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Detection of Most Congested Roads in Khartoum City Center using Geographical Information Systems Methods

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Abstract- The aim of this research is to Detect the Most Congested Roads in Khartoum City Center by studying the different causes of traffic congestion using GIS methods . Spatial and descriptive data of the congestion causes have been collected In the last three months, site plan, traffic plan ,random parking, bus lines and bus stations, natural and artificial obstacles ,entrance and exit of study area. Geographical database is created for geometrical analysis, to find out the most affected roads. This helps in developing economical solutions to the problem of traffic congestion.

Index Terms*: Traffic, Detection ,congestion, Khartoum, road management, entrances and exits,*

*****

I. Introduction

Khartoum is the national capital and the heart of the Republic of Sudan, where more than a quarter of the country's population lives (about 8 million). Thousands of villagers come to it each year to seek services and find work, making the city densely populated, causing increased pressure on resources and infrastructure, especially the transport sector, made this city constantly suffering from traffic congestion..

The traffic system in Khartoum, especially the study area, suffers from many problems despite the efforts of the local authorities to solve this problem, but traffic congestion remains a real problem that needs studies and research to solve them. These problems are the large number of cars brought to this city in the middle of the millennium, old urban planning, poor infrastructure, unstudied traffic plans, The location of study area between the Blue Nile and the White Nile in the Eastern and Western, railway facilities in the south, The concentration of health, education and commercial services on this site, has made it attractive to citizens who come to this area with their cars, causing traffic congestion.

Related studies: There are some researches that dealt with this subject, as a limited part of studies that tried to solve the problem of traffic congestion of the city of Khartoum. but this research focused on the elements causing traffic congestion to identify the most road have traffic congestion elements, in order to provide those who wish to solve the problem of traffic in the region important information, helps reduce the cost of financial and field work effort, by treatment of the least number of roads in the region and reach good results. This research has benefited from the possibilities of geographical information systems (GIS) and their programs in the production of smart maps and in a different way from the previous studies, Here are some research titles that dealt with topics related to the subject of this study .

Study the Characteristics of Traffic and Transport in Central Khartoum and its Impact On Traffic congestion, Elias, Osama Mustafa;

Traffic congestion in the heart (Khartoum) Causes and treatment. Prepared by Affan Ismail Hamida, University of Khartoum .

Khartoum Traffic System:

In this section we review the existing traffic system in the study area which includes:

The Site plan: The planning of the study area dates back to the colonial period ,and no significant changes have been made since then, so we find many narrow roads, some of which are blocked by buildings.

The study area located between the three main cities Khartoum, Khartoum North and Omdurman, due to this site, the area has become a transit point for thousands of cars passing through the three cities.

Also the study area is located between the Nile on northern and western side and railway of the southern and eastern routes due to existence of Nile and railway, the area become a limited to entrances and exits, which cause to an increase of traffic congestion.

Map showing Entrance and Exits of study area

land uses: Most of the land in the study area is a governmental land, where ministries, service centers and educational institutions are concentrated in these areas, in addition to commercial centers, bus stations and a few open squares.

Most of these ministries, service centers, educational institutions and business centers in the study area do not have private parking spaces, although they attract many citizens who park their cars on the road, thus causing an increase in traffic congestion.

Traffic plan : The traffic plan in the study area is constantly changing and is often accompanied by a lot of errors where traffic congestion breaks in some locations to make bottlenecks in other locations, so they are modified from time to time. The following are the main problems that arise when developing and implementing traffic plans in the study area.

- Change roads directions: many times the directions of roads are changed suddenly and without any prior notice to road users, causing bottlenecks and congestion.
- ***Closure of roads:***

- Roads are closed for maintenance reasons, for long periods, days or weeks, causing traffic congestion.
- Roads are closed several times due to official celebrations that generate traffic congestion.
- traffic accidents especially on the bridge of Al-engaz, closes this bridge and roads frequently.

- ***Traffic light signals***

Traffic signals although are distributed in intersect of major roads, but cause some problem due to:

- **Disrupt signals**, are renewed problem, because of the lack of a clear program of maintenance
- **Power outages:** Often, especially in the summer, electricity is cut off from the study area, causing a lot of traffic jams

-sign Synchronization: Often we pass the traffic signal and when we get to the second after several minutes we find that the following mark is red and it was possible to synchronize these signals and account the next signal time by knowing the distance and road design speed, helps to avoid downtime many times.

-Despite the disadvantages(delay, congestion) of these light signals, there are many roads in study area have no signs.

-Cars Type:

In the study area private cars constitute the majority and can be considered to be the main of the cause's of traffic congestion. The Buses :although it's few of number but on the other hand it frequently stopping in road sides without control, its slow movement, in addition to that cross the whole area of study area throughout the day so made its causes traffic congestion.

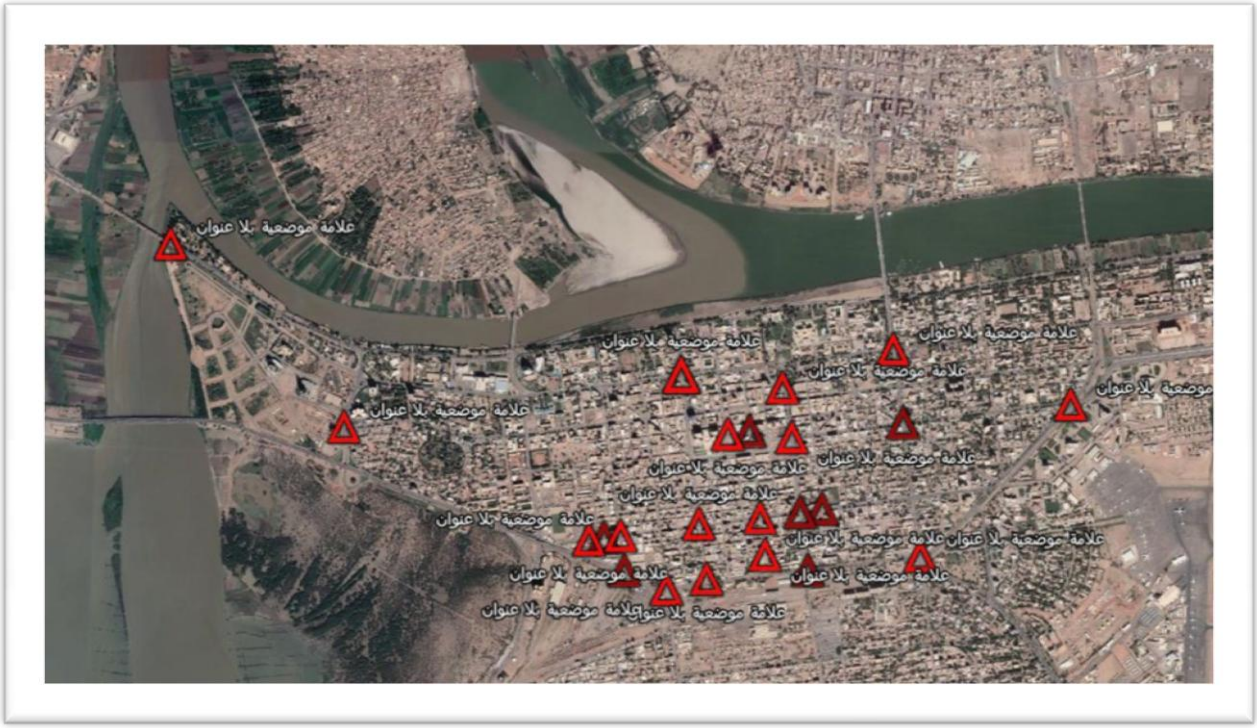
Traffic Infrastructure*:* In the study area there is a lack of strong and modern infrastructure, the most weakness points in:

- There are only a few wide roads with multiple paths.
- There are no upper bridges, most roads intersect with each other, traffic lights are used to regulate traffic.
- There are no tunnels to connect the study area with adjacent sites.
- There are no parking spaces to accommodate all cars targeting the study area.

- There are no bus stops next to roads; they stop anywhere on the road and at any time as required driver.
- There are only five bridges in the study area, the White Nile, the Blue Nile Bridge (now under maintenance), Mek Neneir, the Totti Bridge (connect the small island of Tutti with Khartoum city), Al-Angaz bridge. Both the White and Blue Nile Bridge bridges are very old, since colonial times..
- There is no modern system to guide drivers to avoid congested roads.

The most congested sites:

In the study area there are some sites known by traffic congestion especially in the morning and afternoon, often this site is at the crossroads, near the bus station, commercial centers, markets and service institutions. Map show the most known congestion sites:



Map showing the most congested side in the study area

Congested Site

Intersections of roads: here are some of most crowded roads intersections

AL-Tabia Street and Almek nimerr.

AL-Tabia Street with Alqaser Street:

AL-Tabia Street with Ahoria street.

Alsayed Abd Alrahman St. with almek Nimer st Alsayed Abd Alrahman St. with alhorria st.

Near the bus station: here are some of most crowded sites:
near karkar bus station ,Khartoum stadium bus station.
Near the commercial centers and markets: especially the following area:
Al-soug Alafranji market, nearby shopping sites for the street of alhoria
Near the services institutions: The following sites:
Khartoum Hospital. Medical and Engineering Colleges, Khartoum Bank and Omdurman National Bank.

Traffic Culture:

There are weakness in traffic culture for many drivers, a lot of them do not know much about traffic rules, some do not hesitate to cross the red sign, others want to reach their destination without being subject to the law and without being attend to road companions .causing anger to others and chaos which increase congestion. Here we review some of the behaviors that cause traffic congestion.

- ***Culture of urgency:***

Some drivers are characterized by wheel and wish to reach their destination as soon as possible without taking into account the road partners and without being aware of the traffic laws, causing:
- Accidents: which cause physical and human damage in addition to stopping movement and causing congestion.

-Ignoring of the law: due to break the laws, the cars overlap and object to each other and thus stop the traffic movement

-Differences between drivers:

in many cases, the differences between the drivers among themselves, sometimes with pedestrian ,causes in traffic disruption

- ***The behavior of police men :*** Traffic men often stop the cars on the roads to make sure the license is used, and often this behavior leads to great chaos on the road,and generate congestion
- ***The pedestrian:*** Many pedestrians especially newly arrived people from the countryside, cause congestion when crossing roads especially near large hospitals, markets and bus stations, sometimes they causes fatal accidents due poor traffic culture

Methodology

In this part of the research, a database will be building using Geographic Information Systems (GIS) technology and will benefit from the great possibilities of this Arc-map software.

➢ ***Data collection stage:***

- ***Data Design:***

Here the data will be formatted to help with information searches and spatial analysis processes and be compatible with the ArcMap format at the same time

Coordinated mosaic for study area created at 2011,Karari University.

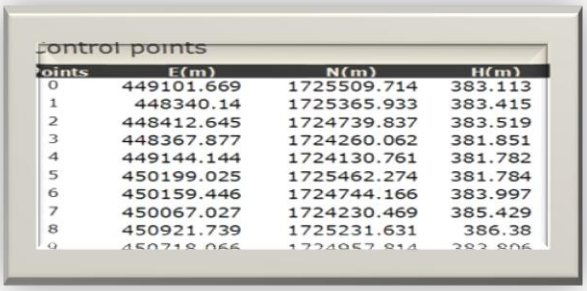
Roads map in study area as a shape file, Ministry of Infrastructure.

Traffic signals map in study area as a shipe file, Ministry of Infrastructure.

Numbers of cars enter and exit the study area, Ministry of Infrastructure.

Google Map

Control Points distributed in study area.



control points

oints	E(m)	N(m)	H(m)
0	449101.669	1725509.714	383.113
1	448340.14	1725365.933	383.415
2	448412.645	1724739.837	383.519
3	448367.877	1724260.062	381.851
4	449144.144	1724130.761	381.782
5	450199.025	1725462.274	381.784
6	450159.446	1724744.166	383.997
7	450067.027	1724230.469	385.429
8	450921.739	1725231.631	386.38

Field survey, data was collected for congested sites, random parking, asphalt width per road and road condition of the study area.

Layer System:

Here the map will be organized into a set of slides to facilitate and organize data processing and analysis.

No	Layer	Type	Color	Function
1	LandUse	Polygon	Yellow	*To show the site plan, and label of the main building*
2	Road	Arc	Black	*To show roads in study area and its properties*
3	Parking	Area	Red	*To show location of randoump parking*
4	Congestion	Polygon	Brown	*To show high congestion sites*
5	Signals	Point	Blue	*To show the light sign and its information*
6	Ent-exits	Area	Blue	*To show the Number of entering and exit cars in study area*

Attribute Table:

Here are some examples for the attributes tables

LandUse layer attributes table*:*

ID	Bu_ name	Bu_type ↓	Area	
		Services *Education* *Commercial*		

Fields Properties:

Field	Field-Type	Length	Precision
ID		Short Integer	-
Bu_ name	Text	30	-
Bu_type	Text	15	-
Area	Number	Real	3

- **Data processing:**

Arc/map software is used to Geo-reference the images, create layers, trace features, and attribute tables.

- **Mosic verification:** Since the mosic obtained is already Geo-referenced, the mosic is verified by reading 5 known points on the photographs and compared with control points obtained. The results show that the mosic is a good Geo-reference.

- **Music Update:** Music obtained is created in year 2011, so need renew, Google Map is used to update mosic by adding new features or deleting nonexistent.

Feature class Creation: For each layer listed in layers system table in the design stage, a corresponding feature class is created in Arc/Catalog.

Tracing Feature: Features are traces created to convert raster image to vector, tracing process start by adding the feature class (layer) to the arc/map windows.

Attribute Table:

For each layer, attribute table is created in Arc/map.

Analysis and Results

In this research, the Arc map program was used to answer queries about the main obstacles and causes of traffic congestion and to identify and study the most crowded road in order to find solutions for traffic congestion in study area. The following chart illustrates the main causes of traffic congestion :

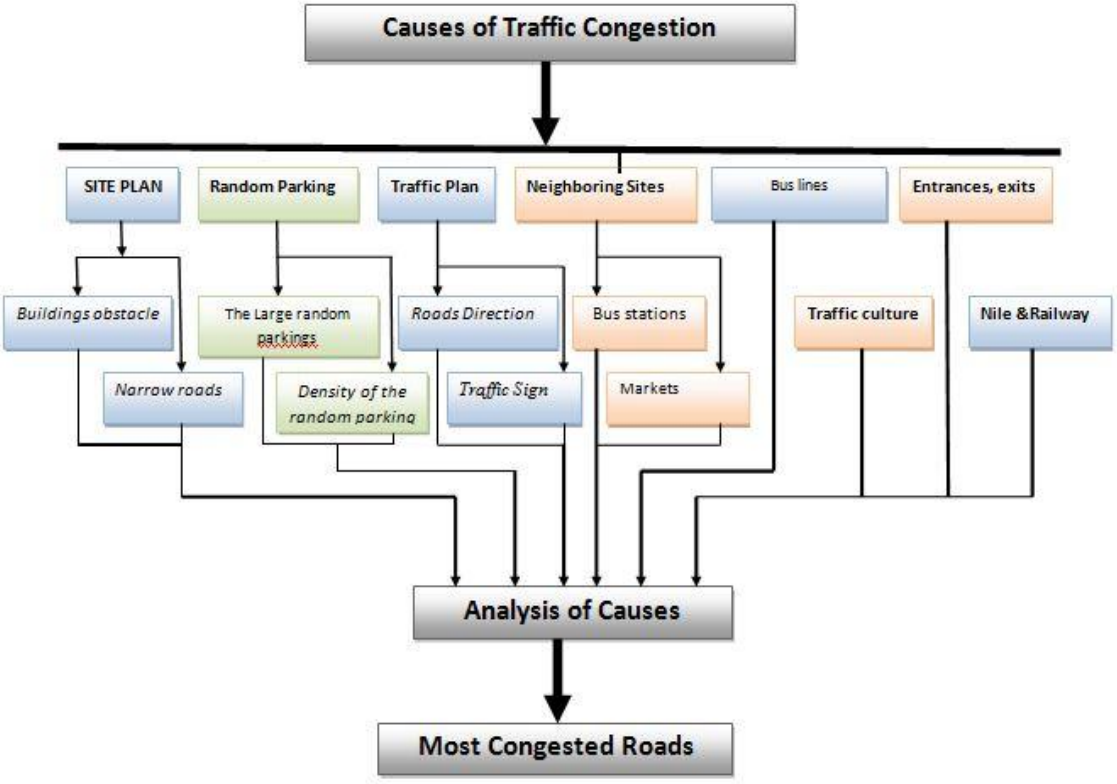


Chart illustrates the main causes of traffic congestion

- **Impact of Site Plan on traffic**:

Here we look for buildings that close or cause narrow to roads.

- **Roads closed by buildings**:
  In the study area there are many buildings that block some important roads. analysis tools were used to detect these buildings ,the software was asked to show the shortest roads in the study area, which does not exceed 1500m and greater than 200m using road layer as following:

Select by Attribute

Target layer: Road.
Field: length.
Condition: length <1300 and length>500

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the blocked roads were displayed, after omitting the short roads that not effect in traffic and not closed by buildings.

Map show roads closed by buildings

Roads closed by buildings

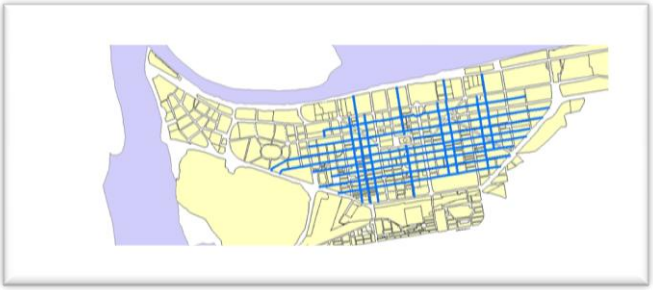
NAME	ROAD_WIDTH	LENGTH	Dirction
AL QASER ST.	40	1224.968412	two way
ABD ALLA ANNI	15	1043.198004	two way
ALI DEINAR ST.	15	1000.327819	two way
ATBARA ST.	20	688.753654	one way
BABEKER BADR	15	916.337088	two way
SALIH PASHA AI	15	1195.779243	two way
CAP. EL JAMEL S	15	1221.271489	two way
TERHAGA ST.	15	506.442417	one way
AL JAMI AL KBII	25	601.605232	one way
SENKAT ST.	15	641.705112	one way
SELIMAN KASHI	15	782.809592	one way
CAP. MARAD ST.	20	663.943021	one way
CAP. AEZ AL DIE	15	729.131974	two way
M. C. ST.	15	941.796406	one way
ABID HAJ AL AM	15	604.245087	two way
Abo garja ST	15	880.072132	two way
A. AL NAGOMI S	25	1000.665516	one way
Altayiar zulfe	15	979.57215	one way
CONT MOKHLES	15	1003.803547	one way
HISHAM BIA ST.	15	943.80104	one way
MOHD ABD ALRA	25	578.836762	one way

Report showing roads closed by buildings

- ***Narrow roads:***
  As a result of the old planning of the study area, there are many narrow roads and some of them have become a cause of congestion so we will look for these roads Software asked to show the roads that its widths less than 25 meters and its lengths greater than one kilometer

  Select by Attribute:
  Target layer: Road
  Fields: Road_width & length
  Condition: ROAD_WIDTH <25 AND LENGTH >1000

  All roads with a width less 25m and length greater than one kilometer were displayed.



Map shows the narrow

Narrow roads

NAME	LENGTH	ROAD_WIDTH	Dirction
AL SAYED ABD AL RAHM	2642.729883	20	one way
AL HURIYA ST.	1500.450271	20	one way
ABD ALLA ANNUR ST.	1043.198004	15	two way
ALI DEINAR ST.	1000.327819	15	two way
AT TIGANI AL MAHI ST	3493.633645	15	two way
SALIH PASHA AL MUK S	1195.779243	15	two way
CAP. EL JAMEL ST.	1221.271489	15	two way
ASH SHERIEF AL HINDI	2960.741994	15	one way
ABU SIN ST.	1305.268063	15	one way
CONT MOKHLES ST.	1003.803547	15	one way
AL KHALIFA ST.	1392.519496	20	one way
AL BALADIYA ST.	3338.092593	20	one way
AL ISBITAIYA ST.	2246.233609	15	two way
AL ZUBAIR PASHA ST.	3332.118527	15	one way
21st OCTOBER ST.	2517.451995	15	one way
AL BRLMAN ST.	2886.308247	15	one way

Report shows the narrow roads

- **Road congested by the random parking:**

In the study area there are many institutions that do not have internal parking's and all workers and customers stops their cars on the roads side near to these institutions. The impact of this random stand depends on the institutions size and services it provides. In this section we look for the

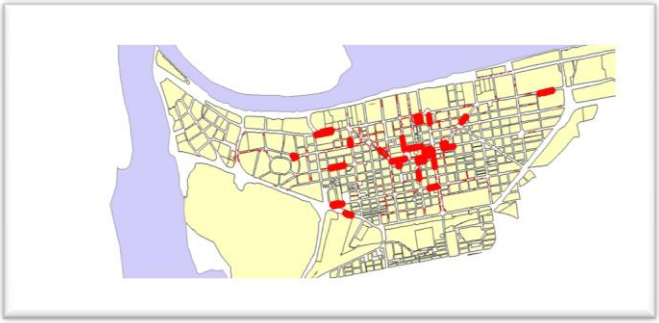
- ***Congestion due to large parking:*** This type of traffic congestion often is in some parts of the road and most other parts of the road without any congestion, the solution in this case by building the internal parking of the institution that cause congestion or change its gate direction to another road if possible.

--First, ask the program to determine the largest area parkings , in the study area by:

Select by attribute
Target layer: Parking layer

Field: area

Condition: shape_Area > 500m



Map show large random parking locations

--Second, the roads adjacent to the large car parking were identified as follows:

Select by Location:

Target layer: Road layer

Source layer: Parking layer

Active selected: large parking

Condition: distance 10m

Roads adjutant to the large random parking were displayed

Roads adjutant to the large random parking

NAME	LENGTH	ROAD_WIDTH	Dirction
ALI ABD AL LTEIF	1366.174444	25	one way
AL GAMHURIYA S	4474.211189	30	one way
AL SAYED ABD AL	2642.729883	20	one way
AL QASER ST.	1224.968412	40	two way
AL GAMA'A ST.	5055.185784	25	one way
ATBARA ST.	688.753654	20	one way
BABEKER BADRI S	916.337088	15	two way
AT TIGANI AL MAI	3493.633645	15	two way
AL JAMI AL KBIR S	601.605232	25	one way
SENKAT ST.	641.705112	15	one way
SELIMAN KASHIA	782.809592	15	one way
AL BRIR ST.	373.558376	25	two way
CAP. MARAD ST.	663.943021	20	one way
CAP. AEZ AL DIEN	729.131974	15	two way
ASH SHERIEF AL I	2960.741994	15	one way
Altayiar zulfe	979.57215	15	one way
CONT MOKHLES S	1003.803547	15	one way
AL KHALIFA ST.	1392.519496	20	one way
AL BALADIYA ST.	3338.092593	20	one way
AL ZUBAIR PASHA	3332.118527	15	one way
HISHAM BIA ST.	943.80104	15	one way
WED HABBOBA ST	320.899307	15	one way
MEHIRRA ST.	441.042964	15	one way
21st OCTOBER ST.	2517.451995	15	one way
AL BRLMAN ST.	2886.308247	15	one way

Report show Roads adjutant to the large random parking

- ***Congestion due* Random parking density:**

  In this type, a large number of random parking lots are distributed along the road. The density of these random parking depends on the spaces beside each road. The solution in this case is the construction of public or commercial car parking in parts of the road.

Map show random parking locations

After examining the random parking layer, the most affected roads were chosen, where random parking appear more than other roads. Total parking's area in each road was calculated and the density was found from equation:

Density= (Total area of random parking)/Space beside the road)

Here is example for calculation of random parking density in al-gamaa road

- ***Calculate the total area of random parking:***

After selecting the Al-gamaa road, the(select by location command) were used

Select by Location:

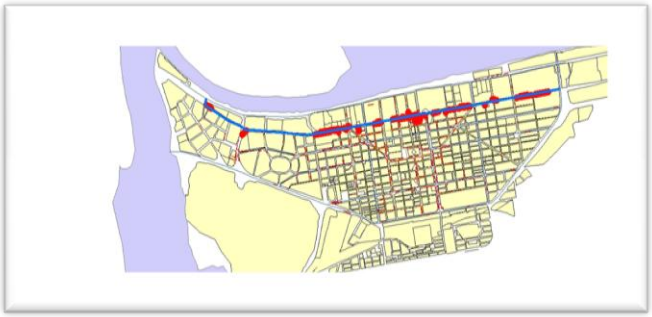
Target layer: Parking

Source layer: road

Active selection: Al- gamaa Street.

Condition: distance within 10m

All random parkings were selected on the Al gamaa Street.



Map show random parking in Algamaa street.

Then report is created to give the statistical value abut parking in Algamaa street.

Random Parking in Al-gamaa street

OBJECTID	Shape_Area
1	1228.056328
20	380.484981
79	118.740617
81	72.647843
85	462.868534
86	138.031015
87	63.236935
88	36.053201
89	80.167474
112	185.887266
124	289.327074
217	343.419778
221	391.078174
244	110.691022
289	140.088296
293	323.548701
296	968.499696
297	686.326878
298	128.377885
299	38.270943
301	264.737909
302	63.849893
304	135.068382
305	68.039183
306	285.033698
307	73.364432

308	422.629868
309	31.172911
310	293.159253
311	3989.807668
312	342.179088
314	76.842506
323	37.288087
324	55.889442
325	55.793183
326	85.691166
327	76.105728
330	365.537278
424	38.841283
425	53.479824
426	65.188781

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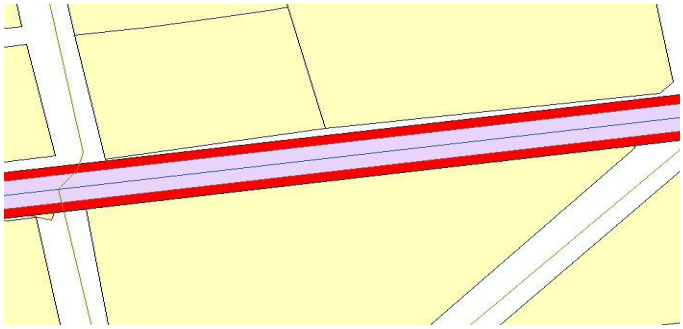
OBJECTID	Shape_Area
427	60.85256
428	200.137549
Average Shape_Area	309.151023
Count Shape_Area	43
Sum	13293.493997

As shown in report :Total area
=13293.493997m^2

- ***Calculation Space beside the road :***
  Two buffer around Algamaa street are created, the first one for total area of road and the second for asphalt area, the different between the two buffers area will give the *Space beside the road.*

Map show buffers in Algamaa street.



show magnification of buffers in Algamaa street.
Area of the two buffers are obtained from attribute table .
Space beside the road= total area of road - asphalt area
= 126373.628183 -75825.409053
= 50548.21913

- ***Calculation of Density:***
- *Density= (Total area of random parking)/Space beside the road*
  = 13293.493997*/50548.21913*
  =0.262986

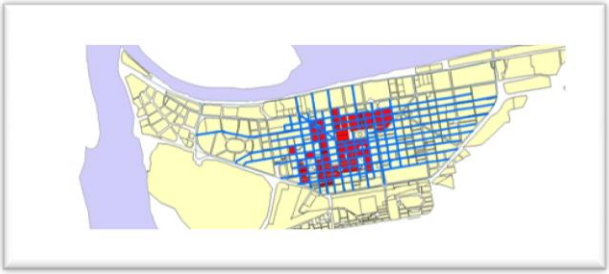
In the same way, the steps have been repeated for the rest of the major main roads
The table below shows the heights density roads.

Raod	**Density**
AL GAMA'A ST	***0.262986***

Table show highest density roads

- **Congested roads due to neighboring sites:**
  There is no doubt that the sites adjacent to the roads are the main factor that affects the traffic congestion. Markets, commercial centers, bus stations and service institutions, whether health or educational or ministries, attract many citizens with their cars to those sites, causing a lot of traffic congestion. Traffic congestion is differ depends on the differ types of locations neighboring to the roads, the solutions are also different, so we will look for congested roads according to neighboring sites type.

  - **Road congestion due to markets and shopping centers:**
    In the study area there are many large markets and malls that contribute to increasing traffic congestion through the density of customers who attend their cars along with roads, in addition to the vendors whom cause the congestion .



Map show the Roads passing through the Markets and commercial centers

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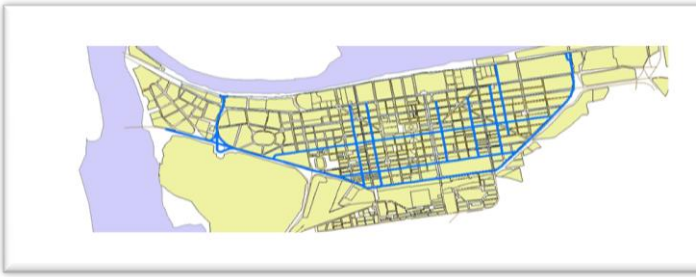
Roads passing through market and commerical centers

NAME	ROAD_WIDTH	Diretion
ALI ABD AL LTEIF ST.	25	one way
AL GAMHURIYA ST.	30	one way
AL SAYED ABD AL RAHM	20	one way
AL QASER ST.	40	two way
AL HURIYA ST.	20	one way
ABD ALMUNAEIM MOHD S	25	two way
BABEKER BADRI ST.	15	two way
AT TIGANI AL MAHI ST	15	two way
SALIH PASHA AL MUK S	15	two way
CAP. EL JAMEL ST.	15	two way
AL JAMI AL KBIR ST.	25	one way
SENKAT ST.	15	one way
SELIMAN KASHIA ST.	15	one way
CAP. AEZ AL DIEN ST.	15	two way
ASH SHERIEF AL HINDI	15	one way
Altayiar zulfe	15	one way
CONT MOKHLES ST.	15	one way
AL KHALIFA ST.	20	one way
AL BALADIYA ST.	20	one way
AL ISBITAIYA ST.	15	two way
AL ZUBAIR PASHA ST.	15	one way
HISHAM BIA ST.	15	one way
21st OCTOBER ST.	15	one way
AL BRLMAN ST.	15	one way

Report shows the Roads passing through the Markets and commercial centers

- **Roads congestion due to bus stations:**

Bus stations are one of the biggest causes of traffic congestion, Because of the Confluence of a large number of public and private cars. In addition, it is usually surrounded by shops and peddler. There are also a large number of traffic attendants, causing congestion in nearby roads, as well as in the entrances and exits of these stations. The following are the main bus stations and roads affected by it.



Blue : two way roads *Red : one way roads*

Map show the roads pass adjacent to the bus stations

Roads congested due to bus stations

NAME	LENGTH	ROAD_WIDTH	Diretion
ALI ABD AL LTEIF ST.	1366.1744	25	one way
AL GAMHURIYA ST.	4474.2111	30	one way
AL SAYED ABD AL RAHM	2642.7298	20	one way
AL QASER ST.	1224.9684	40	two way
AL HURIYA ST.	1500.4502	20	one way
SALIH PASHA AL MUK S	1195.7792	15	two way
SELIMAN KASHIA ST.	782.8095	15	one way
WED HABBOBA ST.	320.8993	15	one way
21st OCTOBER ST.	2517.4519	15	one way
Al-Tabia st	6777.8763	30	two way

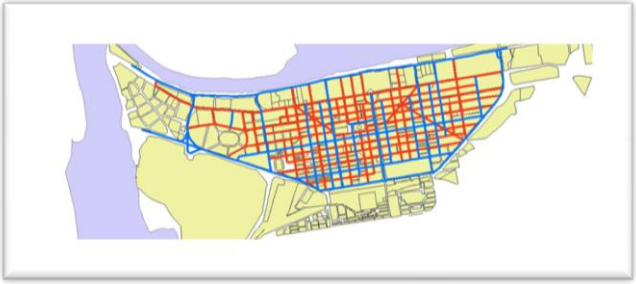
Report shows the roads pass adjacent to the bus stations

- ***Road congestion due to traffic plans:***

The traffic plans affects traffic congestion. Traffic directions and traffic signs are the most important factors, so we look for the congested roads due to these factors.

- **Congestion of two-way roads:**

According to the current traffic plan in the study area, the roads are divided into two types: one-way roads and two-way roads as the shown on map:



Two-way roads, in study area especially narrow roads, are more congested than roads of one-way direction so we asked the database to view the two-way important roads, which asphalt width less than 18 m and length greater than 200m.

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Congestion of two-way roads

NAME	LENGTH	ROAD_WIDTH
AL QASER ST.	1224.968412	40
ABD ALLA ANNUR ST.	1043.198004	15
ALI DEINAR ST.	1000.327819	15
ABD ALMUNAEIM MOI	1515.827377	25
BABEKER BADRI ST.	916.337088	15
AT TIGANI AL MAHI ST	3493.633645	15
SALIH PASHA AL MUK	1195.779243	15
CAP. EL JAMEL ST.	1221.271489	15
CAP. AEZ AL DIEN ST.	729.131974	15
ABID HAJ AL AMIEN S	604.245087	15
Abo garja ST	880.072132	15
ARBAB AL AQAID ST.	1104.159269	25
AL MUK NIMIR ST.	1518.734973	25
AL ISBITAIYA ST.	2246.233609	15
Al-Tabia st	6777.876355	30

Report showing the most congested two way road.

- ***Road congestion due to traffic signs***

The light signals are one of the most important traffic sign in the study area, it organize traffic at road intersections as discussed above, but suffers from many problems such as power outages especially in the summer and unfair distribution of time between intersecting roads and un-synchronization with each other. Causing long or frequent stop that contribute to increased traffic congestion.

Figure (): A map showing traffic lights sign

The delay time for roads that contain a large number of traffic sign is calculated ,in order to find the roads that have a maximum values of delay time , Here we calculated the delay time in Algamaa street as example:

Select by Location:

Target layer: signal layer
Source layer: Roads layer
Active selected: Algamaa street
Condition: distance 20m

All light signals in Algamaa Street are selected

Then the total delay time is calculated by summarizing the field of delay in attribute table

Traffic_lights delay time in Algamaa street

Signal_Id	Delay_Time
4	1.5
5	1.5
6	1
7	1
19	1.5
20	1
36	1

Sum Delay_Time in Minutes 8.5

Using the same steps delay time for the other roads are calculated..

Raod	*Delay Time(min)*
AL GAMA'A ST.	*6.5*

- **Congestion at the entrances and the intersection of roads**

Due to the small number of inputs and exits in the study area, most of the roads entering and exit the area is crowded especially in the morning and afternoon time. *Using aerial imagery and field survey of the study area, the congested entrance and roads intersections were identified on the map, and the roads passing through these sites were identified.*

Map shows the roads passing through the most congested locations

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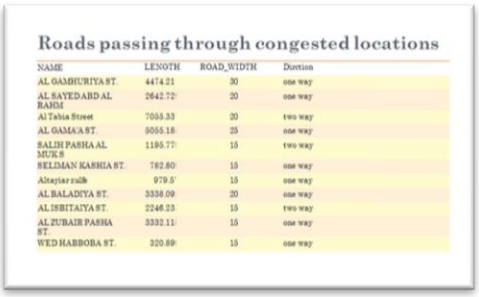


Roads passing through congested locations

NAME	LENGTH	ROAD_WIDTH	Diretion
AL GAMHURIYA ST.	4474.21	30	one way
AL SAYED ABD AL RAHM	2642.72	20	one way
Al Tabia Street	7055.33	20	two way
AL GAMA'A ST.	5055.18	25	one way
SALIH PASHA AL MUK S	1195.77	15	two way
SELIMAN KASHIA ST.	782.80	15	one way
Altayiar zulfe	979.5	15	one way
AL BALADIYA ST.	3338.09	20	one way
AL ISBITAIYA ST.	2246.23	15	two way
AL ZUBAIR PASHA ST.	3332.11	15	one way
WED HABBOBA ST.	320.89	15	one way

Report shows the roads passing through the most congested locations

- **Roads congested due to bus lines:**

There is no doubt that the road used by a large number of bus lines are always slower and busier than others due to the frequent stop of these buses, especially those used in Khartoum City, many of which are old. The map shows the most commonly used roads by bus lines in the study area.

Map show most commonly roads used by bus lines

Roads congested due to bus lines

NAME	LENGTH	ROAD_WIDTH	Diretion
AL GAMHU	4474.21	30	one way
AL SAYED A RAHM	2642.72	20	one way
AL GAMA'A	5055.18	25	one way
ATBARA ST	688.78	20	one way
SELIMAN K	782.80	15	one way
A. AL NAGO	1000.66	25	one way
ARBAB AL	1104.18	25	two way
AL BALADI	3338.09	20	one way
Al-Tabia st	6777.87	30	two way

Report shows the most common used roads by bus lines

- **Congestion due to Railway and Nile**:

Most roads in the study area are closes, either by rail or river Nile, so we chose the most important roads, which have no bridges.

Roads Closed by Railway or River Nile

NAME	LENGTH	ROAD_WIDTH	Diretion
ALI ABD AL LTEIF ST.	1366.1744	25	one way
ABD ALMUNAEIM MOHD S	1515.8273	25	two way
A. AL NAGOMI ST.	1000.6655	25	one way
AL KHALIFA ST.	1392.5194	20	one way
OSMAN DIGNA ST.	1114.9835	25	one way
AL ZUBAIR PASHA ST.	3332.1185	15	one way

The Results

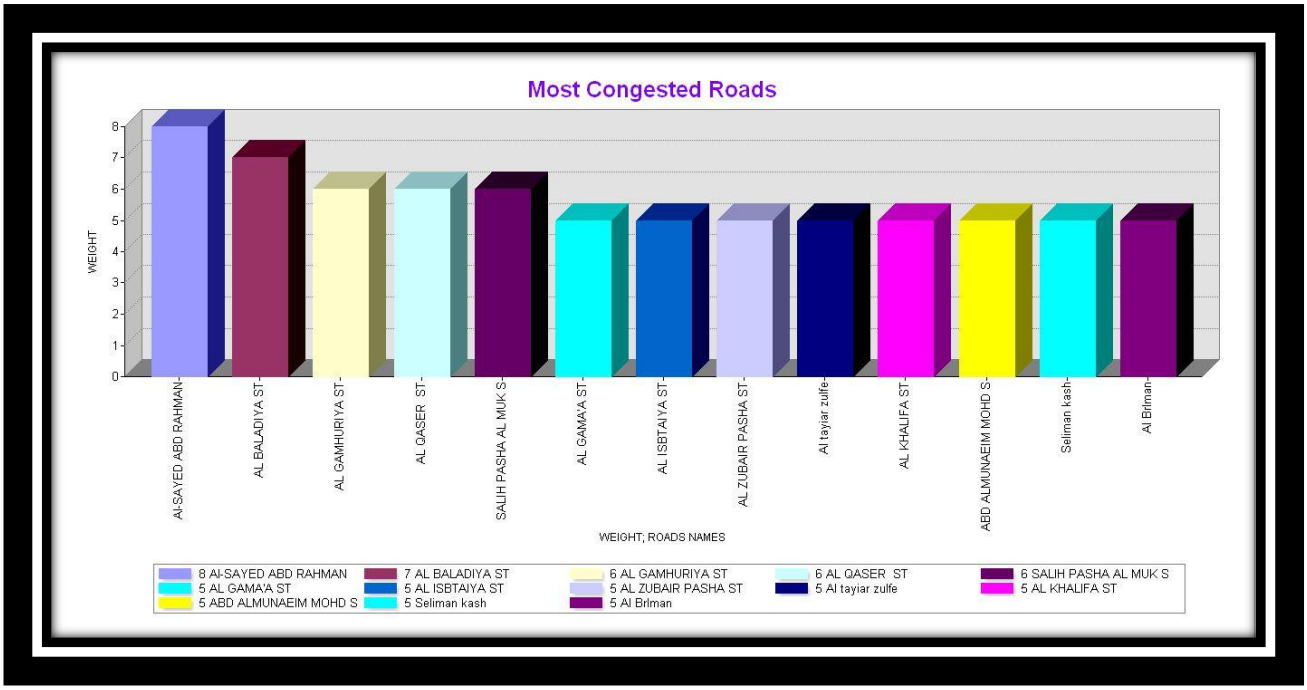
After conducting the analysis above to identify the sites of obstacles and causes of congestion and then scheduled as the following:

Table(1)

The Most Congested Roads in Study Area are:

No.	Roads
1	AL SAYED ABD AL RAHMAN
2	AL BALADIYA .
3	AL GAMHURIYA
4	AL QASER
5	SALIH PASHA AL MUK
6	AL GAMA'A .
7	AL IsbITAIYA
8	AL ZUBAIR PASHA
9	Al tayiar zulfe

10	AL KHALIFA
11	ABD ALMUNAEIM MOHD
12	Seliman kash
13	Al Brlman



Conclusion:

The results above show the most congested road in the study area, providing important information to help solve congestion problems by addressing the least number of roads in the region and thus reducing field processes, effort and time .So this research will contribute to reducing the huge costs associated with solving the problems of traffic congestion in modern cities.

References*:*

[1] *Gomaa Dawod (2015)*,**Principles of GIS Spatial Analysis**,Mecca

[2] *Gomaa Dawod (2014)*,**Principles of GIS science**,***Mecca***

[3] *Alan brimicombe,(2008)*,**GIS Environmental modeling and Engineering.**