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# Analysis urban transportation network in Algerian border cities using geographic information system (GIS). Case study of Tébessa city – far northeast

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**Summary**

Transportation is one of the most important human activities and services closely linked to place and its activities. It is a sensitive nerve in urban life, which either facilitates or hinders movement within the city through the transport network that is distributed throughout the urban environment to achieve accessibility [Lefèvre and Offner 1990].
The transport network is among the factors responsible for population distribution and its activities, representing the arteries of communication and movement that connect different land uses together. It serves as an indicator of economic and social development, and is one of the most important infrastructure services in the city.
To achieve good mobility and accessibility throughout the city, there must be harmony between the urban transport network and the city's morphological, demographic, and economic data, respond to the population's transportation requirements and achieving growth and development in various services [Bailly 1979].
Through this study, which addresses the analysis of Tébessa's urban transport network, considered one of the city's most important components, using geographic information systems (GIS), the aim is to how well the network meets the needs of the population in terms of accessibility, to identify black spots and to show the most central nodes.
The geographic information system utilized the ArcGIS software and network analysis techniques to determine the shortest paths between two points, with the aim to reduce travel distance, save time, and provide alternative routes for more efficient navigation in the city.

**Keywords**

Tébessa • city • transport network • accessibility • route

## 1. Introduction

Cities around the world have witnessed rapid growth, development, and significant expansion in recent decades across all sectors: economic, social, commercial, and residential. This is due to the strategic locations of these cities, and their transport networks, which play a vital role for various functions and activities of a population. This has led to intense movement patterns within urban areas and across road networks, with urban mobility being affected by increasing commercial activity, in addition to the city's location and its distinctive characteristics [Jean-Marc 2022].

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To achieve good mobility and accessibility throughout the city, there must be harmony between the urban transport network and the city's morphological, demographic, and economic data, responding to the population's transportation requirements and achieving growth and development in various services [Frédéric Dobruszkes 2011].

Like other countries worldwide, Algerian cities face problems with their transport networks, particularly in urban areas. They suffer from traffic congestion resulting from high traffic volumes and insufficient road network expansion.

Tébessa is considered one of the most important Algerian cities due to its proximity to border and its network of significant roads, which has led to economic and commercial prosperity. This prosperity, in turn, has attracted population growth as the city serves as a transit zone.

Geographic information systems (GIS) play a distinctive role in studying and analyzing the urban transport network. We have applied GIS to analyze Teressa's urban transport network to produce results and attempt to develop solutions and proposals for the main problems it faces.

## 2. Research problem

Tébessa is considered a transit point between Algeria and Tunisia. As a border city, it holds a unique position compared to other Algerian cities has created international and domestic movement through its important road network, most notably National Road 82 leading to the Tunisian border. This has resulted in the emergence of certain problems within the city's urban transport network, which is considered one of the most

important infrastructure services and a crucial element in breaking isolation, meeting urban population requirements, and facilitating easy movement within the city.

We will use the geographic information systems (GIS) to analyze the urban transport network and identify its positive and negative aspects in order to learn more and assess its efficiency.

This leads us to pose the following questions:

- What is the extent of urban transport network coverage in Tébessa city?
- How efficient is the urban transport network, and what is the degree of centrality of urban nodes in the city?

### 2.1. Reasons for choosing the topic

Our reasons for choosing this study topic are:

- It is a contemporary subject of study.
- The critical importance of Teressa's urban transport network, particularly from social and economic perspectives, as well as its significance in spatial organization and improving quality of life, and its contribution to either the city's development or deterioration.
- Analyzing and diagnosing Tebessa's urban transport network to highlight its fonctioning, understand its condition, and assess its efficiency using geographic information systems, helping us propose appropriate solutions for the network.

## 3. Materials and methods

### 3.1. Literature review and theoretical framework

**Definition of transport**

There are multiple definitions of transport, including:

- Arabic Language Dictionary Definition: Transport is a process of changing the location of people and goods using various means by land, sea, and air.
- Algerian law defined transport in Article 2 of Law 01/13 dated August 07, 2001, as any activity through which a natural or legal person transports people or goods from one place to another, via road or railway, using an appropriate vehicle.
- Transport can also be defined as the transfer of a physical object or person to another location using a specific means or vehicle called a transport unit, for a relatively long distance through a specific passage (infrastructure). Therefore, transport possibilities depend either on the capacity of the transport means used or on the infrastructure.

**Urban transport**

Urban transport is defined as a service that connects different points of urban agglomeration, involving the movement of inhabitants according to a plan that meets needs

and achieves integration and harmony. Its purpose is to ensure that all its users have a dynamic city life [Gabriel 1990].

One of the definitions of urban transport states that it is 'the set of techniques used, development, infrastructure, and means, which collectively or in their entirety aim at administrative and implicit organization of movements of individuals, animals, goods, and information under optimal conditions of time, cost, and comfort' [Leysens 2011].

**Urban transport network**

The nature of the urban transport network in each city, its density, and organization are indicators of urban development. It also reflects planners' ability to ensure an organized city that performs its functions optimally and provides comfort and safety for its residents.

### 3.2. Concept of urban transport network

Urban transport network is a network that mediates the urban environment of the city and connects its various neighborhoods through regular arrangement of roads and basic infrastructure in the form of nodes with a set of links.

The urban transport network is affected by the environment in which it exists. It consists of various urban layouts and structures with different characteristics according to their nature. We find that there are both old and modern networks, as well as types that mediate rough terrain. As a result, we find variations in the quality and width of the roads that cross these areas, as well as variations in the volume of movements, taking into account the differences in population density between different urban areas. This confirms the significant impact of the transport network on the nature of urban structures and movements [Anon. 1998].

**Accessibility**

Accessibility is the possibility of reaching a certain place and moving between different places.. We can measure accessibility from one point (place of residence) to another point in several ways, including by the number of connections and their lengths [Bonnel 2013].

**Urban roads**

Urban roads run within the city and are the product of the structuring and intersection of national roads. These urban roads are divided into three main types: primary, secondary, tertiary. Among the most important primary and secondary roads in there is [Hine 2000] a road that penetrates Tébessa from the western side and ends in the city center – it is an extension of the national road No. (10) Constantine Road It is considered one of the most important roads in the city (Prince Abdul Qadir), as it contributed to directing longitudinal construction. Another important road runs through the city from the northern side and meets the road No. 10 in the city center – it is an extension

of road No. 16 (Annaba Road). There are also: the road that is an extension of the state road No. 08, ending in the city center (Awlad Hilal Road) and the road connecting the Oued Hilal road and the Emir Abdelkader Road (Houari Boumediene Road) [Crozet 2011].

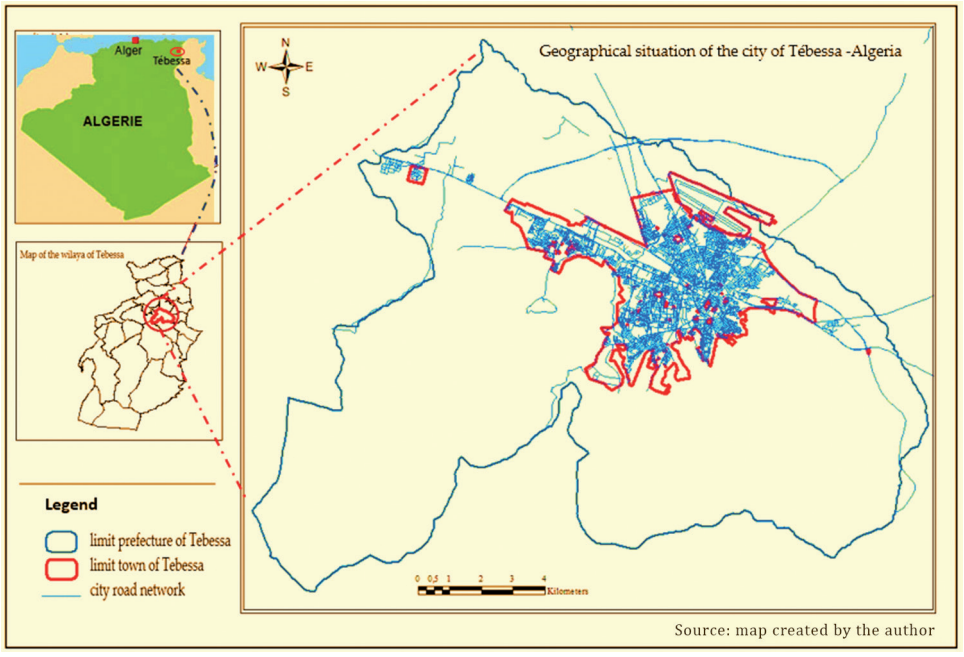
## 4. Introduction to the study area: City of Tébessa

**Administrative location**

Tébessa has been the seat of a border province since the administrative division of 1974. It is also the seat of a district that includes one municipality(the municipality of Tébessa), located in the eastern part of the state. It is bordered :

- from the Northwest: municipality of Hammamet,
- from the South: municipality of El Maa El Abiod and municipality of El Ogla El Malha,
- from the East: municipality of El Kouif and Boulhaf Dir,
- from the West: municipality of Bir Mokkadem,

The municipality covers an area of approximately 184 km².



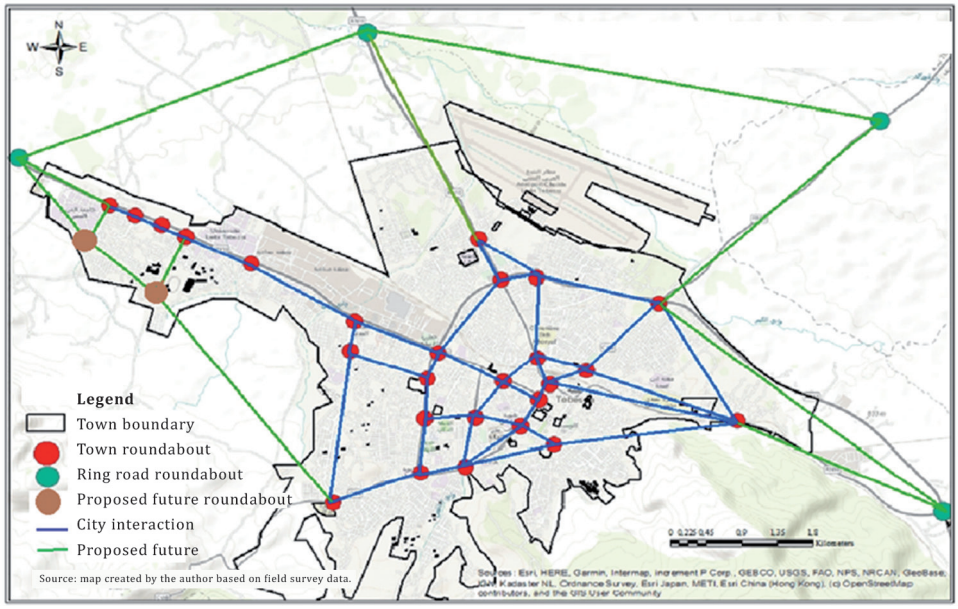

Source: Authors' own study

**Fig. 1.** The geographical location of Tébessa city

**Crossroads (road axes, nodes)**

The city has 26 nodes:

1. University 1
2. University 2.
3. Ali Mihni
4. University attaché.
5. Civil Protection Node – 600 housing
6. Amusement garden
7. Larbi Tebessi roundabout
8. The Great Mosque
9. Larbi Tébessi Node towards the police school
10. Shelf-Chadli
11. Mount Al-Jurf-Belkacem.
12. Cliff Houari
13. State node
14. Daghbouj-Abu Bakr
15. Afifi node – RN10 Bakaria Road




Source: Authors' own study

**Fig. 2.** Map of roundabouts in Tébessa after proposed improvements

16. University Transport
17. Dowan
18. Eagle Square
19. Morocco Cinema Node RN10
20. RN10 Annaba Caracalla Road
21. Electrical center
22. Make point December 11
23. Node towards the head of the eyes
24. Node towards the airport
25. Node towards the road to Annaba
26. Annaba road boulevard Airport

In addition to 4 nodes outside the urban periphery, which are:

1. RN10 – Bakaria road
2. Ras El Oyoun – the north turn
3. Annaba road the north turn
4. Constantine road the north turn

## 5. Results and discussion

**Applied side protocol and fieldwork**

- Accessibility analysis.
- Network analysis of the road network in the city of Tebessa using the geographic information system.
- Access to the urban transport network in the city of Tebessa.
- Accessibility refers to the ability of people and things to move freely from one location to another, from the region's center to other areas within the city. Through the study of accessibility within cities, the best route is identified and the shortest route is known among the city's Nodes to comfort mobiles by cutting down on travel time and expense.
- The number of connections and distance between connections indicate the network's nodes' accessibility to one another.

**Accessibility analysis**

***Accessibility by route***

We followed the same steps as before in adding the proposals, and obtained the matrix presented in the data table.

After analyzing the transport network in terms of accessibility in the city of Tebessa, it was found that:

- The presence of 26 approved urban nodes within the urban environment were connected by 40 links.
- There are 32 nodes, including 2 proposed nodes and 4 nodes outside the urban periphery connected to 53 links.
- At there were nodes whose rank was changed before and after the proposals were added in the accessibility of the transport network.
- Node No. 17 Douane ranked first in terms of accessibility as a central node before adding proposals, but after they were added, it was found that the central node changed to the Amusement Park node No. 7 (Par D'atract), which is contrary to the usual central node of the city of Tebessa the node of Morocco Cinema No. 19 (Maghreb_Rn10).
- University nodes 1 and University 2 (Univ1 and Univ2) ranked last two according to the number of links before and after the proposals were added, and according to the length of the links before the proposals were added. However, the last two ranks have changed to the nodes of Ras El Aioun_Dev_Nor and the RN10 Node of Bakaria road No. 27 after adding proposals for accessibility by link lengths.

**Network analysis of the road network in Tebessa using the geographic information system**

Network analysis is one of the most important features provided by GIS. The network analysis in Arc GIS helps to solve various problems, such as finding the best route through the city, finding the nearest car in case of emergency or facility, and determining the service area on the site, with the possibility of taking into account pedestrian traffic [Flamm, in: Montulet 2005].

The concept of a network refers to the cohesion of a group of elements and their connection with each other, forming a network such as a road network.

The concept of network analysis is an essential technique in the project planning process, as it provides a structural method that will provide all solutions to solve the problem of project management and reach the desired success.

Network analysis includes graphic techniques that enable people with a limited technical background to understand the analysis because it is a collection of network graphs used for the purpose of representing project tasks.

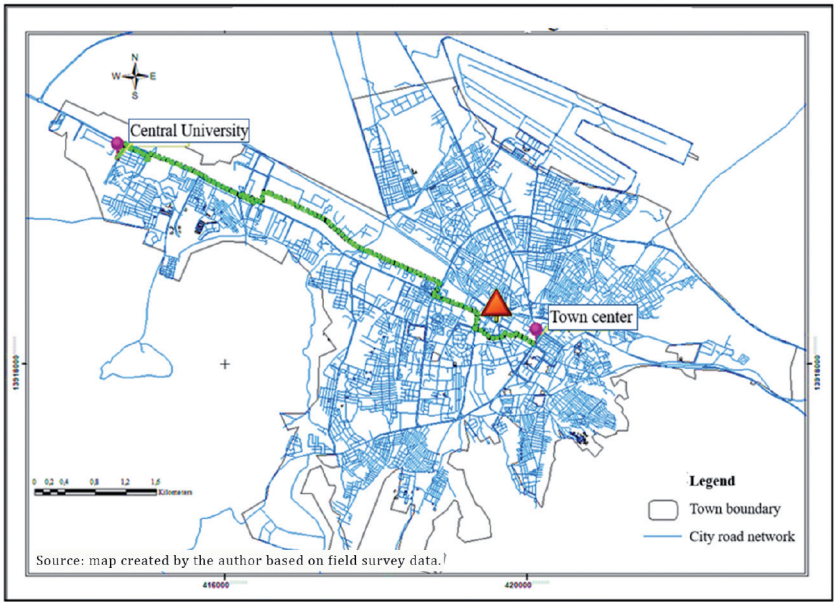
There are many areas of application of network analysis One of the most important is transport sector below we address the application of network analysis to the urban transport network of the city of Tebessa.

**Analysis of the routes of the shortest routes in Tebessa**

We can see that the start of the route was from the Central University 1 to Tifast (city center) with the path avoiding the black point of the rotation node (central node) has an estimated time of 14 minutes across a distance of 7.6 km.

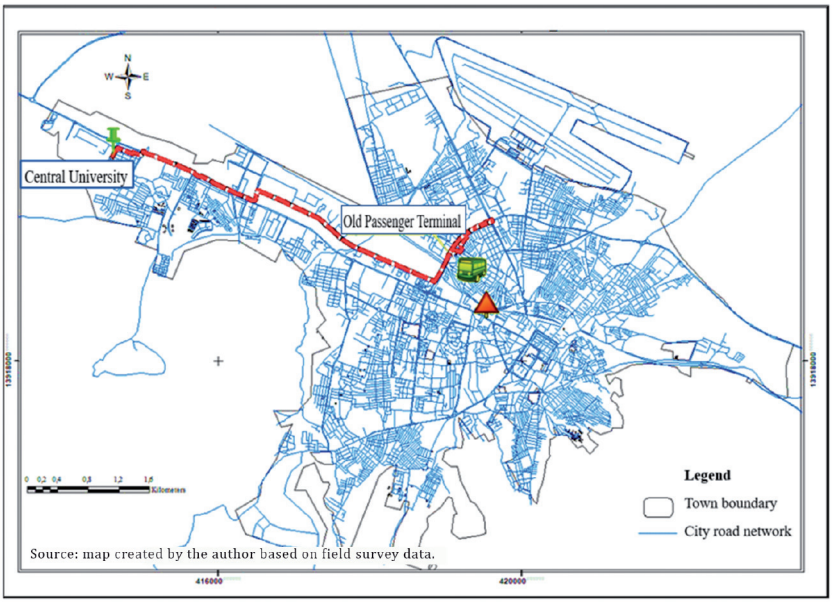
**Route analysis: from the downtown bus station to the Central University**

The map shows that the start was from the bus station in the city center to the Central University, with the path avoiding the black point (rotation knot) takes 13 minutes over a distance of 7 km.



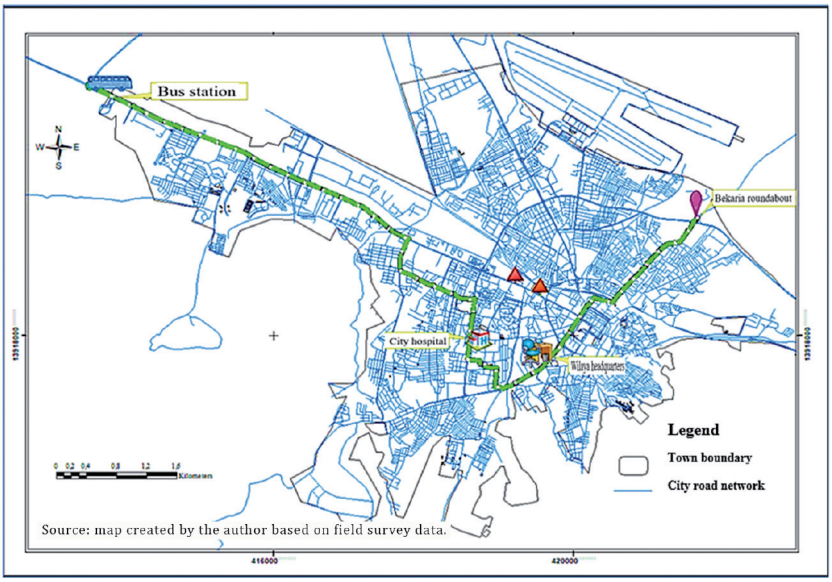

Source: Authors' own study

**Fig. 3.** Map of best route between the central university and the city center



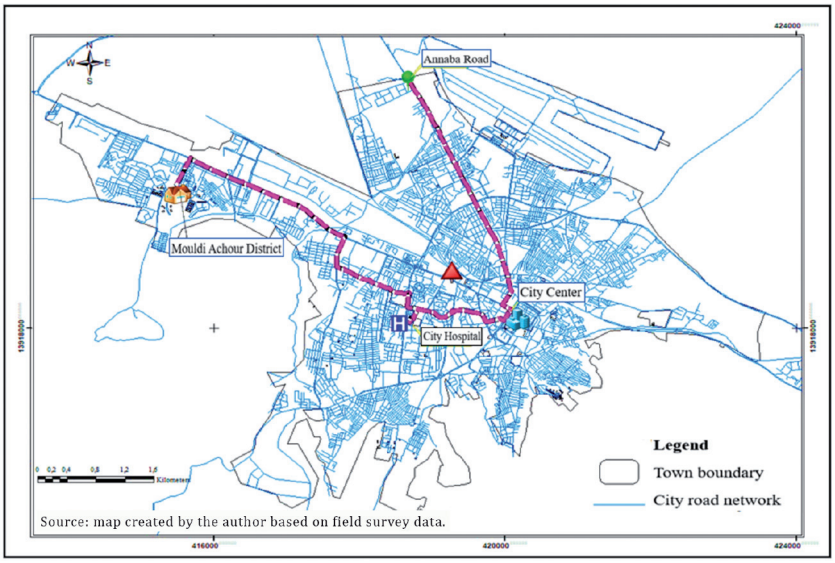

Source: Authors' own study

**Fig. 4.** Map of the best route between the central university and the old transport station




Source: Authors' own study

**Fig. 5.** Map of the best route between the Bekaria roundabout, the wilaya headquarters and the new transport station




Source: Authors' own study

**Fig. 6.** Map of best route between road to Annaba passing through the city center, the city hospital, and arriving at the Mouldi Achour district

**Route analysis: from the axis of rotation of the Bakaria Ras El-Ayoun to the passenger transport station on Constantine Road, passing through the wilaya[1] and Alia Saleh Hospital**

The map shows that route starts at the axis of rotation of the Bakaria Ras El-Ayoun and ends at the bus station, Constantine Road, passing through the headquarters of the wilaya of Tebessa and then Alia Saleh Hospital, while avoiding the path to two congestion points at the level of Constantine Road. It covers a distance of 12.3 km within 23 minutes.

**Route analysis: starting from Annaba Road neighborhood to Mouldi Achour neighborhood located in the western part of the city**

We can see from the map that the route runs from Annaba Road to the Mouldi Ashour neighborhood, passing through the city center and A'ali Saleh Hospital, as the path avoids the central node rotation (black point), in 19 minutes over a distance of 10.9 km.

## 6. Conclusion

Tebessa is characterized by its central location within the country and its border location (transit zone). Like other cities, Tebessa is witnessing rapid urban and population development. It has led to its significant expansion, and the establishment of a dense road network linking the city center, which is the hub of various commercial and economic activities, to the rest of the city.

After using geographic information systems (GIS) to analyze the urban transport network in the city and identify the main problems it faces, we discovered the following:

- Centralized business operations and infrastructure in the heart of the city.
- As they are located near the city's main road, the national road number 10 (Constantine Road),urban nodes are necessary for the customs roundabout and the amusement park, which experiences heavy traffic and high traffic density.
- Increased traffic congestion can be caused by narrow roads, stopping cars on the side of the road, and ignoring traffic lights.

The research hypothesis has been verified, demonstrating that the network roads are in poor condition and have deteriorated in some areas, inhibiting the mobility of residents.

The 'South University Turn' and 'West City Turn' nodes on our proposed route will help relieve pressure on the transportation system.

Some easily accessible point-to-point paths that travelled the shortest distance and took the least amount of time were found using the network analysis technique.

Some roads that have deteriorated require repair.

[1] A wilaya, or sometimes Wilaya (from Arabic 'region, government, prefecture, authority', is an administrative division present in several Arabic-speaking countries.

In order to improve network efficiency, with its degree of interconnection and integration, specific parking spaces along roadsides were designated and additional lanes proposed.

In order to improve traffic in the city, the authorities must intervene and enforce the laws. These solutions require careful planning and management of the city's components as well as the construction of new roads and highly efficient infrastructure.

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