IMPACT OF LAND USE LAND COVER CHANGE ON SURFACE WATER QUALITY IN LAKE TILLA

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Abstract: In this study, an attempt has been made to determine the impact of LULCC on surface water quality in Lake Tilla. The study used Landsat imageries for the dates 1986, 1996, 2005 and 2015 with ten (10) years interval spacing. Twenty water samples were randomly collected from selected points using standard methods suggested by APHA (American Public Health Association). Analysis was done using Smart Spectrophotometer machine to determine the concentration of chemical indicators such as nitrate, phosphate, cadium, hardness, sulphate, ammonia, potassium and turbidity for both dry and raining seasons. The result was compared with guideline values for drinking water provided by World Health Organization (WHO) and Standard Organization of Nigeria (SON). Result obtained show that natural vegetative cover (Forest) and built up area were the most affected land cover class. Built up area has increased from 0.2 hectare (0.42%) in 1986 to 2.9 hectare (5.8%) in 1996 and 7.1 hectare (14.2%) 2005. It equally increased to 10.0 hectares (20.1%) in 2015. Forest degraded from 12.5 hectare (24.9%) in 1986 to 5.6hectare (11.3) in 1996. It further decreased to 0.7 hectare (1.4%) in 2005 and 1.1 hectare (2.2%) in 2015. The decrease in the vegetation cover of the area could be associated with the increase in population globally which have affected virtually every area particularly the study area. This is accompanied with expansion of agricultural lands to meet the food demand of the population and also utilization of trees for building of residential houses for the populace. These have increased surface runoff because most of the vegetative covers which serve as buffer against runoff from agricultural farms have been cleared through bush burning, over grazing, land clearance for settlement or farm lands.Results from water analysis indicated that Turbidity, Ammonia (PO_4^{3-}) and Potassium (K^-) (Mg/l) have exceeded the guideline value and are source of contaminant in Lake Tilla. However the values of Sulphate (SO_4^{2-}), Nitrate (NO_3^-) and Posphate (PO_3^{4-}) that is still within the recommended guideline. Setting up environmental agencies to monitor afforestation programmed and regulate the use of chemical fertilizer will help in restoring the lost beauty of the area.

Key Words: Land Use land Cover, supervised classification, deforestation, guideline value, and water quality.

1.0 Introduction

Rapid urbanization, anthropogenic and socioeconomic activities and environmental changes, are important components responsible for extensive land use land cover changes (LULCC). Land use refers to the way in which land has been used by humans and their habitats, usually with accent on the functional role of land for economic activities. Land cover changes occur naturally in a progressive and gradual way, however sometimes it may be rapid and abrupt due to anthropogenic activities which include: conversion of forest to agricultural land use and build up lands (6). Demand for food and shelters as the population increase are major factors for LULC, more lands have to be cleared to make way for production. Land Use Land Cover Changes has been often identified as primary source of excess nutrients, widespread sedimentation, and toxic and organic pollutant in rivers around the world (14). Destruction of natural riparian land cover, especially wetlands, can further exacerbate nutrient loading from agricultural lands by reducing or eliminating riparian nutrient uptake, deni-trification, and sedimentation of adsorbed phosphorus (1).Key concerns in Land used Land Cover Changes include soil erosion, increase run off, diversion and conversion of water channels into settlement, waste generation and off- site movement of fertilizer nutrients (primarily nitrogen and phosphorus), altered hydrology, removal/ impairment of critical habitat used by wildlife, and global change through production/ sequestration of greenhouse gases, such as carbon dioxide and nitrogen oxides (17). Rapid changes in Land uses cause increase number of people living in a town, based on survey of Tilla, was a small farming settlement but witnesses persistent increase in population which could be attributed partly to upgrading of Lake Tilla by Borno State Government, Numan – Biu road construction and rising insecurity affecting the other part of Southern Borno State. Due to rising population over the years, lots of pressures have been imposed on the land resources in Tilla where approximately 75% of the populace engages in agriculture but only 20% of its land is arable. As a result, the shortage of arable land has led to expansion of cultivation into the wetter margins of rangelands, deforestation and decline of grassland, charcoal burning and other unsustainable land uses (7). These actions have far reaching implications on the integrity of natural resources and ecosystems in the area especially the surface water resource.

This is particularly worrisome because water quality from streams and lake located in agricultural dominated areas contain contaminants such asnitrate, nitrogen, phosphorus, Sulphate are found too often exceeding standards for protection of human health and/ or aquatic life and because detectable changes over recent periods are usually trends of increasing rather than decreasing concentration (Dubrovsky et al. 2010). The presence of contaminants that deviate from acceptable World Health Organization (WHO) guideline values have been associated with the cause of different diseases such as typhoid, fever, dysenteries, cholera, gastrointestinal and infectious hepatitis (5).

Providing safe drinking water is one of the most complex challenges facing African rural communities. The continent has the highest number of people lacking access to safe, drinkable water. According to World heath Health Organization (2012), more than 3.4 million people die each year from water sanitation and hygiene-related causes and majority of these are in Africa. The impact of the consumption of unsafe drinking water in Africa has been likened to "death of children at a rate equivalent of a jumbo jet crashing" (20). Nigeria is one of many African countries facing problem of accessibility to clean water. Although it was reported that 27 million Nigerians have gained access to clean water since 1990, only 47 % of the population can access safe water (19). The biggest population facing water shortages in Nigeria come in rural North Eastern region where over 70% of the population cannot access clean water (21). Lake Tilla is a Crater Lake which was formed as a result of volcanic activities with no inlet nor outlet, and has been the source of water for the community around the Lake, between 1973 – 1983. The lake completely dried up but suddenly resurged between 1980s to 1990s but this time due to erosion it created over six inlet all coming from the hilly site where agricultural activities is dominant (10). It is against this background that this study was carried out to investigate the change in LULC patterns and its impact on the water quality in the area.

2.0 Study Area and Methods

2.1 The Study Area

Lake Tilla is in Huwal Local Government Area on the Biu Plateau. The lake lies between latitude $12^0 14'$ – 12^0 and longitude $10^0 55'$ - 10^0E in KwayaBura district. The Lake is a volcanic crater which has a length of about 840.6 meters and a width of about 653.8 meters with steep side walls rising 40.43 meters above sea level. The shape of the lake could be described as an oval shape or likened to a pear or an egg shape (4). The national population commission (2006) census put the population of KwayaBura district at 17,820 people. The projected population of Kwaya Bura District was 78,336 in the year 2020. Two climatic seasons have been identified in the study area; dry season which is marked by the prevalence of the north east trade wind which is characterized by dry, dusty and hazy north-east trade wind that blows over the area from November-March. The weather condition associated with the wind can even reach the earlier part of March. The wet season (rainy season) commences around April-October and sometimes can be experienced up to early part of novermber though it is rare. Higher amount of rainfall experienced in September, the mean annual rainfall is over 800mm on Biu Plateau (Daura et al 2005). This usually accompanied with heavy storms and thunder with lightning.

Soil in the area can be classified into: alluvial soil of the river, basement complex derived from rocks and these soils have varied from a rich loam soil, clay and sandy soil to silt. The land is rich for the rising of seedlings such as garden eggs, pepper, tomatoes among others. Cultivation of crops like maize, ground nuts, cocoyam, and soya beans are practiced by the rural communities around Lake Tilla.

Vegetation of the study area falls within the Sudan Savannah. Lake Tilla is located in a place or surrounding formally use to be a forest reserve consist of hilly sites, but however, most of the original vegetation in the area was cleared as a result of human activities (4). The few trees found along the river banks include: acacia, Shea-butter, locust bean, tamarind, baobab trees among others.

The topography of Biu is divided into hill/mountainous area which are generally over 600m above sea level and plains of less than 600m above the sea level.

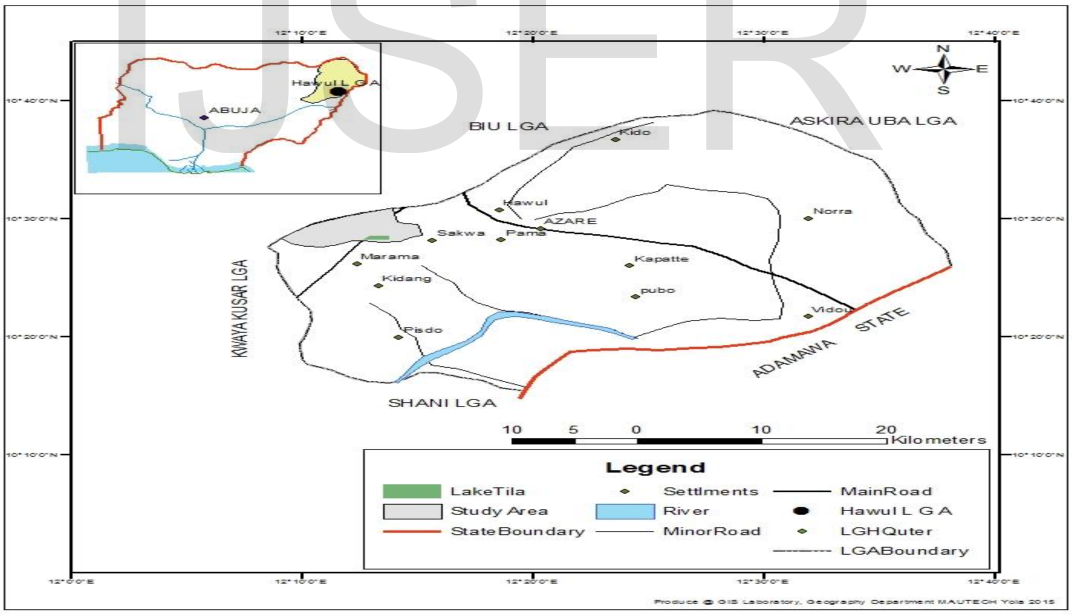

FIGURE 1.1 Location of the Study Area

2.1 Methods

2.2Satellite imageries and Water Sample Analysis

In this study, a topographic series of Nigeria sheet 132 1:50,000 of Biu (S. W 1969) of Biu were used to extract the boundary of Lake Tilla. For LULC mapping of the area, Landsat 5TM, 7 ETM+ 7 and 8 OL1 satellite images of (1986, 1996, 2005 and 2015) were used. Satellite data were procured from National center for remote sensing Jos. The satellite data and cencillary data were processed and field survey was conducted for ground truthing to perform supervised classification. The satellite data was processed in ERDAS Imagine 9.2 software for geometric correction to remove geometric distortions, introduced by the sensor system. The imageries were georeferenced using ground control points with a root mean square error (RMSE) of less than one pixel. The Universal Transverse Mercator (UTM) geographic projection, WGS84 spheriod and zone 32 North datum were used in georeferencing the images. Pixel based supervised image classification with maximum likelihood classification algorithm was used to map the LULC classes. Five LULC classes viz: Built up area, water body, agricultural land use, bare surface and forest were identified for classification.

Twenty water samples were randomly collected from different locations. The samples were collected using a 1.5 litre plastic container and chemical analysis was conducted using standard laboratory methods suggested by APHA (American Public Health Association, 1995).Analysis was done at National Agency for Food Drugs Control and administration(NAFDAC)Laboratory in Maiduguri using smart Spectrophotometer machine.Samples were analyzed to determine concentration of chemical contaminant indicators such as Nitrate, Phosphate, Cadium, Hardness, Sulphate, Ammonia and potassium. Laboratory values were generally compared with the chemical guideline values for drinking water quality provided by World Health Organization (WHO) (2011) and standard Organization of Nigeria (SON) (2007). In situation whereby World Health Organization (2011) does not provide a guideline value we have relied on guideline values from literature including other World Health Organization publications. However, where (15) does not provide a guideline value, we have treated this as unavailable. Chemical concentration of these indicators that deviate from the guideline values were treated as contaminants.

3.0 Result and Discussion

3.1 Land Use Land Cover Changes

Satellite images of 1986, 1996, 2005 and 2015 were analyzed for changes in agricultural land use around Lake Tilla which is one of the objectives of this study. The results are presented in a fashion to understand the static and dynamic distribution of Land use Land cover types changes and factors that influenced the changes over time. The results are shown essentially by maps and statistical tables as follow.

Table 1: Land Use/Land Cover Changes of Lake Tilla

	1986		1996		2005		2015	
Landuse Classes	**Area (hectare)**	**Percentage (%)**	**Area (hectare)**	**Percentage (%)**	**Area (hectare)**	**Percentage (%)**	**Area (hectare)**	**Percentage (%)**
Bare surface	31.1	62.2	27.0	54.0	15.6	31.2	16.0	32.1
Forest	12.5	24.9	5.6	11.3	0.7	1.4	1.1	2.2
Agricultural land	1.6	3.2	11.4	22.8	20.7	41.4	18.3	36.6
Water Body	4.6	9.2	3.1	6.1	5.9	11.7	4.5	9.0
Built Up Area	0.2	0.42	2.9	5.8	7.1	14.2	10.0	20.1
TOTAL	50.02	100	50.02	100	50.02	100	50.02	100

Significant changes were found in the LULC maps, prepared from Landsat imageries of 1986, 1996, 2005 and 2015 (Fig 2), changes analysis was carried to compare the years values (Table 1). Regardless of the proportion of changes in size of the land cover types, significant changes have been observed between 1986 and 2015. In this period of 29 years agricultural land use, vegetative cover (Forest) and built up area were found as most affected land cover classes.

Built up area has increased from 0.2 hectare (0.42%) in 1986 to 2.9 hectare (5.8%) in 1996 and 7.1 hectare (14.2%) 2005 (Table 1). It equally increased to 10.0 hectares (20.1%) in 2015. Forest degraded from 12.5 hectares (24.9%) in 1986 to 5.6hectare (11.3) in 1996. It further decreased to 0.7 hectare (1.4%) in 2005 and increased to 1.1 hectare (2.2%) in 2015. The decrease in the vegetation cover of the area could be associated with the increase in population of the study area. This is accompanied with expansion of agricultural lands to meet the food demand of the population and also cutting down of trees for building of residential houses for the populace. Agricultural land use increased from 1.6 hectares (3.2%) in 1986 to 11.4 hectares (22.8%) in 1996. It further increased to 20.7 hectares (41.4%) in 2005 and decreased to 18.3 hectares (36.6%). This increased surface runoff because most of the vegetative covers serving as buffer against runoff from agricultural farms have been cleared through bush burning, over grazing, land clearance for settlement or farm lands.

The result reveal bare surface from 31.1 hectares (62.2%) in 1986 to 16.0 hectares (32.1%). This could be attributed poor farming techniques such as over utilization, poor used of chemicals which reduce soil fertility which is clearly reveal in the result on why bare soil keep on increasing. Afforestation program done in the area together with construction/ upgrading of lake tilla to a Tourist by Borno State government helped in restoring the vegetative loss of the area as reveal in the result 2005 to 2015 (table 1).Increase in population could be another factor where much pressure will be on the little resource to produce more output for the teaming population. The crater was formed over 65 million years, an enclosed depression with no inlet nor outlet (10). But with time due to denudation processed that has taken place within the Lake catchment from the hilly parts of western side six gullies were opened which serve as recharge point (Dibal et al. 2020). Pattern of change clearly have impact on quality of water in the lake as a source of drinking water.

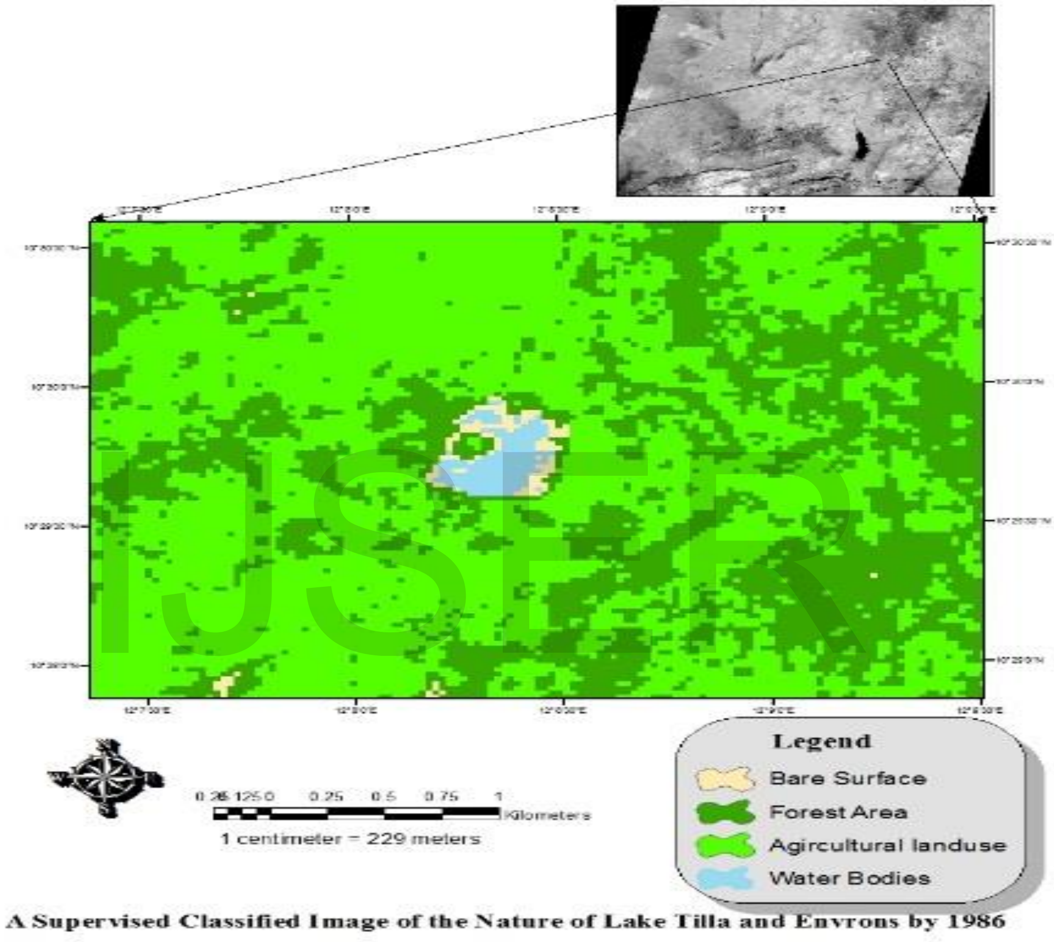

Fig 2: Analyzed image of the Lake Tilla for the year 1986.

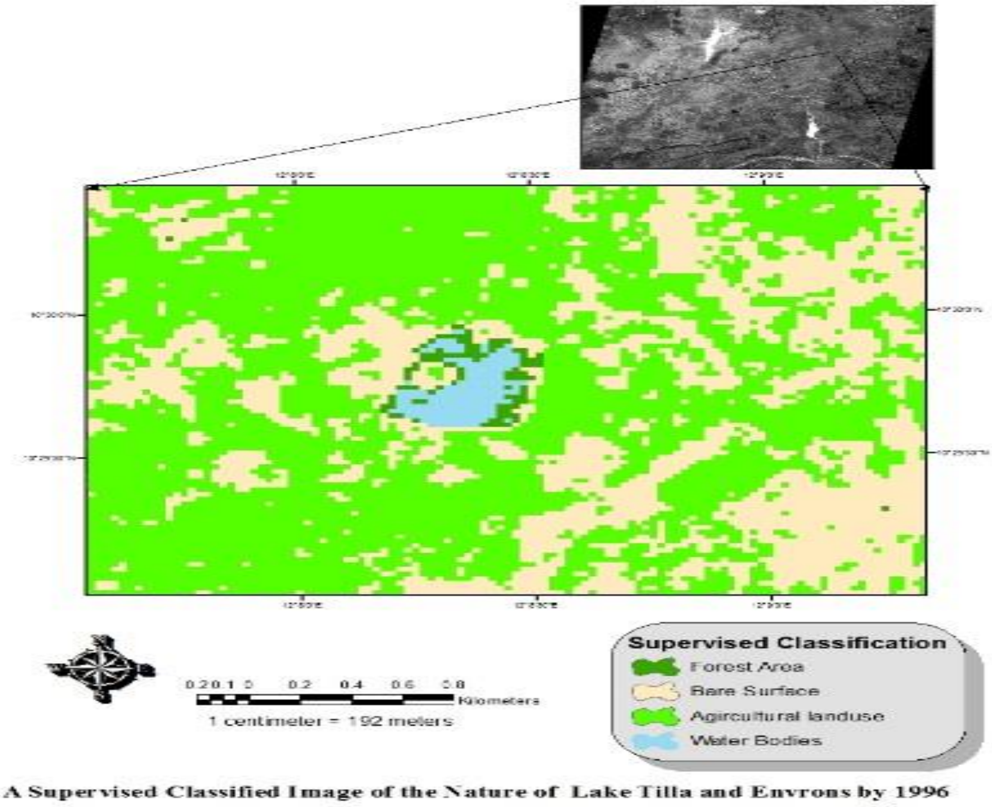

Fig 3: Analyzed image of the Lake Tilla for the year 1996.

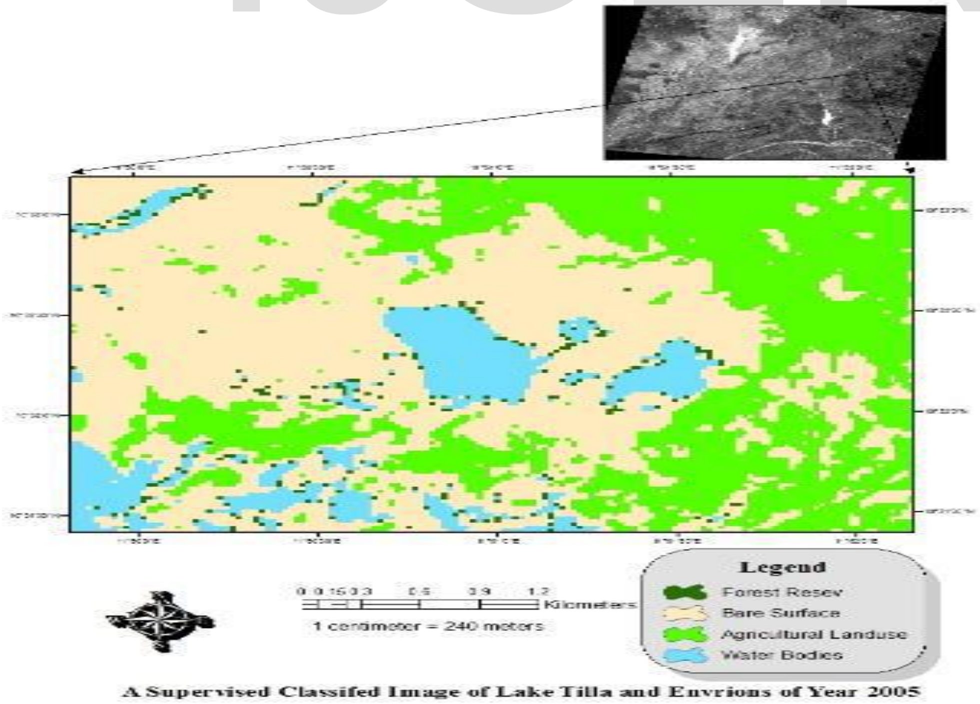

Fig 4: Analyzed image of the Lake Tilla for the year 2005.

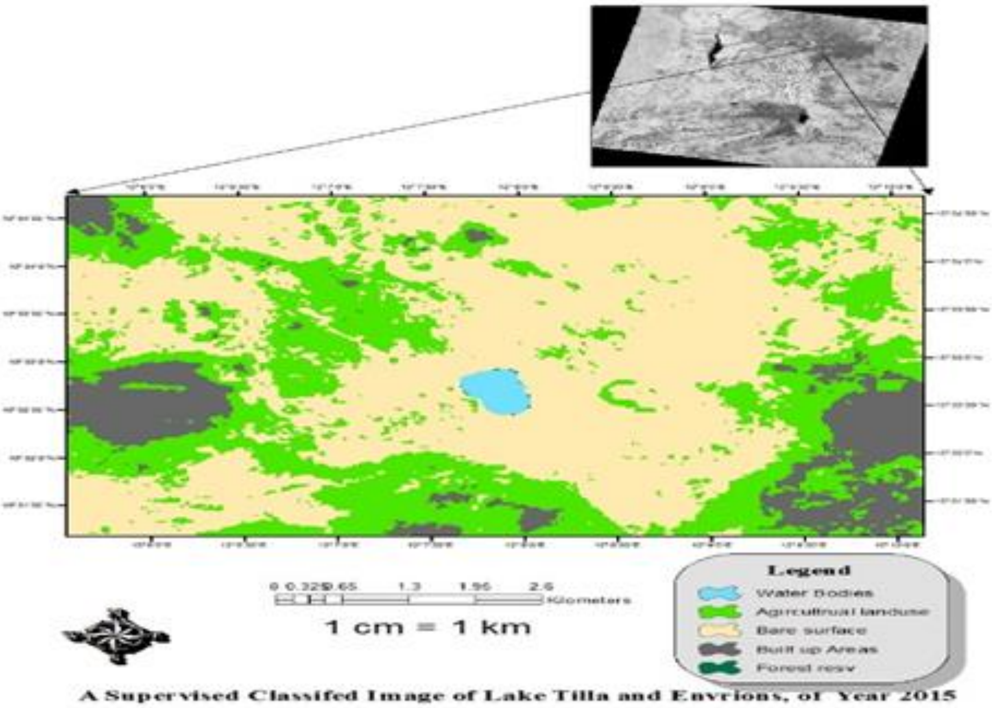

Fig 5: Analyzed image of the Lake Tilla for the year 2015.

*3.1*Water Quality Results

Water analysis was carried out so as to ascertain the likely impact of land Use Land Cover Change on the water quality of Lake Tilla as a source of drinking water. Table 2 shows results of dry season. Six elements were assessed for two seasons and the results presented in table 2 and 3 below:

Table 2. Chemical concentration of water samples from Lake Tilla in Dry Season

SAMPLING LOCATION	Nitrate (NO_3^-) (Mg/l)	Ammonia (PO_4^{3-}) (Mg/l)	Posphate (PO_3^{4-}) (Mg/l)	Sulphate (SO_4^{2-}) (Mg/l)	Potassium (K^-) (Mg/l)	Turbidity (NTU)
POINT (1)	0.91	0.22	0.70	0.91	59	20.00
POINT (2)	0.92	0.19	0.86	0.50	77	35.00
POINT (3)	0.90	0.22	1.07	0.70	58	37.00
POINT (4)	0.77	0.29	1.01	5.90	44	40.00
POINT (5)	0.97	0.38	0.70	0.91	68	50.00
POINT (6)	0.90	0.19	0.62	0.59	50	26.00
POINT (7)	1.04	0.50	0.70	0.58	34	35.00

POINT (8)	0.99	0.20	1.00	0.61	50	60.00
POINT (9)	1.15	0.50	0.94	0.60	100	55.00
POINT (10)	1.20	0.19	0.80	0.91	89.0	40.00
Mean Value	**3.94**	**0.48**	**0.84**	**1.22**	**57.9**	**30.8**
WHO Guideline	50	0.3	1[A]	500	82[B]	6.12
SON Guideline	50	0.19		100		45.00

A: no health – base guideline was proposed for phosphate in world Health Organization 2011, value is based on Fadiran et al. (2008).

B: no health – base guideline was proposed for phosphate in world Health Organization 2011, value is based on world Health Organization (2009).

3.2.1 Water Quality evaluation for dry Season

The results showed that one (1) chemical indicator tested from the water sampled was outside the guideline limit prescribed by SON and WHO in dry seasons which is Ammonia (PO_4^{3-}) (Table 2). Ammonia (PO_4^{3-})mean concentration is0.48 mg/l in dry Season; the WHO guideline value is 0.3 mg/l while SON value is 0.19mg/l (Table 2). It will be sufficient to conclude that this parameter poses a health problem as far as WHO and SON guideline for drinking water is concerned as is likely to be source of contamination in the lake.

Table 3. Chemical concentration of water samples from Lake Tilla in Raining Season

SAMPLING LOCATION	Nitrate (NO_3^-) (Mg/l)	Ammonia (PO_4^{3-}) (Mg/l)	Posphate (PO_3^{4-}) (Mg/l)	Sulphate (SO_4^{2-}) (Mg/l)	Potassium (K^-) (Mg/l)	Turbidity (NTU)
POINT (1)	2.15	0.39	0.60	0.71	60	22.00
POINT (2)	5.50	0.43	0.70	0.40	70	39.00
POINT (3)	5.00	0.44	0.60	0.50	50	43.00
POINT (4)	4.22	0.40	1.00	0.90	40	40.00
POINT (5)	4.11	0.60	0.55	2.91	52	46.00
POINT (6)	3.22	0.35	0.45	0.55	50	20.00
POINT (7)	4.04	0.60	0.70	0.60	36	47.00
POINT (8)	1.12	0.59	0.70	0.55	50	60.00
POINT (9)	4.00	0.70	0.55	0.60	80	45.00
POINT (10)	4.00	0.39	0.60	0.47	50	43.00
Mean Value	**3.74**	**0.49**	**0.65**	**0.82**	**53.8**	**40.5**
WHO Guideline	50	0.3	1[A]	500	50[B]	6.12

SON Guideline	50	0.19		100		45.00

A: no health – base guideline was proposed for phosphate in world Health Organization 2011, value is based on Fadiran et al. (2008).

B: no health – base guideline was proposed for phosphate in world Health Organization 2011, value is based on world Health Organization (2009).

3.2.2Water Quality evaluation for Raining Season

The results showed that three (3) chemicals indicators tested from the water sampled were outside the guideline limit prescribed by SON and WHO in raining seasons these are Ammonia (PO_4^{3-}),Potassium (K^-) and Turbidity (Table 3).Ammonia (PO_4^{3-}) concentration is0.49mg/l in rainy Season; the WHO guideline value is 0.3 mg/l while SON value is 0.19mg/l (Table 3). It will be sufficient to conclude that these parameters pose a health problem as far as WHO and SON guideline for drinking water is concerned as is likely to be source of contamination in the lake.

Nitrate concentration in raining Season 3.74mg/l,the guideline value for WHO is 50mg/l while that of SON is also 50mg/l (Table 3). It will be sufficient to conclude that this parameter does not pose a health problem as far as WHO and SON guideline for drinking water is concerned as is unlikely to be source of contamination in the lake.

Posphate (PO_3^{4-}) concentration in raining season is0.65 mg/l, the guideline value for WHO is 1 mg/l while that of SON is Nil (Table 3). It will be sufficient to conclude that this parameter does not pose a health problem as far as WHO guideline for drinking water is concerned as is unlikely to be source of contamination in the lake.

The mean concentration value of Sulphate (SO_4^{2-}) in raining season is 0.82 (Mg/l)and WHO guideline value is 500mg/l while SON guideline value is 100mg/l (Table 3).It will be sufficient to conclude that this parameter does not pose a health problem as far as WHO guideline for drinking water is concerned as is unlikely to be source of contamination in the lake.

3.3 Water quality evaluation: parameter outside any of the guidelines

Turbidity

Turbidity is a physical parameter, which is a measure of cloudiness of water. It is caused by particles suspended or dissolved in water that scatter light making the water appear cloudy or murky. The particulate matter can include sediment – especially clay and silt, fine organic and inorganic matter, soluble coloured organic and inorganic compounds, algea, and other microscopic organisms (12). Turbidity generally has no direct health effects; however, it can interfere with disinfection and provide a medium for microbial growth (2). This may indicate the presence of disease causing organism such as bacteria, viruses, and parasites that can causing symptoms such as nausea, cramps, diarrhea, and associated headaches (13).

In this study, the value of turbidity is outside the WHO but is well within SON guideline for drinking water in riningseasons. In rainy season, turbidity value was40.5 Mg/l and guideline value for WHO is 6.12Mg/l while SON men value for turbidity is 45.00Mg/l. The concentration was generally better in dry season with the value of 30.8Mg/l (Table 2). It will be sufficient to conclude that this parameter still post a health problem as far as WHO guideline for drinking water is concerned as is likely to be source of contamination in the lake.

In this study, the source of turbidity is most likely due to run off from farm lands, loose soil through the process of tillage, cultivation and harvest. These form solution either as mud or silt and are all being carried to the Lake through run off.

Ammonia (PO_4^{3-})

Concentration of ammonia in the water from the study astearanges from 0.48Mg/l to0.49 Mg/lfrom dry season to raining season. This valueis well outside the SON and WHO guideline values of0.3Mg/l and 0.19Mg/l (Table 3 & 4).

Ammonia can occur naturally in ground water, while in the environment, ammonia originates from metabolic agricultural activities especially from intensive rearing of farm animals. Ammonia in water is an indication of possible bacteria, sewage and animal waste pollution. In the study area, this could be as a result of possible application of organic fertilizer (animals waste) in the farm. This is a general practice in the study area where especially wastes from animals will be applied in the farm before tillage which help improves the soil nutrient of the farm and increases harvest (4).

It will be sufficient to conclude that this parameter still poses a health problem as far as WHO and SON guidelines for drinking water is concerned as is likely to be source of contamination in the lake.

Potassium (K^-) (Mg/l)

The concentration of potassium in water sample range from 53.8 Mg/l in raining season to 57.9 Mg/l in dry season. This is outside the entire standard cited in literature including the value of 50Mg/l cited in World Health Organization (2008) as average potassium concentration in drinking water, based on the Canadian province with highest measured potassium concentration.

4.0 CONCLUSION

Lake Tilla is typically a well vegetated area which is characterized by hills, forest cover and beautiful sceneries, it is known to provide source of water to communities around that area. However a long period of uncheck anthropogenic activities such as deforestation, bush burning over grazing, deep gully erosion, over cultivation have transformed the area from what it used to be. Excessive use of fertilizer to support crop production along the hilly area which is the major source of recharge is being transported via run off to the Lake.This has affected the quality of the water as a source of drinking, such that turbidity, ammonia and potassium were found to be sources of contaminations in the lake.

5.0 RECOMMENDATION

Base on the findings above, the following recommendations have been put forward;

1. Action should be taken by all stakeholders including community participation on reforestation of the area in order to restore the lost vegetation cover of the area.
2. Farming along the slope of the Lake should be discouraged so as to minimize transportation of sediment and deposition into the Lake.
3. Action should be taken by the government to ensure sustainable development around the lake for sustainable economic development of the region.Farming and grazing on the slope and close to the lake should be minimize.
4. Setting up of environmental agency in Tilla to Monitor poor sanitary condition and educate the community on dangers of water contamination.
5. Setting up of small water treatment plan so as to have all the contaminants treated before use for any domestic purposes.
6. Promoting the use of appropriate technologies for increase crop production, for example sustainable irrigation systems and popularization of water harvesting techniques as other suitable agronomic practices.

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