Seabed Mapping of a section of Ethiope River in Oghara, Delta State, Nigeria Using Acoustic Techniques

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Abstract

This study was conducted in Ethiope West Local Government Area of Delta State. The aim of the study is to produce a chart showing the depth variations and possible obstruction on the seabed. The research used acoustic technique. Global positioning System DGPS was used to determine the geospatial position of obstructions on the seabed. The echo sounder was used to determine the depth variations while the side scan sonar in conjunction with the other equipment was used to scan the seabed for obstructions. The field data were collected and processed with EIVA navigational software where some analyses were performed. The deep view software was used to analyze the dimension of the obstacles detected and Surfer 9 software to create the digital terrain model of the area. The study conducted shows a total number of 5 obstructions which will pose no threat to the project but to other marine activities. It also shows that the water depth within the area ranges from 0.7m to 5m which is not suitable for the project as well. Finally, the study recommends the removal of the obstructions on the seabed and dredge the river channel to an acceptable depth required for the project.

Key Words: Seabed, Depth, Acoustics, Geospatial, Obstacles.

I. INTRODUCTION

The construction of a tank farm is ongoing. These tank farms will store petroleum products when imported into the state for easy distribution to consumers. The need to have a jetty where vessels berth and discharge the petroleum products into the tanks is of utmost importance to the project. The jetty would be located along the shoreline of a section of Ethiope River adjoining the landed property acquired for the construction of the tank farm. The jetty would also afford some consumers within the coastal communities a safe berthing location during purchase of products from the tank farm. Seabed mapping provides vital information about the seabed which will aid the construction of the jetty and show the depth variation within the area for mariners to know the safe passage to and fro the jetty. In constructing a jetty, it is important to take some precautionary measures like knowing the depth of the river and possible obstructions on the seabed to aid the construction of the project [2]. This should be in accordance with the guidelines provided by the International Hydrographic Organization (IHO) [4], [3].The jetty should be free from obstructions that will impact negatively to its sustainability with variance to damaged or submerged jetties due to negative impact and considering the purpose of the jetty it is imperative that the study examined the possibility of obstacles and determine the water depth variation within the river channel hence the study to bring to fore the geospatial information of the seabed to aid the construction of the jetty and safe navigation.

Aim of the study

The aim of the study is to produce a chart showing the depth variations and possible obstruction on the seabed to aid construction project at Oghara, Delta State.

Objective of the study

The objective of the study will focus on bathymetric survey to determine the depth variation and side scan sonar to detect possible obstructions on the seabed.

II. STUDY AREA

The Study area (Oghara Town) the capital of Ethiope local government Area being one of the 25 Local Government Areas in Delta state, found in the southern part of Nigeria, otherwise called the Niger Delta Region of Nigeria as shown in figure 1. It has an area of 536sqkm, with a population of 203,592 (2006 Census). It is located between latitude 5^0 56' 36.00''N and 5^0 56' 32.07''N and longitude 5^0 37' 29.80''E and 5^0 37' 24.31''E.

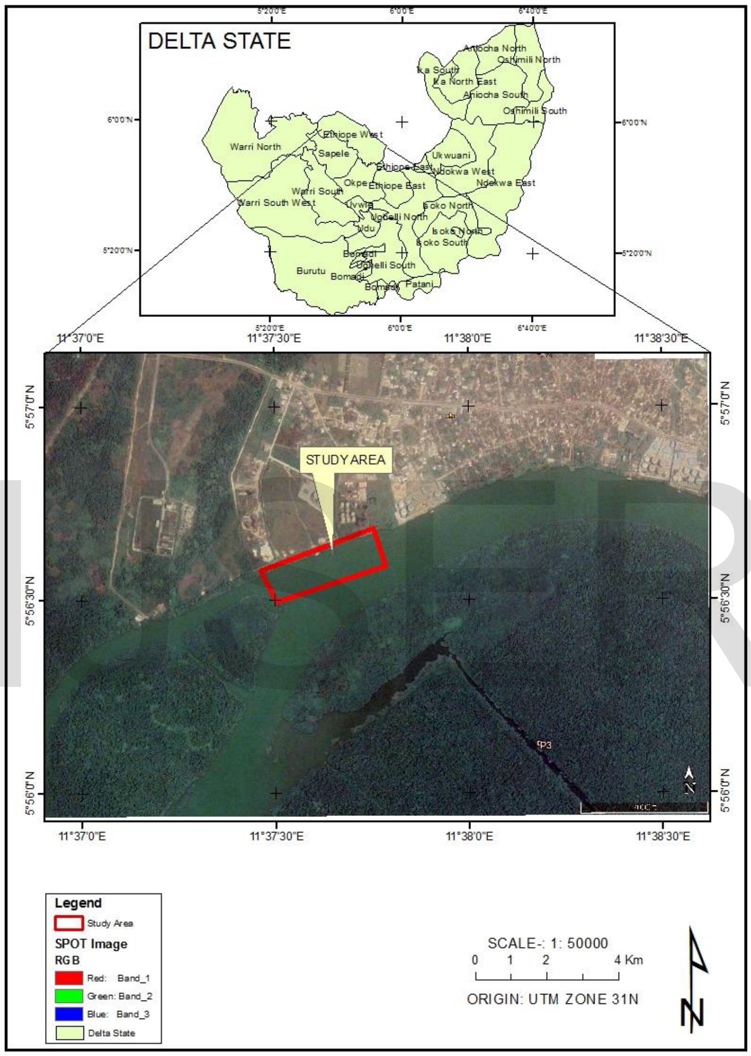

Fig. 1: Study Area (Oghara).

III. METHODOLOGY

Sounding Equipment / Materials

Table 1 and fig 2 shows the equipment and materials used for the research and the equipment setup during data acquisition.

Table 1: List of Acoustic equipment and materials

S/N	Name	Quantity
1	Single Beam Echo Sounder	1

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2	Side Scan Sonar	1
3	Global Positioning System	1
4	Gyro Compass	1
5	Survey Boat	1
6	EIVA Navigational Software	1
7	Laptops	2
8	Tide Gauge	1
9	Deep view Software	1

Fig. 2: Equipment Setup

Equipment Calibration

Two Peg Test (Leveling)

The level instrument was checked by two-peg test method. This was done by setting up and leveling the instrument on a tripod halfway between two staffs that of fifty meters apart. Centre the bubble. Staff reading was taking to A = 1.495 and forwarded to B = 1.757, the height difference between A and B was found to be -0.262 (H=A-B=-0.262). A is lower than B by 0.262. The instrument was moved closer to A about 2m and back sight to B = 1.742 and forwarded to A = 1.481. The height difference is 0.261 as shown in table 2.

The result of the test was satisfactory.

Table 2: Two-Peg Test Result

STN	ROD SET UP	STAFF READING		DIFF	REMARKS
		BACK	FORE		
1	A	1.495			
	B	1.742	1.757		
	A		1.481	0.001	OK

Bar Check (Echo Sounder)

The bar check is a flat bar or plate suspended by precisely marked lines to known depth below the water surface and under the transducer [6]. The bar-check measures actual depths relative to the recorded depths on the echo sounder with an assumed average velocity. With the echo-sounder mounted in a survey boat, the transducer is clamped on the side of the boat with a traducer clamp and immersed into the water. A GPS Receiver for positioning determination is interfaced into the echo-sounder. The transducer is firmly held on the side of the boat and immersed into the water in a vertical position. The bar check is used to confirm the functionality of the echo sounder [5]. This was done by lowering the Bar-check plate with a calibrated rope attached directly under the transducer. It was initially lowered to 1m and the depth observed on the echo-sheet; the position was cross checked with the reading on the echo sheet for correspondence with the exact depth of rope lowed. Again the plate was lowered to 2m and 3m under the transducer and depth observed on the echo-sheet. The plate was moved out 1m, 2m and 3m with the positions marked and verified on the echo sheet to be of same readings to complete the bar-check calibration**.**

Rub / Wet Test (Side Scan Sonar)

Rub test was done when the Side Scan Sonar is interfaced with other equipment with the aid of the navigation software. The side scan is switched on and monitored on the screen for visual display. The left eye of the fish of the side scan sonar is rubbed through the screen and the display is monitored for functionality. Same procedure is done on the right eye and observed also. Again same procedure is applied for wet test however it is necessary to note that the side scan sonar is dropped into a pool of water for the wet test and same procedure applied for functionality.

Data Acquisition

The EIVA navigational software was used to generate the sailing route on the area to be surveyed. The area was subdivided into mainlines having 10m interval and crosslines having 10m interval respectively.
Single beam echo sounder in conjunction with the Global Positioning System (GPS) receiver was used to determine the depth of the river channel. This process shows that electric energy is converted to acoustic energy and it involves a two way travel time of acoustic energy. The sound pulse is reflected from the seabed and the time of its return is recorded. The two-way travel time (TWT) is then calculated. Given that the speed of sound through the water column (v) can be measured, the TWT may be converted to local depth (D) as:

$$D = v \times \frac{TWT}{2} \qquad \text{… (eqn 1)}$$

The side scan sonar in conjunction with the Global Positioning System (GPS) receiver was used to determine geospatial positions of possible obstructions as the boat sailed along the lines with a velocity of 4nots within the study area. The functionality of the side scan depends on the sonar equation which simplifies and describes each of the factors involved in the acoustic echo-sounding process [1].

$$RT = SL - 2TL + TS - NL + DI + PG \qquad \text{… (eqn 2)}$$

(RT) is reception threshold, (SL) is the source level, (TL) is the transmission loss, (TS) is the target strength, (NL) is the noise level. (DI) is the directivity index, (PG) is the processing gain.

EIVA navigational software was used to interface with all equipment to acquire and process the acquired data. The sensor offset as shown in table 3 was imputed into the software to align the positions of all equipment prior to data acquisition.

Table 3: Equipment Offset Onboard the Survey Boat

S/N	Sensors	Athwart (x)m	Along (y)m
1	CRP	2.500	2.75
2	Side Scan Sonar	2.39	-9.88
3	Single Beam Echo Sounder	-0.59	9.79

The deep view software was used to analyze the obstructions detected. A tide gauge was setup to obtain the tidal variation of the river. This will serve as a correction factor to the sounded depth acquired from the echo sounder.

Data Analysis

Tide correction was applied to the sounded data acquired to reduce to the sounding datum. The correction was applied serially to all acquired depth by using the tide readings and corresponding time the tide was gotten from the tide gauge. The mean time of sounding from the start to the end and the mean tidal level was computed using the equation one as shown.

$RD = SD - T$ Where … (eqn 3)
RD= Reduced Depth
SD=Sounded Depth
T= Mean Tidal Level.

Deep view software was used to determine the dimension of the obstructions detected by the study by using the tool bar to precisely delineate the exact shape of the obstruction on the imagery. The tool bar was also used to mark off the dimension of the obstruction and records on the screen the exact distance observed.

IV. RESULTS AND DISCUSSION

The field observation shows that the depth of the river varies from 0.7m to 5.9m depth within the study area. Table 4 and fig 3 shows the depth variation within the study area. Some sonar contacts were detected within the study area as shown in table 5 and fig 3 indicating signs of disturbance but would not impact negatively on the proposed jetty as the contacts are not within close proximity to the location for the jetty.

Table 4: Reduced Depth of the River

S/N	Northings	Eastings	Reduced Depth
1	214796.40	355276.10	4.5
2	214742.70	355307.60	3.6
3	214816.00	355306.90	5.4
4	214798.90	355307.30	4.2
5	214806.10	355317.40	4.6
6	214780.80	355304.40	3.8
7	214793.40	355317.30	5.2
8	214771.10	355322.00	3.7
9	214788.40	355331.10	4.1
10	214806.70	355346.70	5.7
11	214824.20	355345.40	5.6
12	214856.10	355371.60	4.8
13	214793.40	355386.60	4.2
14	214819.30	355390.40	4.5
15	214846.80	355396.80	4.1
16	214841.40	355340.00	5.3
17	214882.10	355399.50	3.9
18	214811.70	355433.80	3.8
19	214824.00	355437.30	4.6
20	214842.10	355440.70	5.0

Table 5: Coordinates of some Sonar Contacts

S/N	Northings	Eastings	Features
1	214796.40	355276.10	Shoreline
2	214742.70	355307.60	Linear Reflection
3	214816.00	355306.90	Drag
4	214798.90	355307.30	Debris
5	214806.10	355317.40	Debris
6	214780.80	355304.40	Disturbed Seabed
7	214793.40	355317.30	Disturbed Seabed

Table 6: Dimension of Obstructions

S/N	Obstructions	Height (m)	Length (m)
1	Debris	1.2	2.4
2	Debris	0.9	1.1
3	Debris	2.3	1.0

Table 6 shows the dimension of the obstructions detected within the study area and as shown in fig 5 and fig 6. The digital terrain model shown in fig 7 shows a gentle slop from the northern part of the river to the southern part of the river where the jetty would be cited.

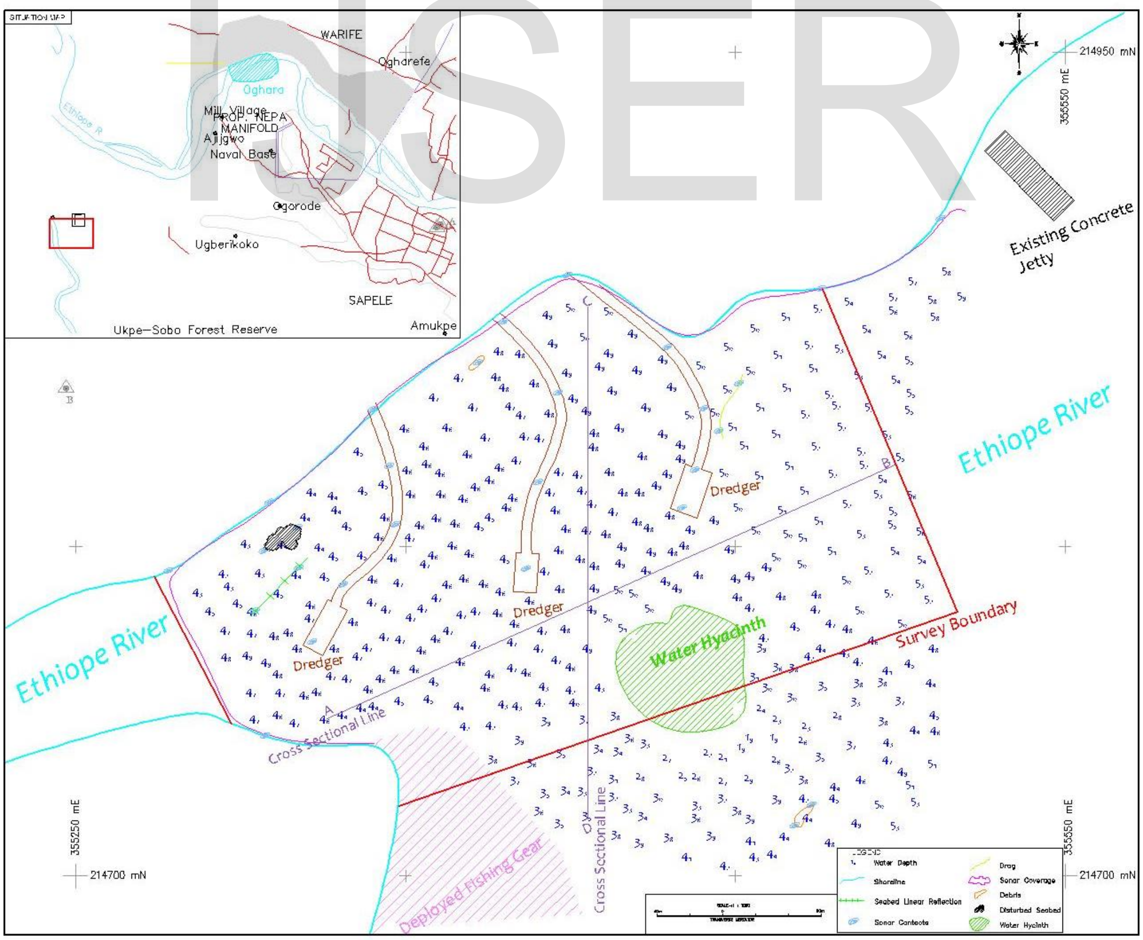

Fig.3: Reduced Depth from Bathymetric Survey.

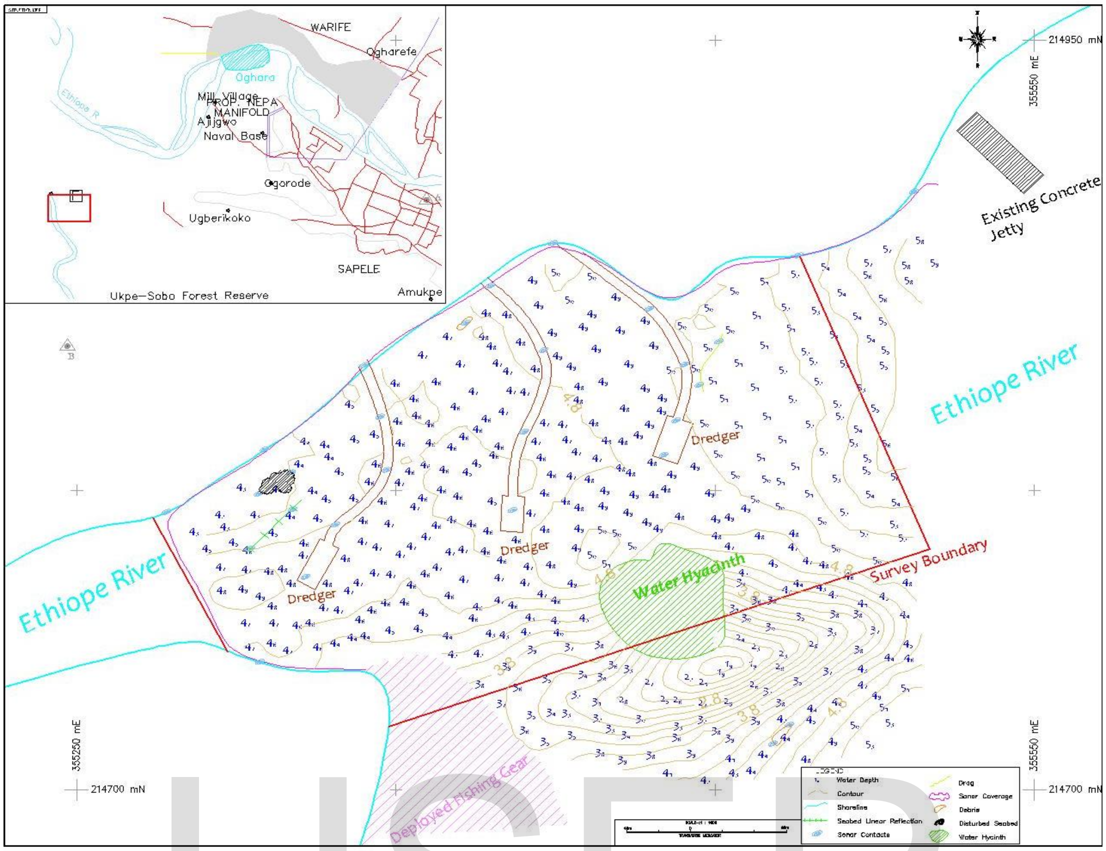

Fig.4: Contour Map of Survey Area.

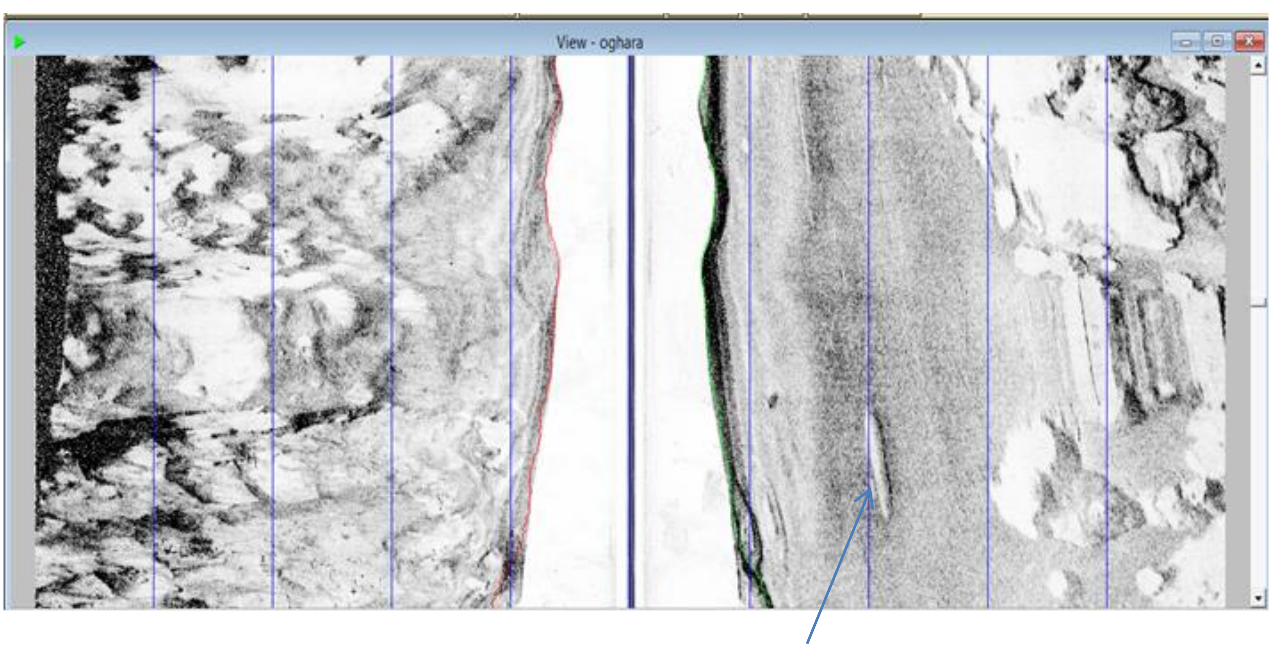

Fig.5: Contour Map of Survey Area. Detected Debris

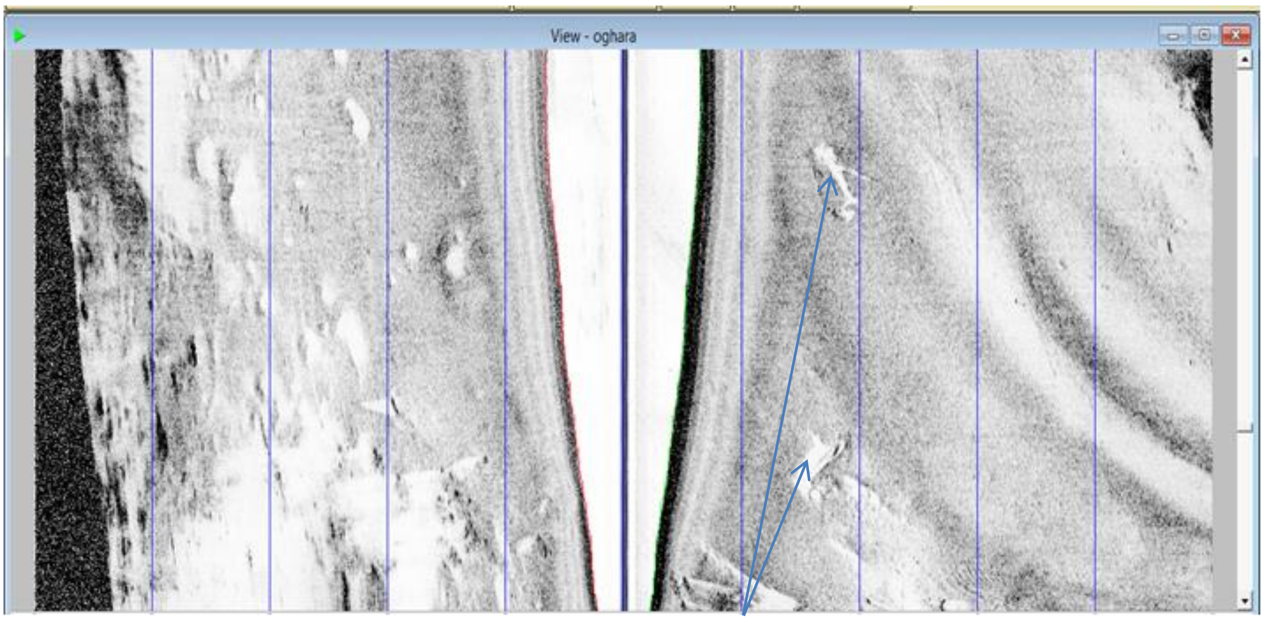

Fig.6: Contour Map of Survey Area. Detected Debris

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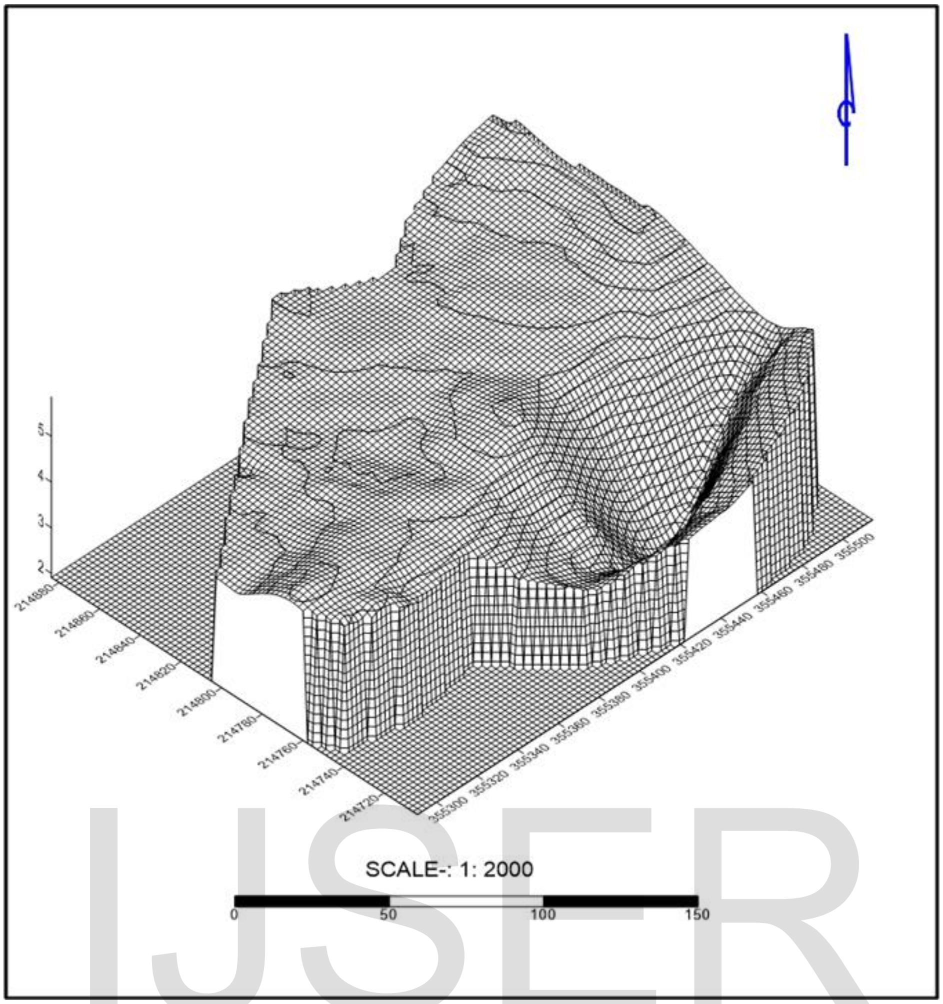

Fig.7: Digital Terrain Model of Survey Area.

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V. CONCLUSION & RECOMMENDATION

The river depth for the position of the jetty is within 3.9m to 4.2m and shows that the position and its surroundings is shallow and cannot allow vessels with high draft to berth at the jetty. The seabed within the study area is characterized with a gentle slow from the northern part to the southern part of the river thereby having the southern part deeper than the northern part. The obstructions observed would not cause any harm to the construction but would serve as a danger to vessels sailing through the channel.

To ensure maritime safety this study therefore makes the following recommendations:
The study recommends for an update of the seabed information of the Ethiope river channel leading up to the sea to afford mariners the safety status of the river.
The study also recommends that regular and effective monitoring should be carried out by the regulating bodies to ensuring total safety of the waterways and river channels.

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