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A GIS Approach to the study of oil Spillage on Agriculture in Jesse Community, Delta State, Nigeria.

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Abstract: Oil spillage has been an intractable problem in the Niger Delta region of Nigeria. This paper uses GIS to assess the effects of oil spillage on Agriculture in Jesse Community in the Niger Delta Region of Nigeria. Objectives stated include: capture the various agricultural landuse in the study area over a period of 20 years; identify causes/sources of oil spillage and area affected by the spillage over the years; determine the impact of oil spillage on agricultural land; and evaluate landuse change of the study area. Primary and secondary sources of information were employed to obtain needed data. Landcover were classified with the use of ARCGIS 10.1 software into oil spill area, cultivation, built up areas and vegetation. Findings revealed that the principal cause of spills was attributed to human errors and equipment failure. Result from the supervised classification revealed that oil spillage is increasingly affecting agricultural land use in the study area. The study further revealed that oil spill has a negative and statistically significant impact on agricultural land use in a manner consistent with economic expectation. Using flow accumulation model the vulnerable areas were ranked in order of very low, low, moderate and very high. Recommendation includes qualitative employee training and preventive maintenance culture as remedy to continuous oil spillage.

Introduction

Agriculture and petroleum sectors are important sectors in the economy of Nigeria. Agricultural sector was the backbone of the economy in the 1960s and early 1970s. Nigeria was heavily dependent on agriculture, which contributed over 50percent of the GDP and engaged about 80percent of the labour force. It was the major source of information for implementing the first development plan, 1962-1968. Within a decade up to 1983 however, there was a decline in agricultural output in Nigeria from 18.4 percent to 1.9 percent and export fell to 7.9 percent. Agricultural imports as a share of the total imports increased from 3 percent in the late 1960s to 7 percent in the early 1980s (Aminu and Anono, 2012). Unfavorable agricultural development in Nigeria resulted from the loss of compositeness among farm exports hence, the real values of the Nigerian Naira appreciated substantially from 1970 to 1972 and from 1982 to 1983 (Aminu and Anono, 2012). The sector has however suffered from years of

mismanagement, and inconsistency in the government policies and the era of huge oil revenues has also contributed to the neglect of the agricultural sector.

Over six decades now the oil industry has remained the leading sector of the Nigerian economy. The economy of the country is now heavily dependent on the oil sector which accounts for over 95 percent of export earnings and about 85 percent of government revenues (Energy Information Administration (EIA) (2009). The oil industry is primarily located in the Niger Delta area of the country. All stages of oil exploitation impact negatively on the environment and oil spillage is the greatest single intractable environmental problem caused by crude oil exploration in the Niger Delta region. Oil spillage is one of the contentious issues facing the oil industry, host communities especially the Niger Delta and the government of Nigeria (Aminu and Anono, 2012). These oil spillages occurred primarily in the main oil producing communities of the riverine areas of the

Niger Delta, in which the Jesse Community of Delta state forms a part. Furthermore, most of the inhabitants of Jesse Community are involved in agricultural activities which mostly involve farming and fishing.

Over 50 years of oil exploration as a result of several cases of oil spills and uncontrolled flaring of gas in the Niger Delta has resulted in an unduly high level of environmental degradation (Douglas, 2006). Oil spills have degraded most agricultural lands in the State and have turned hitherto productive areas into wastelands. Increasing soil infertility due to the destruction of soil micro-organisms, and dwindling agricultural productivity, have forced farmers to abandon their land, to seek non-existent alternative means of livelihood. Aquatic lives have also been destroyed due to the pollution of traditional fishing grounds thereby exacerbating hunger and poverty in fishing communities. Oil pollution affects the physicochemical properties of the soil such as temperature, structure, nutrient status and pH among others.

Although a number of studies have been carried out to determine the socio economic effect of oil companies on the host communities, For instance Okpako (2012) studied the Influence of Oil Activities on the Socio-Economic and Environmental Health of Host Niger Delta Communities in Nigeria and concluded that oil activities in the oil producing areas of Delta-State negatively influence the entire gamut of the lives of host communities: socially, economically, the environment and their sources of nutrition. Onosode (2003) explained that the activities of oil exploration and exploitation at the Niger Delta have exposed their land to soil erosion and flooding Furthermore, oil spillage and marine resources are systematically depleted, traditional occupation (farming and fishing) are endangered and communities economically

impoverished. Elum et al (2016) examined **Oil exploitation and its socioeconomic effects on the Niger Delta region of Nigeria and concluded** that oil exploitation has increased the rate of environmental degradation which has perpetuated food insecurity as a result of death of fish and crops as well as loss of farm lands and viable rivers for fishing activities leading to loss of livelihood. Despite these, little or no progress has been made in determining the impacts of oil spillage on agricultural lands with the use of GIS in Jesse Community. Hence, there is the need to evaluate the effect of oil spill on Agricultural land with the use of GIS. Specifically, the study will capture the various agricultural land use in the study area over a period of 20 years (1993-2013); identify sources of oil spillage and area occupied over the years (1993, 2003 and 2013); determine the impact of oil spillage on agricultural land over a period of 20 years (1993-2013); and evaluate Land use change of the study area, 20 years interval.

The impact of oil spillage on Agricultural production/activities

Generally, agricultural technology has remained relatively unchanged over the years and over 90% of the farmers are subsistent farmers operating on traditional methods using basic tools. Azibolomari, (1998), stated that: "Farming technique practiced in the Niger Delta still remain the use of land rotation or bush fallow system characterized by land and labour being the principal inputs of production."

The organic farming technique widely used in the Jesse area is highly susceptible to environmental changes affecting the soil, water and or deforestation because it is not technologically inspired, but rather land and labour intensive. Oil extraction and production has led to adverse environmental

impact on the soil, forest and water of Jesse community. This has ultimately affected peasant agriculture in a variety of ways. Some of the landless farmers migrate to more fertile lands in other rural communities, putting pressure on scarce fertile lands. While some of the displaced farmers out-migrate to the urban areas in search of other means of livelihood (Worgu, 2000: 4).

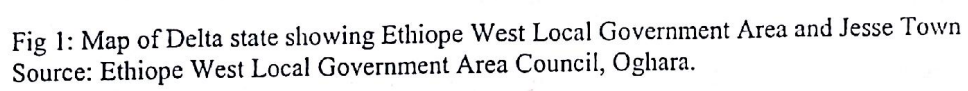
In this farming community, most people are engaged in crop farming, with greater emphasis upon household consumption. And their most severe problems were poor quality soils and pollution of the land even though they were somewhat distant from the oil-producing sites. Other serious problems related to their farming operations were found to be lack of inputs, insufficient capital and inadequate extension services (Hassan et.al, 2002). During crude oil extraction, harmful and toxic substances are introduced into the natural environment. This changes the geo-chemical composition of the soil, river and other components of the environment. Stanley, (1990:67-79) noted that "7.7% of the 797 people interviewed on the socio-economic impact of oil in Nigeria identified farm land pollution as a major problem".

Study Area and Methods of Study

Jesse is situated in Ethiope West Local Government Area of Delta state (Fig.1). It is located on latitudes $5^{\circ}15'N$ and $6^{\circ}00'N$ and longitudes $5^{\circ}40'E$ and $6^{\circ}25'E$. It occupies an area of about 500 square kilometers in the southern part of Delta State. The town is about 55kms from Asaba the capital city of Delta State. The Niger

Delta is a home to numerous oil wells in the country and also the geo political zone mostly affected by oil spillage (Figure 2). The estimated population of Jesse is about 7000 persons (NPC, 2006). The climate of Jesse is humid sub-equatorial with a long wet season lasting from March to October that alternates with a short dry season that lasts from November to February. The climate is influenced by two prevailing air masses namely South West Monsoon Wind and the North East Trade Wind. Annual rainfall is high throughout Jesse; being usually up to 2500mm. annual temperature average in Jesse is about $27^{\circ}C$ with no marked seasonal departure from the average temperature as the annual range of temperature is quite small, rarely exceeding $30^{\circ}C$ (UNDP, 2006).

The vegetation is diverse and economic plants like raffia and rubber thrive in commercial quantity (Egbe and Thompson, 2010). The most important river in Jesse is river Ethiope and it is prone to flooding during the wet season mainly because of the heavy rainfall, high ground water table and the flat-floored valleys (UNDP, 2006). The major occupation in Jesse community includes farming, fishing, trading, lumbering, mining, palm wine tapping and manufacturing. Farming is the mainstay of the people which is mainly subsistence and commercial in nature. The farmers usually grow tree crops, especially rubber purely in order to generate income. The main food crops grown in Jesse include cassava, water yam, plantains, cocoyam and groundnuts.



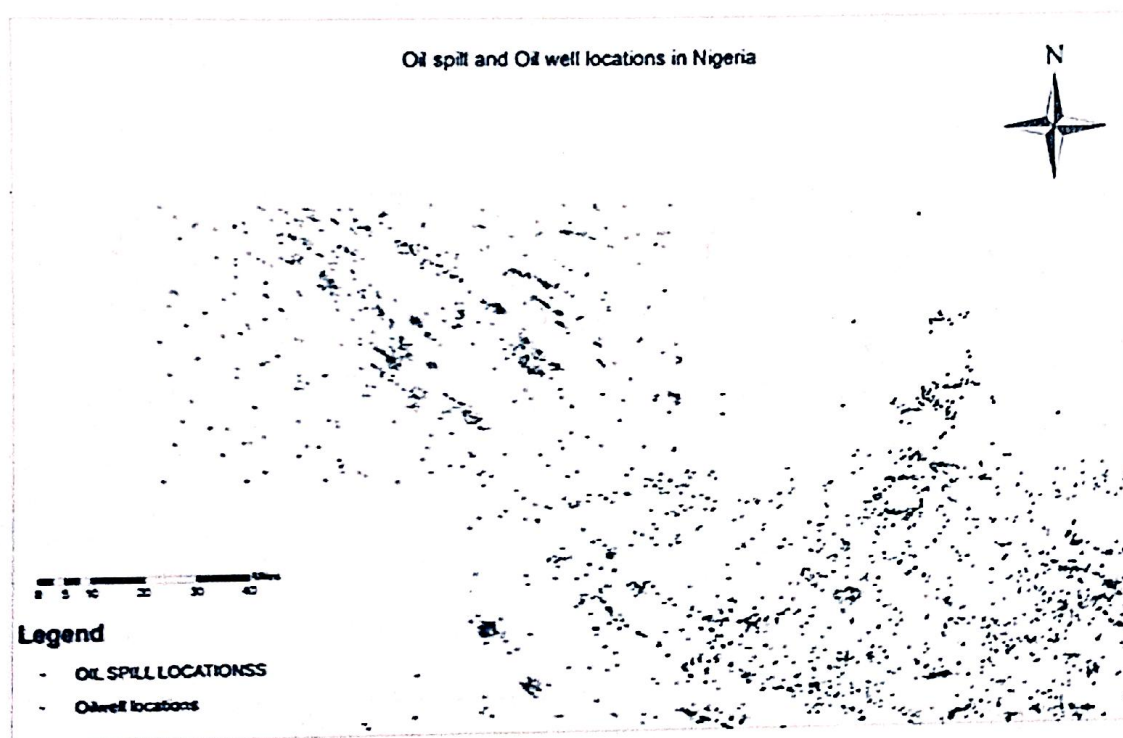


Fig 2: Oil Spill and Oil Well locations in the Niger Delta region of Nigeria.
Source: Department of Petroleum Resources, Abuja

Data was collected from primary and secondary sources. Primary source involves data collected from satellite images such as landsat as they are direct observation images. The imagery show the land use, land cover map of the study area from which the physical implications of oil spills was derived. Secondary sources include textbooks, seminar papers, journals, and magazines.

Results and Discussion

Various Agricultural Land Use in the Study Area

To examine the land use activities within the study area, land use and supervised classification of the land use types were analyzed. It was discovered that one of the major land use type in the study area is Agriculture. Agriculture is the mainstay of the people which is mainly subsistence and commercial in nature. The study area was therefore mapped out using high resolution satellite imagery. Various agricultural land uses in the study area were captured and clearly revealed.

Table 1: Summary of the Agricultural Land Area in the Study Area

	Area (HA)	%	Area (HA)	%	Area (HA)	%
	1993		2003		2013	
Agricultural land/bare land	20617	71.10	13713.3	47.29	10250	35.35

Source: Authors' field work, 2015

The agricultural land was seen to occupy a total area of 20,617ha which represents 71.10% of the total study area in the year 1993. In 2003, it occupied a total of 13,713.3ha which is 47.29% of the total study area. In 2013, it occupied 10,250ha which is 35.35% of the total study area (Table 1). The decrease in percentage could be attributed to oil spillage which had made farmers abandon their farms for another occupation.

Identification of the sources of Oil spillage and Area Occupied

Sources of oil spillage were identified to be 8% leakage facility, 2 % natural cause and 90% vandalism in Jesse Community. The area occupied by the oil spill each year in the study area was identified using high

resolution satellite imagery. Classification of the various ground covers was carried out. This was done to review the dynamics of the land use and land cover changes and also to know the area covered in each year. Oil spill area was digitized for 1993, 2003 and 2013 respectively. In 1993, no oil spill case was recorded, in 2003; Oil spill area occupied a total area of 4595.959ha which represents 14.78% of the total study area. This was attributed mostly to leakage. In 2013, oil spill occupied a total area of 4265ha which represents 14.71% of the total study area. The oil spill in 2013 was attributed to pipeline vandalism. It is therefore evident that oil spillage has been spreading to larger area from 1993 to 2003 and showed a decline in 2013.

Table 2: Area Occupied by Oil Spill

Activity type	c	Area covered				
		1993	2003	2013	2013	2013
Oil Spill area	a	0	4595.959	4	2	6

Source: Authors field work, 2015

The spread is shown by an increase of 21.72% from 1993 to 2003 and a decline of 7.01 % from 2003 to 2013 indicating a total spread of 28.73% from 1993 to 2013 (Table 2).

Estimation of the Impact of Oil Spill on Agricultural land

After creating a common signature classes for agricultural land on the high

resolution satellite images, it was observed that the majority of the farmers have lost their lands due to increasing soil infertility, as a result of subsequent oil spillages in the community. Table 3 shows the differences in the agricultural land area in the community of study.

The impact is shown by a decrease of 6,903.7ha from 1993 to 2003 and a decrease of 3463.3 from 2003 to 2013. The

major impact of oil spill includes destruction of farm fields; destruction of soil fauna and flora; poisoning of both surface and

underground water due to the high hydrocarbon level present.

Table 3: Rate of Change and Difference in Agricultural Land Area

Activity type	Area covered		Difference	Percentage decrease
	1993	2013		
Agricultural Land/bare	20617	10250	10367	50.3

Source: Authors' field work, 2015.

Evaluation of the Land use Change of the Study Area. Table 4 shows that the area affected by oil spillage in 1993, 2003 and 2013 are 0 ha, which is 0% of the study area; 6298ha which is 21.72% of the area, and 4265ha which is 14.71% of the study area respectively. The built-up area covered 2671ha that occupied 9.21% of the study area in 1993; 4287.311ha which also constitute 15.85% of the land area in 2003; and 10527 ha, 36.31% in 2013. There is a general expansion of the built up area from 1993 to 2003. An expansion of 6.64% was observed between 1993 and 2003, and 20.46% from 2003 to 2013 indicating a total expansion of

27.1% from 1993 to 2013.

Water bodies are well discernible in 1993 with an area of 738 ha occupying about 2.25% of the study area, to an increment of 913.4092-ha which is 3.150% of the town due to exposure of some vegetation cover and probably high rainfall for that year but later decreased to 467-ha constituting 1.61% of the area due to spillage occurrence in the land channeled to the tributaries through surface run off then into the large sea.

As revealed in Table 4, the bare land/cultivation as a result of oil spill has reduced from 20617 hectares which constitutes 71.0% of the area in 1993 to 13713.3 ha that covers 47.29% of the study area in 2003 and further decreased to 10250 ha covering about 35.35% in 2013.

Table 4: Land use Change in the Study Area

Activity Type	s	Area covered (Hectare)				Difference	Increase / Decrease			
		199	3	201	3	1986 - 201	3	1986 - 201	3	
Water body	y	73	8	46	9	269 (decrease)	)	- 57.	4	
Vegetation	n	496	9	348	4	1485 (decrease)	)	- 42.	6	
Oil spill area	a	0		426	5	4265 (increase)	)	+10	0	
Bare ground/ Agricultural land	us	2061	7	10	25	0	10367 (decrease)	)	- 50.	3
Built up	p	267	1	1052	7	7856 (increase)	)	+294.	1	

Source: Authors' Field Work, 2015.

Digital Elevation Model (DEM): This was extracted from SRTM data of 30m resolution. Hydrology DEM shows the DEM (fig.3) generated from the SRTM imagery in which all the sinks exist, meanwhile most sink is as a result of error in the data, and before the drainage basin can be delineated, the sink can be filled to obtain a depression-less DEM, so the hydrology DEM in this study is DEM which the sink has not been filled. The DEM shows the elevation of Jesse town in Delta state which ranges from the highest elevation of 89.72 metres to the lowest elevation of 0

metres above mean sea level.

Fill: Fills (fig.4) sinks in a surface raster to remove small imperfections in the data. This is done to fill up areas of no data from the DEM of the study area before any further analysis could be done. Fill can also be used to remove peaks. A peak is a cell where no adjacent cells are higher. To remove peaks, the input surface raster must be inverted. This can be performed with the Minus tool. Specify the highest value of the surface raster as the first input to Minus and surface

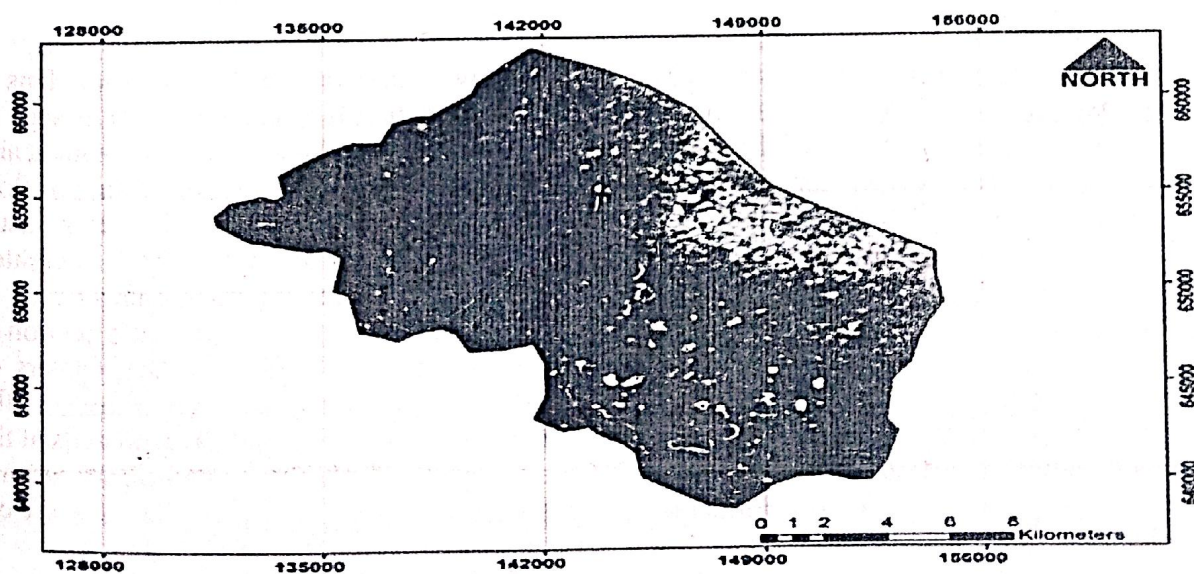


Fig 3: DEM of study area.
Source: Author's Field Work, 2015

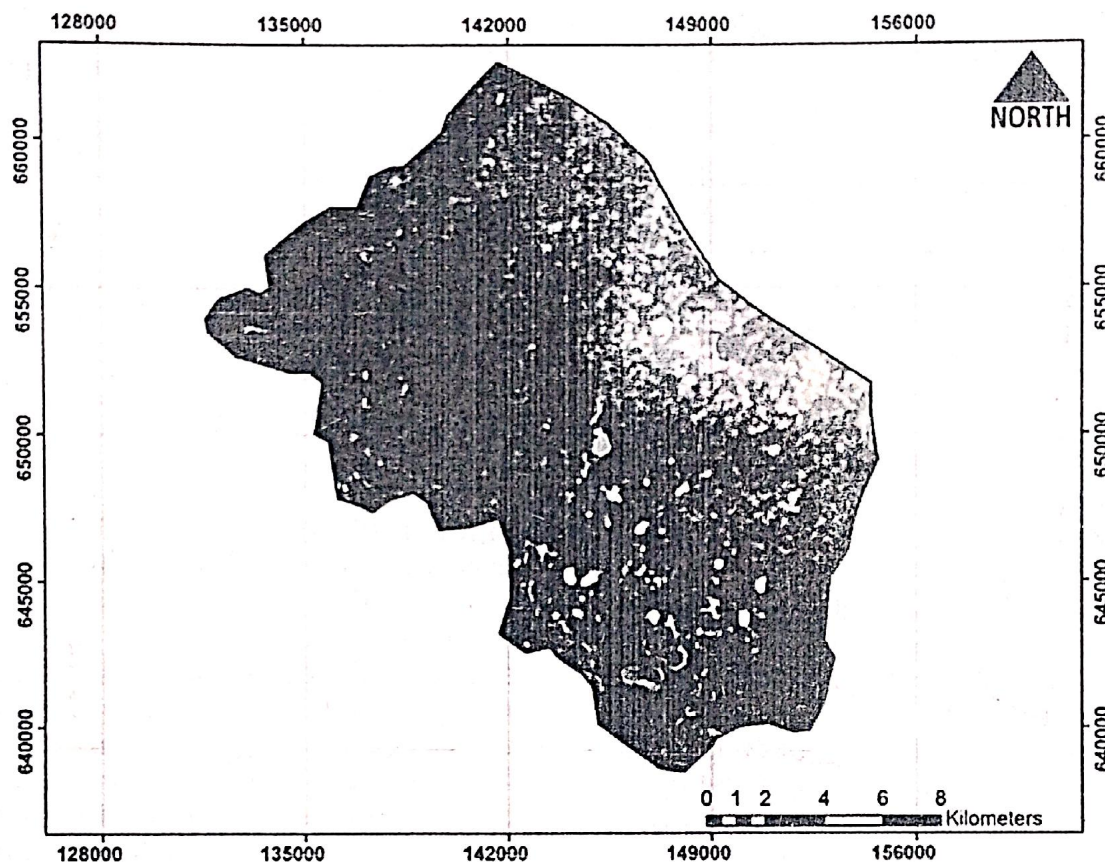


Fig 4: Fill of the study area
Source: Authors' Field Work, 2015

raster as the second input. Perform a Fill. Invert the results to obtain a surface that has original surface raster values with the peaks removed. The z-limit can be applied to this process as well. If nothing is specified for z-limit, then all peaks will be removed. If it is specified, where the difference in z-value between a peak and its highest adjacent neighbor is greater than the z-limit, that peak will not be removed.

Flow direction: One of the keys to deriving hydrologic characteristics of a surface is the ability to determine the direction

of flow from every cell in the raster. This is done with the Flow Direction tool as seen in figure 5. (This tool takes a surface as input and outputs a raster showing the direction of flow out of each cell). If the Output drop raster option is chosen, an output raster is created showing a ratio of the maximum change in elevation from each cell along the direction of flow to the path length between centers of cells and is expressed in percentages. If the flow outward option is chosen, all cells at the edge of the surface raster will flow outward from the surface raster

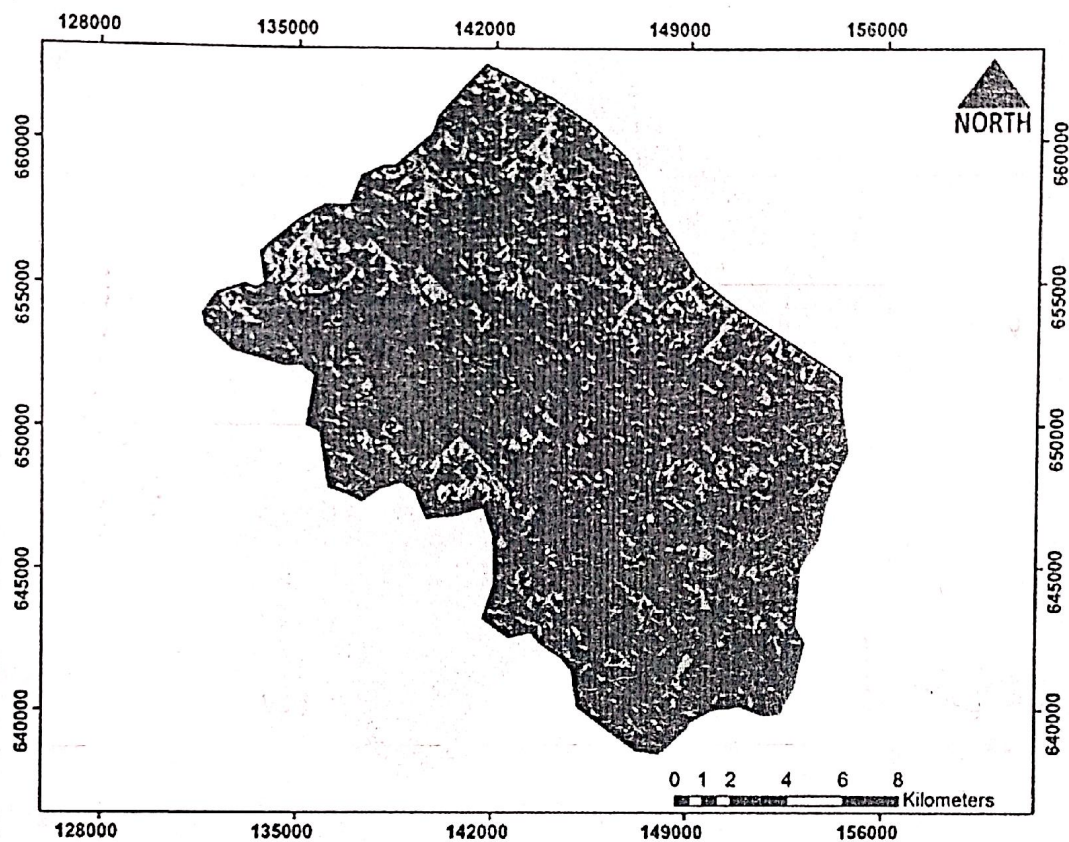


Fig 5: Flow direction of the study area
Source: Authors' Field Work, 2015

Flow direction analysis creates a raster of flow direction from each cell to its steepest down slope neighbor. This analysis is done to

show the path which the oil spill would take based on the terrain of the study area.