# Using GIS to Find the Best Safe Route between Khartoum and Arqin-Crossing

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## Abstract
The paper aims to clarify how to make a decision using geographic information systems and how to choose the best route between two cities to suit the expectations of the driver and his sense of safety and comfort on the road. Use a special model for network analysis, where the network analysis tool relied on the following data (maximum speed of the road - number of intersections - road width - peak period) in choosing the best safe path.
The paper concluded that the best safe route for refugees between the cities of Khartoum - Arqin crossing is ( Khartoum - Shendi - Atbara - Meroe - Abu Hamad - Wadi Halfa). We advise all GIS users to use the theories of spatial analysis when creating a new model.

***Keywords:***
*Best Path; GIS; Arc GIS; Map Layers.*

## 1. Introduction

GIS can address complex network problems such as advising a company on which route the company's trucks should take when transporting goods to several places [1]
In light of the circumstances that Sudan is going through now from the war and the migration of citizens to neighboring countries, especially the State of Egypt through the Arqin crossing, where the number of citizens who were displaced from the war to the State of Egypt reached (3,000,000) three million citizens to escape the scourge of war, as the crossing receives more than 1,000 trips per day, despite the fact that the road is dedicated to transporting goods and trucks pass through it from Sudan to Egypt and vice versa, while before 14/4/2023, a trip or Two trips at most from travel buses and with the increase in numbers after the war the owners of the travels needed a road or a path that reduces them from traveling and reduces time and distance .

The road paths system is closely related to the terrain and the nature of the surface, we mean by the paths here industrial navigational channels and land lines, it is clear to us that the path needs a flat area, in order for the path to be economical, it must extend in one plane for a long distance, so we find it extending parallel to the contour lines and that any slope in the surface plane requires backfilling work and any height in the surface requires excavation work, but it can extend across areas with A slight slope does not exceed the rate of slope of (40:1) and it is also noted that the shortest roads may be the steepest and the most flat roads may be the longest extension and to avoid rough areas are held tunnels and bridges and the path of the highway can extend through areas with steep slopes up to (10:1) and often follow direct lines does not prevent the passage of valleys, rivers or heights extended so that bridges arise on rivers and open tunnels when needed with Cost study and take into account linking production areas in the extension of the path as it is necessary to link areas rich in their products to major markets and gaps and to represent this data with (GIS) on the map must represent the features drawn in the map objects from the real world each have a location and shape represented by (point, line or polygon) chosen according to the scale of the drawing of the map, for example, polygons refer to large objects Which are difficult to represent using points such as (land bodies - provinces - forests ..... etc) and lines or arcs represent (rivers - roads and drains) and because the system (GIS) supports linking spatial data with metadata as it depends on the system of layers and the relationship between them and analysis and the creation of maps that represent the sequence of analysis such as linking the agricultural land layer layer to the layer of road paths and how to choose the most appropriate path.

From the above, it is clear to us that the choice of the path depends primarily on the nature of the surface and the topography of the area it passes through, when choosing the path, all of the above is taken into account, for example, the road (Khartoum - Arqin crossing the Egyptian border) where there is a path east of the Nile River that passes (Khartoum - Shendi - Atbara - Meroe - Karima - Dongola - Karma - Delgo - Ibri - Wadi Halfa - Arqin crossing), and it is one of the arduous roads for the citizen if the journey time by tourist bus is about 18 A continuous hour. As for the western path of the Nile River, which passes (Khartoum - Omdurman - Dibba - Dongola - Saleem - Karma - Delgo - Ibri - Wadi Halfa - Arqin crossing) is one of the arduous roads for the citizen as well, if the journey time by tourist bus is about 20 hours continuously, if we want to shorten the path of any direct path (Khartoum - Arqin crossing the Egyptian border), is there a better path that can connect the two cities? We will clarify the best path using (GIS) techniques and using the best path algorithms after we enter all the necessary requirements to create a better evening between (Khartoum - Arqin crossing the Egyptian border)

Manuscript received November 5, 2023
Manuscript revised November 20, 2023
https://doi.org/10.22937/IJCSNS.2023.23.11.5

## 2. Methodology

GIS software has been used as one of the methods of the scientific method with its three packages in the latest version of program (Arc GIS 10.3) and the three packages are: (Arc map, Arc catalog, Arc toolbox). (See **Figure (1)** analog modeling method)..

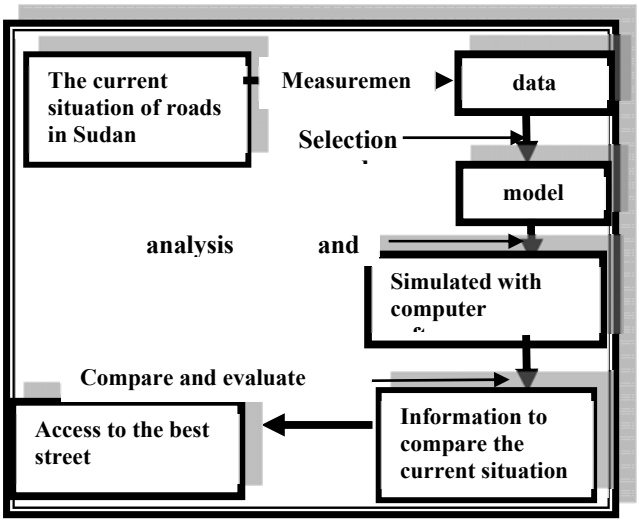


**Fig 1:** The Diagram Explains the analog model methodology

As (Arc map) is the central application in Arc GIS, it includes a set of important operations in dealing with maps such as addition operations, map analysis, surveying, addition, design and analysis, and provides different ways to display such as viewing geographical data and viewing roads.

The Arc catalog helps in the organization of information collection (GIS) and includes tools to find and display geographic information as well as display, modify and analyze descriptive tables.

Arc toolbox is a simple application that includes most of the GIS tools used, and includes two types of applications:

(1) Complete Arc toolbox, which is present with the program (Arc/Info) with more than 150 transformations and integrated organization.

(2) Lighter is available with Arc view and has about 20 common conversions.

The three applications are designed to work together in an integrated format. For example, you can search for a map file in (Arc catalog) and then the file can be opened in (Arc map) and we can clear the information through the tools available in toolbox) .

The first concern of this effort is to seek to design a safe and fast route for refugees to return from Egypt to Sudan. The second concern is mainly directed to highlight the paths between Sudan and Egypt - the lived reality - to find out the best safe path for citizens so that services are available and reduce their suffering. The third concern comes in presenting the basic principles and concepts of how to use geographic information systems (and showing the capabilities of the program in addressing such problems) and the last keenness of this study after mastering the corner of knowledge in how to develop an analog model to find the best route between Khartoum and the Arqin crossing on the Egyptian border.

## 3.The Theoretical Framework

Geographic Information System (GIS) is a set of principles and modern technologies that are used in living applied fields. The idea of GIS basically means the best solution to an economic, social, political, planning or development problem. It is a mechanism to link the spatial location with the descriptive entity of a phenomenon that exists on the surface of the earth, and thus geographic information systems Linked to economic, social, political, planning or development decision-making. Making the best decision or choosing the most appropriate location or route is at the heart of GIS work. Software was used in this study to build a road database and to determine spatial accuracy and compare the preference of existing roads; all these software were used as an approach to designing a safe road between Sudan and Egypt for citizens, which became an obsession for everyone who wanted to exit through the Arqin crossing .

The engineering design of the road is defined as the process of finding the geometric dimensions of each road and arranging the visual elements of the road such as the path, visibility distances, widths and slopes, starting Roads must be classified in terms of being main, secondary or local roads so that the design speed and slope can be determined after balancing some factors such as the importance of the road and estimating the size and characteristics of traffic, terrain and available funds. Design speed and governing slope are the basic basis for setting standard minimum boundaries for both vertical and horizontal planning of the road and then the designer can by trial and error adapt these boundaries or terrain in order to arrive at a horizontal projection and a longitudinal section of the road. Then comes the stage of detailing the geometric dimensions of single-level or multi-level intersections, service roads and other features. Finally, the details of signs, lines, traffic signs, if any, and other traffic control measures must be determined. A road that does not cause accidents and achieves smooth flow can be reached by bringing all road elements in line with drivers' expectations by avoiding sudden changes in design specifications. These global roads are universal in terms of foundations and standards have

several classifications, and the following is a presentation of the functional classifications of roads[4]

**(3-1)Measuring distances turning paths and intensity of movement on them:**
They are used as indicators of development through the following:

**(1) How to measure detours ( Detours)**

Straight paths between two places are known as desire lines because road users usually want to use short paths to shorten the time and costs of the trip..... etc., but straight connections are rarely found in reality, and if they exist, they often deviate from the straight line and the causes of deviation are due to (human, natural reasons..... etc) and such deviations are measured by the inflection index of the following equation

$$\text{Turn indicator} = \frac{\text{actual lane length} \times 100}{\text{Straight path length}}$$

It is also possible to calculate the average deviation of the grid and the square of the deviation, and the turn indicator has a large value, for example, it determines the effects resulting from adding or deleting a path in the network.

**(2) How to find the** network density
It is used at the local, state and global levels as an indicator of development and is measured by the following formulas:

**(3) How to find the ratio of the length of the path in the state**
In the design of roads and streets, the following equation was used:

$$\text{Ratio to track length} = \frac{\text{Track length} \times 100}{\text{State Area}}$$

The output is expressed in kilometers per 100 $km^2$

**(4) How to find the average area served:**
The following equation was used to find the mean served

$$\text{Average Area} = \frac{\text{Area of the state in km}^2}{\text{Track length}}$$

The output is expressed in kilometers

**(5) How to find the lengths of paths relative to the population**

The following equation was used for the population

$$\text{Path relative to population} = \frac{\text{Track length} \times 1000}{\text{Number of individuals in the state}}$$

Expressed in kilometers for tracks per 1,000 inhabitants

**(6) How to find beneficiaries of the population in the path:**

$$\text{Beneficiaries of the population} = \frac{\text{Number of individuals in the state}}{\text{Track length}}$$

Output per kilometer of tracks

These are the different bases for measuring network density, but there is no doubt that measuring density on the basis of individuals is the best, on the basis that individuals are road users and are the source of economic activity, and the higher the density of the network, the state enjoys a good network, while its decrease means that there are many areas of the state deprived of the network, which shows that the network needs more intensification and development, and the deviation from the average networks between States, then the deviation box and then the explanation of the causes of deviation: [5]

**(7) How to find** traffic density
Traffic density is one of the important indicators by which the importance of paths is measured, and it is measured at the link level and the state level through the following:

**(8) How to find the average traffic volume in the lane**
**Average Traffic Volume on the Route = Traffic Volume by Track * Route Length**

The result is the average volume of traffic for cars (vehicles) per km

**(9) How to find traffic density in relation to time:**

$$\text{Traffic density} = \frac{\text{Average traffic volume on the track}}{\text{Number of hours per day}}$$

The result of traffic density is important for each lane, but this density may sometimes be in honest, and therefore you find that some engineers find what is called calculating the relative importance of the track from the following:

**Relative importance of the route = average traffic volume × the length of the lane**

These are the different bases for measuring network traffic density, and the higher the network track density in the state, the more important the state enjoys economic activity.

**(3-2)Foundations of the analysis stage**

**(1) Measurement of road network density**

The density of the road network is measured according to Table (1) below:

| States | Ways |
|---|---|

| | density | Service | density | Served |
|---|---|---|---|---|
| Nile River | 0.11 | 5145 | 27.3 | 3735 |
| Northern | 0.73 | 135.5 | 0.21 | 4709 |
| Khartoum | 1.01 | 98.8 | 0.043 | 23162 |
| Red Sea | 0.93 | 106.9 | 0.107 | 9371 |

**Table (1) shows the density of the road network**

We find that the Nile River State is the first state in the density of the road network according to the area, which is 2.48 linear kilometers per 100 square kilometers. River Nile State is also the first state in the density of the road network according to the area served, which is 27.3 square kilometers per linear kilometer of route. Khartoum is also the first in the density of the road network per population, which is 2.8 square kilometers per 1,000 inhabitants. We also find that Khartoum State is the first state in the density of the road network according to the population served, which is **23,162** people per kilometer of the path, Figure No.

Fig 2: **Explains Measuring the density of the road network**

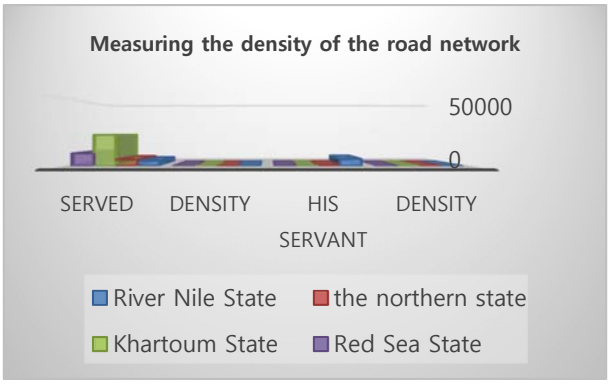


**Fig 2:** Explains Measuring the density of the road network

(2) shows the density of the road network

**(2) Mesh turn measurement:**
Which is shown in Table (2)

| roadway | Turn rate % | Reason for the turn |
|---|---|---|
| **The eastern path of the Nile River** | | |
| Khartoum – Shendi | 113 | Positive deviation for increased movement, negative deviation of the Nile River |
| Shendi – Atbara | 168 | Positive deviation to increase movement |
| Atbara – Merowe | 120 | Positive deviation to increase movement, and to avoid agricultural land, |
| Meroe – Karima | 126 | Positive deviation to increase movement, to avoid agricultural land, and negative deviation to avoid the reservoir |
| Karima – Dongola | 136 | Positive deviation to avoid agricultural land |
| Dongola – Karma | 122 | Positive deviation to increase movement and avoid agricultural land |
| Karma – Delgo | 118 | Positive deviation to increase movement and avoid agricultural land |
| Delgo – Hebrew | 115 | Positive deviation to increase movement and avoid agricultural land |
| Ibri – Wadi Halfa | 145 | Positive deviation to increase movement and avoid agricultural land |
| Wadi Halfa – Crossing | 126 | Positive deviation to increase movement and avoid agricultural land |
| **The western path of the Nile River** | | |
| Khartoum – Omdurman | 118 | Positive deviation to increase movement |
| Omdurman – Al Dibba | 112 | Negative deviation to avoid the Nile |
| Al Dibba – Dongola | 122 | Positive deviation to increase movement |

| | | |
|---|---|---|
| **Dongola – Proper** | **123** | **positive deviation to increase mobility,** |
| **Proper – Vine** | **102** | **Positive deviation to increase movement** |
| **Karma – Delgo** | **118** | **Positive deviation to increase movement and avoid agricultural land** |
| **Delgo – Hebrew** | **115** | **Positive deviation to increase movement and avoid agricultural land** |
| **Ibri – Wadi Halfa** | **145** | **Positive deviation to increase movement and avoid agricultural land** |
| **Wadi Halfa – Crossing** | **126** | **Positive deviation to increase movement and avoid agricultural land** |

**Table (2) shows the turn of the road network**

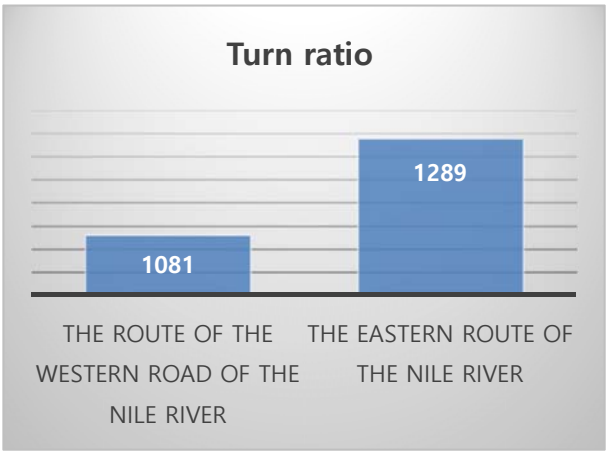


**Fig 3** Explains Turn ratio

From the above, we find that the deviation of the road network in the eastern road is greater than the western road, and we find that the deviation of the network ranges between 102% and 168% Figure No. (3) shows the percentage of deviation between the eastern and western roads

## 4. Traffic density:

**(4-1) Traffic density by road length**
Which is illustrated by the data of Table (3) below.

| roadway | Movement intensity |
|---|---|
| **The eastern path of the Nile River** | |
| **Khartoum – Shendi** | 17.61 |
| **Shendi – Atbara** | 7.38 |
| **Atbara – Merowe** | 2.66 |
| **Meroe – Karima** | 2.64 |
| **Karima – Dongola** | 0.13 |
| **Dongola – Karma** | 3.27 |
| **Delgo – Hebrew** | 5.82 |
| **Ibri – Wadi Halfa** | 7.36 |
| **Wadi Halfa – Crossing** | 10.3 |
| **The western path of the Nile River** | |
| **Khartoum – Omdurman** | 4.94 |
| Omdurman – Al Dibba | 2.73 |
| Al Dibba – Dongola | 3.36 |
| Dongola - proper | 1.95 |
| Proper – Vine | 1 |
| Karma – Delgo | 3.27 |
| Delgo – Hebrew | 5.82 |
| Ibri – Wadi Halfa | 7.36 |
| Wadi Halfa – Crossing | 10.3 |

Table No. (3) shows the traffic density of the network

From the above table, we find that the Khartoum-Shendi road is the densest road due to its importance because it connects the Nile River State and the capital, followed by the Wadi Halfa road and the Arqin crossing, which is the main link for the entry of trucks and buses from Egypt.

**(4-2) Traffic density according to traffic volume**
Which is shown in the data of Table (4)

| roadway | Movement intensity |
|---|---|
| **The eastern path of the Nile River** | |
| **Khartoum – Shendi** | **137.25** |
| **Shendi – Atbara** | **80.12** |
| **Atbara – Merowe** | **24.45** |
| **Meroe – Karima** | **38.75** |
| **Karima – Dongola** | **1.12** |
| **Dongola – Karma** | **77.95** |
| **Delgo – Hebrew** | **20.68** |
| **Ibri – Wadi Halfa** | **25.21** |
| **Wadi Halfa – Crossing** | **22** |
| **The western path of the Nile River** | |
| **Khartoum – Omdurman** | **85.68** |
| **Omdurman – Al Dibba** | **22.54** |
| **Al Dibba – Dongola** | **15.39** |
| **Dongola - proper** | **2.29** |
| **Proper – Vine** | **13.29** |
| **Karma – Delgo** | **4.92** |
| **Delgo – Hebrew** | **20.68** |
| **Ibri – Wadi Halfa** | **25.21** |
| **Wadi Halfa – Crossing** | **22** |

Table No. (4) shows the traffic density according to the volume of traffic

Also, from the previous table, the Khartoum-Shendi-Atbara road comes in the foreground, followed by the Halfa-crossing road.

**(3-3) Traffic density by road**

The average volume of traffic × the length of the road, which is shown in Table (5)

| roadway | Movement intensity |
|---|---|
| **The eastern path of the Nile River** | |
| **Khartoum – Shendi** | 615978 |
| **Shendi – Atbara** | 383724 |
| **Atbara – Merowe** | 128480 |
| **Meroe – Karima** | 326430 |
| **Karima – Dongola** | 55125 |
| **Dongola – Karma** | 195910 |
| **Delgo – Hebrew** | 707302 |
| **Ibri – Wadi Halfa** | 138171 |
| **Wadi Halfa – Crossing** | 162096 |
| **The western path of the Nile River** | |
| **Khartoum – Omdurman** | 448530 |
| **Omdurman – Al Dibba** | 104544 |
| **Al Dibba – Dongola** | 400326 |
| **Dongola - proper** | 4278544 |
| **Proper – Vine** | 100170 |
| **Karma – Delgo** | 424810 |
| **Delgo – Hebrew** | 707302 |
| **Ibri – Wadi Halfa** | 138171 |
| **Wadi Halfa – Crossing** | 162096 |

Table (5) shows the density of movement by road

From the above table, we also find that the Khartoum-Atbara road comes in first place in density, and in second place is the Wadi Halfa road - the crossing that replaced the Atbara - Merowe road due to the length of the road, which is also an extension to the western road.

## 5.Application framework

**(1)Set up Map Layers:**

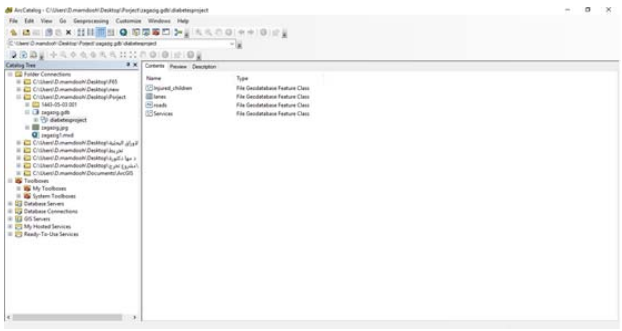

**Fig.4:** Explains the preparation stage in the Arc Catalog program

**(2)Database setup**

This stage begins with the preparation of the layers and includes the path of the constructed highways and the path of the proposed roads First, the layer of highway paths constructed according to the report of the National Authority for Roads and Bridges[-2] and Figure (5) shows the paths of highways in Sudan and includes the layer database (road name, road length, date of construction, validity period and current situation) and the data has shown that most of the roads are 7 meters wide and shoulders are

two meters and their current situation is between bad, medium and good, and most roads have exceeded maintenance periods for long periods, and some of them Concrete

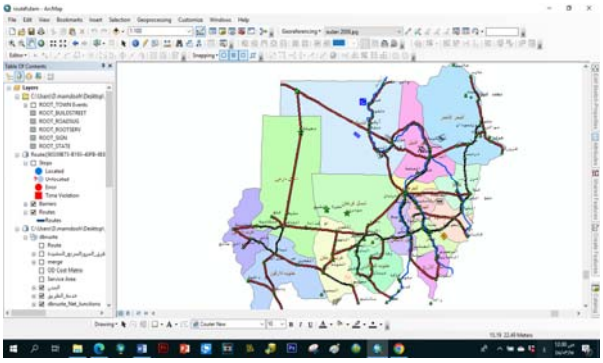

**Fig 5:** shows the highways built in Sudan

Then comes the layer of the proposed traffic routes paths, which were prepared according to international road standards by the American Association of Transport and Road Officials (AASHTO) and took into account that it has two separate directions on an island and the number of lanes is sufficient to accommodate the expected traffic volume and speeds on the road from the lower speed and transition to lanes with high speeds, Figure No. (6) shows the proposed traffic routes

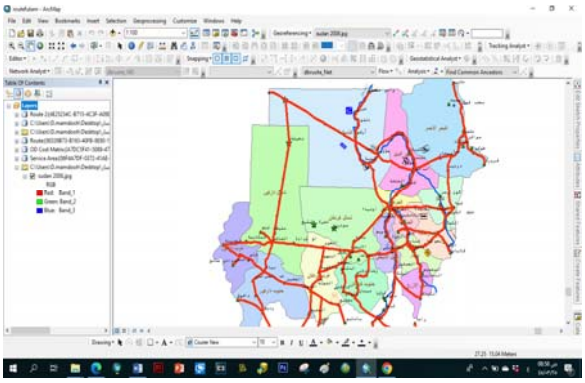

**Fig 6:** shows the proposed traffic routes

The first stage is completed after completing the data of all layers and the second stage begins, which is the stage of merging the two layers with each other, when the merging process is carried out, a new layer arises that includes both layers to become one network with one database that includes the same data of the proposed methods layer
We also mentioned that the geographic information system helps in decision-making, and here we explain how to choose the best route in terms of smooth flow by making all road elements in line with the expectations of drivers to avoid sudden changes in design specifications . When choosing the best route between Arqin - Khartoum crossing, this process depends on the database and requires knowledge of the following (maximum speed of the road - number of intersections - road width - peak period)

**(3) Database analysis:**

We create new performance using the model that requires the entry of special data into the algorithm designed to choose the best path requires the introduction of several layers, then the network is created and the constructed traffic roads layer is chosen after merging all types of roads with it, then determining the best path and extracting the value of the best roads as shown in Figure (7)

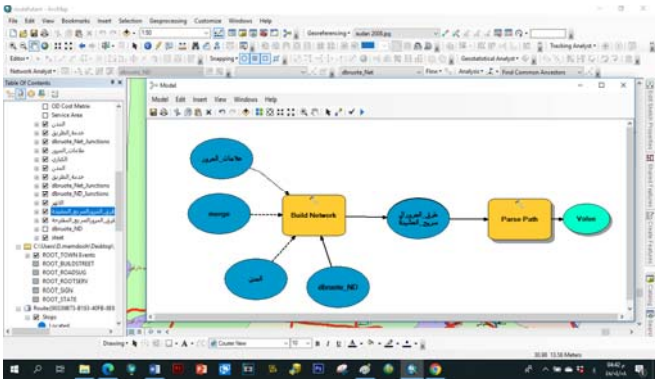


**Fig 7**: Explain the model

**Algorithm:**
The Beginning
Define the first track, the second track, the best path and the best path with numerical variables
Enter the details of the constructed roads
Enter suggested methods data
Combine constructed and suggested road data
After merging the road data, a trade-off was made between the routes
Call function number (1)
Call function (2)
Best route = (maximum road speed + number of intersections + road width + peak period)
If ( Path = Best Path )
Draw the path
Or give a message that says there is a mistake
If neither paths is suitable, draw a new path
The end
Function No. (1)
The Beginning
Enter the path data from the number of points, the length of the path and the area of the path
Select the beginning of the path with the number 1
Select the end of the path with a different color
End of function number (1)
Function No. (2)
The Beginning
Enter the first track data
Enter speed data Select the maximum speed of the road
And enter the number of intersections
And enter the road width data choose the biggest road width
And enter the peak period data choose the least fake period
Enter the data of the second track
Enter speed data Select the maximum speed of the road
And enter the number of intersections
And enter the road width data choose the biggest road width
And enter the peak period data choose the least fake period
Put the first path = the path
Put the second path = the path
end of the function number (2)

**The algorithm was prepared by the researcher**

code

```
' Get the view and the line theme
'
aView = av.GetProject.FindDoc("View1")
aStreetFTab = aView.FindTheme("Streets").GetFTab
' Make sure you can perform network analysis on this theme
'
if (not (NetDef.CanMakeFromFTab(aStreetFTab))) then
  msgBox.Error("Can't make a network from this FTab","")
  Exit
end
' Make the NetDef and Network objects
'
aNetDef = NetDef.Make(aStreetFTab)
aNetwork = Network.Make(aNetDef)
' Check for error creating network
'
if (aNetDef.HasError) then
  msgBox.Error("The network has an error","")
  Exit
end
' Show a message box for a user to select a cost field
'
aSelectedCostField = msgBox.Choice(aNetDef.GetCostFields,
                                   "Select a cost:",
                                   "Network cost selection")
' Set the cost field for the network problem.
'
aNetwork.SetCostField(aSelectedCostField)
' Get the customer point feature table
'
a BestFTab = aView.FindTheme("Best Path ").GetFtab
aPointField = a BestFTab.FindField("drawpath ")
' Make a list validated points from the customer theme
'
aPointList = {}
for each rec in a a BestFTab
  p = aBesFTab.ReturnValue(aPointField, rec)
  if (aNetwork.IsPointOnNetwork(p)) then
    aPointList.Add(p)
  end
end
' Find the best between the routes
'
travelDistance = aNetwork.FindPath(aPointList, True, False)
' Create a new path and a graphic representing the route and add it to the view
'
aView.GetGraphics.Add(GraphicShape.Make(aNetwork.Return PathShape))
```

**Algorithm code in Python**

## 6.Implementation and Experimental Results

Each time, the route is entered with a number of numbers, which mean cities and service centers on the road using the form and the network analysis tool associated with all the data related to the path with the algorithm The following is the first track (Khartoum - Shendi - Atbara - Merowe - Karima - Dongola - Karma - Delgo - Ibri - Wadi Halfa - Crossing)

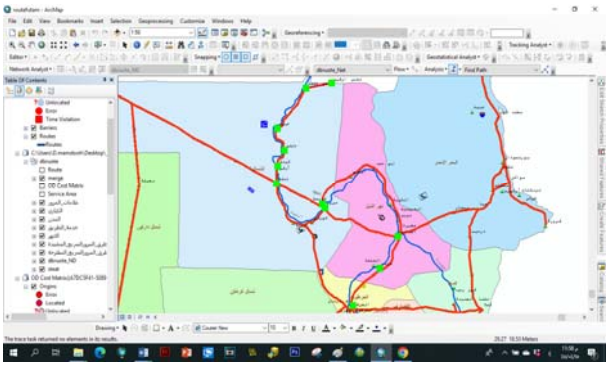

**Fig 8** : Explain the

The second track (Khartoum - Omdurman - Dibba - Dongola - Saleem - Karma - Delgo - Ibri - Wadi Halfa - crossing) does not create a path and a message appears that the path is wrong and Figure No. (9) explains that

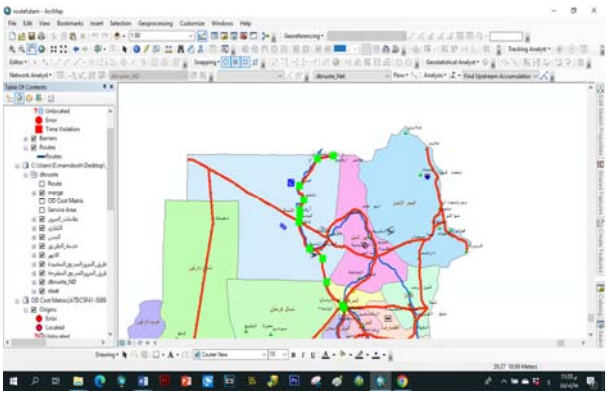

**Fig 9**: Explain the

After entering the data for the first track and the second track, the algorithm is tested through the network analysis tool according to the model formed by comparing the two tracks and choosing which one is better or drawing and proposing a new path According to the tool and the data entered from the first track and the second track of the following (maximum speed of the road - number of intersections - road width - peak period) does not choose a path and gives an error message, which means that the two lanes are not suitable as shown in Figure (10 ) and Figure (11 )

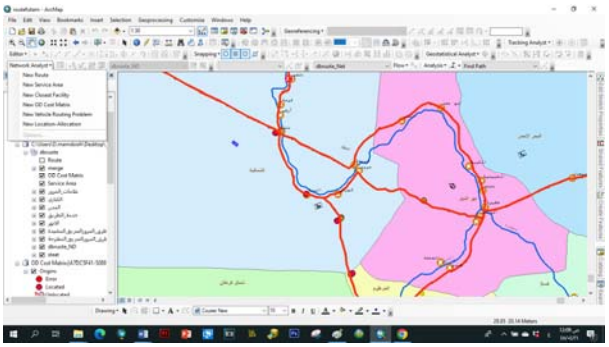

**Fig 10:** Explain the

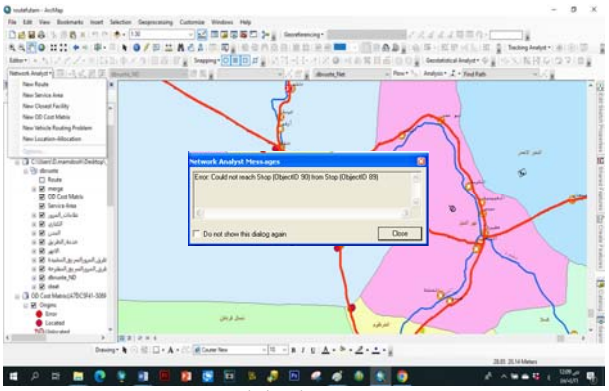


**Fig 11:** Explain the

Through the network analysis tool, the algorithm draws a new route linking Khartoum to the Arqin crossing, which will form a new link between Abu Hamad and Wadi Halfa. The new link after testing is characterized by the fact that it shortens the citizens about (370) kilometers, which means that it shortens more than five hours as the new road is characterized by being on flat land free of obstacles and is faulted by the lack of services between Abu Hamad and Wadi Halfa as shown in Figure No. ( 12)

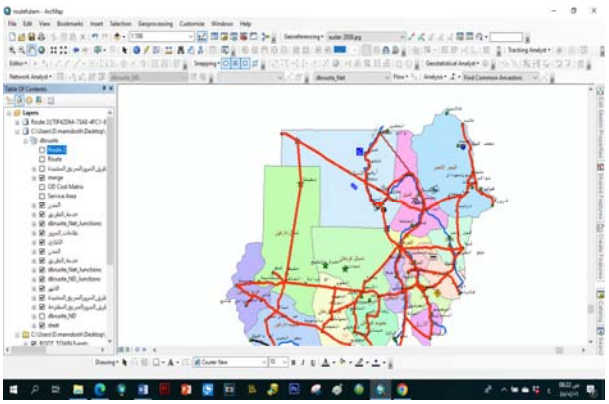

**Fig 12**: Explain the

## 7. Conclusion and future work

- GIS provides tools that help in various spatial analysis processes and enable researchers to reach new and useful results.
- Techniques used in GIS software were used to reach a safe path for refugees who want to reach Egypt through the Arqin crossing.
- GIS software enabled me to add special tools in spatial analysis for dealing with network analysis in finding the best assistant.
- Building the model for the analytical process helps in reaching good results based on spatial data.
- I was able to use the model to find the best route between Khartoum and Arqin crossing
- The new route shown by the tools between Abu Hamad and Wadi Halfa, the best safe route for travel buses.
- The new route shortened travel by (370) kilometers, which is about five hours

The importance of geographic information systems stems from the possibility of creating methods that would exploit informatics with the greatest possible return, in addition to its active role in being a tool that contributes to making the optimal decision and drawing up future policies, and this is evident through the previous narrative on how to choose the best path.

The paper explained that the best route between the cities of Khartoum - Arqin crossing is (Khartoum - Shendi - Atbara - Merowe - Abu Hamad - Wadi Halfa), which was limited to travelers about five hours of travel

Road area: Roads form the backbone of transport and communications in the world, which requires their compliance with international specifications in terms of area and separation of routes.

GIS relied in choosing the best path on the road network analysis tool and the model it developed, and we can benefit from it in more than one analysis for all types of networks. The network analysis tool relied on the following data (maximum speed of the road - number of intersections - road width - peak period) in choosing the best safe route.

Road engineering: When constructing the road, the engineering aspect must be taken into account in coordination with the competent authorities, and the placement of international traffic signs helps the driver to read the road

## References

[1] Mumdouh M. M. Hassan , Yusuf Perwej , Awad Haj Ali Ahmed, Firoj Parwej ,Using Intelligent Transportation Systems the Modern Traffic Safetyon the Highway in the Sudan ,y (IJCST) – Volume 7 Issue 3, May - Jun 2019, p 4-7

[2] General Authority for Roads and Bridges - Annual Report for the Year 2022, pages 23-27

[3] Nikhat Akhtar, FirojParwej, Yusuf Perwej, "A Perusal Of Big Data Classification And Hadoop Technology," International Transaction of Electrical and Computer Engineers System (ITECES), USA, ISSN (Print): 2373-1273 ISSN (Online): 2373-1281, Vol. 4, No. 1, page 26-38, May 2017,

[4] Sheng-hai An, Byung-Hyug Lee , Dong-Ryeol Shin," A Survey of Intelligent Transportation Systems", Third International Conference on Computational Intelligence, Communication Systems and Networks, IEEE , Bali, Indonesia, July 2011

[5] General Traffic Department - Planning Unit - 2021 . Page 70-73

[6] Ousmane Sadio, Ibrahima Ngom, Claude Lishou, "Rethinking intelligent transportation systems with Internet of Vehicles: Proposition of sensing as a service model", Computer and Communications (ICCC) 2017 3rd IEEE International Conference on, pp. 2791-2796, 2017

[7] ZHANG Guang-An, "Highway Engineering Environment and Protection Measures", Communication Science and Technology and Economic, no. 3, 2009

[8] QUAN ming-xing, "Road construction on the environment impact analysis and prevention measures", Popular Science, no. 11, 2008

[9] Public traffic department planning limit, 2019 Marián Lamr, Jan Skrbek," Real-time approaches to improving traffic safety", 5th Mediterranean Conference on Embedded Computing (MECO), Bar, Montenegro, IEEE, June 2016

[10] Esri ,"Understanding of GIS ",Redlands , California, 2022

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