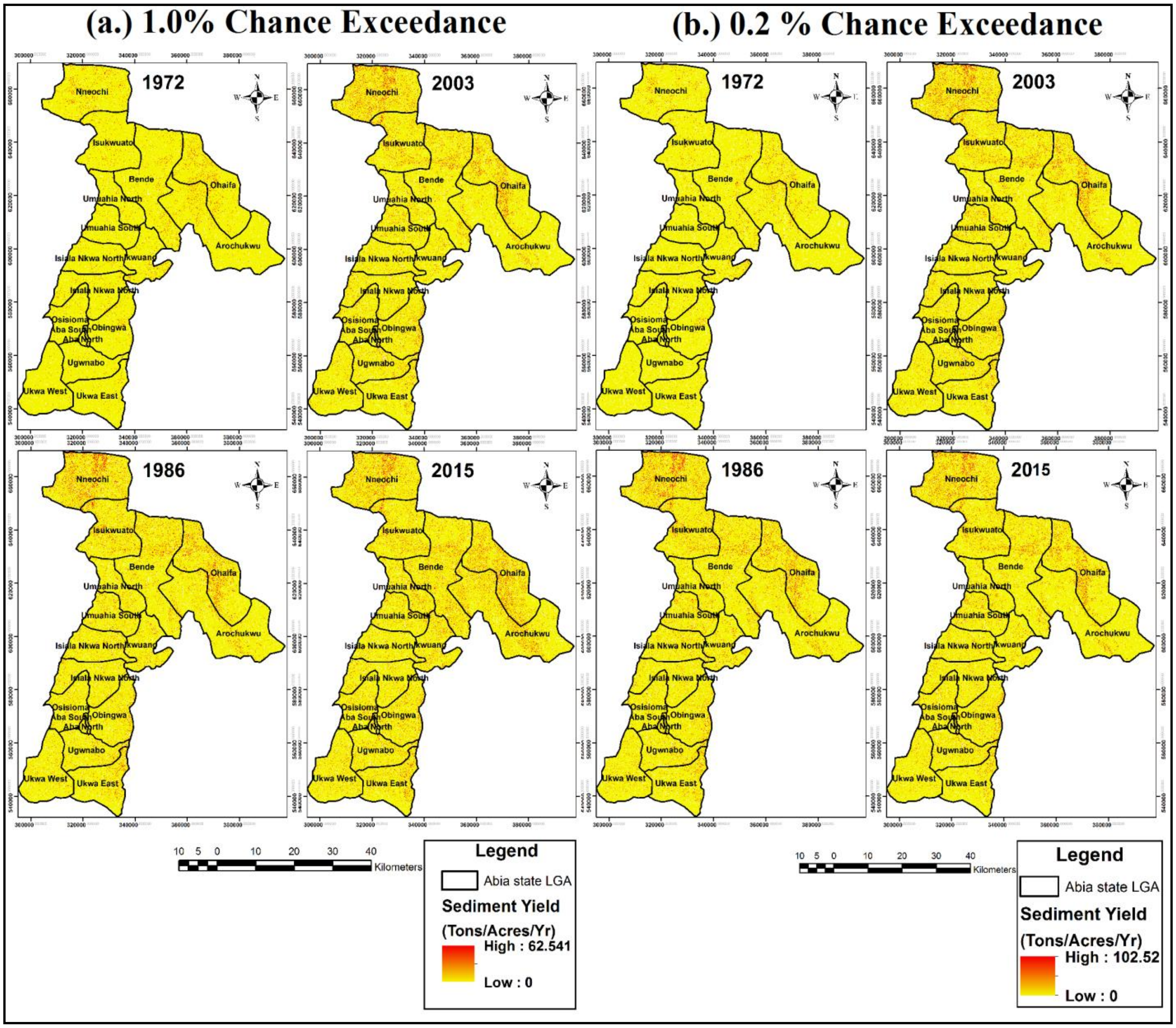

Figure 5: Sediment yield map for (a.) 1.0 % Chance Exceedance and (b.) 0.2% Chance Exceedance (Rainfall Event) for Abia state between 1972 and 2015.

In the study area sediment yield estimation for a 0.2 and 1 % Chance Exceedance (rainfall event) are presented in figure 5a and b. For a 0.2 % Chance Exceedance, (Figure 6a) a mean sediment yield of 43.66 tons/acre/year was observed for Imo river basin, 35.36 tons/acre/year for Enyong Creek sub basin, 102.51 tons/acre/year for cross river basin, and 29.9 tons/acre/year for Ikwa Ibo river basin in 1972. While the annual mean value of 50.4 tons/acre/year for Imo river basin, 53.9 tons/acre/year for Enyong Creek sub basin, 75.21 tons/acre/year for cross river basin, and 22.01 tons/acre/year for Ikwa ibo river basin in 1986. The annual mean value of 54.55 tons/acre/year for Imo river basin, 53.9 tons/acre/year for Enyong Creek sub basin, 100.58 tons/acre/year for cross river basin, and 32.77 tons/acre/year for Ikwa ibo river basin in 2003. And the annual mean value of 47.19 tons/acre/year for Imo river basin, 53.9 tons/acre/year for Enyong Creek sub basin, 47.07 tons/acre/year for Cross River basin, and 37.36 tons/acre/year for Ikwa Ibo river basin in 2015. Sediment yield (for a 1 % Chance Exceedance) (Figure 6b) were recorded for the Abia state watershed with an annual mean value of 26.63 tons/acre/year for Imo river basin, 21.57 tons/acre/year for Enyong Creek sub basin, 62.54 tons/acre/year for cross river basin, and 18.25 tons/acre/year for Ikwa Ibo river basin in 1972. While the annual mean value of 31.53ton/acre/year for Imo river basin, 32.88 ton/acre/year for Enyong Creek sub basin, 45.88 tons/acre/year for cross river basin, and 13.42 tons/acre/year for Ikwa Ibo river basin in 1986.

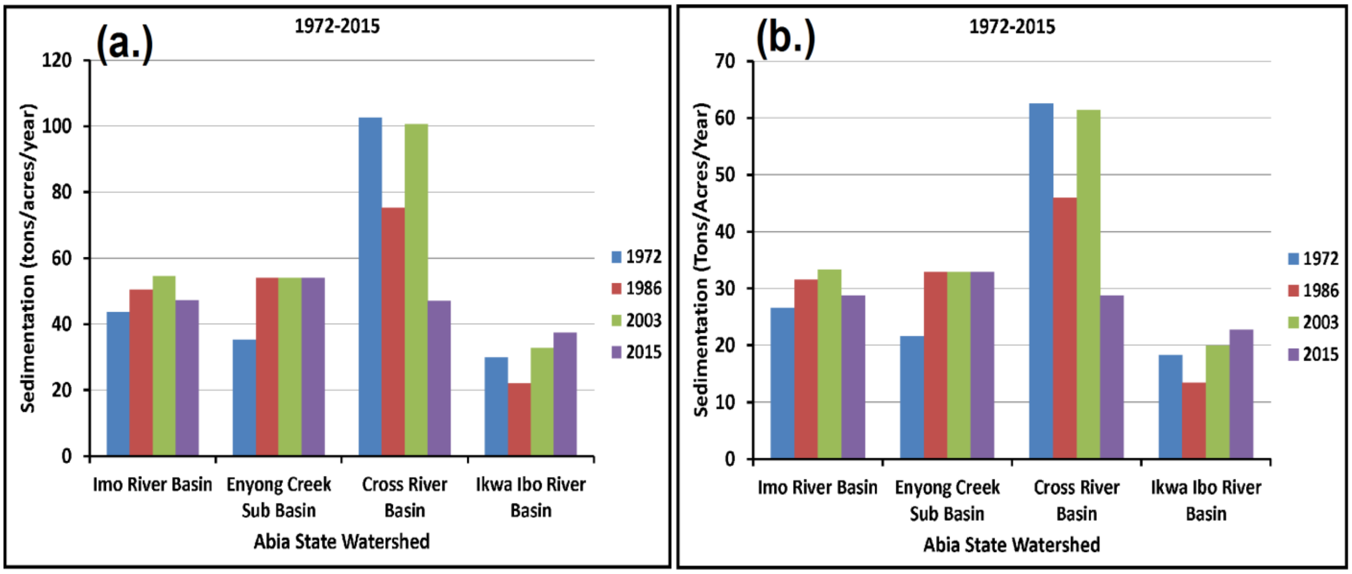

Figure 6: Sediment yield for a (a.) 0.2% Chance Exceedance and (b.) 1% Chance Exceedance (Rainfall Event) between 1972 and 2015 for Abia state.

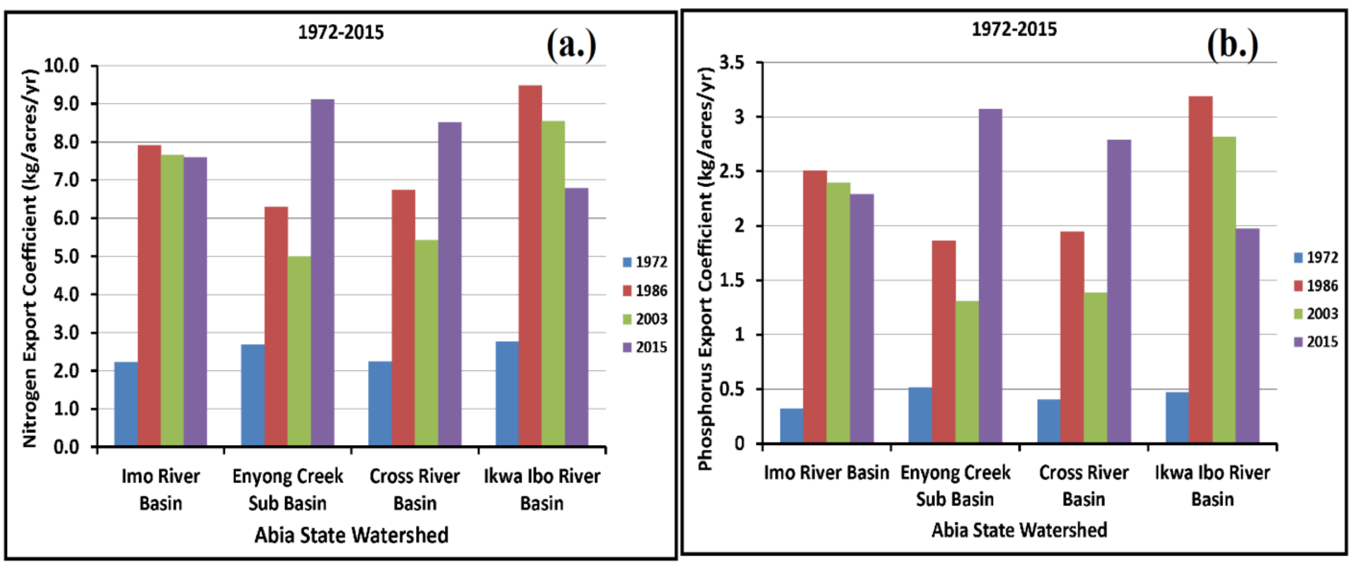

Figure 7: (a.) Nitrogen and (b.) Phosphorus export for the different hydrology watershed in Abia state.

The annual mean value of 33.28 tons/acre/year for Imo river basin, 32.88 tons/acre/year for Enyong Creek sub basin, 61.36 tons/acre/year for cross river basin, and 19.99 tons/acre/year for Ikwa Ibo river basin in 2003. And the annual mean value of 28.79 tons/acre/year for Imo river basin, 32.88 tons/acre/year for Enyong Creek sub basin, 28.71 tons/acre/year for Cross river basin, and 22.78 tons/acre/year for Ikwa Ibo river basin in 2015. This implies that large amount of sediment yield is transported within the in Abia state drainage basin for 0.2 % Chance Exceedance than a 1 % Chance Exceedance which implies that a change in rainfall amount means a change in sediment runoff. The Abia basin is part of the state watershed, which supplies drinking water for Abia residents. Natural landscape characteristics, agronomic and economic conditions result in high nutrient (phosphorus and nitrogen) transport to the reservoir in amounts that affects current water quality standards (figure 7a and b). The major land use in the basin is characterized by shifting cultivation, compound farm, manure and fertilizer applications on fields, cropland drainage, high soil erosion, and barnyard runoff contribute to a reduction in water quality resulting from elevated nutrient content and eutrophication; this also affects the soil and agricultural productivity found in Abia state because soil is somewhat-poorly drained soils (0.748) which implies that 74.8% of the sediment eroded is transported to the stream, companied with high surface runoff and high nutrient loss (Figure 8a and b).

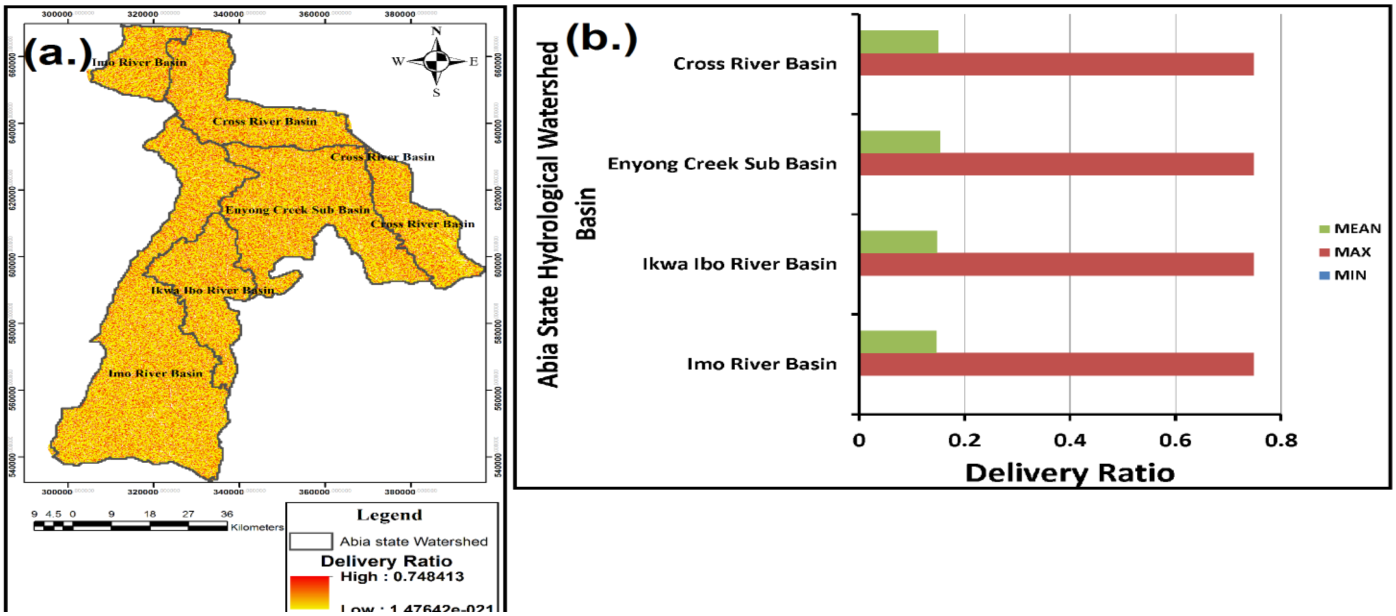

Figure 8: (a) Delivery Ratio map and (b) chart for the different hydrology watershed in Abia state.

For Enyong Creek Sub Basin, Cross River and Ikwa Ibo River Basin, the stream power is greater than that required to transport the available sediment (supply limited), than there is net loss in sediments and the stream will erode in relation to Imo River Basin. With a mean time of concentration or estimate travel time for contaminants in water is 97.17hrs for Imo river basin, 71.98hrs for Enyong creek sub basin, 119.49hrs for Cross river basin and 110.32hrs for Ikwa Ibo river basin time (figure 9a and b). This implies that the increase in rain days and intensities favors probability chance of water contamination however small for a 0.2 and 1 % Chance Exceedance. An increase in the frequency and duration of rainfall is harmful to the soil and agricultural productivity of Abia state. The outputs from this research have shown that climate change induced rainfall in one area in the watershed can cause sedimentation problems and nutrient loss at other locations. The result reveals the impact of climate change on frequency and duration of heavy precipitation events in Abia state (table 1) has resulted to soil erosion increase (figure 4) and low productivity due nutrient loss (figure7). This had an adverse effects on quality of surface water; contamination of water supply and introduction of high pollutant and sediment observed in the study area (figure 8) which has an impacts in agricultural areas.

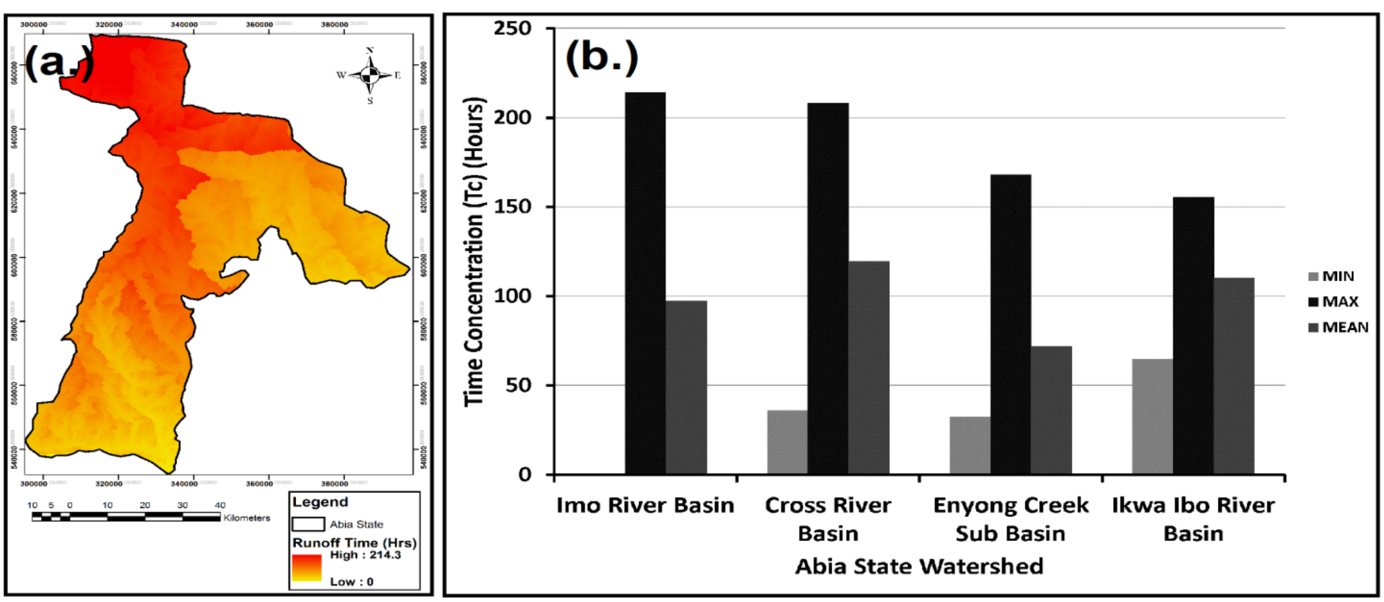

Figure 9: (a) Runoff Time map and (b) chart for the different hydrology watershed in Abia state.

IV. CONCLUSION

Recent projections on climate change have shown that global warming will continue in centuries ahead even if emissions of greenhouse gases and aerosol concentration stabilize in Nigeria. This implies that predicted impacts of climate change mentioned earlier will intensify above previous expectations. Abia state is vulnerable to climate change because of their geographic exposure (soil) and greater reliance on climate sensitive sectors such as agriculture. Together these mean that impacts are proportionally greater and the ability to adapt smaller. Abia state in her bid to improve food production and overall standard of living of the urban and rural populace has faced a myriad of problems among which climate change is very outstanding. For Abia state to achieve its objective there is an urgent need for the government, populace and necessary climate change stakeholders to rise up to this challenge. Moreover, the many impacts of climate change and soil erosion must be examined in the context of the myriad other environmental and behavioral determinants of soil erosion. All these amongst other factors if neglected will surely make the efforts of agriculture, food production practice to bring about food security a mirage, as the threat and risk posed by climate change will in no doubt affect the yield and overall productivity of the farmers.

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