Impact of Gully Erosion on Landuse /Land Cover in Bida Town Niger State, Nigeria

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Abstract
Gully erosion, the most impressive and striking erosion type, has been recognized as one of the major global environmental problems. It has threatened and even destroyed many of the urban infrastructures, properties and endangers human lives. This research work therefore, assessed the impacts of gully erosion on land cover and land use in Bida urban area. Data used in this study were derived from satellite imageries, Global positioning system (GPS). The study observed that forest/vegetation decreased by 41.9 percent during the study period indicating a change to other land uses and termination of construct drainage system half way (before getting to the natural drainage channel) identified as the main factors that triggered the formation of gully erosion in the study areas Dokodza and Darachita. Gully have been initiated by the both natural and anthropogenic factors such as rainfall intensity, soil and the slope characteristics and erected structures on the natural flow path way. Therefore, both natural and anthropogenic activities contributed to the development and expansion of this menace. Results from the interpretation of satellites imageries showed that gully variables (length, and widths) have significantly increased. At Dokodza Gully claimed a total land area of 123.6m^2 in 2005, 476.1m^2 in 2010 and 1285.2m^2 in 2015 and at Darachita Gully destroyed a total land area of 391.2m^2 in 2015 and 2549.m^2 in 2016. The length of Gully at Dokodza also increased from 182.6m in 2005 to 202.3m in 2010 and to 219.5m in 2015 and for the Darachita, it increases from 322.1m in 2015 to 444.8m in 2016. Finally, This paper recommends structural and non-structural landscaping measures as good control and management techniques to check continuous gully erosion problems and its impacts, regular clearing or dislodge of drainages to enhance free flow of storm water and debris, diversion of runoff water to less or no risk areas, public awareness campaign to enlighten the inhabitants on the dangers and needs to control erosion.

Keywords: *Gully Erosion, Global Environmental Problem, Forest/Vegetation, Endangers.*

Introduction

Human activities disturb the land surface of the earth and thereby induce the significant alteration of natural erosion rates. Soil erosion by water has been recognized as the most severe hazard threatening the protection of soil as it reduces soil productivity by removing the most fertile top soil (Vrieling, *et al.*, 2008).
Gullies are channels deeper than 30cm that cannot be removed by normal cultivation. They can be spectacular to look at but over time actually lose less soil than sheet and rill erosion. Gully is the worst stage of all types of soil erosion and it is a highly visible form of erosion (Abdulfatai *et al.,* 2014), which affects several soil functions (food and other biomass production, water storing, filtering and transformation, habitat and gene pool, physical and cultural environment for mankind, and source of raw materials) and hence soil quality.

There are contradictory views about the share of gully erosion in the total amount of soil loss;

however, gully erosion represents a major sediment producing process, generating between 10% and 95% of total sediment mass at watershed scale whereas gully channels usually occupy less than 5% of the total watershed (Hailu *et al.*, 2015; Poesen *et al.*, 2003). Moreover gully erosion is often the main source of sediments in water bodies and results in severe land degradation (Tebebu *et al.*, 2010).

Consequently, erosion affects a large proportion of the earth's population. The direct (on-site) effects of erosion include soil loss (soil depth reduction), water loss, gully development, decreasing soil fertility with consequent productivity decline as well as disturbance of the water regime. However, indirect effects of erosion are environmental pollution, river sedimentation, and reduced water reservoir capacity, damage to buildings and infrastructure and effects on areas located on a further distance from the location where actual erosion is taking place (offsite effects). The world map on the status of human-induced soil degradation shows that the effects of loss of top soil and terrain deformation as a result of soil erosion include deforestation, removal of natural vegetation and overgrazing (Shrestha, *et al.*, 2007).
Like in other parts of the world, gully erosion is one of the major environmental challenges facing Nigeria. Previously, soil erosion has been identified as the most threatening environmental hazard in the country (Albert, *et al.*, 2006). In Nigeria, the incidences of soil erosion from various sources have constituted much nuisance to man's environment. This has been in terms of causing road accidents, blocking of drainages and destroying road networks, burying of fertile soils surfaces, and increase in water treatment coats, damage to buildings, fences and silting of reservoirs among others (Jimoh and Ajewole, 2007). This occurrence emerges solely due to man's incessant interaction with the land surfaces.

Accordingly, the factors of soil erosion in Nigeria resolve into two components: physical (geologic or natural) and anthropogenic (human or accelerated). Study has however, revealed that the human component in soil erosion is often exaggerated while the effects of physical component are usually underestimated (Ofomata, 2005).
Recently several change detection techniques have been developed that make use of remotely sensed images. A variety of change detection techniques and algorithms have been developed and reviewed for their advantages and disadvantages. Among these Unsupervised classification or clustering, Supervised classification, PCA, Hybrid classification and Fuzzy classification are the most commonly applied techniques used in classification (Rundquist *et al.*, 2001, cited by butt, *et al.*, 2015). Several other researchers have employed the same technique and achieved highly satisfactory results including Rawat and Kumar (2015), who applied the same technique to monitor land use/land cover change in Hawalbagh block, district Almora, Uttarakhand, India.

The most affected in all the states in Nigeria is Anambra State where Agulu, Nanka and Oko communities are areas that erosion has impacted most (Abdulfati, *et al*., 2014). Threat to soil is not peculiar to South-Eastern part of Nigeria only, but also the Northern part particularly North Central in states like Niger, Benue and Kogi (Adewuyi, 2014). Some of the factors responsible for soil erosion in north central include urbanization, deforestation, cutting down of trees as fuel for cooking and dug out pit created from soil excavation activities (Adewuyi, 2014). Bida metropolis in Niger state cannot be excluded because it has similar factors responsible for erosion.

The specific objectives for this study are to assess the land- use/ land cover change and the temporal changes of the gully erosion.

Materials and Methods

Study Area

Bida is a Local Government Area in Niger State, Nigeria and a city on the A124 highway which occupies most of the area. It is located southwest of Minna, capital of Niger state. Bida has an area of 51 km² and a population of 188,181 at the 2006 census. Bida lies between latitude 9°5′30″ - 9º2'07″N and longitude 5º58'30″- 6°3′0″E on the Nupe Sandstone formation which consists of plains with ironstone capped hills and has an altitude of 151m.

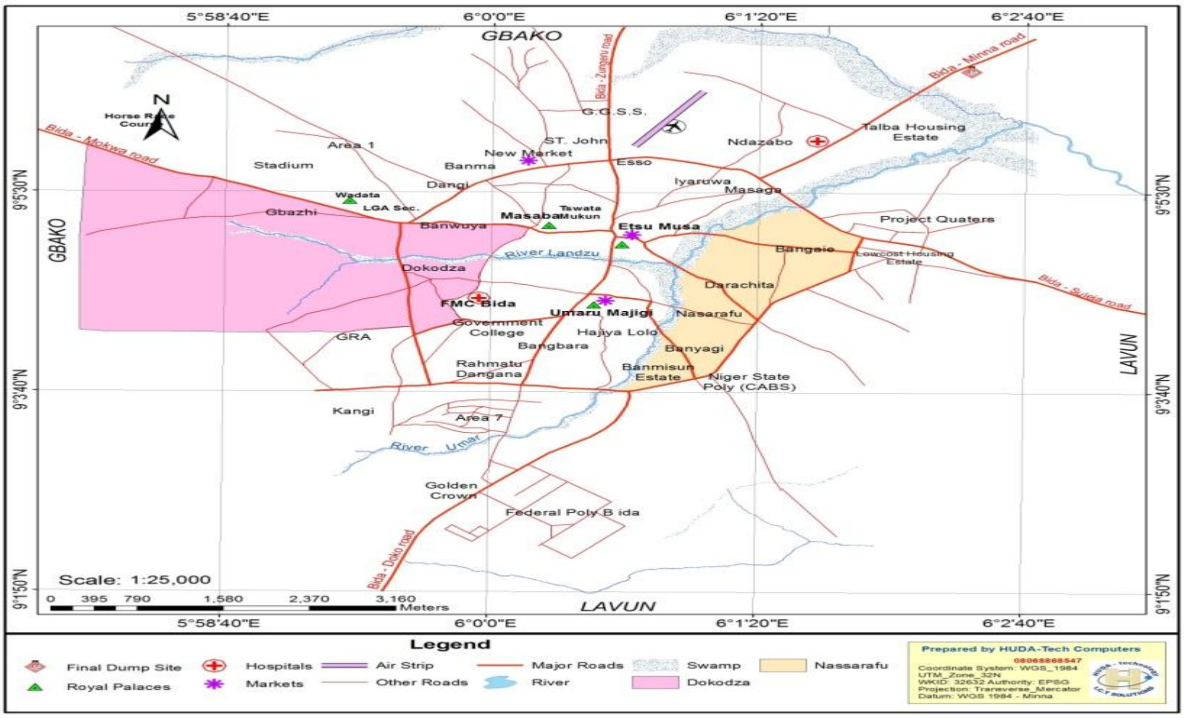

Figure 1: Bida Showing the Study Areas

Data Collection

The data collected for the study are classified into primary and secondary data. The primary data are coordinates of already existing gully sites obtained from GPS observations during reconnaissance survey of Bida and attributes data during oral interview. Secondary data source includes five satellite imageries, journals, textbooks and internet. Some of the approaches employed in the work include the integration of Geographic Information System (GIS) and Remote Sensing with use of Global Position System (GPS), direct field observation and oral discussion with the inhabitants to assess the impact of gully erosion on settlement, identifying the gully locations in the study area, establishing the various causes of soil erosion in the study areas The soft ware's used in the work include ArcGIS 10.1, excel sheet.

Data processing procedures

Both the remote sensing technique and field survey were applied for interpreting the satellite images taken by Land sat ETM, 7 and 8 in order to investigate the land use of the study area from 1995 to 2015. The gully in the study area was not observed in the land sat imageries because of the scale. The images were classified in to various land use types in Erdas imagine for image processing, Arcgis was used to generate map layout and determined the area using supervised and unsupervised classification techniques and ground- trothing of the major land uses done within the study area. The images were classified into four classes, namely forest area, agricultural area, built up, and bare land. For the purpose of estimating rate of gully development a method was adopted from Musa *et al.*, 2016. Satellite imageries (SRTM) of 2005, 2010 and 2015 for the first site and 2015, 2016 for the second with 1 m resolution were acquired from Global Land Cover Facility (GLCF) as shown in Figures 2, 3, 4 , 5 and 6 respectively. The interval in years was taken in order to identify a significant increase of the gully. The size of the area devastated by the gully was determined by importing the imagery into ArcGIS 10.1 software environment. The area was then calculated by editing and digitizing along the gully edge and path on the satellite imagery using polygon features on the Arctool box and the area lost to the gully was automatically calculated in square meter in the attribute table of the software. Subsequently, the total area lost to the gully erosion between the study periods was determined by repeating the same procedure on the ArcGIS 10.1 environment.

Results and Discussion

Land use and Land Cover of the Study Area from 1995 to 2015

Land use and land cover types in the study area have changed from1 995 to 2015. Ground trothing was carried out despite the fact that the images were more than a decade, using physical features like routes as sample points. The analysis reveal that in 1995 the predominant category of land-use/cover types is forest/vegetation 22154.202 km^2 (43%) of the study area. The inhabitants were very small in number and their occupation then was farming and hunting and other primary activities. Built up area occupied only 8758.638km^2 (17%), bare surface covered 10819.494 km^2 (21%) and Farm land 9789.066 km^2 (20%). The land use changing and the changes were shown in table 1.

In the 2005 land use category, there was a decline in forest decreases to 16486.848km^2 (32%) of the total land cover of the study area. Built up areas increased to 12880.350km^2 (25%). There was settlement expansion. The sudden change in demography and other physical modifications was as a result of continued influx of people due largely to urbanization. Farm land occupied 10304.280km^2 (20%) Bare soil increased to 11849.922km^2 (23%) due to the opening of new areas for construction of houses and transport routes.
The land use distribution trend differed slightly from 2005 to 2015 as seen in table 4.3. Despite its continuous decline over the years largely to human activities in the study area, Forest/vegetation now covered 12880.350(25%). More land is covered by farm lands because there is an increase in farm land category to 11334.708(22%). Build up land category increased has to 15971.634 (31%) and Bare land decreases to 11334.708(22%).

Table 1: Land use/cover change in Bida (1995-2015)

Land cover type	**1995**		**2005**		**2015**		**Relative Change of area (%)**
	Area(km)	%	Area(km)	%	Area(km)	%	1995-2015
Farm Land	9789.066	20	10304.280	20	11334.708	22	+15.8
Build up land	8758.638	17	12880.350	25	15971.634	31	+82
Forest/Vegetation	22154.202	43	16486.848	32	12880.350	25	-41.9
Bareland	10819.494	21	11849.922	23	11334.708	22	+4.8
Total		**100**		**100**		**100**	

Source: Author's data analysis 2018

Satellite image analysis showed that land use and land cover changes have occurred in the area between 1995 and 2015. Between 1995 and 2015 from the table 1 above, built up area, bare land and farm land continued to expand, while forest land decreased. Forest/vegetation land was therefore converted to built-up area, bare land, and farm land. Although built up areas, agricultural/ farm land, bare land, forest/ vegetation land did not change significantly for the period under investigation, An increase in built up area, bare land and agricultural land and a decrease in forest/vegetation are probable drivers of gully erosion. An increase in built up area results in a decrease in forest/ vegetation.

In line with this, numerous studies have given justification to the probable impact of landcover change on gully erosion. According to Maitima *et al*., (2009) land use changes in East Africa have transformed land cover to farmlands, grazing lands, human settlements and urban centres at the expense of natural vegetation. These changes are associated with deforestation and land degradation. Similar results to this study were observed by Gachene, *et al.*, (2015) in Lower Tana River Forest Complex reveals that most of the area previously under forest was lost to cultivation. Opening the forest for cultivation and degradation is still continuing at an alarming rate, which is also the Scenarios in the study area.

A study by Ayuyo *et al*., (2014) also showed that changes in land use and land cover had occurred in the Mau forest complex, resulting in the reduction of forest cover. This is because the local community depend on forest products for farming, building materials, wood fuel, and charcoal burning which could be the Scenarios in the study area. Another study by Njoka *et al*., (2003) in Lambwe Valley, south western Kenya reveals that human settlement caused land-use and cover changes, resulting in a scramble for the remaining high potential land, which could be the case in the study area. In Bida, forest/vegetation decreased by 41.9 percent in 2015 indicating a change to other land uses. With no interventions, gully erosion activity will continue resulting in a threat to livelihoods. Scenarios of land-use and land cover change therefore help to explore possible futures and can generate indicators of ecological sustainability or of vulnerability of ecosystems and people.

Temporal Change in Gully Morphology

The satellite imagery was processed to determine the temporal changes of gully erosion in study area site 1 between 2005 and 2015 and then 2015 and 2016 for the site 2. Figure 2, 3, and figure 4 reveals the significant changes in gully morphological variable at site 1 (Dakodza). The width of gully has been expending over time, figure 2 shows that a total land area of 123.6m^2 (6.6%) was claimed by gully in 2005, figure 3, showed that in 2010 gully expended and covered a total area of 476.1m^2 (25.2%) and figure 4, revealed that this disaster occupied a total land area of 1285.2m^2 (68.2%)in 2015. At site 2, figure 5, reveals that gully eroded a total land area of 391.2m^2 (13.3%) in 2015 and figure 6 shows that gully covered a land area of 2549.m^2 (86.7%) in 2016.

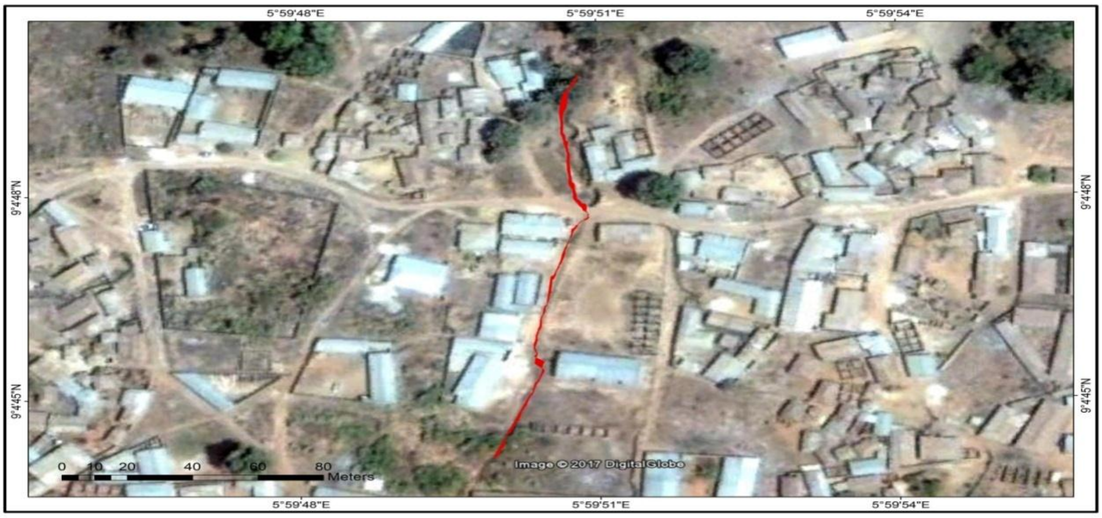

Figure 1: Satellite Image Showing the Gully in 2005 at Site 1 (Dakodza Area)

Gully length also witnessed changes from 182.6m^2 to 219.5m^2 and from 322.05m^2 to 444.85m^2 at both site 1 and 2 respectively. The interpretation of the satellite image shows an increase from 182.6m^2 (30.2%) in 2005 to total areas of 202.3m^2 (33.5%) in 2010 and 219.5m^2 (36.3%) in 2015 for the site 1 and for the site 2 gully increases from 322.1m^2 (42.0%) in 2015 to total areas of 444.8m^2 (57.0%) in 2016. This indicates that gully erosion is developing at an alarming rate especially at the study site 2. If the erosion menace is not urgently addressed, buildings and other vital infrastructure as well as vegetation that protect the top soils within the vulnerable areas will be devastated within few years.

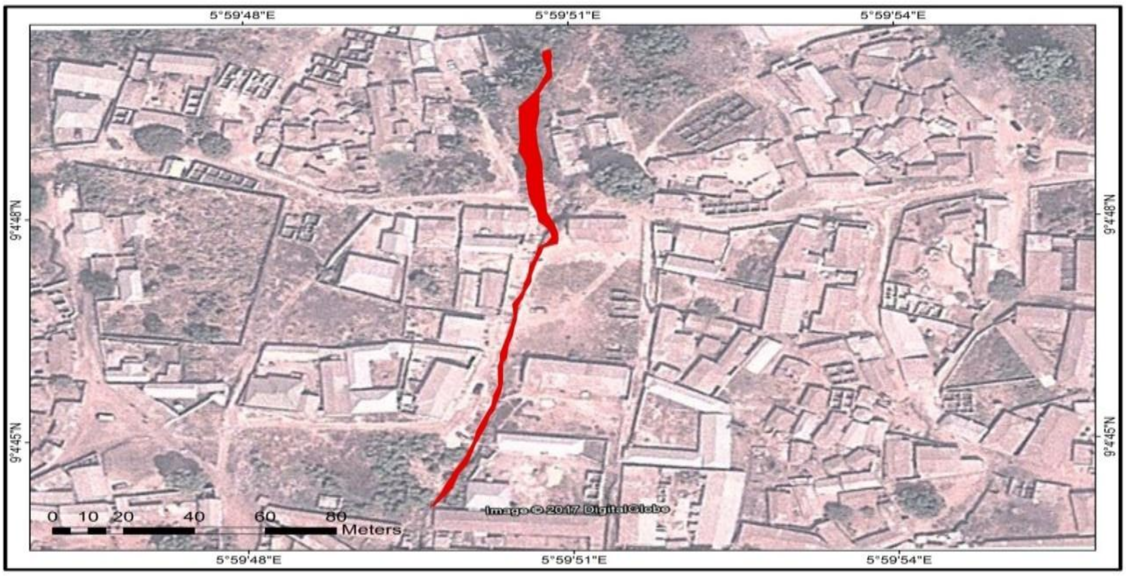

Figure 2: Satellite Image Showing the Gully in 2010 at Site 1 (Dakodza Area)

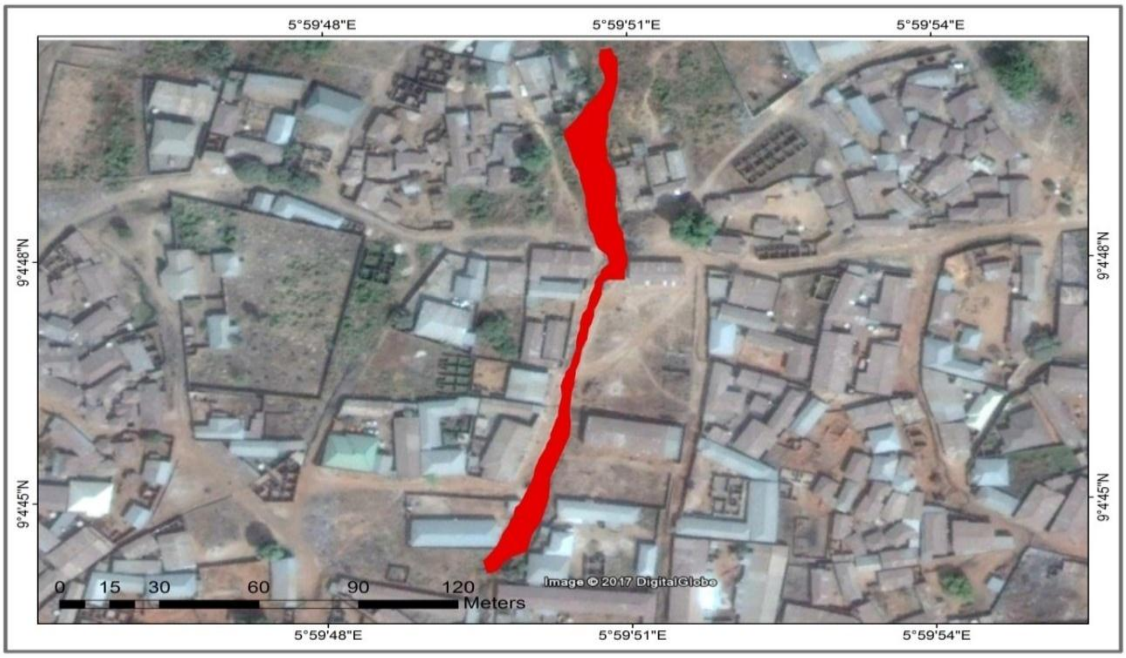

Figure 3: Satellite Image Showing the Gully in 2015 at Site 1 (Dakodza Area)

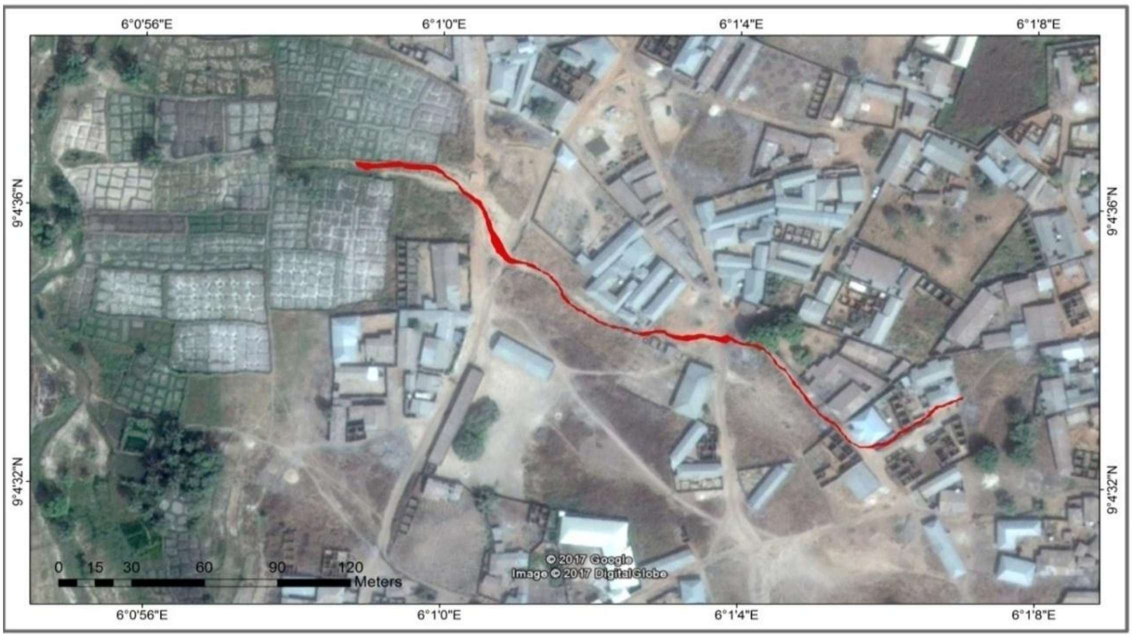

Figure 4: Satellite Image Showing the Gully in 2015 at Site 2 (Darachita Area)

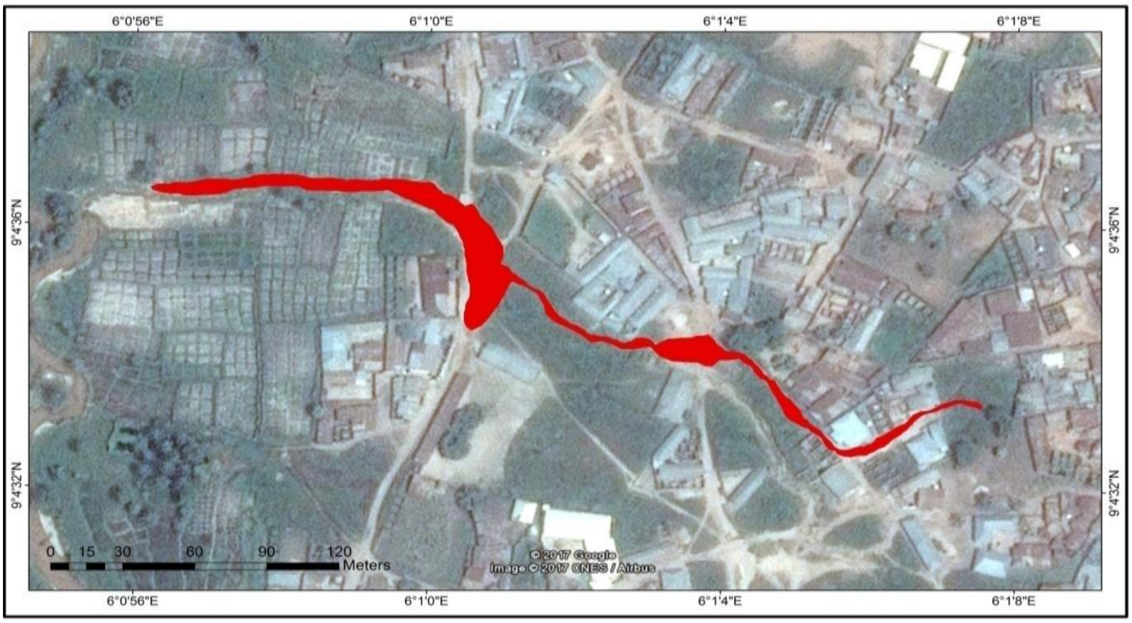

Figure 5: Satellite Image Showing the Gully in 2016 at Site 2 (Darachita Area)

Conclusion and Recommendations

It is highly imperative and pertinent to note that after thorough examination of the causes and consequences of gully erosion in the study area. It is established beyond reasonable doubt that both natural and anthropogenic activities contributed to the development of this menace. Forest/vegetation decreased by 41.9 percent during the study period indicating a change to other land uses. This study observed that the main factors that have triggered the formation of gully erosion in Dokodza area (study site 1) is the termination half way (before getting to the natural drainage channel) of the construction work of the erosion channels being constructed some years back and in Darachita area (study site 2) gully have been initiated by the natural factors such as rainfall intensity, soil and the slope characteristics. From the visual observation, most of the affected buildings were not constructed with regard to the Town Planning regulations.

Conclusively, the continuous increase in gully development is mainly as a result of the observed human activities in the study area ranges from deforestation and conversion in the land cover type, the improper channelling of runoff water, indiscriminately development of building on the water ways, and Infrastructures such as roads are built without proper environmental studies and some of the roads were constructed with sufficient drainages to channel the runoff into the nearby stream. Due to the significant changes that can be seen from the imagery urgent attention is required for mitigating or addressing this disaster. Therefore, there is a need of an intervention with effective gully control measure to impede the gully expansion so that the degradation of lands of the Bida and sediment yields to the River Landzun from gully erosion will be reduced. The use of Remote sensing and GIS and excel sheet has proved effective in mapping and determination of the extent of gully erosion menace at near accurate level.

There should be deliberate efforts by the government to refill and construct a proper drainage system that will be channelled to a safe discharge points down the stream. The erosion channels should be diverted from critical areas to areas with little or no risk as well as construction of concrete culverts to channel the storm water.

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