IMPACT OF CLIMATE CHANGE ON GULLY EROSION FORMATION IN GOMBE TOWN, NORTH EAST NIGERIA

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Abstract

The processes involved in the impact of climate change on soil erosion by water were examined. Climatic data were collected from Gombe State University Meteorological station and National Meteorological station Gombe. Climatic elements collected were daily, monthly and annual rainfall, minimum and maximum temperature; evaporation, soil and grass temperature. Data spanning over 4 decades, from 1970 – 2013 were obtained from the two stations. Data collected were analyzed and presented in time series. Results revealed that climatic change have accelerated soil erosion directly through increases in surface air temperature and decreases in rainfall regimes, and indirectly through changes in vegetation and surface cover. Furthermore there was an increase in soil and grass temperature that have impacted on soil erosion through changes in vegetation and soil organic matter. It was suggested that as climate change will continue in the 21st century and beyond, planting of drought resistance plant such as Pitadeniastrum africanum **(kashe kwari or kafi kansila)**, can effectively help in gully erosion control.

Keywords: Climate Change, Gully Erosion, Rainfall Gombe

Introduction

Climate change represents a significant and lasting change in the statistical distribution of weather patterns over periods ranging from decades to millions of years, manifested in the form of deviation in average weather conditions, or in the increased probability of extreme weather events. Climate scenarios analyzed by Building Nigeria's Response to Climate Change [1] projected significant changes in climatic variables. The projection shows temperature has increased to about 0.04^{o} C annually and this will last up to 2046. Building Nigeria's Response to Climate Change (BNRCC) further revealed that the northeastern part of Nigeria will experience the highest increase in temperature of 1.5 – 3.2^{o} C (35.5 – 38.5^{o}C) between the years 2046 – 2065. Rainfall has also witnessed increase and decreased in some parts of the country, the overall scenario showed a peak monthly increase of 1mm in the savanna zones while witnessed a general decrease in total annual rainfall days. The scientific and political consensus revealed that climate change poses considerable threats to Nigeria's environment. The actual and potential impacts of climate change in Nigeria varied between the eco zones and affecting many aspects of people's daily lives. Increases in temperature, rainfall, decreased rainfall days, the drying up of soils, increased pest and disease pressure, shifts in suitable areas for growing crops and livestock, increased desertification, floods, deforestation, and erosion are all signs that climate change is already happening and represents one of the greatest environmental, social and economic threats facing the northeastern Nigeria in particular.

Global warming according to [2] associated with landuse put more regions at risk of gully erosion in future, with particular threat on the semi-arid zones. Gombe town is located within the semi arid zones of Nigeria and gully erosion is a major environmental disaster facing the town. The town is fast becoming hazardous for human habitation. Hundreds of people are directly affected every year and have to be re-located. This study examined how climate change has accelerated gully erosion in the study area.

Material and Methods

Gombe town is located between latitudes 10^0 00 to 10^0 20′ N and longitudes 11^0 01′ E and 11^0 19′ E (Figure 1). It shares common boundary with Akko LGA in the South and West; Yamaltu-Deba to the East and Kwami to the North. The climate of Gombe is characterized by 4 -5 months of rainy season and 7 - 9 months of dry season. As in other parts of the Nigerian Savanna this precipitation distribution is mainly triggered by a seasonal shift of the Inter -Tropical Convergence Zone (ITCZ). For the years 1977 to 1995, the mean annual precipitation was 835 mm and the mean annual temperature was about 30°C whereas relative humidity has same pattern with rainfall, being 94% in August and dropping to less than 10% during the harmattan period [3]. The relief of the town ranges between 650m in the western part to 370m in the eastern parts. Subsequent dissection and stream incision in the area have carved a landscape consisting of flat topped to conical hills, a granitic residuals and pediment landscape.

Climatic data were collected from the Gombe State University Meteorological station and National Meteorological station in Gombe state. Climatic elements collected were daily, monthly and annual rainfall, minimum and maximum temperature; evaporation, soil and grass temperature. Data spanning over 4 decades, from 1970 – 2013 were obtained from the two stations. Data collected were analyzed using descriptive statistics such as time series and graphic presentation.

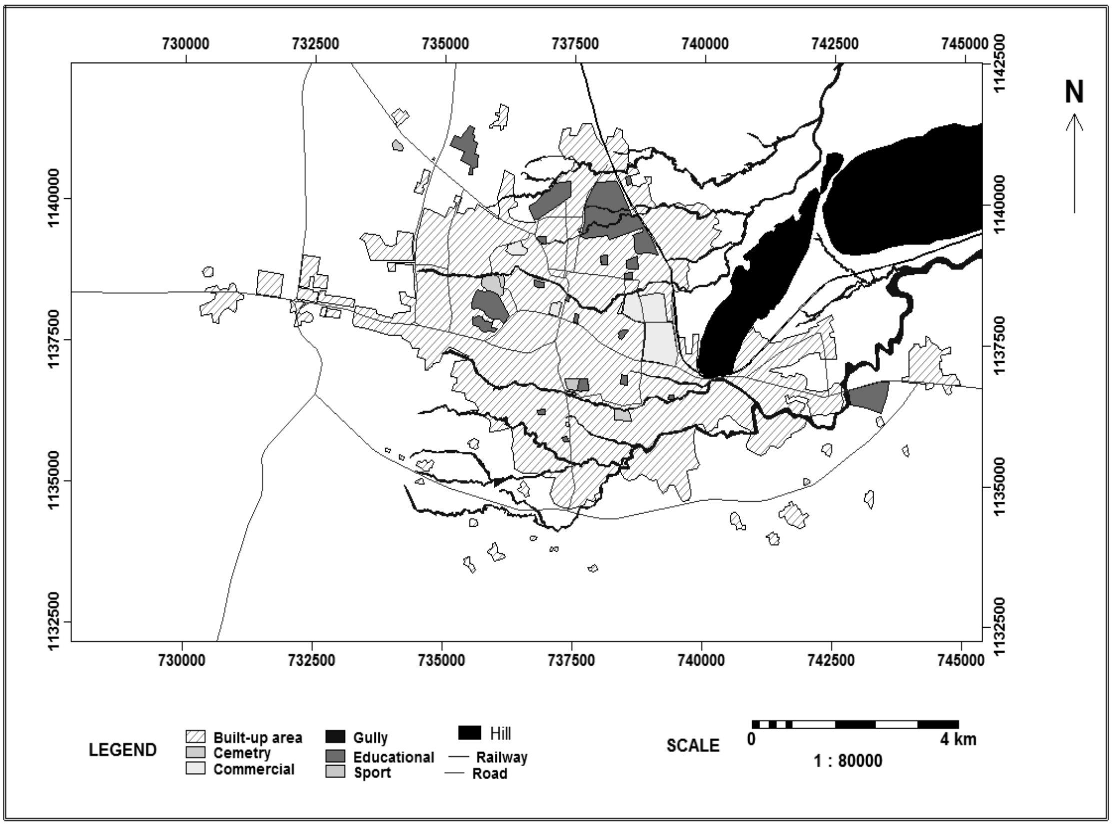

Fig.1: Map of the study area
Source: Ministry of Environment and Water Resource, Gombe, 2003

3. Result and Discussions

3.1 Rainfall Amount

Gully erosion, is a threshold phenomenon in terms of flow hydraulics and rainfall. Fig.2 and 3 shows the rainfall variability of the 44 hydrologic years, particularly with regards to annual rainfall. It revealed that of the 44years period under study, only 5 years (2004, 2005, 2007, 2009, 2010 and 2012) has total annual rainfall less than the mean annual (856mm), while the 39 years received more than the mean annual total, representing 88.6%. This implies that only 11.4% of the 44 hydrologic years has relatively low rainfall compared with the mean annual of 856mm. However, this amount is high in an urban environment with increasing sealing surfaces. This finding is in line with [4], who found out those areas in Nigeria with mean annual rainfall of 762mm to 1524mm lies within the maximum fluvial erosion zone.

3.2 The mean annual rainfall days

The mean rainfall days depicted in Fig.4 shown decrease in mean annual rainfall days from 78 days during 1970s to 49 days in 2013. The decreasing trends however, does not implied that the higher the number of rainy days the higher the amount of rainfall expected. The implication of this is that, with decreasing rainfall days and relatively stable annual rainfall above 700mm accelerate gully erosion will continue. Climate change therefore has accelerated and will likely continue to increase gully erosion in the study area. The finding also showed that monthly rainfall increase from the onset and reached its peak in August. This implies that, it was during the months of July, August and September that gully growth and destructions took place. This is as a result of exceeding threshold of rainfall and soils saturation, coupled with increased sealing surfaces. The implication of this finding is that with increase monthly rainfall from June – September, the soils left for the long dry season are exposed to high temperature disperse and disintegrate easily on contact with rainfall – runoff impact.

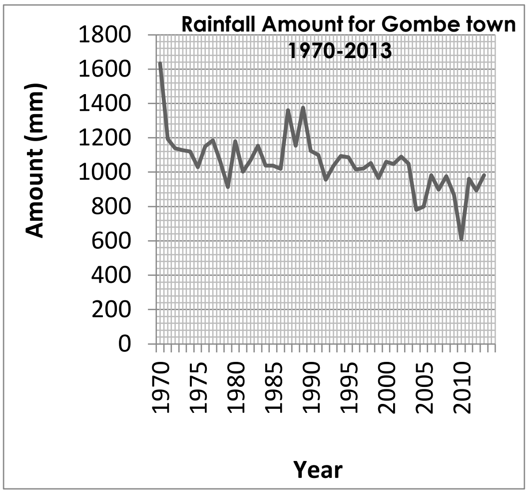

Fig 2: Mean Annual Rainfall Events 1970 – 2013

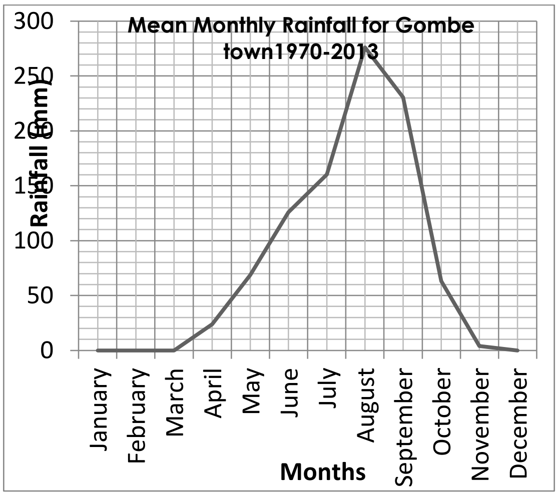

Fig 3: Mean Monthly rainfall amount 1970 – 2013

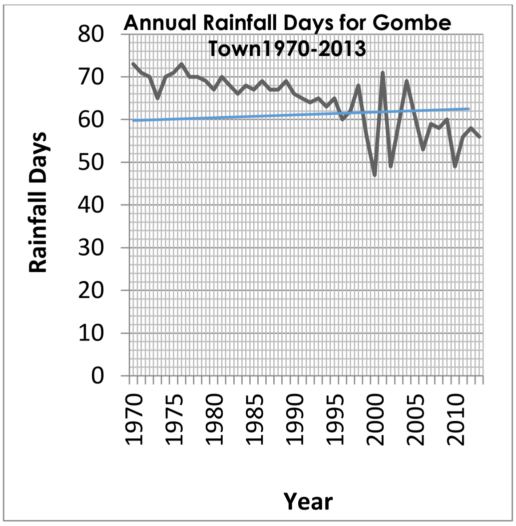

Fig 4: Mean Annual Rainfall Days 1970 – 2013

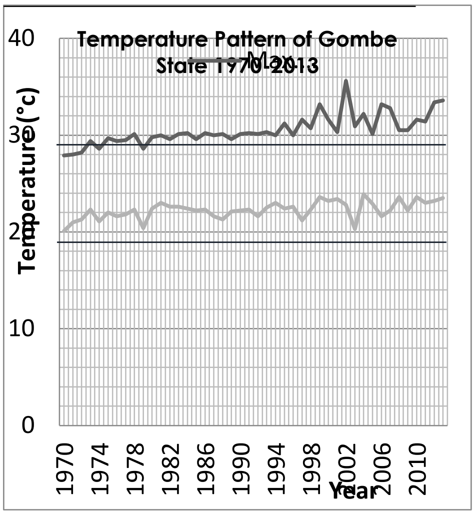

Fig. 5: Mean annual maximum and minimum Temperature 1977 – 2013

3.3 Surface Air temperature

Fig.5 and 6 depicts a trend in surface air temperature over the period of 44 years. The mean minimum and maximum air temperature between 1970 and 1985 was 22.3 and 30.6^{o}C respectively. On the other hand the year 1986 to 2013 witnessed an increase in both minimum and maximum air temperature to 23.2 and 31.0^{o}C. This shows that there is an increase of air temperature of 0.90 and 0.40^{o}C between 1970 and 2013 for the minimum and maximum air temperature respectively. This increase in maximum air temperature is lower than the global average of 0.6^{o}C over a century as reported by [5]. Although the increase (0.40^{o}C) seems little, however increased air temperature is likely to have a negative effect on Carbon allocation to the soil, leading to reductions in soil organic matter, increasing soil disintegration. With increasing temperatures plants are likely to be more active and thus increase their evapotranspiration. In combination with reduced rainfall and increase temperature there will be less seepage flow available to keep gully heads active. [6] has found that soil of Gombe town is characterized by low organic matter content, moderately acidic, and low exchangeable cations, with serious implication on biological methods of erosion control.

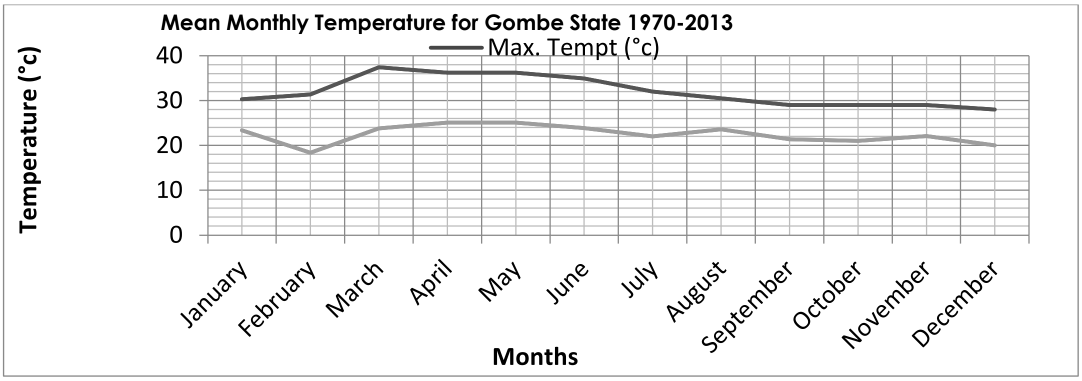

Fig.6: Mean Monthly Air Temperature of the study area 1970- 2013

3.4 Soil temperature

Soil temperature for the study area is presented in Figure 7 and 8. The trends shows that soil temperature at 10 and 15cm depth has increased from 27^{o} C and 26^{o} C in 1970 to 30 and 27^{o} C in 2013 respectively. This revealed an increase of 3 and 1^{o} C in or an increase of 10 and 3% under the period of study.

The mean monthly soil temperature also depicts increases more especially January to June reaching up to 33^{o}C in April. The trends in soil temperature follow that of air temperature (Fig. 6). This has an implication on the survival of biomass that is planted to control soil erosion and consequently increases erosion hazards.

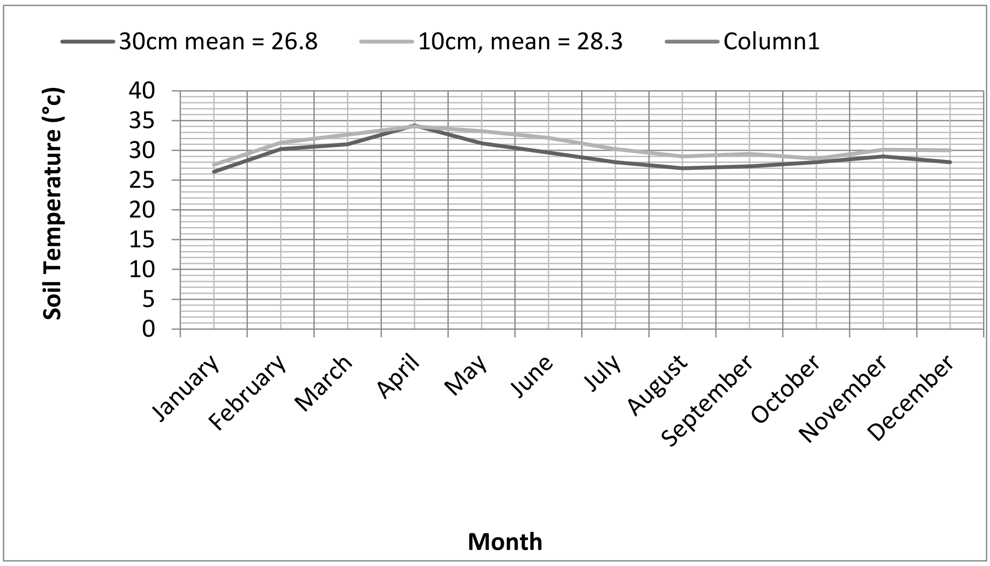

Fig 7: Mean Monthly Soil Temperature of the study area 1970 – 2013

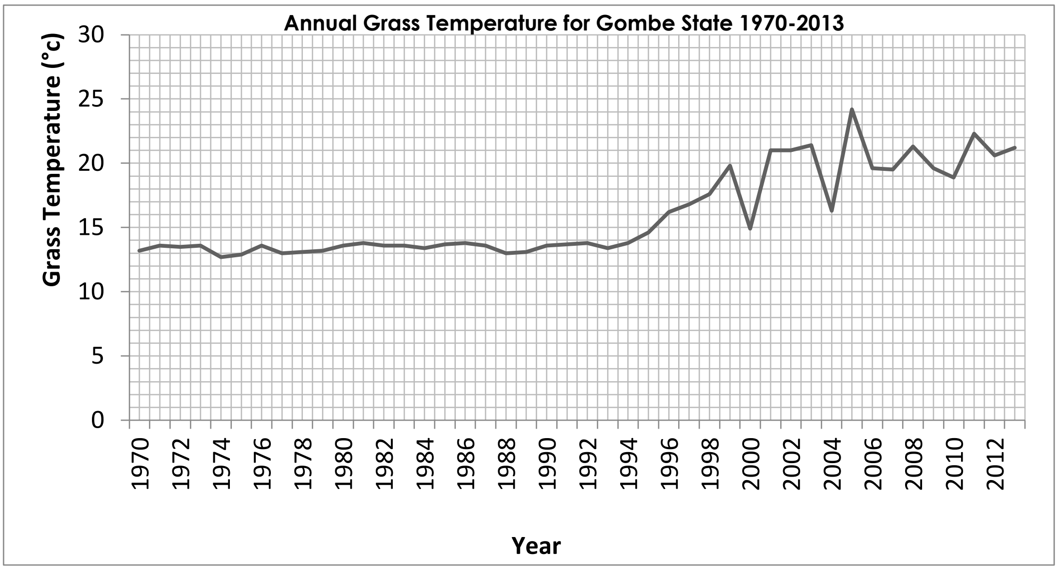

Fig.8: Mean Annual Grass Temperature of the study area 1970 - 2013

3.5 Evaporation

Fig. 9 shown trends in evaporation of the study area and revealed increases in evaporation of 6% from 1970 – 1974; from 1975 – 1994 it further increased reaching 7%, an increase of 1% in 20 years over the 1970 – 1974. The 1995 – 2013 also witnessed increases in evaporation by 3% reaching 10% in 18 years. This is attributed to rising temperature which has increases the potential evapo transpiration. This will affect plant canopy, due to limited water supply thereby induced drought, low precipitation and or limited water storage capacity in the soil, thereby affecting soil aggregate stability. This further accelerated gully erosion and its menace in the study area

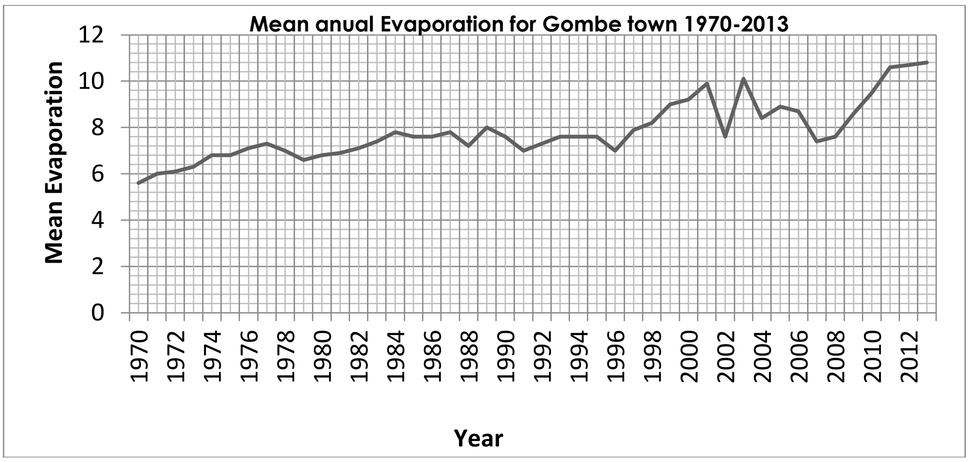

Fig. 9: Mean Annual Evaporation 1970 – 2013

Conclusion and Recommendations

Gombe town is facing serious problem of gully erosion causing untold hardships and misery on the lives of the people. Climatic variability in form of rainfall intensity, duration and amount, increase in maximum and minimum surface air, grass and soils temperature has accelerated the growth of gullies in the study area. This has increased deep cutting, take up valuable land, raised the cost of building and sinking of well water. This chain of cause and effect hits most of the low income groups of the community, where the population density is highest and where the worst damages of gully erosion are found. It was therefore suggested that reforestation of the catchment areas and eroded lands can be effective at reclaiming and controlling gully corridors in the affected areas. Planting deep-rooted perennial pastures, trees, or an appropriate mixture of both, such as *Pitadeniastrum africanum* **(kasha kwari)** can help maintain healthy soils. This specie of plant thrive well during dry season (drought resistant), not palatable to animals, have high roots density and length are within the upper soil profile.

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