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IMPACT OF LAND USE CHANGE ON WATERSHED DYNAMICS IN SULEJA, NIGER STATE NIGERIA.

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Abstract
Suleja is an average-low income settlement area with an increasing population growth due to its proximity to the Federal Capital City (Abuja). The aim of this study was to observe land use change on watershed dynamics within Suleja to better understand the social and environmental problems that can arise in consequence. Multi-temporal satellite imagery of the study area were analyzed to see the effects of changes in the land use on the watershed using GIS methods. A population of the study area was sampled and questionnaire administered to get insight into how past scenarios of the watershed have been influenced by land use change. Significant changes in land use were quantified between 1999, 2009 and 2018. Results suggest that in this period, total water bodies have minimally reduced, Farm land decreased drastically and settlements increased. Survey and interview responses suggest that much of this change is due to population growth.. Urban expansion and development have led to the land degradation, which has increased environmental disasters for local communities. The results of this study are timely and important for analyzing the dynamics between Land use and watersheds in order to improve future management efforts in Niger state and Nigeria.

Keywords: Land Use Dynamics, Watershed, Degradation

Introduction

A watershed, also called a drainage basin or catchment area, is defined as an area in which all water flowing into it goes to a common outlet. People and livestock are the integral part of watershed and their activities affect the productive status of watersheds and vice versa. Everyone lives in a watershed (New York State Department of Environmental Conservation, 2009), and because we all live in a watershed, there is an inherent need to manage our watershed. Therefore, watershed management is the integrated use of land, vegetation and water in a geographically discrete drainage area for the benefits of its residents with the objective of protecting or conserving the hydrologic services that the watershed provides and reducing or avoiding negative downstream or groundwater impacts (Heal, 2000). Watershed area supplies water by surface or subsurface flow to a given drainage system or body of water, be it a stream, river, wetland, lake, or ocean (World Bank., 2008). The characteristics of the water flow and its relationship to the watershed are a product of interactions between land and water (geology, slope, rainfall pattern, soils, and biota) and the basic building block for integrated planning of land water use. Wetlands are also believed to play a significant role in global climate change by acting as a source of atmospheric green-house gases such as methane, carbon, nitrogen (Biswasroy, Samal, Roy, Mazumbar, 2010). The principal element in the watershed management is capturing of the rainfall in the wet season and increasing availability of water during dry periods. This offers several potential benefit including increasing soil moisture for rain fed agriculture, augmenting ground water recharge for dry season irrigation or drinking water purposes, arresting runoff in to storage structures (e.g. tanks, reservoirs etc.) for various consumptive and productive usages.

Nigeria environment today is being confronted with myriads of ecological problems, which have resulted in serious degradation of many watersheds. These environmental problems are occurring at increasing and alarming rates and are being accelerated by man's activities such as urbanization, increased agricultural activities, deforestation, bush burning, civil construction works, and over-grazing and poor water resource management among others (Iroye and Tilakasiri, 2015).

Suleja Local Government Area (LGA), due to its close proximity to the Federal Capital city of Nigeria (Abuja) is inhabited by an increasing majority of average earners from the Federal Capital City. However, reports abound that the study area has been impacted by Land use change. (Buba, Makwin, Ogalla, Okoro, Audu, 2016) submitted that increased infrastructural development and forest destruction due to continued population increase have resulted in an increased watershed degradation in the study area. The flooding of the study area 2017, which claimed many lives and properties and rendered many homeless (Vanguard, 2017) and the rise in gully erosion and steep slopes (Munir, 2011) in the study area, are clear illustration that the study area is being impacted by change in land use, and its watershed is degrading. Although, various authors, (Ejaro and Abdullahi, 2013; Buba *et al.*, 2016; Umar, 2013; Ilya, 2015; Munir, 2011) assessed and performed land use classification, and investigated urbanization rate across land use pattern, but did not investigate into its watershed dynamics. Elsewhere, impacts of land use (Charlton and Tufgar, 2013; Debnath, 2016; Yimnang *et al.*, 2011; Xiaoming *et al.*, 2008; Mohammed *et al.* 2011; Yan *et al.* 2017) on watershed dynamics are reportedly negative. (Adhikari, 2016) concluded that Land Use change is a major driver of environmental problems like water pollution, decreased soil quality, and natural resource scarcity, deforestation, change in soil moisture and ground water, reduction of retention capacity of soil. Measuring Land use change is necessary to better understand the present condition of watersheds.

Benefits from adoption of watershed management approach are reported from many arid and semi-arid tropic regions, where it has helped enhancing agricultural productivity, improving livelihoods of the watershed community and alleviating poverty (Hope, 2007). The approach for watershed management has significantly evolved since its initial years of implementation in 1950s (Reddy *et al.*, 2004; Wani *et al.*, 2008). It has progressed from being merely externally imposed biophysical interventions to a more people–centered and participatory approaches encompassing a broader range of activities (GoI, 2008). Now, poverty alleviation and improving living standards by enhancing sustainable livelihood opportunities for the watershed community should be a focal point. Despite the growing importance of watershed management as an approach to rural development and natural resource development, to date there has been relatively little research on their socio-economic implications watershed management. Very less information is available on improvement of livelihoods of the watershed community and poverty alleviation, even though it uses huge budget (Hope, 2007). Evaluative methodology that could measure the changing livelihood profiles of the watershed community quantitatively is needed as it would help determine that how livelihood cab be improved and poverty alleviated in watershed community. Therefore this study is aimed at investigating the impacts of land use change on watershed dynamics in the study area with the objectives of examining the land use pattern and the effects of the land use practice in the study area.

Study Area

Suleja Local Government Area lies between latitude 9°6'13.8'' and 9°17'49.35'' North of the equator and longitude 7°6'58.6' and 7°12'18.41' East of Greenwich Meridians (figure 1). It has an area of 136.33km.^{2}. The LGA is only 110km south-east of the State Capital Minna and bounded by the Federal Capital City of Abuja at the west in just about 65km away. Suleja lies on the physiographic unit known as central highland and is located on relatively high grounds of over 1200 feet or 366m above sea level. The driest month is December with highest amount of precipitation occurring in August/September, with an average of 272 mm. March is the warmest month of the year with an average temperature of 29.0 °C. The lowest average temperatures in the year is recorded in August, when it is around 24.5 °C. The vegetation is savannah mainly dominated by shrubs, grasses and light vegetation sparsely populated by trees of moderate height and sizes. Soil weathered from rock in Suleja is very rich in humus and favored production of crops like guinea corn, maize, melon and groundnuts with yam and rice which can all serve as cash crops and food crops.

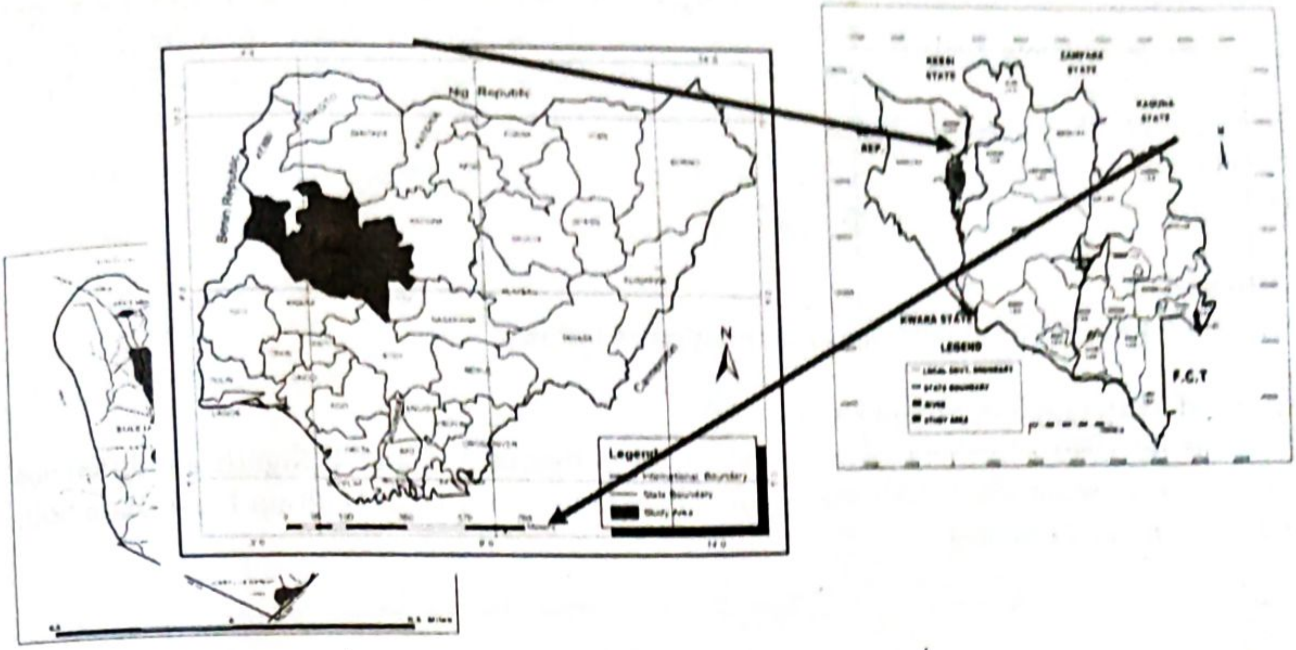

Figure 1; Study Area

Methodology

Satellite imagery of the study area for the years 1999 and 2009 and 2018 were downloaded from Global Land Cover Facility (GLCF) and US Geographic Satellite (USGS). These were processed to get the land use of the area by classifying the image into the different land use classes of built-up, farm land, bare ground water bodies and forest land. The analysis were done using the Arc GIS 10.1. Techniques used were DEM (Digital Elevation Model) preparation, delineating land-cover, giving symbol to land cover and calculating area through spatial analysis. Field verification of land cover map was carried out for confirming that land cover map created lies within corresponding natural boundary. After field verification, some corrections were made in land use map before finalizing.

Additionally, survey data from local people and key informants living in the Suleja LGA were collected through questionnaire to better understand and interpret the Land Use Land Cover (LULC) scenarios that emerged from image analysis. Survey was conducted by purposive sampling method. All people responded to the survey questions. Key informants like official members of Municipality and District Office along with elderly people of the study site who has day today experience of land use change of Suleja LGA were interviewed. Format of semi structured schedule survey is provided below in annex. Purpose of conducting this survey is to understand the people's perception about land use change and its impact. Sample size was calculated from formula given by Arkin and Kolton

$$n = \frac{N\{d^2 + Z^2 \times P(1-P)I\}}{NZ^2 \times P(1-p)}$$

Where,
n=sample size
N=total no. of household
Z=abscission of normal curve i.e., confidence level (at 95%, Z=2)
P= estimated population proportion (0.05)
d=margin of error limit (± 5 i.e., 0.05).

With a population of 215,075(National population commission of Nigeria and National bureau of statistics, web 2006) and a population projection of 302,200((National population commission of Nigeria and National bureau of statistics, web 2016) with a growth rate of 3.46% per year from 2006 to 2018. To project the population of the study area for the year 2017, the following formula will be used, given by (Doston, 2018).

$$p_t = Pe^{rt}$$

Where P_t = projected population

P = Present population

e = Natural logarithm base of 2.71828

r = growth rate

t = Time

Results and Discussion

The results obtained for the different land use are presented as follows

Land use Pattern of Watershed in Suleja LGA.

The land use classes for 1990, 2009 and 2018 are presented in figures 2, 3 and 4. Significant difference was found in Land use between 1999, 2009 and 2018. Changes in Forest land, Built-up Land, Bare Soil, Water Bodies and Farm Land can be 4

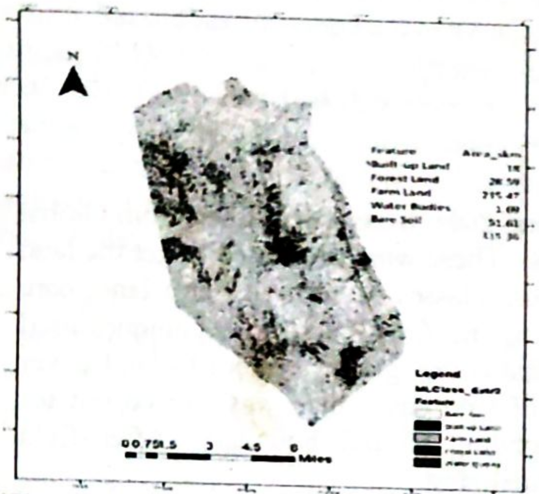

Figure 2; Landuse class 1999

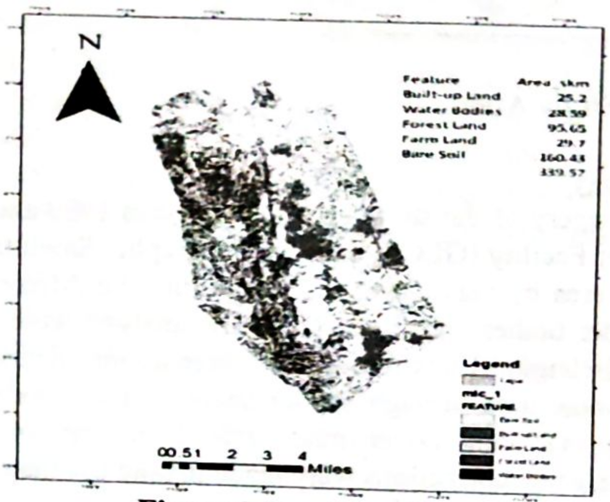

Figure 3; Land use class 2009

The distribution of land uses class in Suleja LGA for 1999 is presented in figure 2, where Built-up covers an area of 18.00km^2, Water Bodies covered 1.69km^2, Forest Land is 28.59km^2, Bare soil 29.70km^2 and Farm land with a total area coverage of 215.47. While figure 3 shows the distribution of land use classes in Suleja for the year 2009, where Built-up covers an area of 25.20km^2, Water Bodies covered an area of 2.39km^2, Forest Land a total area of 95.35km^2, Bare soil 160.43km^2 and Farm land with a total area coverage of 29.70km^2.

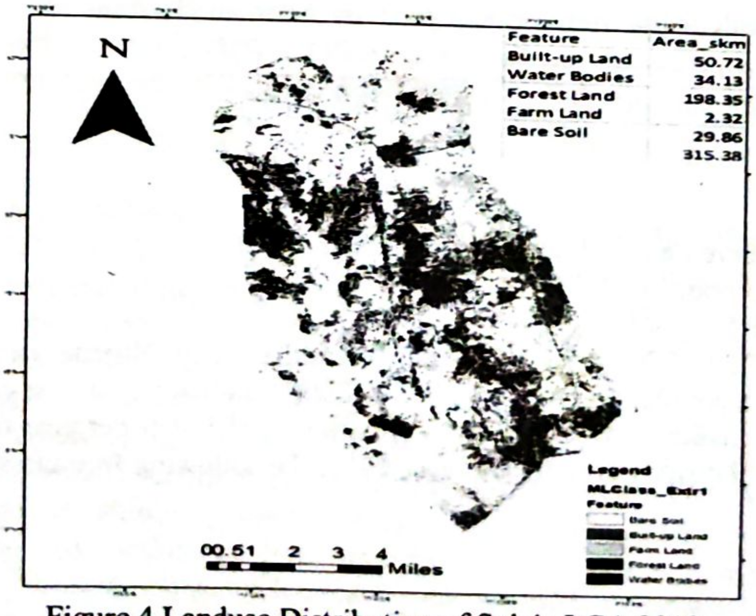

Figure 4 Landuse Distribution of Suleja LGA 2018

Figure 4 presents the distribution of land uses class in the study area for 2018, with Built-up accounting for 50.72km^2 area, Water Bodies covering an area of 2.31km^2, Forest Land covers a total area of 34.13km^2, Bare soil 198.35km^2 and Farm land with a total area coverage of 29.870km^2.

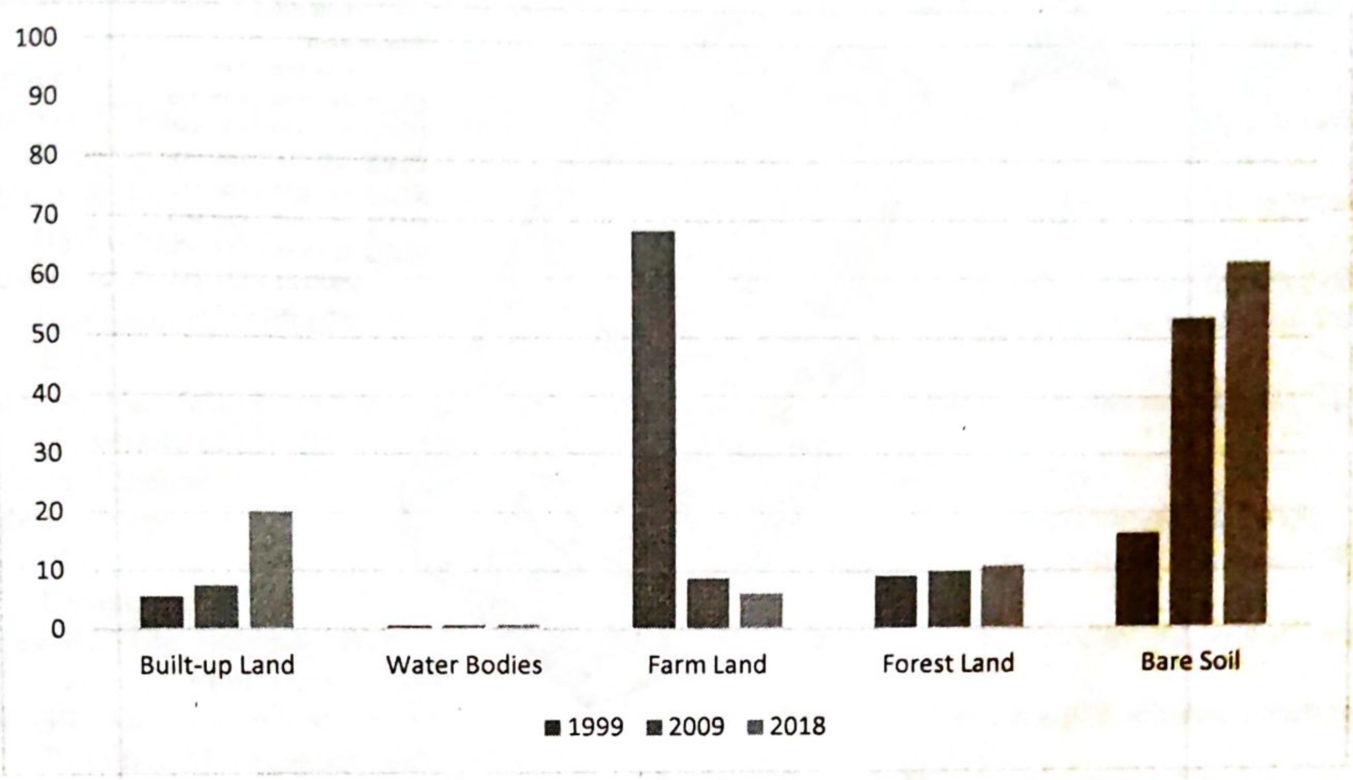

Figure 5: Land use Distribution of Suleja LGA.
Source: GIS Analysis, 2018

Analysis for the three epoch made shows that there was a remarkable increase in bare soil from 16.38 % (1999) to 47.32 % (2009) to 62.89 % (2018) (Figure5). This however indicates that residents of Suleja reduced in the cultivation of land or in other words, a higher percentage of the residents found an alternative mode of income, like trading, servicing and governmental jobs as a result of the proximity of the Federal Capital. Which in the other way round, affected the watershed, exposing the soil to the risk of hazardous events like flooding, erosion, soil infertility. Because most of the region to which the increased percentage in bare soil occupied where more of farm land (Figure 2, 4).

Furthermore, the results also shows that there was also a high increase in the built-up land from 5.56 % (1999) to 7.43% (2009) to 16.10% (2018). This rate of increase in built-up land apparently is due to the proximity of the Federal Capital to Suleja LGA, therefore, residents who cannot afford settle in the Federal Capital, tend reside in close or neighboring towns, and Suleja happens to be one of those towns. The increase in the built up has reduced the vegetal cover increased runoff and reduced infiltration of water into the ground.

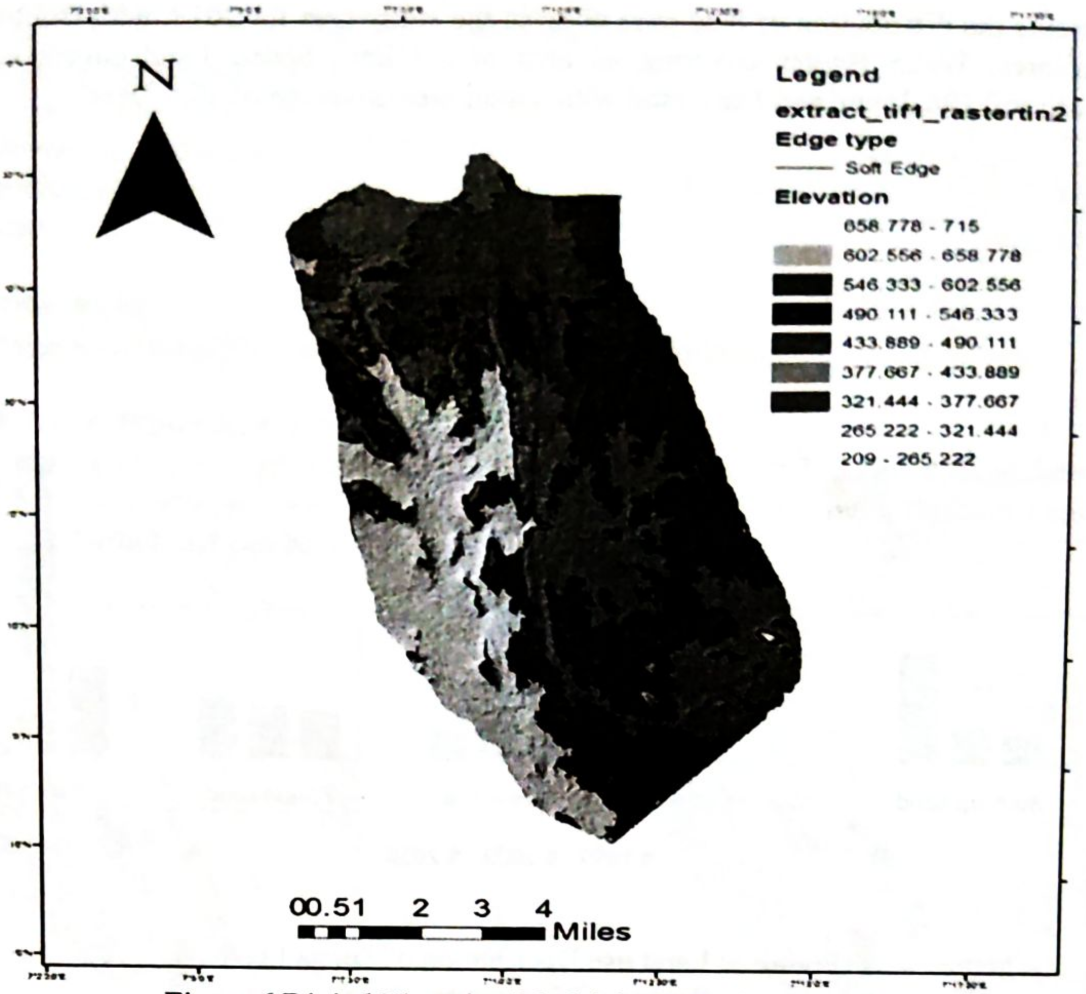

Figure 6 Digital Elevation Model (DEM).of Suleja LGA
Source: www.usgs.gov

Figure 6 shows the Elevations of Suleja LGA, with 209.000 – 265.222m as the lowest elevation, and 658.778 – 715.000 as the highest Elevations. Apparently, areas with one of the lowest elevation, are areas with less built-up land (Figure 4), and regions with high elevation are dominated by built-up (Figure 4). This however, indicating that the flooding recorded in 2017 (Vanguard) in the built-up land was not due to high run-off from rainfall. From the analysis, the increase in Water bodies (figure 5) shows that it was as a result of high run-off coming from the region with increased bare soil.

The analysis also shows that the built-up land is situated at one of the highly elevated part of the local government. Implying that the flooding recorded (Vanguard, 2017) was not due to low elevation terrain. From the field survey, it was noted that, solid waste were dumped on water channels, hindering easy and free flow of water to the streams and drainage channels, Causing waterlogging and in cases with high downpour, resulting into flooding.

According to the local people's perception, a higher percentage strongly agreed that there is no proper drainage system in the locality, making run-off from rainfall and sewage disposal create their own path. This caused the washing away of the top layer of soil, leading to soil erosion at the long run, large gully now posing threats to households in the locality. Field observations made, indicated that individuals from respective households use preventive measures like sand bagging to redirect flowing water away from their homes.

Conclusion and Recommendations

The study was able to look at the dynamics of watershed in suleja. It shows the dieeferend land use clasess for the periods under study. The results suggest that there between 1999 and 2018 there were significant changes in forest land, built-up, Water bodies, bare soil and farm land in the Suleja LGA. Forest and farm land area has been decreased while Built-up land and bare soil area has been increased. Results for survey in Farm land area and interview with the locals also show an increase in the surface run-off. These changes in land use and land cover have had negative impacts on the soil and properties of residents within the watershed. For these important reasons, this study provides invaluable data to better our understanding of the effects of past land use trends so that we can empirically predict the future environmental effects of human behavior in the Suleja watershed and elsewhere in Niger state, Nigeria.

Reference

Adedayo A. Balancing Land use and the Environment in Nigeria: Lesson from other Countries. Journal of Geography, Environment and Planning. 2007; 3 (2): 8-16.

Adediji A & Jeje Lk. Channel Erosion in Opa Basin, Southwestern Nigeria. Journal of Environmental Hydrology. 2008; 2: 1-10.

Adejuwon Jo & Jeje Lk. Land Elements of the Environmental System of Ile-Ife Area. In: Ojo A., editor. Environment Resource Based Project. No. 2, Department of Geography, University of Ile-Ife; 2015.

Ayoade Jo. Rainfall, Evapotranspiration and Water Balance in Nigeria. Unpublished Ph.D. Thesis, University of London. 2014.

Ayoade Jo. Tropical Hydrology and Water Resources. Agbo-Areo Publishers; 1988.

Ayoade Jo. Tropical Hydrology and Water Resources. Macmillan and Agbo Areo Publishers; 2013.

Barrow CJ. River Basin Development Planning and Management: A Critical Review. World Development. 1998; 26 (1): 171-186.

Chorley RJ. The Drainage Basin as a Fundamental Geomorphic Unit. In: Chorley RJ, editor. Water, Earth and Man. London: Methuen;.2009. 77-99.

ClapP GR. An Approach to the Development of a Region. In: Burton I and Ka RN, editors. Readings in Resource Management and Conservations, Chicago; 2010. 298-307.

Cunningham GM. Total Catchment Management: Resource Management for the Future. Journal of Soil Conservation NSW. Australia. 2016; 42 (1): 4-5.

Delleur Jw. Introduction to Urban Hydrology and Storm Water Management. Kibler DF, editor. Water Research Monogr. Washington D.C; 2010; 7: 1-34.

Edwards Pj, Williard Kwj & Schoonover, JE. Guiding Principles for Management of Forested, Agricultural and Urban Watersheds. Journal of Contemporary Water Research and Education, 2015; 154: 3-2011.

Oyegun Ro. Discomfort in the Use of Domestic Tap Water in a Developing Tropical City. Weather. 2008; 32(2): 41-43.

Oyegun Ro. Man-Induced Movement of Earth Materials unto Ilorin City, Nigeria. Environmental Education and Information. 1987; 6 (2): 142- 152.

Sale K. Dwellers in the Land: The Bioregional Vision. San Francisco, C.A.: Sierra Club Books. 1985.

ScuddER T. Recent Experiences with River Basin Development in the Tropics and Subtropics. Natural Resources Forum. 2014; 18(2): 101-113.

Sinha S, Shulkla M & Shukla R. A Text Book of Environmental Studies. A.I.T.BS Publishers, India; 2008.

Srinivas H. Environmental Management and Disaster Reduction: An Introduction. GDRC Research Output E-021 Retrieved from http://www.gdrc.org/vem/disasters/disenvi/intro. html on the 10th Nov. 2015.

Strahler AN. Quantitative Analysis of Watershed Geomorphology. Trans. American Geophysical Union. 2009; 38: 913-920.