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NETWORK ANALYSIS FOR THE STUDY OF TRANSPORT IN THE METROPOLITAN AREA OF ALGEIRS

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Abstract: Transport in the metropolitan area of Algiers is very complicated, so we used the powerful tools of geographic information systems in the analysis of transport in the study area. Through the utilization of network analysis and GIS capabilities, our study focuses on optimizing transportation networks and enhancing port accessibility in the metropolitan regions of Boumerdes, Blida, Tipaza, and Algiers. Our methodology involves data collection, GIS analysis, and mapping to generate databases and maps of metropolitan networks. Through assessing port accessibility, road connectivity, and population-based hotspots analysis. Our study reveals Algiers as the most accessible municipality, attributed to its strong centralization. The road-based analysis and population-based hotspot analysis provide valuable insights into port accessibility, road connectivity, and high-density townships, facilitating informed urban planning and infrastructure development.

Keywords: network analysis, transportation, business activity, the geographic information system (GIS), accessibility, connectivity, Algerian metropolitan business areas.

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INTRODUCTION

The National Spatial Planning Policy is currently at the heart of the concerns of the public authorities. The fundamental instrument of this policy is the National Spatial Planning Scheme (SNAT 2030). The latter is based, horizontally, on the Sectoral Master Plans and vertically, on the Schemes of Territorial Programming Spaces (SEVEN for the nine program regions) as well as on the Development Plans of the Wilaya Territory (PATW). Note that metropolitan areas are equipped with instruments, in this case the Metropolitan Area Development Plans (SDAAM).

The National Planning Policy and sustainable development of the territory aims at a harmonious development of the whole national territory, according to the specificities and the assets of each regional space.

Its purposes consist in:

- Creating favorable conditions for the development of national wealth and employment;
- Providing equal opportunities for promotion and development among all citizens;
- Encouraging the appropriate distribution, between regions and territories, of the bases and means of development by aiming to alleviate pressure on the coast, metropolises and large cities and the promotion of mountain areas, regions of the Highlands and South;
- Supporting and revitalizing rural areas, territories, regions and areas in difficulty, for the stabilization of their populations;
- Rebalancing the urban framework and the promotion of regional, national and international functions, of metropolises and large cities;
- Protecting and enhancing ecologically and economically sensitive spaces and groups;
- Protecting territories and populations against the risks associated with natural hazards;
- Protecting, enhancing and rationalizing the use of heritage, natural and cultural resources and their preservation for future generations.

To situate the importance of the role of ports in supporting and driving the economic and social activity of a country, it is crucial to highlight the nation's heavy reliance on trade with the rest of the world, with over 95% of these exchanges being conducted through maritime transportation (World Bank, 2021). This statistic underscores the critical role of ports in facilitating international trade connections and emphasizes their significance in the country's economic development and social progress. In light of the significant dependence on maritime trade, the efficiency and development of ports play a crucial role in driving the economic development of the country. The continuous pursuit of improving port performance is imperative (World Bank, 2019). Achieving efficiency relies on having suitable and well-adapted infrastructure that meets

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the demands of evolving maritime transport technologies and the impacts of globalization (UNCTAD, 2020). This necessitates the availability of appropriate facilities and high-performance operational equipment, as well as an organizational and management system that adheres to international norms, standards, and market economy principles (UNCTAD, 2020).

The perception of ports has evolved beyond being merely a connection point between different transportation modes and a hub for goods movement. They now serve as dynamic components and essential elements within national and international logistics systems (Notteboom and Rodrigue, 2020). Recognizing their pivotal role, ports can significantly contribute to gaining a competitive advantage in the global market (Lam and Yap, 2019). Consequently, there arises a crucial requirement for a well-defined port policy that prioritizes the development of national potential and assets (Wilmsmeier and Notteboom, 2018). Transportation is the most critical and complex component of urban development and plays a vital role in the lives of the people and development of the country's economy (Mb and Vera, 2021) especially in underdeveloped nations. Investing in transportation is a powerful tool for regional development (Filip and Popa, 2014). The sustainable development of a region facilitates efficient route planning and accessibility to the desired service locations. Efficient accessibility is considered an essential input for socio-economic development. Access to input resources and output markets determines potential production and investment opportunities for products and services (Amin Hamdi, 2019).

The manner of balancing equity and efficiency is an important step to achieving spatial balance in the distribution of public service resources (Nitin and Kriti, 2023). Geographic Information System (GIS) technology is one of the hottest research tools in the world and is one of the fastest growing high technologies for monitoring (Ahmed et al., 2017). It is widely recognized as an organized collection computer hardware, software, geographic data, and personnel to capture, store, update, manipulate, analyze, and display all forms of geographically referenced information efficiently (Amrapali et al., 2015).The ArcGIS Network Analyst extension enables users to dynamically model realistic network conditions including turn restrictions, speed limits, height restrictions, and traffic conditions at different times of the day (Kumar and Kumar, 2016). An accurate examination of the current road network is essential for sustainability and for enabling people to travel with ease, at lower cost, and in less time, among other things (Debashis et al., 2019).

Port development leads to enhanced trade activity, increased supply, and reduced prices for commodities (Brooks, and Pallis, 2016). The role of the transportation network and access to ports are highly significant in facilitating unconstrained imports and exports of raw materials, machinery, and products (Ng and Ducruet, 2020). Port regionalization represents a new phase in port development, emphasizing the importance of efficient port systems (Notteboom, and Rodrigue, 2018). Evidence from China demonstrates the impact of port development on trade (Kunz and Hesse, 2017).

The primary objective of this project is to analyze the connectivity between ports and activity areas, identify optimal routes, and identify areas with high and low population densities. Onthe one hand, the GIS will provide management assistance based on functional and decision-making support based on several thematic analyzes spatial anal (Manel and Djamel, 2022). Utilizing GIS software, we aim to efficiently represent this spatial information. ArcGIS has been recognized as a highly user-friendly and efficient tool in the fields of traffic engineering and transportation planning. The approach used for this purpose is based on road network modeling, travel time calculations and functions integrated into geographic information software (Manel and Djamel, 2023).To implement our suggested improved approach, we selected thewe selected the road networks of Boumerdes, Blida, Tipaza, and the capital Algiers in Algeria as a case study.

Analogical models simplify diversity by describing, naming, classifying and cataloguing objects of study and grouping them into generic types; mathematical models simplify the complexity of their behavior by describing it in the form of laws and formulas. Depending on the spatial issues involved in a research or study project: the scale of observation (urban, regional), the type of network (monomodal or multimodal), and the object addressed (road traffic, accessibility), etc., a network can be assessed and modeled differently:

- Nodes can represent a network of cities, a network of ports or airports, the location of a high demographic concentration, economic potential, a city, a crossroads within a city, a simple intersection of roads, etc. It's a question of seeing from what angle we approach the question of transport.

- An arc corresponds to a section of homogeneous transport network (roads, bus lines, tramways, etc.), and must reflect the technical and functional characteristics of the transport infrastructure (cross-sections, speed, etc.) (Farid and Tahar, 2022).

The aim of this article is also to highlight the efficiency of using GIS in territorial governance on the one hand and to optimize travel time in economic activities in general and relations between ports and business parks in particular, in order to minimize time wasted on long journeys.

MATERIALS AND METHODS

The analysis in this paper is based on the road network connectivity and on the geographic locations of ports and the activity areas, and the population density to identify the statistically significant communes that have best routes providing accessibility to ports and activity areas using GIS software. We began by collecting and preparing the data that would be used in the analysis and this would be followed by the creation of a Geo-database for storing store the prepared data. Then both the network topology and network dataset would be built. Next, the network analysis process would be applied to the road network of the four states, and finally the hot spot analysis of the communes' population identified from the network analysis is made. The study area in this research consists of four states:

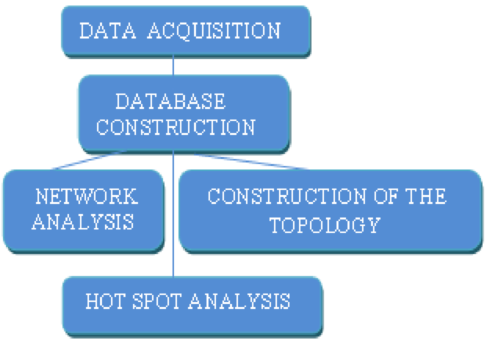

Figure 1.Geomatization method

Boumerdes, Blida, Tipaza, and the capital Algiers located in the north of Algeria country between longitudes 1″32’25” E and 4″2’26” E, and latitudes 36″49’25” N and 36″20’50” N. They cover a total area of around 5427.71 km^2 (Figure 2).

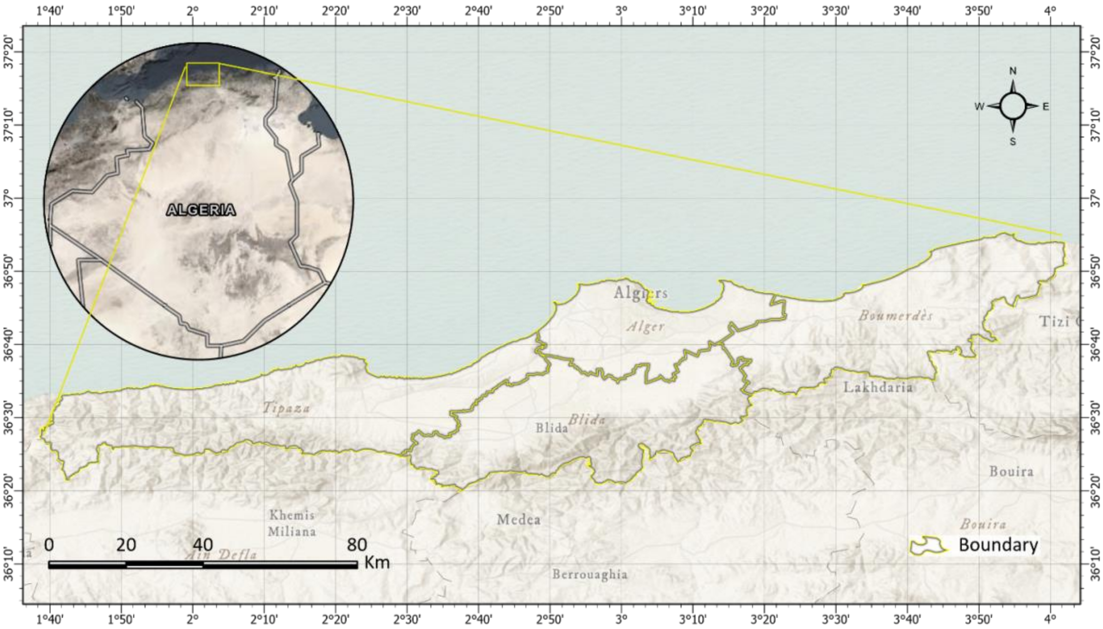

Figure 2. Location map of the Study area (Source: www.diva-gis.org)

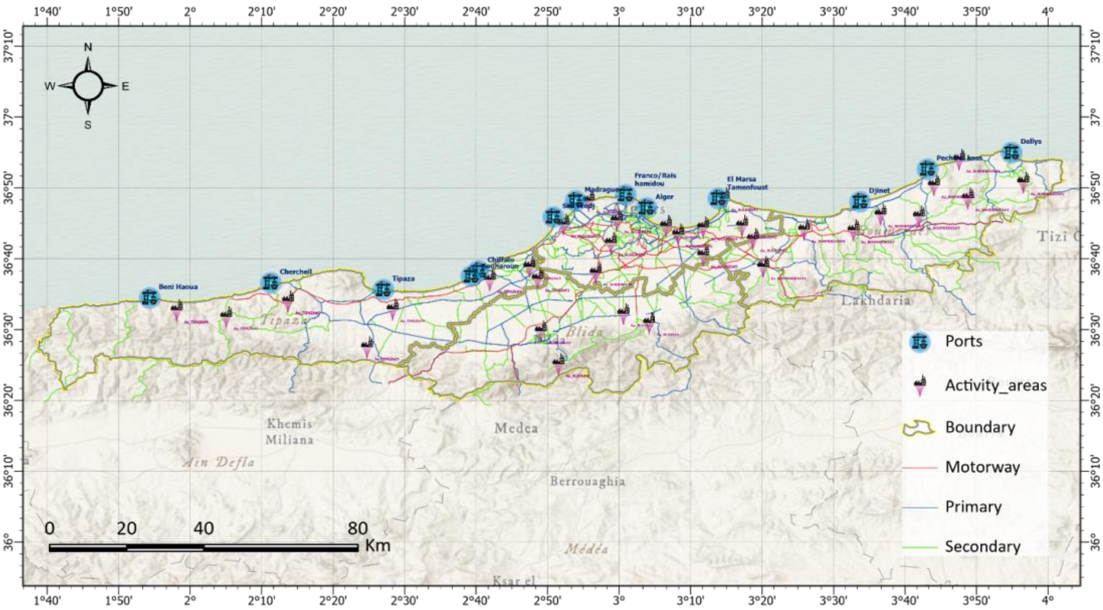

Figure 3. Road network map with Locations of Ports and Activity areas (Source: realised by TinaBENFERHAT)

DATA PREPARATION

A Modern Antique world base map was added to ArcGIS Pro software for network analysis of the study area, which can be accessed as an ArcGIS Online Service that provides free read-only unique vector web map customization. Updating the look of 18thand 19th century antique maps in the modern world of multi-scale mapping (Esri). Open-source national road network datasets are available from the OpenStreetMap (OSM for short), a worldwide spatial dataset, with unlimited use by everyone, generated and processed by interested parties with no limitations to download the data. We used Qgis software with the help of QuickOSM Plugin to extract three layers of the highway road network data.The studied roads were classified according to a hierarchy, based on the main function each road had in the road network. They were categorized as motorway, primary, secondary road. The data contain an attribute (Meters) to store the length of each road segment in the roads network, an attribute (Direction) to store the direction of each segment, and an attribute (Name) to store the name of each road segment and the max speed of each segment. Distance and time are essential to perform analysis on transportation networks. With the length attribute, we created a new field of distance for each road segment and, from distance and max speed attributes, we calculated the estimated travel time of each segment of our dataset. With the help of Remotely Sensed Data from Google Earth, digitization of ports and activity areas has been done. Also the data contain an attribute (Name) to store the name of each port and finally the count of 2018 population data of each state was added to the attributes table of the study areas and a map in ArcGIS Software showing the data in a spatial context was generated (Figure 3).

1. Creating geodatabase file:

A geodatabase within ArcGIS software was used for to store the data which is the native data structure used in ArcGIS and it is the fundamental data format used for both editing and management of the data (Esri). All the files were within one single dataset which ensured thatall had the same coordinate system, which was a vital condition for the operation to be correct It will contain the data of the road network, ports and activity areas The advantages of using a database include: centralized data, all within the same place; high speed for access and manipulation of data; high security, with measures to ensure the data is not damaged or corrupted.

2. Creating Network topology:

To manage better our geographic road network dataset, we need a network topology to ensure data integrity checks and maintain the connectivity between features. By applying some topology rules, such as ensuring that there are no dangles in the road network and the roads do not intersect or overlap with themselves, network information can be read and processed by tracing and diagram functions in an effective way.

3. Creating Network dataset:

After the download and preparation of the dataset it is ready for being used in building the network dataset that will be used in the network analysis. The line feature class elements are dataset. A network geo dataset was created which resulted in the links over which agents travel and Junctions connect. In addition, network elements have attributes that control navigation generated from the source of the highway road layers features it which will represent the road network and must be stored in a featurelayer consisting of the junctions connected topologically to each other. Edges connect other element's (junctions) edges facilitate navigation from one edge to another (Esri). The geometry of the source features helps establish connectivity over the network. The Network analyst extension was used in ArcGIS pro to create the network dataset shown in Figure 4.

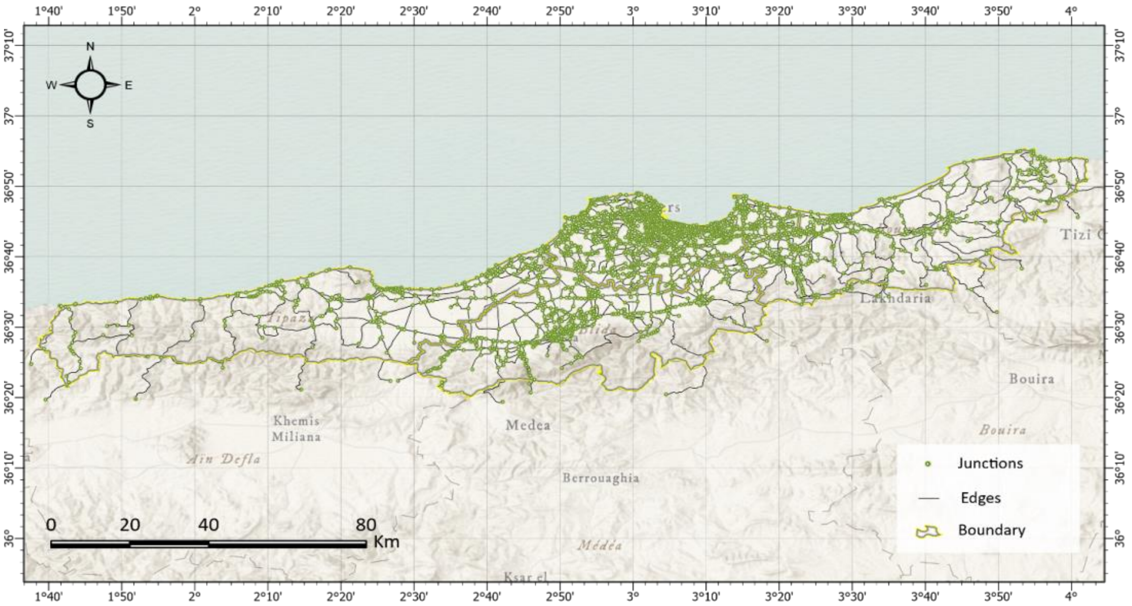

Figure 4. Junctions and edges of the road network generated by network analyst tool in ArcGIS
(Source: generated by network analyst tool in Arcgis)

4. Network analysis

The road network analysis has been implemented using the ArcGIS Network Analyst Extension. It helps organizations, businesses, and public services improve strategic decision-making (Esri), model realistic network conditions, which include turn restrictions, speed limits, height restrictions, and traffic conditions at various times of the day, and facilitates understanding and solving problems of a transportation nature. Network analysis is used for measuring the effective distance, rather than the Euclidian distance, between habitat patches. This method has been used in planning to assess the connectivity of existing or proposed reserves. There are several extremely efficient algorithms for determining the optimal route, the most widely cited of which was developed by Edgar Dijkstra (in 1959) and calculates the least accumulated cost between the destination node and every other node in the network (Khaing et al., 2018). To serve the purposes of our study, two types of network analyses were applied to solve the network for the determination of the shortest route: the closest facilities analysis and the origins-destination matrix analysis.

4.1. Closest facility

The closest facilities analysis finds the closest facilities that can be reached in a specific period from an incident location based on travel time and traffic information available (Debashis et al., 2019). In our case, the facilities represent the ports and the incident represents activity areas; this helps finding the closest facilities and specifies how many ports are there, the impedance factors in the analysis, the start time, the period to reach the closest activity areas, and whether the direction of travel is toward or away from them. The closest facility solver displays the best routes between activity areas and ports, reports their travel costs, and returns driving directions. Then, by using the network analyst extension solver, the closest ports to the location of an activity area can be found, as shown in (Figure 5) below.

	ObjectID *	Shape *	FacilityID	FacilityRank	Name	IncidentCurbApproach	FacilityCurbApproach	IncidentID	Total_Length	Total_Time_travel	Shape_Length
1	1	Polyline M	8	1	Aa_ALGIERS#1 - El Marsa Tamenfoust	Right side of vehicle	Right side of vehicle	1	1218.139613	1.593104	0.013276
2	9	Polyline M	10	1	Aa_ALGIERS#7 - Madrague	Right side of vehicle	Right side of vehicle	9	2654.765835	3.022496	0.027545
3	23	Polyline M	5	1	Aa_TIPAZA#3 - Chiffalo	Left side of vehicle	Right side of vehicle	28	5304.898387	6.36794	0.056226
4	27	Polyline M	2	1	Aa_TIPAZA#8 - Beni Haoua	Left side of vehicle	Right side of vehicle	33	5964.029701	6.564162	0.065642
5	17	Polyline M	11	1	Aa_BOUMERDES#3 - Peche el koss	Right side of vehicle	Right side of vehicle	20	7304.278313	7.680589	0.076806
6	25	Polyline M	4	1	Aa_TIPAZA#6 - Cherchell	Left side of vehicle	Left side of vehicle	31	8708.834715	7.939671	0.088626
7	3	Polyline M	12	1	Aa_ALGIERS#11 - Sidi Fredj	Right side of vehicle	Right side of vehicle	3	6756.228977	7.999079	0.071367
8	11	Polyline M	1	1	Aa_ALGIERS#9 - Alger	Right side of vehicle	Left side of vehicle	11	8372.772958	9.029904	0.085146
9	10	Polyline M	1	1	Aa_ALGIERS#8 - Alger	Left side of vehicle	Left side of vehicle	10	8717.249816	10.97721	0.089744
10	8	Polyline M	1	1	Aa_ALGIERS#6 - Alger	Left side of vehicle	Left side of vehicle	8	12255.024117	13.788448	0.12507
11	4	Polyline M	8	1	Aa_ALGIERS#2 - El Marsa Tamenfoust	Left side of vehicle	Right side of vehicle	4	11918.754492	14.785348	0.119057
12	22	Polyline M	5	1	Aa_TIPAZA#1 - Chiffalo	Left side of vehicle	Right side of vehicle	26	12385.308672	16.246857	0.132751
13	26	Polyline M	4	1	Aa_TIPAZA#7 - Cherchell	Left side of vehicle	Left side of vehicle	32	15367.194871	17.122838	0.159815
14	6	Polyline M	8	1	Aa_ALGIERS#4 - El Marsa Tamenfoust	Left side of vehicle	Right side of vehicle	6	12944.861731	17.797606	0.131852
15	18	Polyline M	11	1	Aa_BOUMERDES#5 - Peche el koss	Left side of vehicle	Left side of vehicle	22	18140.851469	18.462544	0.184625
16	5	Polyline M	8	1	Aa_ALGIERS#3 - El Marsa Tamenfoust	Left side of vehicle	Right side of vehicle	5	16748.61566	19.002729	0.166282
17	12	Polyline M	1	1	Aa_ALGIERS#9 - Alger	Left side of vehicle	Left side of vehicle	12	15429.284013	19.026606	0.153867
18	24	Polyline M	13	1	Aa_TIPAZA#4 - Tipaza	Right side of vehicle	Right side of vehicle	29	17053.875122	20.461066	0.174522
19	21	Polyline M	7	1	Aa_BOUMERDES#8 - Djinet	Right side of vehicle	Left side of vehicle	25	21887.122067	20.629684	0.226389
20	2	Polyline M	1	1	Aa_ALGIERS#10 - Alger	Left side of vehicle	Left side of vehicle	2	26521.472928	22.167964	0.261352
21	20	Polyline M	7	1	Aa_BOUMERDES#7 - Djinet	Right side of vehicle	Left side of vehicle	24	22256.096649	23.587693	0.233515
22	7	Polyline M	1	1	Aa_ALGIERS#5 - Alger	Right side of vehicle	Left side of vehicle	7	21226.277058	25.053138	0.21644
23	19	Polyline M	7	1	Aa_BOUMERDES#6 - Djinet	Right side of vehicle	Left side of vehicle	23	27996.736913	28.464079	0.284041
24	14	Polyline M	1	1	Aa_BLIDA#2 - Alger	Left side of vehicle	Left side of vehicle	14	33127.334486	30.168406	0.314308
25	13	Polyline M	1	1	Aa_BLIDA#1 - Alger	Right side of vehicle	Left side of vehicle	13	33715.137369	33.380066	0.315997
26	15	Polyline M	5	1	Aa_BLIDA#3 - Chiffalo	Right side of vehicle	Right side of vehicle	15	31540.999074	37.754293	0.313093
27	16	Polyline M	5	1	Aa_BLIDA#4 - Chiffalo	Right side of vehicle	Right side of vehicle	16	45084.980014	54.369074	0.446365

Figure 5. The attribute table of the Closest Facility Roads (Source: generated by network analyst tool in Arcgis)

	ObjectID *	Shape *	Name	OriginID	DestinationID	DestinationRank	Total_Length	Total_Time_travel	Shape_Length
1	52	Polyline	El Marsa Tamenfoust - Aa_ALGIERS#1	34	67	1	1218.139613	1.593104	0.012949
2	78	Polyline	Madrague - Aa_ALGIERS#7	36	75	1	2654.765835	3.022496	0.022668
3	32	Polyline	Chiffalo - Aa_TIPAZA#3	31	94	1	5304.898387	6.36794	0.035384
4	17	Polyline	Beni Haoua - Aa_TIPAZA#8	28	99	1	5964.029701	6.564162	0.070553
5	90	Polyline	Peche el koss - Aa_BOUMERDES#3	37	86	1	7304.278313	7.680589	0.075605
6	79	Polyline	Madrague - Aa_ALGIERS#11	36	69	2	8124.123816	7.837191	0.066087
7	20	Polyline	Bouharoun - Aa_TIPAZA#3	29	94	1	6767.488721	7.88268	0.043793
8	28	Polyline	Cherchell - Aa_TIPAZA#6	30	97	1	8708.834715	7.939671	0.059659
9	95	Polyline	Sidi Fredj - Aa_ALGIERS#11	38	69	1	6756.228977	7.999079	0.031511
10	1	Polyline	Alger - Aa_ALGIERS#9	27	77	1	8372.772958	8.2165	0.064022
11	2	Polyline	Alger - Aa_ALGIERS#8	27	76	2	9948.18824	9.986973	0.076787
12	3	Polyline	Alger - Aa_ALGIERS#6	27	74	3	13033.40036	11.698992	0.098438
13	62	Polyline	Franco/Rais hamidou - Aa_ALGIERS#7	35	75	1	10630.789388	11.826598	0.088077
14	63	Polyline	Franco/Rais hamidou - Aa_ALGIERS#8	35	76	2	13363.675668	13.060569	0.066984
15	42	Polyline	Dellys - Aa_BOUMERDES#3	32	86	1	12724.520222	13.198905	0.123991
16	96	Polyline	Sidi Fredj - Aa_ALGIERS#7	38	75	2	12691.34836	13.989351	0.09307
17	80	Polyline	Madrague - Aa_ALGIERS#8	36	76	3	12894.712797	14.264778	0.099128
18	53	Polyline	El Marsa Tamenfoust - Aa_ALGIERS#2	34	70	2	11918.754492	14.785348	0.087495
19	64	Polyline	Franco/Rais hamidou - Aa_ALGIERS#9	35	77	3	14446.037631	14.935059	0.121389
20	4	Polyline	Alger - Aa_ALGIERS#4	27	72	4	18191.081442	14.945283	0.140564
21	54	Polyline	El Marsa Tamenfoust - Aa_ALGIERS#4	34	72	3	13220.955745	15.770491	0.07993

Figure 6. Image showing the attribute table of the first 20 OD Lines (Source: Generated by network analyst tool in Arcgis)

4.2. Od cost matrix:

The OD cost matrix and the closest facility solvers perform very similar analyses; the main difference, however, is in the output and the computation speed (Debashis et al., 2019). An origin-destination (OD) cost matrix solver finds and measures the least-cost paths along the network from multiple origins that represent ports in our case to multiple.Destinations representing the activity areas. We can specify the number activity areas to find, as well as a maximum distance from ports to search, which reduces cost and avoids traffic congestion, resulting in less pollution. After adjusting the OD cost matrix settings, we chose the origins to ports and the destinations to activity areas, and then used the OD cost matrix solver tool to store the values in the Lines attribute table reflecting the network distance (Fig 6), not the straight-line distance.

4.3. Hot Spot Analysis

The hot spot analysis tool identifies statistically significant spatial clusters of high values (hot spots) and low values (cold spots). It creates an Output Feature Class province, with a z-score, p-value, and confidence level bin field (Gi-Bin) for each feature in the Input Feature Class. The measures of statistical significance tell whether or not to reject the null hypothesis. The Gi-Bin field identifies statistically significant hot and cold spots. Features in the +/-3 bins reflect statistical significance with a 99 percent confidence level; features in the +/-2 bins reflect a 95 percent confidence level; features in the +/-1 bins reflect a 90 percent confidence level; and the clustering for features in bin 0 is not statistically significant (Debashis et al., 2019).In this paper, we present a hot spot analysis of the commune's population density that includes a portion of the routes from the closest facility analysis. These determinations help government and accessibility routes business entrepreneurs access population hot spots that have the best route to ports or activities; they will also reduce cost and avoid traffic congestion, resulting in less pollution (Figure 7).

	GiZScore	GiPValue	NNeighbors	POP	Gi_Bin	Name
1	2.343059	0.019126	4	80890	2	Bordj El Kiffan
2	2.039609	0.041389	4	181496	2	Bordj El Bahri
3	1.968448	0.049017	5	75241	2	Rouiba
4	2.111661	0.034716	7	49396	2	Sidi Moussa
5	2.287936	0.022141	8	115607	2	Baraki
6	2.03304	0.042048	4	66593	2	Khraissia

Figure 7. Image shwing the attribute table of statistically significant hottest population (Source: generated by network analyst tool in Arcgis)

RESULTS AND DISCUSSION

The functional space of the city of Algiers, measured by the spatial scope and the intensity of commuting to the center of Algiers, covers a vast space that includes several bordering territories. At the heart of the Algiers region, the hyper center of Algiers plays the role of engine of economic and demographic dynamics, but this space remains very vulnerable given the incompatibility between transport supply and demand. The price of land and the displacement of centrality provided by the fast road network lead space-consuming activities to leave the city.A new spatial reality is taking shape, interweaving center and peripheries, in which functional specialization (employment, residence) accentuates the spacing of places frequented on a daily basis, which have been gradually redefined according to this spatial configuration.

The growing dependence on networks is accompanied by a heightened focus on organizing the areas surrounding the capital. This involves prioritizing the enhancement and expansion of the transportation network and the relocation of significant enterprises, particularly industrial ones. These efforts aim to alleviate pressure and reduce the influx of people and activities towards the capital and its center.The authorities responsible for urban planning and transport have made considerable financial efforts to improve the supply of public transport and to try to improve traffic conditions and reduce car use. However, sectoral interventions have not reduced car use or the nuisances associated with it, because at the same time suburbanization has increased the use of cars, including for very short journeys.In this paper, three analyses were done. The facility analysis and the Origins – Destinations cost matrix of the network analyst extension determined the locations of the ports as well as the activity areas for determining the shortest and best paths.

To navigate from one location to another, either the route with the least length (shortest route) or the route with the least travel time (best route) will be selected, depending on the impedance factor we choose to solve and it is necessary to set the attributes of the analysis of the facilities, incidents and origins, destinations, as well as travel type: from ports to activity areas or from activity areas to ports, allowed U-Turns at Junctions, distance units, number of facilities, to find and attribute parameters: curb approach, cut-off length. In this analysis, the road length was chosen as the impedance factor for the closest facility, and the travel time with a cut-off of 40 minutes was chosen as the impedance factor for the origins-distensions cost matrix. The tow results can be represented graphically in figures 8 and 9.The result shows that the distribution of employees in the study area highlights the predominance of the central region (Algiers).

The Grand Urban Project (GPU) was designed as an action strategy aiming to achieve the objective of "metropolisation" by brandishing the issues of influence, image and attractiveness, with the aim of raising Algiers to the rank and status of metropolis that shines in the Mediterranean (Amina, 2018).From this point, it can be said that transport occupies a central position in the country's development strategies (Mourad, 2019).

The cause of this centralization is indeed the concentration of the majority of activities in the study area. For this problem, Professor Abedelmadjid,B. proposes the relocation of his units aimed at their judicious reorganization of industrial units so as to loosen the state on the metropolitan area by transferring certain industries to the second ring, as recommended by all the planning and urban planning instruments in force (SNAT, SRAT, PDAU) (Abdelmadjid, 2007) declares that "The challenge is clear, the more a city is well connected to the networks, the more its potential for attraction increases, the more its capacity to attract capital, skilled labor and infrastructure structuring increases"(Mohamed, 2018).

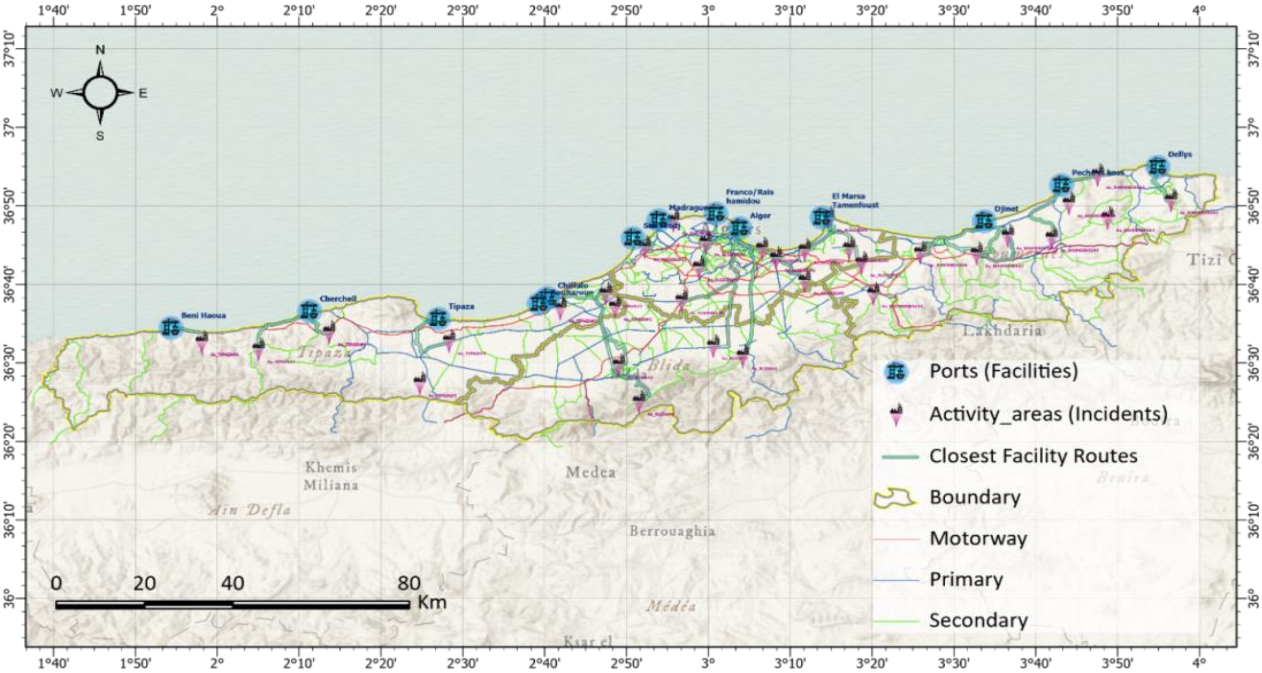

Figure 8. Result of the Closest Facilities Analysis (Source: realised by authors)

Firstly through external articulation with other international metropolises and with those of the Mediterranean in particular. This is how the city of Algiers can hope to be the engine of development for all of Algeria (Tarek et al., 2015).

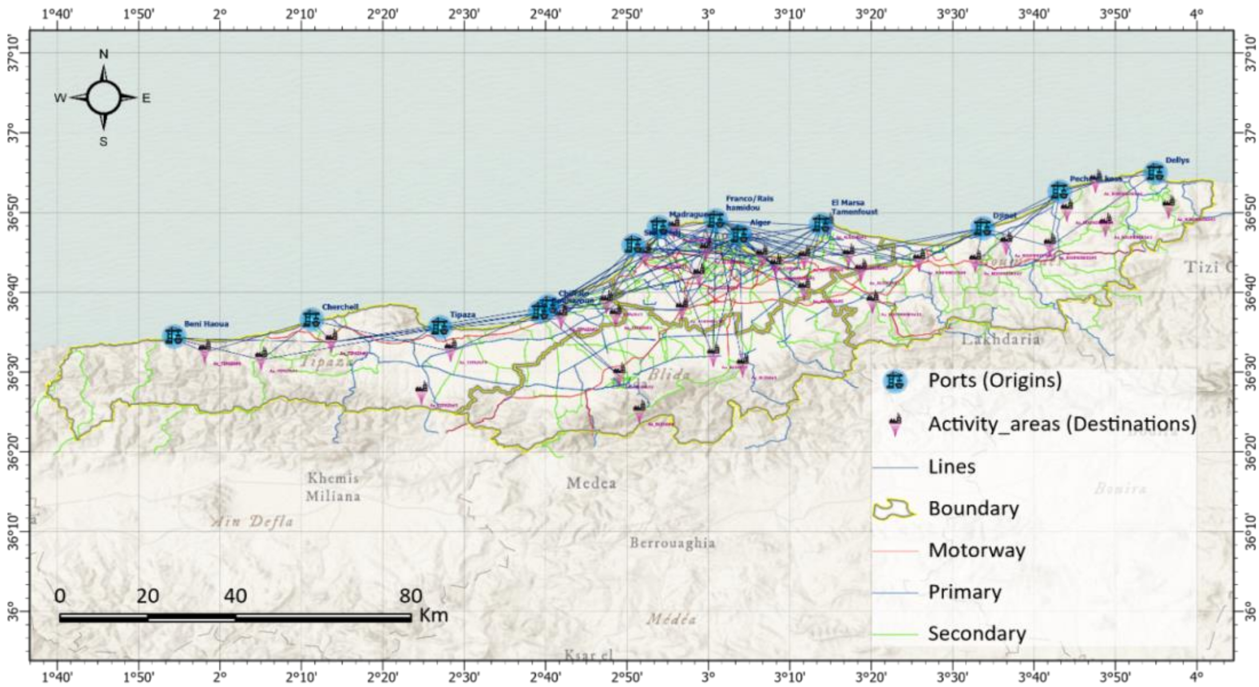

Figure 9. Theresult of origins destinations cost matrix analysis (Source: realised by authors)

For the hot spot analysis, we selected the communes that contained the closest facilities analysis routes with the population density attribute of 2018 to be evaluated as an input field to provide statistically significant communes of the hot population and have the best route accessibility to ports and to the activity areas, and the result isshowed in Figure 10.

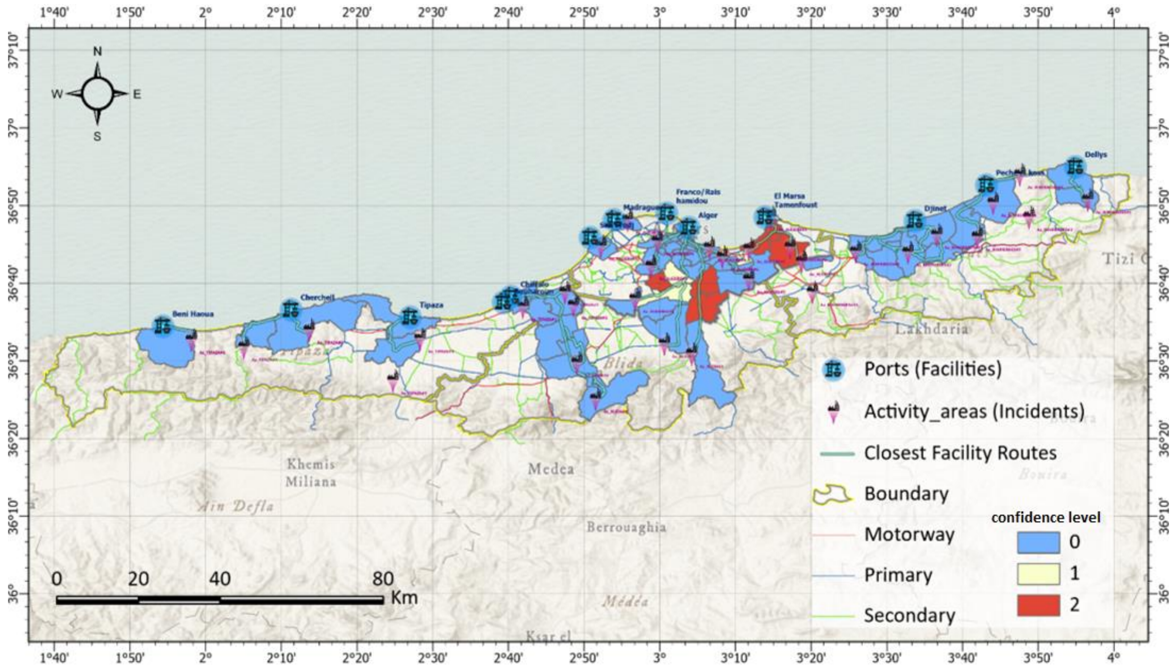

Figure 10. The Result of Hot Spot Analysis (Source: realised by authors)

CONCLUSION

This paper examines the application of GIS on transportation network analysis implemented and applied to the capital Algiers and the three surrounding states Boumerdes, Blida, Tipaza based on spatial analysis methods using ArcGIS components. The Dijkstra best routing algorithm, which is built into the ArcGIS software, is the best method for network analysis, particularly in a densely populated state like Algiers, where it saves transportation costs, time, and avoids traffic congestion. The Network Analyst extension has produced the best routes between port locations and the activity areas on the road network based on travel time and length. Furthermore, the proposed method incorporates historical population data to be used in the hot spot analysis on the communes that contained these routes, identifying statistically significant hot and cold spots population communes with the best transportation accessibility to ports and activity areas. Findings from this study can provide directives for future infrastructure policy development and investment. In general, the study strengthens the idea that GIS has many direct or indirect applications in the field of transportation, because the study of existing road network problems and their solutions can dramatically increase the profitability of a local place to a great extent. The authors of the paper have made a valuable contribution by utilizing GIS software and incorporating road network connectivity, geographic locations of ports and activity areas, and population density to identify statistically significant communes with optimal accessibility to ports and activity areas. Their analysis provides insights into transportation network efficiency and its impact on regional development.

After half a century of urban transformations (consequences of successive urban policies), Algiers today is a sprawling, fragmented agglomeration, fragmented and discontinuous. She is also confronted to real challenges in terms of planning transport and mobility (Mohamed, 2018). To further enhance the study, the authors suggest considering additional factors such as traffic flow, utilizing live data when available, and taking into account road width, road state, road type, and time delays on the road. By incorporating these factors, the analysis can generate more realistic results and improve the overall performance of the model. This suggestion highlights the authors' commitment to refining their research methodology and providing more accurate and comprehensive findings.

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