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Rainfall Trends: A Veritable Tool for Climate-Smart Soil Management.

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Abstract

Global warming will exacerbate extreme weather events, and high rainfall will pose a significant challenge of continuous soil degradation through soil erosion each year. Adequate knowledge of rainfall trends will serve as a veritable tool for climate-smart soil management which informed the study. This study was carried out over Enugu State with the aim of mapping and delineating rainfall distribution within the state and showing the rainfall trend over the state. Rainfall data from 1979 to 2013 were downloaded from SWAT for ten climatic stations over the state. Statistical means of rainfall for the period were derived and interpolated in a Geographic Information System (GIS) to show the spatial distribution of rainfall and contours were extracted joining points of equal rainfall to inform climate-smart soil management in the state. This paper x-rays rainfall regimes of Enugu State over 35 years and its trend within 11 climatic stations in the state as it will inform climate-smart management option for improving systems of soil degradation, rehabilitation and conservation.

Keywords: Rainfall trends; Geographic Information System and Climate-Smart Soil Management

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1.0. Introduction:

Many properties can represent the status of the soil. However, how well they represent soil status depends on the level of rainfall in the area (Ruiz-Sinoga & Diaz, 2010). Significant threats to soils in woodland and tall grass savannah regions include erosion (gully erosion) due to high rainfall and degradation due to human activities (FAO, 2016). These processes are linked with a decline in soil structure, a resultant loss of soil water storage and quality, and the emission of atmospheric greenhouse gases (GHGs) as the soil losses its structure due to erosion and release back sequestered CO_2 into the atmosphere.

Rainfall energy can be expressed as the erosive power of rainfall and was found to be closely associated with the rainfall amount. (Adelaide 2012), Correlating the two parameters had a correlation's coefficient of r = 0.977, indicating that the higher the rainfall amount, the higher the rainfall energy, that is, its erosive power. In soil erosion research, rainfall amount, and intensity (erosive power of rainfall) is the fundamental factors affecting soil erosion [Hudson, 1992, and Cassel, Raczkowski, and Denton, 1995.]

Land degradation is the decline in the extent to which land yields products useful to local livelihoods (Scoones and Toulmin 1999) or, in more recent terminology, in decline in 'ecosystem services' (MEA 2005) is further accelerated by high rainfall amount where land cover is limiting. Soil erosion which is a form of land degradation is a major environmental threat to the sustainability and productive capacity of agriculture, with global estimates of around 10 million hectares of cropland being lost to erosion annually (Pimentel, 2006; Yang, Kanae, Oki, Koike, & Musiake, 2003) at a rate approximately 20 times that of soil formation (Govers, Merckx, van Wesemael, & van Oost, 2017). In general, climate-smart soil management entails recognizing and mirroring naturally occurring cycles and processes of any region, which is adapted within the context of a changing climate and cultural and socioeconomic conditions (Garcia-Franco N., Hobley, E., Hübner, R., & Wiesmeier, M., 2018).

Geo-informatics which has been described as "the science and technology dealing with the structure and character of spatial information, its capture, its classification and qualification, its storage, processing, portrayal and dissemination, including the infrastructure necessary to secure optimal use of this information (Raju, 2019). The application of the geo-informatics tool will help delineate rainfall boundaries and further produce a rainfall map that would inform climate-smart soil management within the state. Rainfall distribution in a territory and their changes within a year has a significant impact on hydrological phenomena, soil formation and plant growing seasons (Bukantis, 1994). Rainfall as a crucial climatic variable whose extremes leave the soil in a highly degraded state that will take several millions of dollars to reclaim, if not understood will militate against the achievement of the Sustainable Development Goals SDGs goal 1 (No poverty), goal 2 (Zero Hunger) and goal 15 (life on land) therefore the objective of this paper is to x-ray rainfall trends and its spatial distribution over Enugu state to inform climate-smart soil management within the state.

2.0. Materials and Methods

The study weather stations centred on the area covering Enugu State, and other stations bothering Enugu State viz. Anambra, Ebonyi and Kogi States. The area is located around coordinates 6° 27' 35.8704" N and 7° 32' 56.2164" E and a total landmass area of 447.545km^2 (QGIS 2.18.24). Rainfall records from 1979 to 2013 (Thirty-Five years) for eleven weather stations were sourced from free online global satellite stations installed at 34.4 km apart over the study area (globalweather.tamu.edu). Daily rainfall data gotten were processed in Microsoft Excel 2016 into annual rainfall. They were analyzed using three years moving average, and the means were also determined for each of the climatic stations over the state within the study area.

2.1. Geo-Informatics and data processing

The mean rainfall amount results obtained from the analysis were interpolated in a GIS environment (QGIS 2.18.24) to show the spatial distribution of rainfall amount over the study area as seen in Figure 2, to inform climate-smart soil management practices within the study area.

2.2. Interpolation and Contouring

The analyzed results of the mean rainfall were interpolated in a QGIS 2.18.24 environment to show its spatial distribution within the extent of the study area. The Inverse Distance Weighting (IDW) interpolation method was used for plotting the rainfall map of the state. The result of the interpolated raster was then clipped to the masked layer of Enugu State Nigeria to produce the rainfall map. Contours were extracted from the raster file for mean rainfall at 40mm interval joining points of equal rainfall in the QGIS 2.18.24 environment.

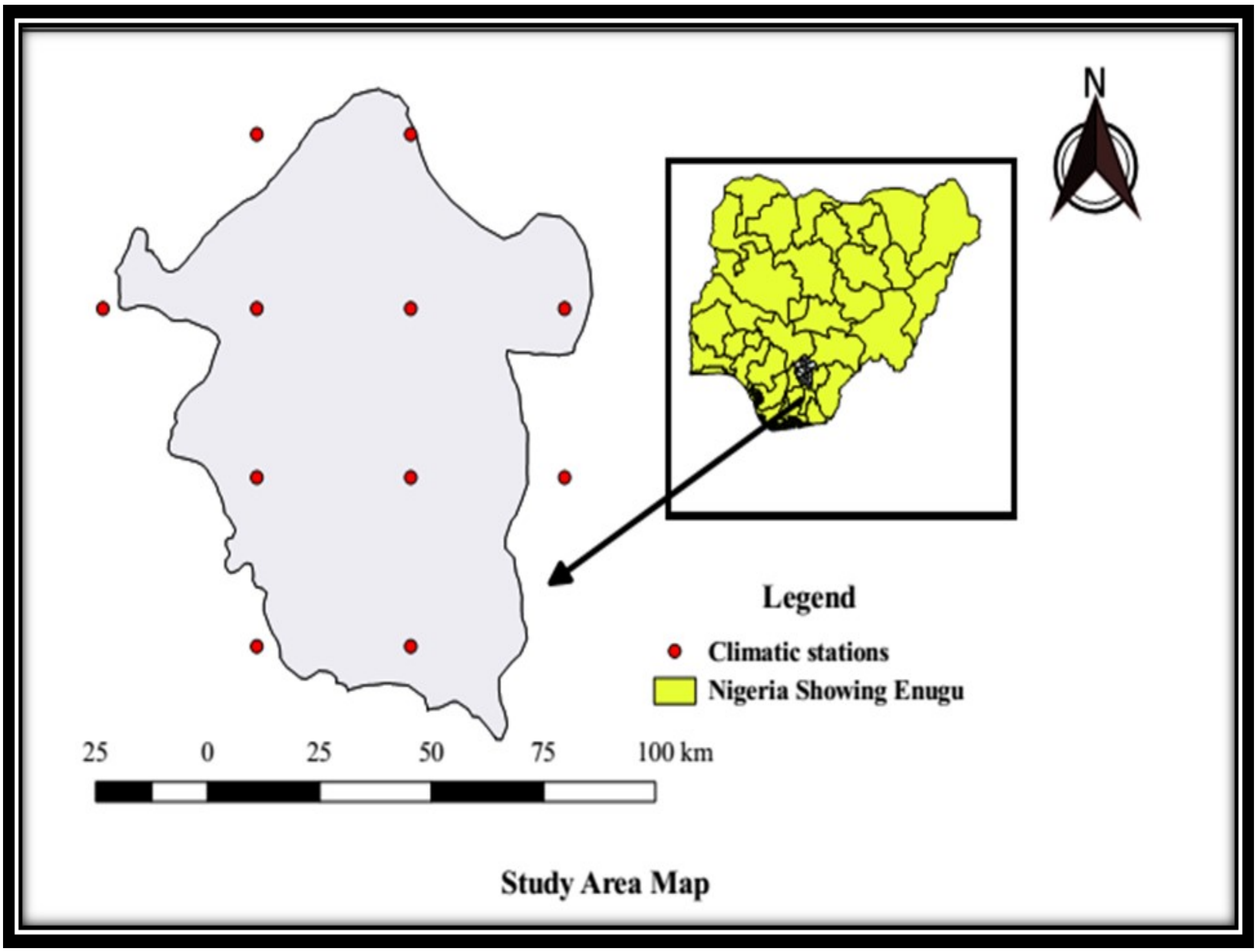

Figure 1: Study area, showing climatic stations.

3.0. Results

3.1. Rainfall Trend

3.1.1. Rainfall trend for Awgu L.G.A., of Enugu State from 1979-2013.

Result of Awgu L.G.A. rainfall, as seen in Figure 3 showed a mean annual rainfall of 1377.7 mm per annum over 35 years from 1979-2013. The 3 years moving average rainfall showed that between 1979, 1992, 1979-2001, 2003-2006 and 2010-2011 rainfall was below the mean annual rainfall with the lowest rainfall of 933.5 mm per annum recorded in 1999 while between 1980-1991, 1993-1996, 2002 and 2007-2009 the 3 years moving average rainfall was above the mean annual rainfall with the highest rainfall of 1739.6 mm per annum recorded in 1989. Out of the 35 years of the study period covered, rainfall of Agwu L.G.A. of Enugu State was with only a few intervals highly above the mean annual rainfall indicating high threats of runoff and erosion especially in areas with limiting vegetation cover which could serve as a shield to the soil against the impact of high rainfall.

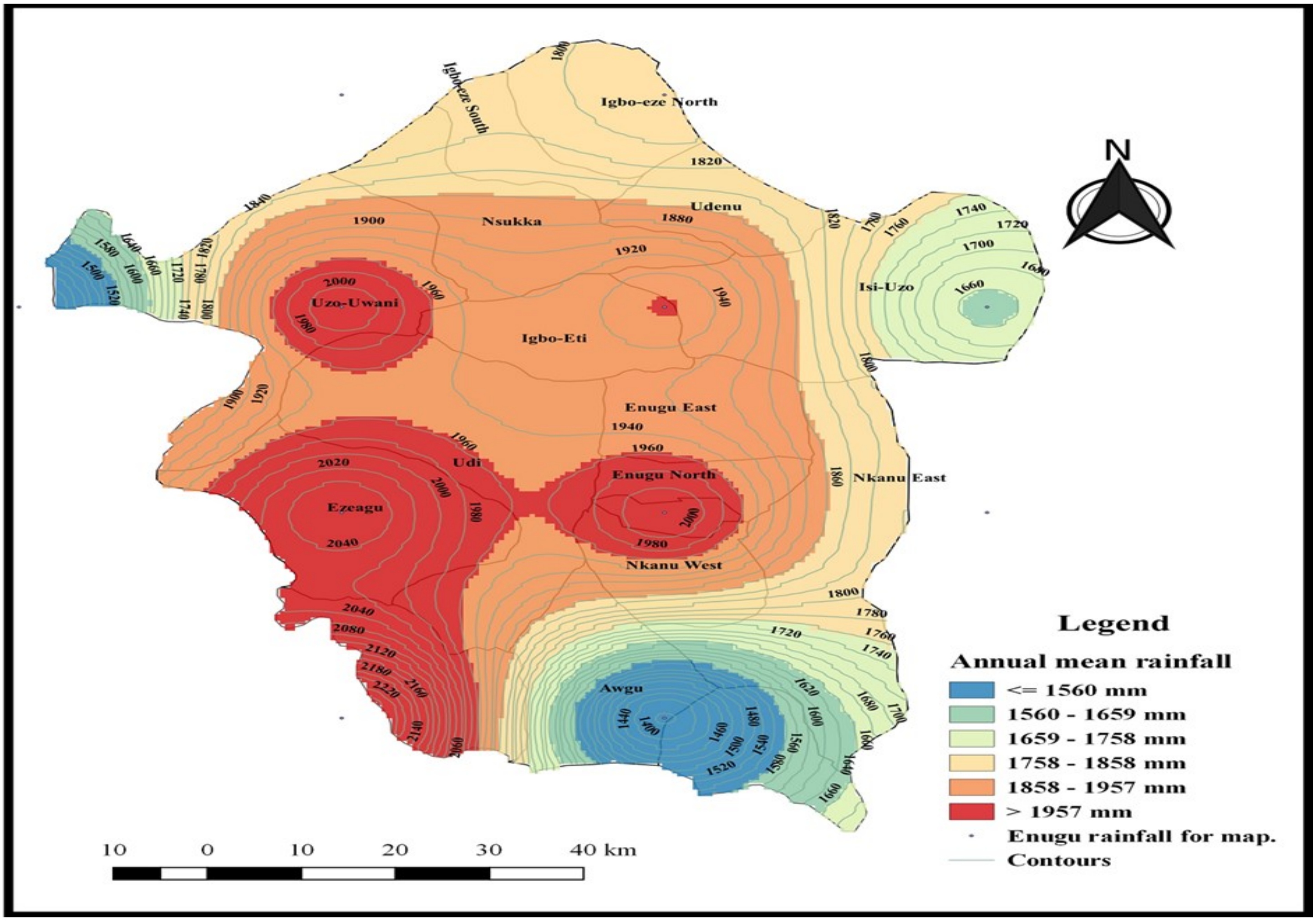

Figure 2: Spatial Distribution of Mean Annual Rainfall over Enugu State.

3.1.2. Rainfall trend of Enugu South LGA, of Enugu State from 1979-2013

Results of Enugu South LGA, rainfall as seen in Figure 4 showed a mean annual rainfall of 2016.9 mm per annum over 35 years from 1979-2013. The 3 years moving average rainfall revealed that between 1979, 1981, 1998-2006 and 2010-2012 rainfall was below the mean rainfall with the lowest rainfall of 1331.0 mm per annum recorded in 2000 while between 1980, 1982-1997 and 2007 -2009 rainfall was above the mean annual rainfall with the highest rainfall amount of 2395.4 mm per annum recorded in 1989. From the results, for a period of 16 years from 1982-1997 rainfall was always above average showing a constant erosive impact of rainfall on the soil where vegetation cover is not well managed.

3.1.3. Rainfall trend of Anambra West LGA, of Anambra State from 1979-2013.

Results of Anambra west rainfall, as seen in figure 5 showed a mean annual rainfall of 1377.7 mm per annum over 35 years from 1979-2013. The 3 years moving average rainfall revealed that between 1979, 1992, 1997-2001, 2003-2006 and 2010-2011 rainfall was below the mean annual rainfall with the lowest rainfall of 933.5 mm per annum recorded in 1999 while between 1980-1991, 1993-1996, 2002 and 2007-2009 the 3 years moving average rainfall was above the mean annual rainfall with the highest rainfall of 1739.6 mm per annum recorded in 1989. Rainfall of the area showed that out of the 35 years studied, 20 years recorded very high rainfall amount above average signifying 20 years of the high erosive impact of rainfall on the soil.

3.1.4. Rainfall trend of Igbo-Eti L.G.A., of Enugu State

from 1979-2013

Result of Igbo-Eti rainfall, as seen in figure 6 showed a mean annual rainfall of 1958.4 mm per annum over the studied period of 35 years from 1979-2013. The 3 years moving average rainfall revealed that between 1979, 1983, 1985-1986, 1992 and 1998-2006 rainfall was below the mean annual rainfall with the lowest rainfall amount of 1247.2 mm record in 2000, while between 1980-1982, 1984, 1987-1991, 1993-1997 and 2007-2011 the 3 years moving average rainfall was above the mean annual rainfall with the highest rainfall amount of 2316.8 mm per annum recorded in 2009.

3.1.5. Rainfall trend of Igbo-Eze North LGA, of Enugu State from1979-2013

Result of Igbo-Eze North rainfall, as seen in figure 7,

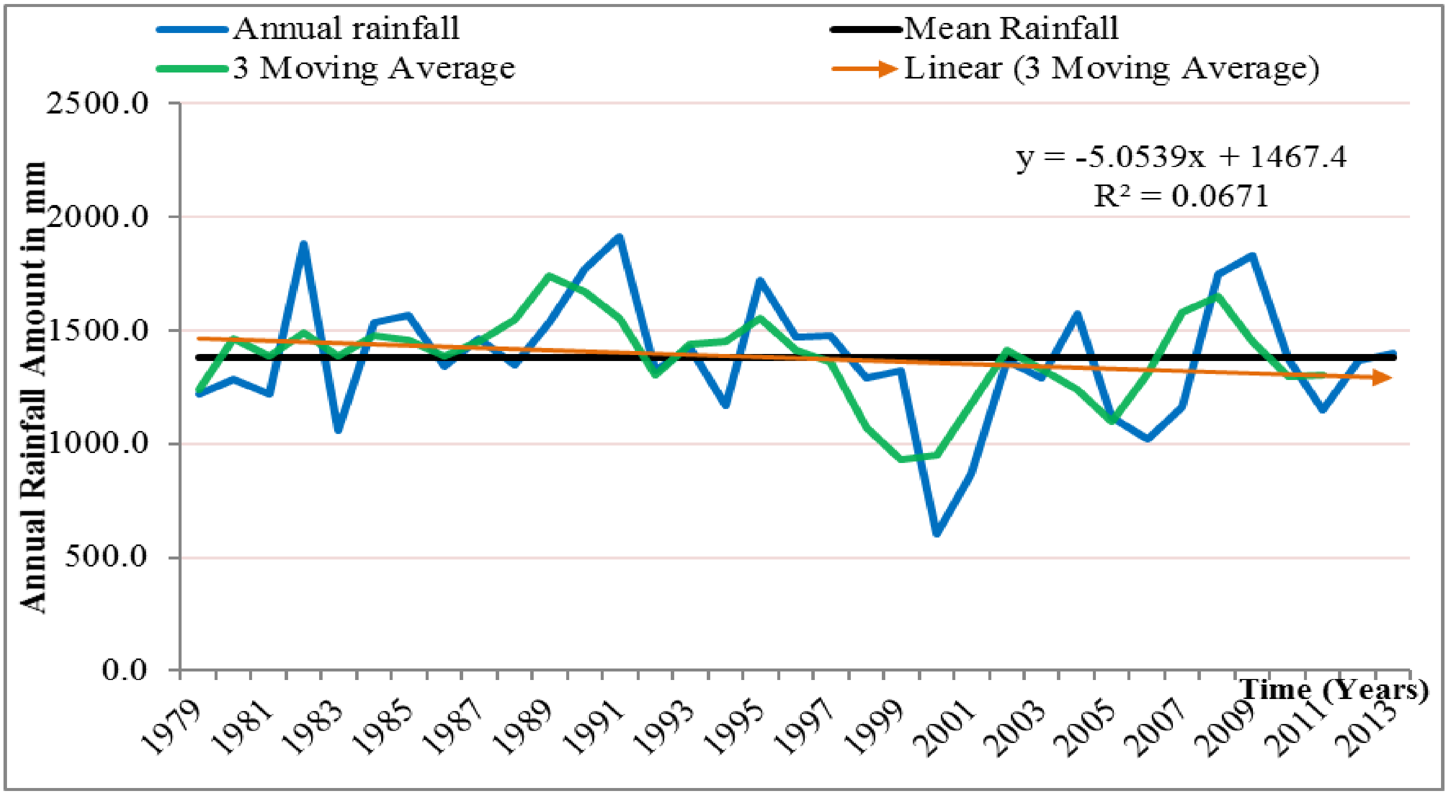

Figure 3. Rainfall trend for Awgu L.G. A. of Enugu State from 1979 -2013

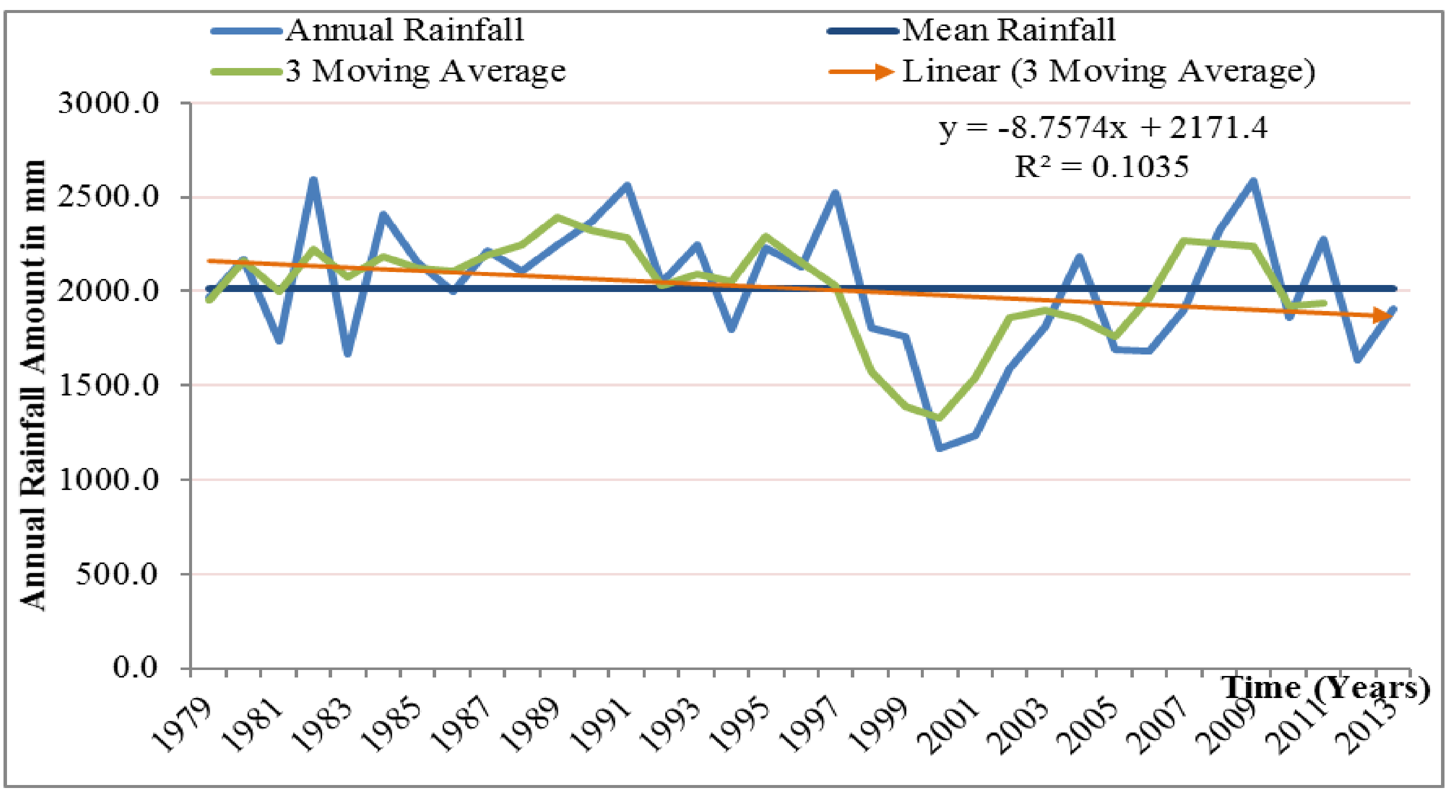

Figure 4. Showing Rainfall trend for Enugu South LG A., of Enugu State from 1979 -2013

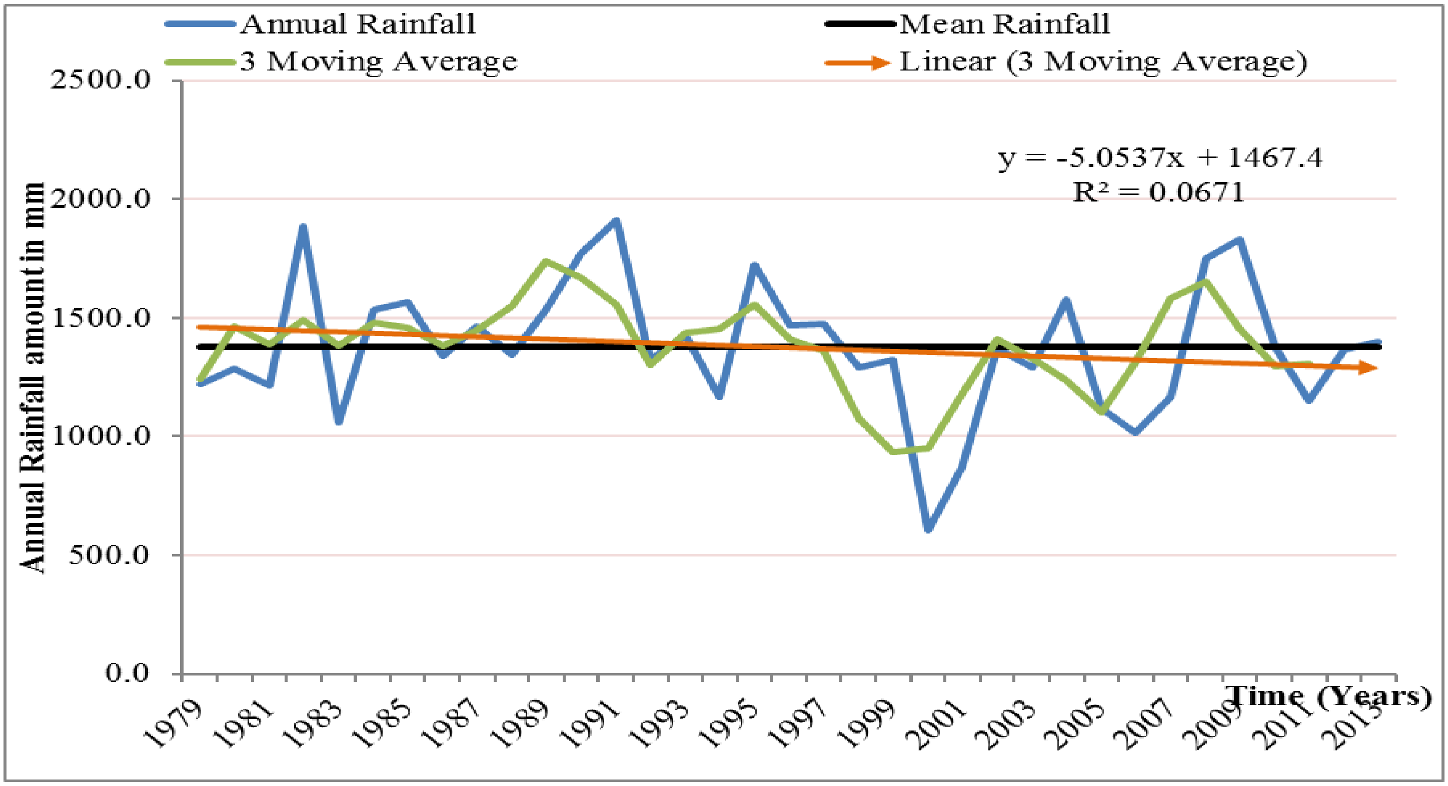

Figure 5. Showing Rainfall trend for Anambra West LG A., of Anambra State from 1979 -2013

showed a mean annual rainfall of 1784.2 mm per annum over the studied period of 35 years from 1979-2013. The 3 years moving average rainfall revealed that between 1984-1986, 1992, 1998-2001, 2004-2005 and 2010-2011, with the lowest rainfall of 1096.9 mm per annum recorded in 1999, while between 1979-1983, 1987-1991, 1993-1997, 2002-2003 and 2006-2009 rainfall was above the mean annual rainfall with the highest rainfall amount of 2197.8 mm per annum recorded in 2008.

3.1.6. Rainfall trend of Isi-Uzo L.G.A., of Enugu State from 1979-2013

Result of Isi-Uzo rainfall, as seen in figure 8 showed a mean annual rainfall of 1653.0 mm per annum for a period

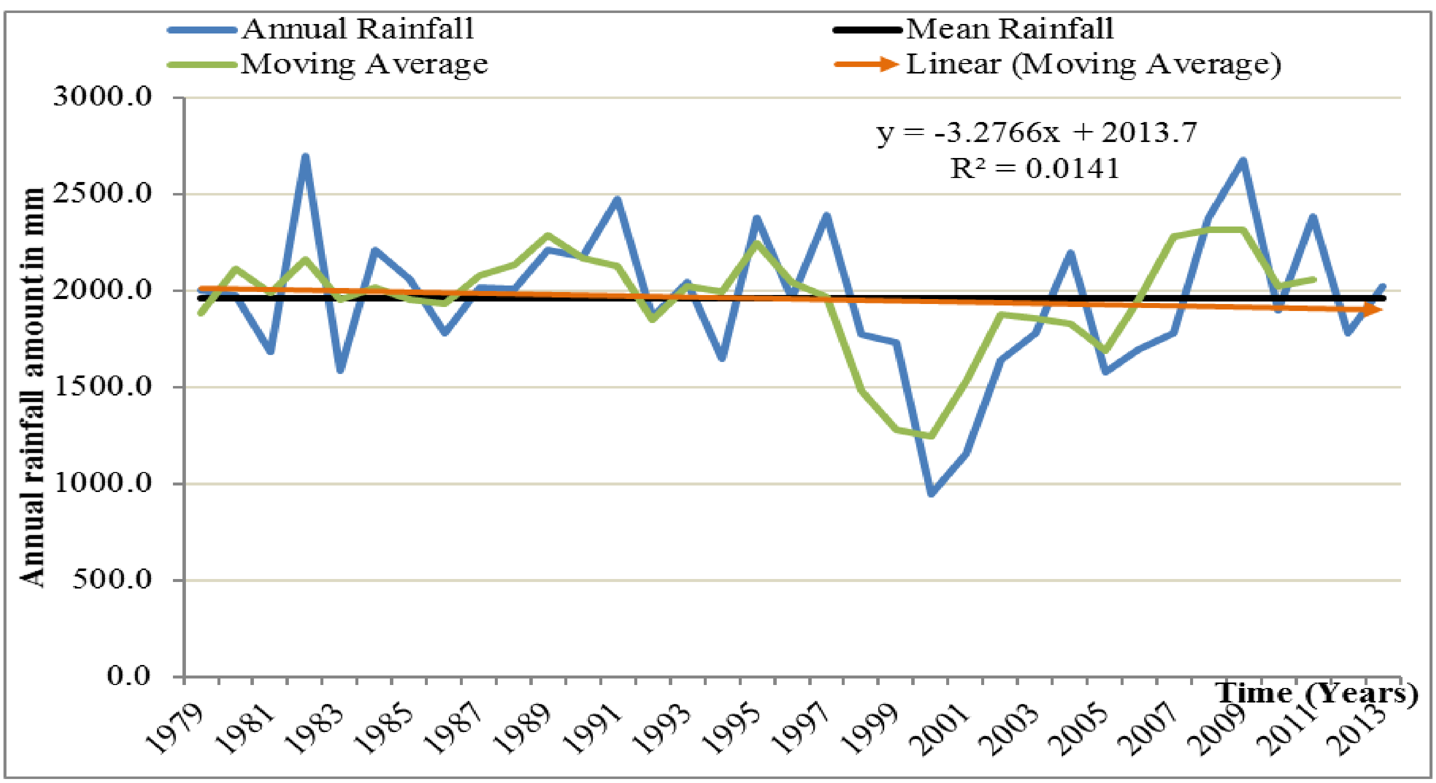

Figure 6. Showing Rainfall trend for Igbo-Eti L.G. A., of Enugu State from 1979 -2013

of 35 years from 1979-2013. The 3-year moving average rainfall revealed that between 1979, 1981, 1983, 1985, 1992, 1998-2005 and 2010-2011 rainfall was below the mean annual rainfall with the lowest rainfall amount of 1025.0 mm per annum recorded in 2000 while between 1980, 1982, 1984, 1986-1991, 1993-1997 and 2006-2009 the 3 years moving average rainfall was above the mean annual rainfall with the highest rainfall of 2074.8 mm per annum recorded in 2008.

3.1.7. Rainfall trend of Ezeagu L.G.A., of Enugu State from 1979-2013

Result of Ezeagu rainfall, as seen in figure 9 showed a mean annual rainfall of 2059.6 mm per annum for a period

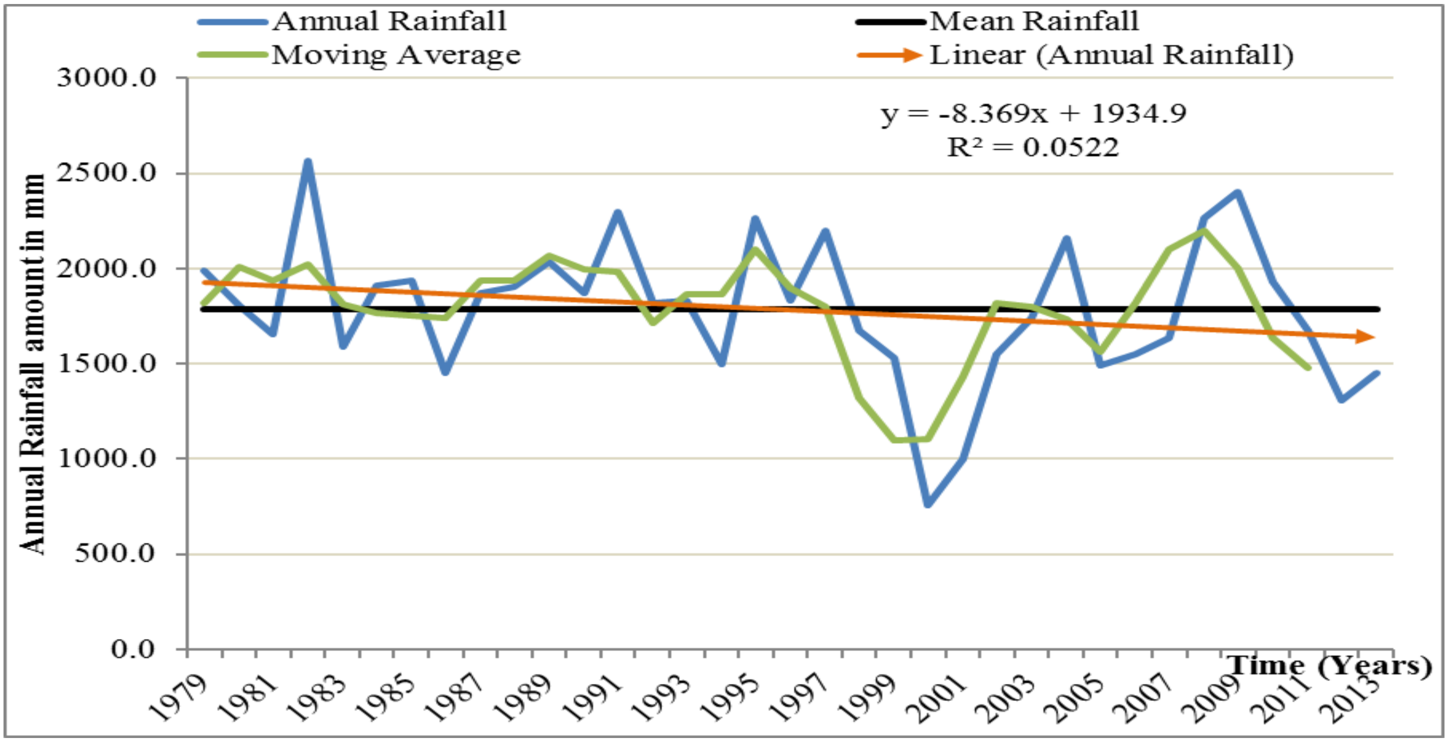

Figure 7. Showing Rainfall trend for Igbo-Eze North LG A., of Enugu State from 1979 -2013

of 35 years from 1979-2013. The 3 years moving average rainfall revealed that between 1979, 1981, 1983, 1992, and 1997-2006 rainfall was below the mean annual rainfall with the lowest rainfall amount of 1373.0 mm recorded in 2000 while between 1980, 1982, 1984-1991, 1993-1996 and 2007-2011 the 3 years moving average rainfall was above the mean annual rainfall per annum with the highest rainfall amount of 2669.7 mm per annum recorded in 2011.

3.1.8. Rainfall trend of Uzo-Uwani L.G.A., of Enugu State from 1979-2013.

Results of Uzo-Uwani rainfall, as seen in figure 10 showed a mean annual rainfall of 2012.3 mm per annum for the

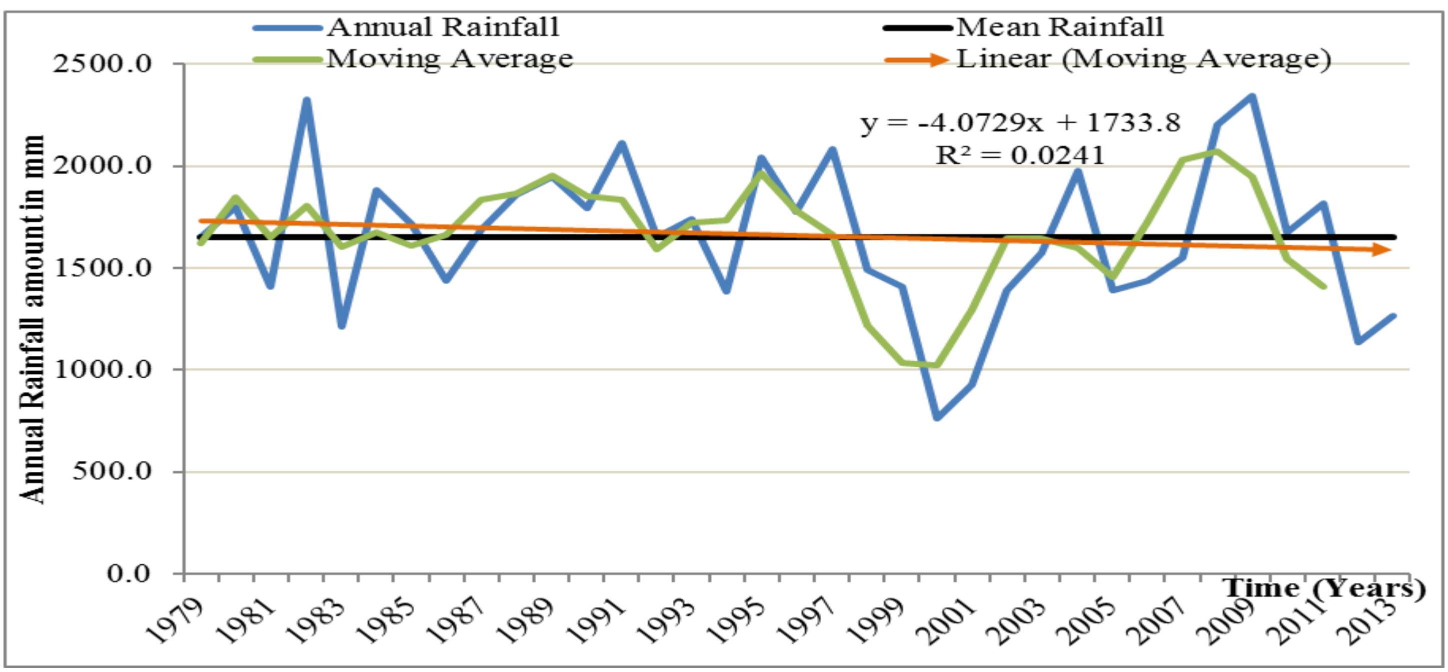

Figure 8. Showing Rainfall trend for Isi-Uzo L.G. A., of Enugu State from 1979 -2013

over 35 years from 1979-2013. The 3 years moving average rainfall revealed that between 1986, 1992, 1998-2001, 2003-2006 and 2010-2011rainfall was below the mean annual rainfall with the lowest rainfall amount of 1152.3 mm per annum recorded in 1999 while between 1979-1985, 1987-1991, 1993-1997, 2002 and 2007-2009 rainfall was above the mean annual rainfall with the highest rainfall amount of 2159.0 mm per annum recorded in 2008.

3.1.11. Rainfall trend of Ishielu L.G.A., of Ebonyi State from 1979-2013

Results of Ishielu rainfall, as seen in figure 13 showed a mean annual rainfall of 1779.3 mm per annum over the studied period of 35 years from 1979-2013. The 3 years moving average rainfall revealed that between 1979, 1981, 1997-2005 and 2010-2011 rainfall was below the mean annual rainfall with the lowest rainfall amount of 1126.6 mm per annum recorded in 2000 while between 1980, 1982-1996 and 2006-2009 the 3 years moving average rainfall was above the mean annual rainfall with the highest rainfall amount of 2107.0 mm per annum recorded in 1989.

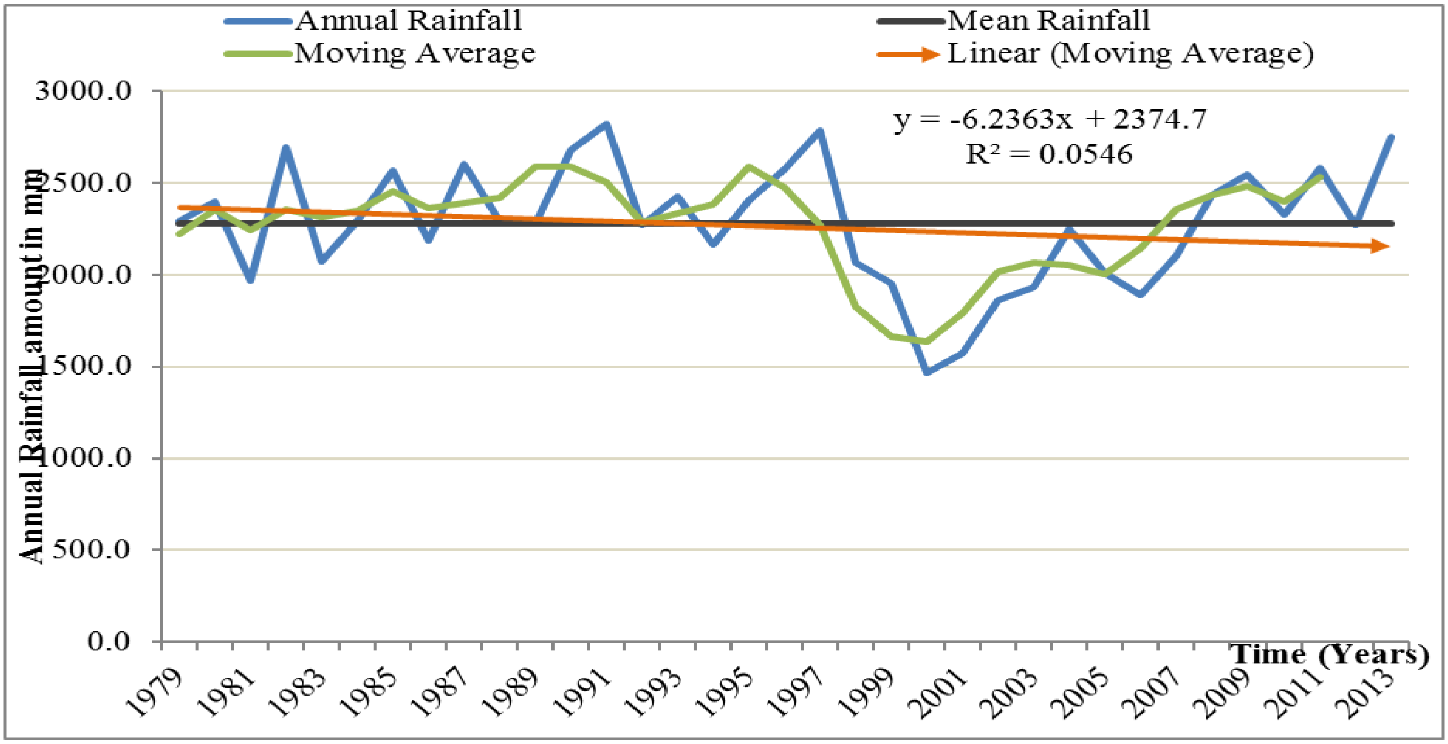

Figure 11. Showing Rainfall trend for Orumbano L.G. A., of Anambra State from 1979 -2013

4.0. Discussions

Rainfall trends as a veritable tool for climate-smart soil

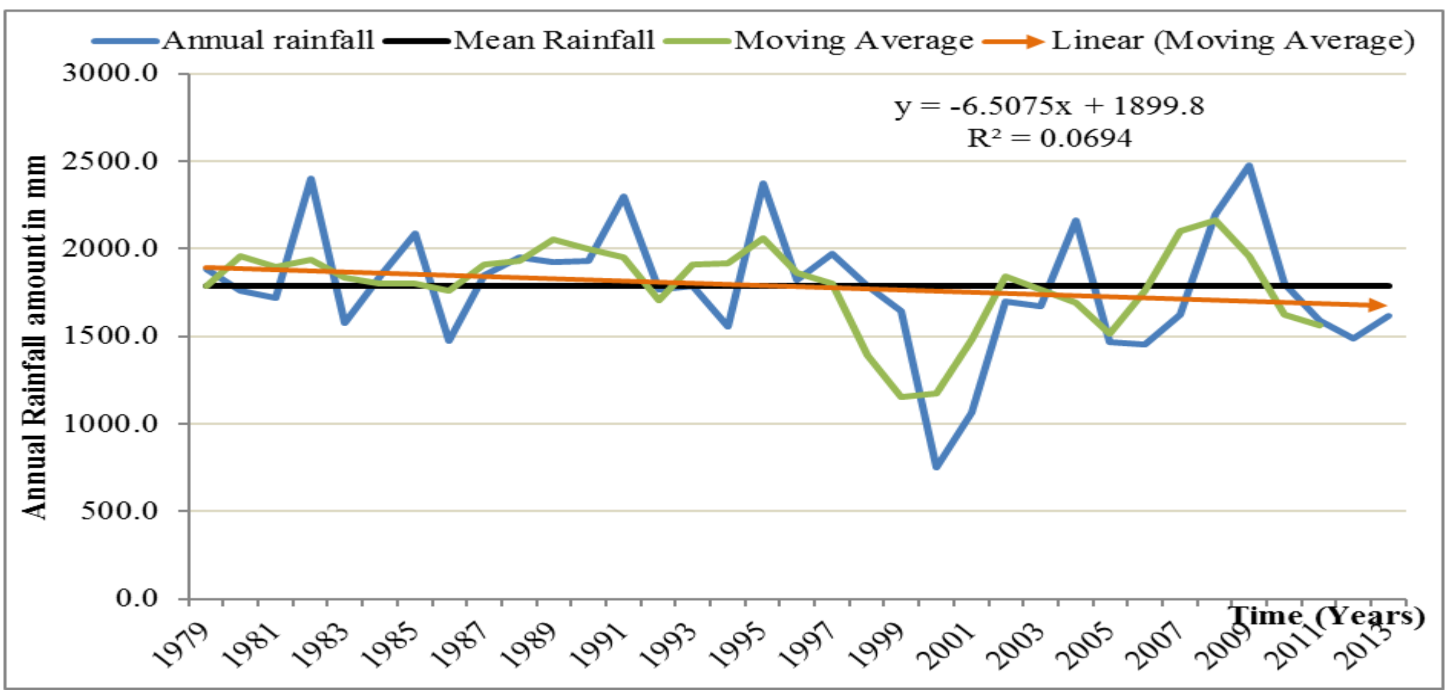

Figure 12. Showing Rainfall trend for Igalamela-Odolu L.G. A., of Kogi State from 1979 -2013

management with the findings of this research, and owing to the assertion that the higher the amount of rainfall and intensity the more significant the rainfall energy and its erosive power (Adelaide, 2012) Orumbano, Ezeagu, Enugu South and Uzo-Uwani receiving over 2000 mm mean annual rainfall per annum will be highly prone to soil water erosion and are the danger spots for severe soil conservational measures to avert further soil degradation due to high amount and intensity of rainfall over this area in Enugu State. More than one soil conservational measures can be employed in areas with higher rainfall for optimum soil health and quality to be actualized.

5.0 Summary and Conclusion

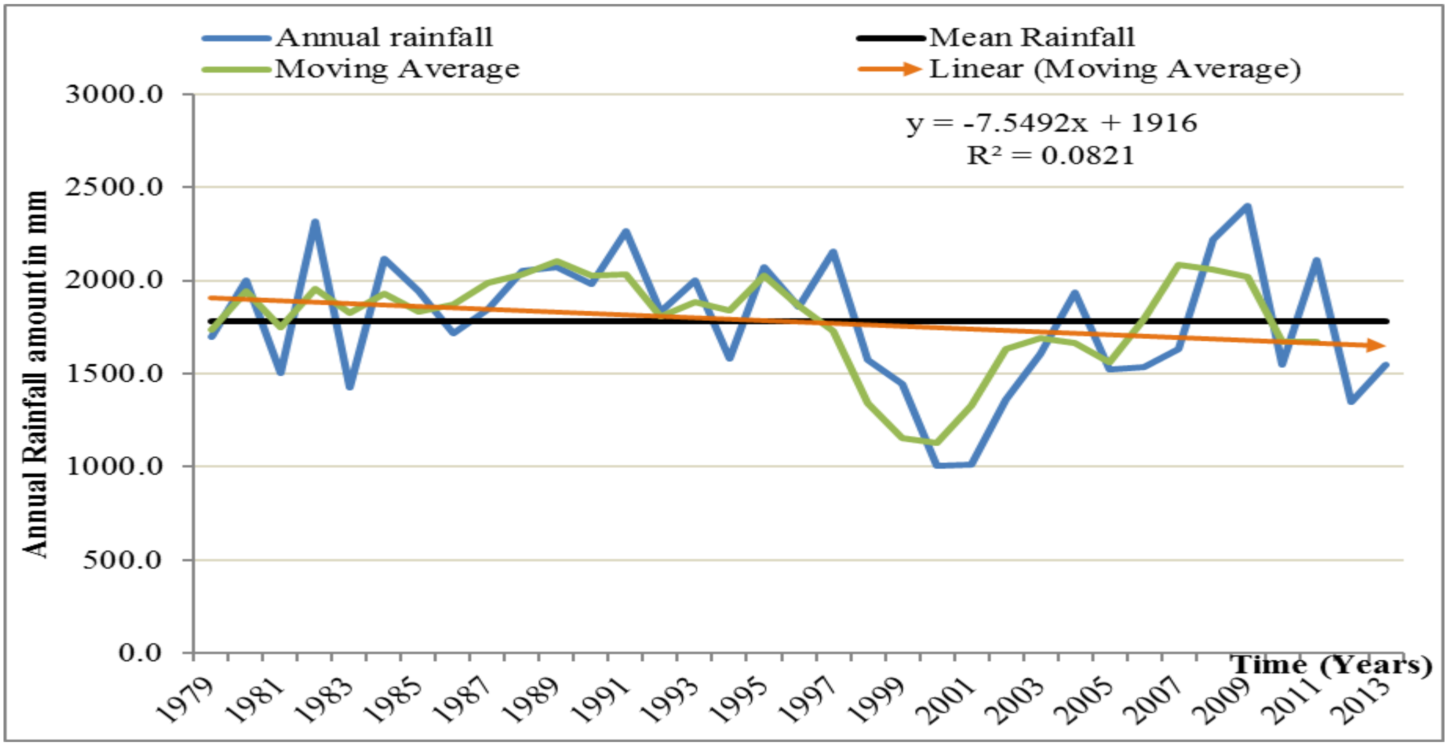

Figure 13. Showing Rainfall trend for Ishielu L.G. A., of Ebonyi State from 1979 -2013

Since rainfall energy can be expressed as the erosive power of rainfall and is found to be closely associated with the rainfall amount, from the map inference could be made that areas with higher rainfall are more prone to soil degradation (Erosion by water) depending on the erodibility of the soils than an area with less rainfall.

Conclusively, with the findings from the rainfall trends and maps, different conservation measures (

- *Agronomic:* such as plant/soil cover, conservation farming methods, contour farming
- *Vegetative:* such as planting barriers (vegetative strips -Vetiver technology), live fences, windbreaks
- *Structural:* such as terraces, banks, bunds, cut off drains, barriers
- *Overall management:* such as area closures, selective clearing) could be applied in different locations to achieve Climate-Smart Soil Management.

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studied period of 35 years from 1979-2013. The 3 years moving average rainfall revealed that between 1979, 1981, 1983-1986, 1992 and 1997-2006 rainfall was below the mean annual rainfall with the lowest rainfall amount of 1300.2 mm per annum recorded in 2000, while between 1980, 1982, 1987-1991, 1993-1996 and 2007-2011 rainfall was above the mean annual rainfall with the highest rainfall amount of 2912.7 mm recorded in 2011.

3.1.9. Rainfall trend of Orumbano L.G.A., of Anambra State from 1979-2013

Results of Orumbano rainfall, as seen in figure 11 showed a mean annual rainfall of 2279.4 mm per annum over 35 years from 1979-2013. The 3 years moving average rainfall revealed that between 1979, 1981 and 1997-2006 rainfall was below the mean annual rainfall with the lowest rainfall amount of 1633.8 mm per annum recorded in 2000 while between 1980, 1982-1996 and 2007-2011 the 3 years moving average rainfall was above the mean annual rainfall with the highest rainfall amount of 2588.3 mm per annum recorded in 1995.

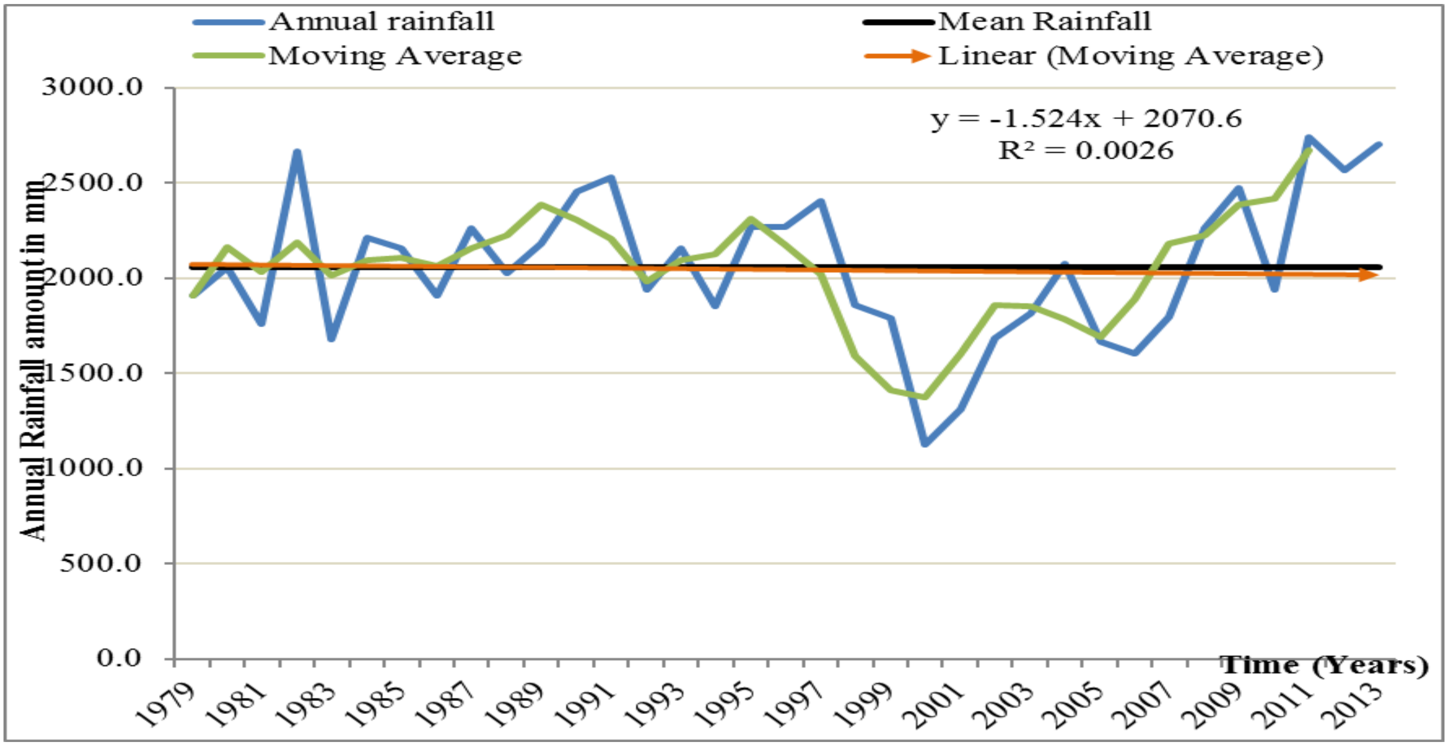

Figure 9. Showing Rainfall trend for Ezeagu L.G. A. of Enugu State from 1979 -2013

3.1.10. Rainfall trend of Igalamela-Odolu L.G.A., of Kogi State from 1979-2013.

Results of Igalamela-Odolu rainfall, as seen in figure 12 showed a mean annual rainfall of 1784.5 mm per annum

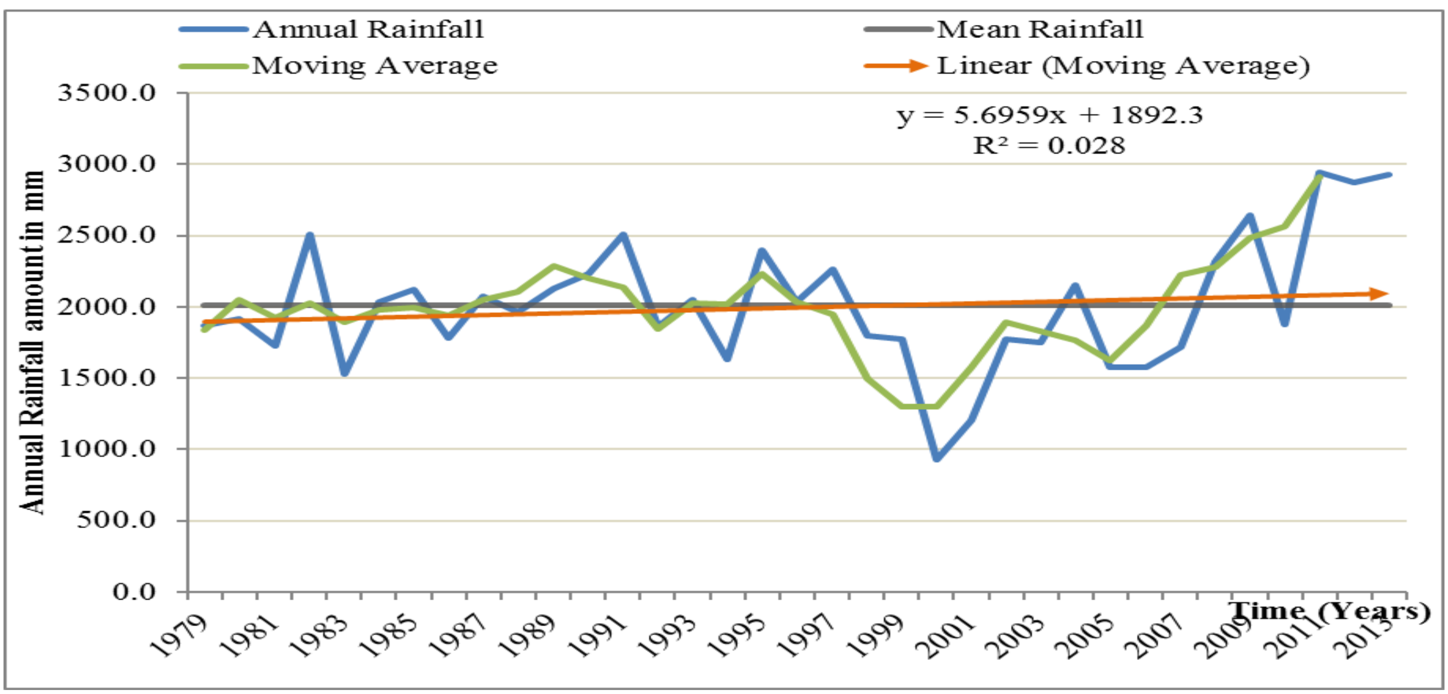

Figure 10. Showing Rainfall trend for Uzo-Uwani L.G. A., of Enugu State from 1979 -2013

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