Towards Implementing Intelligent and Smart Transportation Systems in Cities: Learning from an Exercise for Tikrit City, Iraq

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Abstract

A transportation system is the main artery of any city, due to its importance in linking the parts and activities of the city with each other and providing ease of movement between them. It links cities to other cities, and transports the residents to their places of education and work, facilitating their access to the daily needs. Any defect in this system within the city will lead to traffic jams, delays in arrival time, and more fuel consumption, and thus a decrease in the economic prosperity and ease of movement in the transport sector. It increases the costs of living and environmental pollution. Hence, it is important to apply the concept of smart transportation in organizing and improving traffic in all cities by activating communication techniques and modern technologies.

In this context, this research examines the importance of implementing smart transportation in an integrated manner with the urban structure of a city. It employs the research used the descriptive approach in the analysis. Collecting data through field surveys on the status of transportation and from the competent authorities. She also examined and prepared maps and collected traffic census data. Analyzing the transportation network and developing mechanisms for using geographic information systems to activate smart transportation, so that appropriate planning decisions can be taken.

The findings indicate that there is a relationship between transportation and the urban form of a city within the urban fabric through different time stages. Activating the mechanisms of smart transportation lies in the importance of studying city plans as well as the use of geographic information systems (GIS) in transport management. It concludes that decision-making and setting mechanisms must be made to achieve the vision to activate transportation. It calls for the use of devices such as smart phones, which could reduce pressure on the streets at peak hours, organizes trips, and provide enormous conveniences for the people.

Keywords: Smart transportation, urban form, urban fabric, Tikrit, Iraq

introduction

Transportation connects the different parts of a city and facilitates the movement of residents from their places of residences to work and social activities. Therefore, the planners link the transportation axis of a city to all the components within its urban environment and consider the roads as one of the most important lands uses. This land allocated for transportation helps people to meet their daily and life needs from other activities such as trade, health, education, etc.

However, due to the modern developments of life that have affected the people and their activities and events in a city, as well as the increase of population that has resulted in a large number of vehicles, the transport sector has led to problems. They include pressure on the roads, traffic congestions, and serious traffic problems resulting from the lack of scheduling and planning for the movement of vehicles. Undeniably, they have negatively affected the city. Hence, the idea and the methods of 'smart transportation', which could resolve many of these problems should be immediately explored. This involves engaging modern technologies in transport, enabling the organization of and scheduling of trips based on traffic. The location of these points could be in relation to land uses within the urban fabric of the city. The events and activities could be attracted by the availability of the roads as needed by the residents. Thus, it is clear that smart transportation could play a significant role in the resolution of the urban problems created by the changing life styles, the increase in population and the urbanization and movement of people to cities.

This research thus argues that traditional development of cities is isolated from the preparation of systems for traffic problems in relation to the planning and absorption of the transportation network. They do not follow any smart transportation policies and thus bring about tremendous pressure on transportation. In this connection, the research hypothesizes that there is a strong relationship between the activation of smart transportation mechanisms and the possibility of the formation of a good urban environment of a city: a meaningful urban form.

The Research objective is to provide the necessary theoretical and practical foundation to activate smart transportation mechanisms within the reality of the urban fabric of the study area.

It is intended to facilitate the reduction of pressure on the transportation networks so that people can be provided with comfortable transport in Iraq. The study examines this issue in the context of the realities in 2022 in terms of spatial limits focused on the city center of Tikrit.

The theoretical Basis

Intelligent Transportation

Intelligent transportation systems are defined as methods in which computer technologies are used and the mechanisms of modern technologies, electronics, and communications are used in order to reduce the traffic problems in the transport sector. They are aimed at improving safety, productivity, and public movement, in a manner that improves production on the economic and social levels in the transport sector (Heinovski,2016).

1. Concept of urban form

The concept of the urban environment means the formation of masses, spaces and patterns of connection among them in a densely occupied setting. These patterns depend on several variables such as densities, land uses, and the activities, as they are the generators of mobility and the formation of the spatial structure for the use of people. Urban form is a result of a set of functional relationships between services and activities of the urban environment and the daily needs of the people. Urban forms arise from two dimensions: the

first is related to the scale of the spatial structure, and the other dimension is related to transportation and mobility (Moughtin,2003).

Urban Structure

This concept is expressed as a system of places where the urban fabric is linked by roads and traffic paths. The city is connected between its different parts through linear, network, circular or double path traffic paths of different types and shapes, as they may be in addition to roads of their various classifications (express, main, secondary) and it is also considered the basic component of the urban form of the city, in other words, the concept of urban structure is based on the arrangement of land uses within urban areas. (Shearmur,2004)

The urban structure is also known as the structure or a group of urban structures, which are related to people and their products in the surrounding environment in particular, and to their reactions as well. Indeed, they represent moral and material components (Wong ,2011).

From the whole of what this dealt with, it was found that there is a connection and integration between the city and its parts through transportation, as this sector represents the main axis in the city and affects its shape and urban structure. As a result of road accidents and congestion, research and decision makers in their plans for cities tended to activate the concepts of sustainability in the transportation sector by introducing modern technological concepts, which are finally known as smart transportation.

Review of Literature

Many have examined intelligent transportation systems. Many definitions also exist. Bekiaris and Yuko (2004) define it as a system that enhances transportation through safe and effective movement of people, goods and information, achieves more freedom of movement, increases operating efficiency, fuel efficiency to reduce pollution, and achieve security and safety. According to Bekiaris and Yuko (2004), the system should be understood to serve the interests of the government, individuals and companies who want to develop competitiveness in the transportation technology market. Ayman and Kate (year) see that Intelligent Transportation Systems (ITS) is a general term that expresses integrated applications of sensor technology, computers, and advanced management of electronics and communications. As they point out, it is a strategy to provide information to travelers, increase safety and improve the efficiency of the transport network systems. They say that the concept of (ITS) has another concept related to management strategies, and that these strategies directly affect transport operations and therefore are more user-oriented than the strategies aimed at improving traditional infrastructure. In fact, intelligent transport systems do not care not only about using new technologies, but also help how to use technologies to develop the effectiveness of information integrated to enhance operations, and to integrate services (ITS) with each other. Smadi (2005) adds that it is the key to an efficient chain of transmission. Williams (year) defines intelligent transportation systems as systems of services that support the travelers of all categories such as drivers, passengers, and pedestrians, and help manage the road network. It improves performance by using information and communication systems and control urban and rural transport networks to provide safety, improve the level of travel, as well as improve the level of various means of transporting passengers and goods. They point out that these services include accident prevention, mitigation of their effects, immediate response to emergencies, driver support and assistance services, passenger information, traffic management, public transport, commercial transport, entertainment transport services, prevention of theft, as well as security and safety. Similarly, Ryan, Mashrur and Jefferey (year) see: them as systems that combine traffic engineering, computer technologies, and communication systems to achieve integration and merging between multiple agencies to provide different services in the areas of improving traffic and safety of land transport networks. According to them, it includes the road system, bicycle paths, pedestrian paths, mass transit, railway systems, and the infrastructure of networks (surfaces) of the land transport system, Chowdhury (2009) adds

that they increase customer satisfaction, lower fuel consumption and promote environmental preservation.

Ezell (2010) shows that improving the transportation system in countries depends on building new roads or repairing the old infrastructure only. However, the future of the development of transportation systems does not lie in the development of technology for road construction, including tunnels, bridges, intersections, etc. only, but rather in the application of technology for communication and information devices, and sensors responsible for collecting and disseminating information regarding the transportation system network. Keller (2006) adds that the benefits offered by intelligent transport systems through the application of information and communication technology can revolutionize the way people and goods move, reduce travel times and deter operating costs and environmental impacts. According to Bekiaris and Yuko (2004), however, the task is to improve the level of security and safety of the transportation system at the country level by knowing and understanding the rules that should be applied, and changing behavior through control systems. Yokota (2004) extends this to reducing energy consumption and the emission of polluting gases, while reducing costs to achieve the elements of sustainable development by saving energy and preserving the environment. For Gordon (2009) these involve enhancing personal transportation by improving access to transportation services and information for all categories of users, and achieving comfort and reassurance in transportation. He says that ITS can be spread, develop and flourish very soon. Stephen (2010) adds that these will increase current and future productivity and job opportunities for individuals and institutions, and expand the growth of the economy in general. However, as Sandor & Czar (2013) point out, the most important is to improve the level of security and safety of transport users and operators.

Research methodology

The research employed a descriptive approach in analysis. It collected data through field surveys on the reality of the state of transport in Tikrit, and from the competent authorities. It also examined and prepared maps and gathered traffic count data. It analyzed the transport network and developed mechanisms to use geographic information systems ArcMap 10.7 to activate smart transport, so that appropriate planning decisions can be taken. In the case of the study of the city of Tikrit, the data of the Tikrit Municipality Department were relied upon to classify the roads, and in this study the selection of two main streets, the Arbaeen Street, was highlighted. Al-Zuhur Street The reason for choosing these two streets is due to their spatial importance within the urban environment of the city and their vital connection to the activities and uses of the land. The traffic census was conducted by the researcher with the assistance of the Traffic Department in Tikrit during the morning peak hours and the noon time, i.e., the end of working hours.

The Case study: Tikrit City

The spatial borders of the city of Tikrit comprises one of the districts of the Salah al-Din Governorate, represented by where Salah al-Din is located in the North-central part of Iraq. Its location is between the central and northern Iraq: Erbil, Kirkuk, Sulaymaniyah and Diyala from the South Baghdad Governorate, and the Anbar Governorate from the West. The Tikrit Governorate is defined according to the basic design boundaries for the year 2010, where the city extends from the Wadi Sheshin in the South to the fence of the Tikrit University in the North. It is bordered by the highway from the West and from the East by the left bank of the Tigris River. Thus, it is in the coordinates between the latitudes (34˚ 34˚ 42˚) and (34˚ 40˚ 12˚) in the North, and between longitudes (43˚ 37˚ 52˚) and (43˚ 43˚ 11˚) in the East, as shown

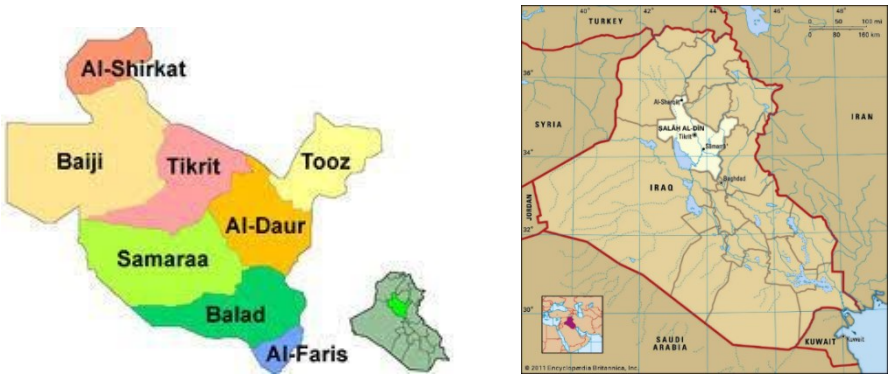

Fig. 1: The location of the site
Source: https://www.britannica.com/place/Tikrit

The city of Tikrit A number of neighborhoods The number of neighborhoods 21 Residential neighborhoods (Al-Hara Al-Jadidah, Al-Qala'a, Salah Al-Din, Sheshin, Al-Asri, Al-Baladiyat, Al-Awja, Al-Jami'ah, Al-Jami'ah, Al-Mu'aleem, Al-Tahrir, Al-Shuhada, Al-Qadisiyah, Al-Wahda, Al-Zuhur, Al-Muharram, Al-Souq, Al-Sina'I, and Al-Dayyum (except for Al-Tin neighborhood) (the cemetery), which is the neighborhood located adjacent to the University of Tikrit, because it is empty of residents, but it anyway contains the religious represented by the mosque and the cemetery, in addition to some green areas that serve this use, in addition to that it includes neighborhoods, copy, urban, Within it, the uses of the land and activities vary, and there are links between them and the traffic light that connects them to the other outside.

Al-Ali, Salah Omar, Tikrit, Encyclopedia of the Two Rivers of Iraqi Cities, Issue (5-6), Elaf Press, 2006.

2. Morphological Periods of the Study Area

Three morphological phases were chosen to study the urban form of the city center of Tikrit and how this affected the transportation system through the study of mass and space during those phases. These included the following time periods

Time Period 2000

The urban form of Tikri was studied in 2000 first. During this period, the form of the urban blocks of the city were dispersed and were of varying sizes. The coverage of the building was intermittent and was not continuous with the presence of spaces or voids. The buildings were organized in a regular manner allowing the residential road system to follow a grid pattern. The rest of the region was organized and distributed within this urban fabric.

Fig. 2: The morphological stages of the study area in 2000
Source: Author

Time Period 2010

In 2010, when the city was studied, the pattern of the urban blocks took it from what it had been in the past. Thus, the physical parts appeared more clearly within the urban fabric. The area of the urban blocks was equal to 196.06 hectares of the total area of the borders of the study area of the city. This was due to the development of life and the increase in the population and the return of life to normal after the political turmoil the city witnessed, during the year 2003 AD. The increase in population had led to an increase in the urban blocks, which included residential buildings, activities, and services. Urban spaces could also be clearly distinguished between the blocks.

Fig.3: The morphological stages of the study area in 2010
Source: Author

Time Period 2022

During this period, within the stage of the reality of the situation, the city and the residential neighborhoods witnessed developments and diversification of activities and services and the developments were taking place in the transportation system. All this had an impact on the city in terms of the physical elements within the urban fabric of the city. In the street paths and transportation clearly, there was a rela e components of the urban fabric of the city, the distribution of transportation, and the road network in it. The development of activities, services, land uses, and the dominance of residential use, which we will address later, requires a transportation system that seeks to facilitate accessibility for the residents in order to meet their needs. Following map shows the urbanization patterns of the city during the three morphological stages.

Fig.4: The morphological stages of the study area in 2022
Source: Author

Through the different morphological stages and the analysis of the urban form in the above figure and by calculating the percentages of urban coverage and solid building blocks in relation to the three different morphological stages (2000, 2010, 2022), one can deduce There is a relationship between the urban form and the changes of the urban blocs over time within the study area and between transportation, because the city in its urban form affects the transportation network, because there is a direct link between land uses, activities and transportation, with which it becomes easy to move and perform the life services of the population.

Data and satellite images are available for these stages which enable the calculation and analysis of the study area: its urban form in particular, and from observing the above figure, it is possible to know the percentages of the areas of urban blocks during the years 2000, 2010 and 2022. It is noted that there is a relationship between the urban form and the changes of the urban blocks over time within the study area and between transportation. This is because the city and its urban form affects the transportation network since there is a direct link between land uses, activities, and transportation. It thus becomes easy for the people to move. An increase of the coverage is noted and by 17% and this has also led to an increase in the number of people demanding the activities and services within the urban fabric of the city. Thus, there is pressure on transportation. It is thus clear that smart transportation mechanisms must be studied to determine the urban form of the city and also to determine the amount of change in the urban form, with the aim of developing solutions and strategies that are commensurate with the nature of the reality of the city in general and the study area in particular.

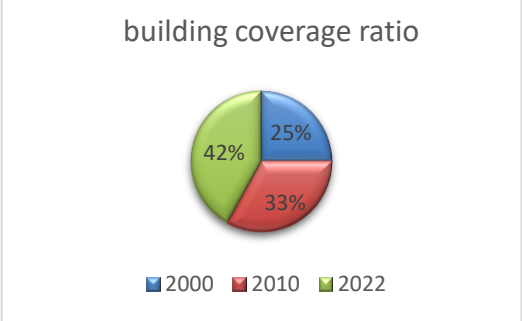

Fig. 5: Structural coverage during three morphological stages
Source: Author

Findings

Existing Transportation of the Study Area

The transportation network of Tikrit is similar to the rest of the cities, where the organic pattern of the streets has emerged from the road patterns in the ancient times. This is characterized by twisting, zigzagging, and closure in many of its roads and has been followed in the transportation planning. Indeed, this is what distinguishes the old city. As the city developed with modern life styles of people, along with the increase of the population, land uses have become diverse. Tikrit has responded this diversity and now is characterized by the reality of the situation. By 2022 it still retains diversity with a gradation of the transportation system. It is today identifiable in terms of main, secondary, and residential streets and roads. before analysing the transportation system of the study area, it is necessary to study and analyze transportation in the city of Tikrit as a whole to understand the transportation network comprehensively. This is shown in the Fig. 4.

It is noted that the gradation according to the morphological criterion of the transportation system, starts with the main roads, which are characterized by the fact that they contain large traffic volumes. Traffic congestions exist in them, as the streets attract a lot of traffic movements. They include a great momentum resulting from the flow of traffic within

the city of Tikrit. In addition, the streets provide traffic services to all land uses present within the urban spaces. The main streets run from one side of the street to the other. The city holds a diverse means of transportation to serve its parts. It is to be noted that the airport shown on the map is only a suggested site that has not been constructed yet. However, the main street is planned to reach the airport as if it exists.

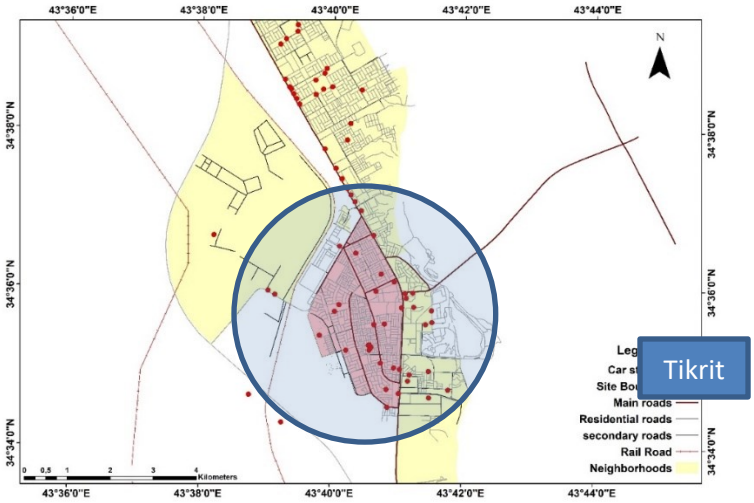

Fig.6: Classification of transportation and roads in Tikrit
Source: Author

Further, there are smooth streets parallel to the train tracks; they exist, cannot be used. They come after the secondary roads in terms of the hierarchy of streets. The secondary roads connect the main roads with the local residential streets, and therefore they are considered a link between these two types of streets. The idea of classifying the residential streets that serve the residential neighborhoods in the city has importance because the residential streets are either corridors for movement or provide commercial services. They also provide access to the housing areas in all the neighborhoods.

The city has a residential character. The following map shows the gradation of the streets in the neighborhoods, according to the functions the streets serve. They are commercial, residential, educational, health, or entertainment, in addition to service functions. The streets thus serve the prevailing functions of the city providing for transportation. They link spaces and the prevailing activities giving rise to the prominent spatial features related to the functional activities. The importance of the streets arises from their land use of which the most important is connectivity and access between functions and events. They facilitate to conduct various urban activities in addition to traffic.

In this context, a part of the city of Tikrit: the city center was chosen to examine how to implement smart transportation systems. The two main streets were chosen for their importance because they link the city with its parts, especially the commercial centers.

It is noted that Tikrit is a commercial center. It is concentrated with commercial activities represented by markets, restaurants, hotels, and shops distributed on both sides of the street. The Arbaeen Street is linked to educational activities and services through secondary roads to the residential neighborhoods.

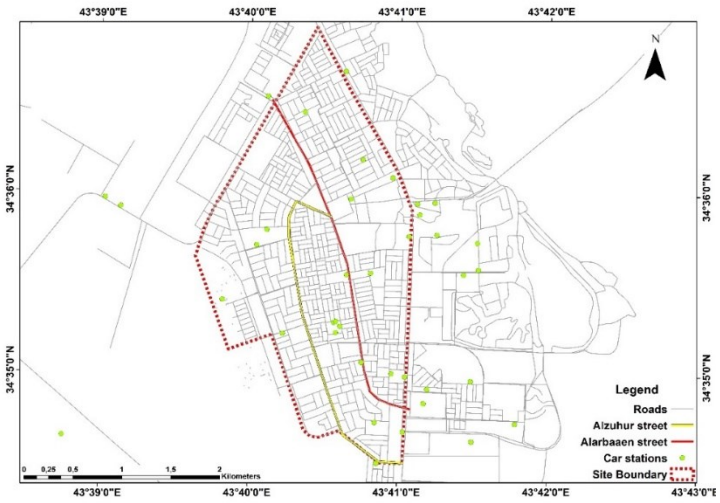

Fig.7: Al-Zuhur Street, the main Alarbaaen street
Source: Author

The traffic count data the researcher gathered with the assistance of the Traffic Department in Tikrit shows the momentum in the morning peak hours and at noon, the end of the working hours. They are as follows:

Time	Number of vehicles
Vehicles entering Tikrit from three entrances at the peak time (7:45 – 9:45)	(19600) cars
The time of exit of vehicles at the peak time, i.e. the end of working hours from (13:00-16:00) is	(15,600)
The time of entry of vehicles into Tikrit after (10:00) in the morning	(3500) vehicles

leaving the vehicles after 10:00-22:00 at approximately the same rate, and these statistics are according to the Tikrit Traffic

Smart Transport Possibilities

After studying the existing transport network and the roads, the analysis of the transport networks was examined to ascertain the shortest road paths with the aim of developing strategies to activate the mechanisms of smart transport. The intention was to set out the points for starting trips, taking into account the urban form of the city and its urban fabric. Moreover, the transport network is analyzed and nodes added to the roads. The transport network analysis helps in building a knowledge system connected with geographic information systems so that the passengers-to-be can inquire about trip paths and the shortest time between two points. This will facilitate the process of selecting trip points across all the parts in the neighborhoods, as shown in the Fig. 6.

The analysis of the transportation network, leads to the identification of points A, B, and C, which relate to the shortest distance, taking into account the time, up to the proposed points. They commence from the engineering centers of the neighborhoods shown on the map, identified with the car parks.

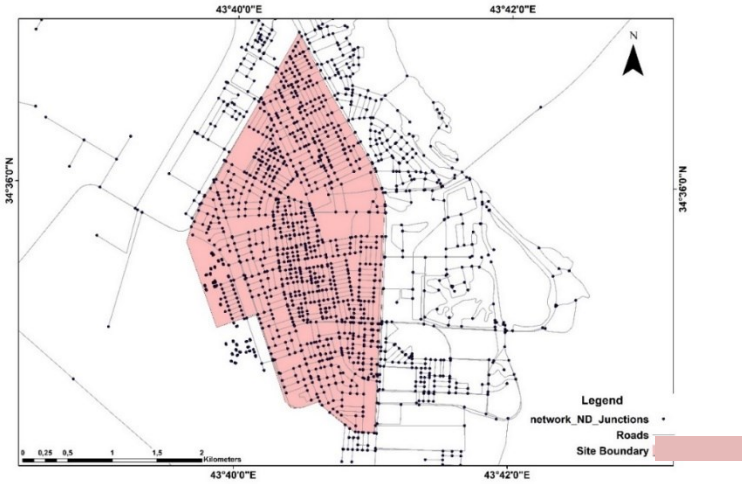

Fig. 8: An analysis of the road network in the study area site
Source: Author

These new points are located in empty lands so that they do not affect other uses of the land, as shown in the satellite images of the maps. It is noticeable that the creation of the two points in relation to the Al-Arbaeen Street are identified with crowd and traffic volume, and a point in relation to Al-Zuhur Street, is equipped identified with a telephone service and a mobile application, through which a call for the trip can be requested, using the application provided with information and GPS locations. The point of where the person is present is determined and wit this information, it is possible to give the length of the trip and time as well as the cost. Undeniably, the urban form of the city as a traditional city plays a role here.

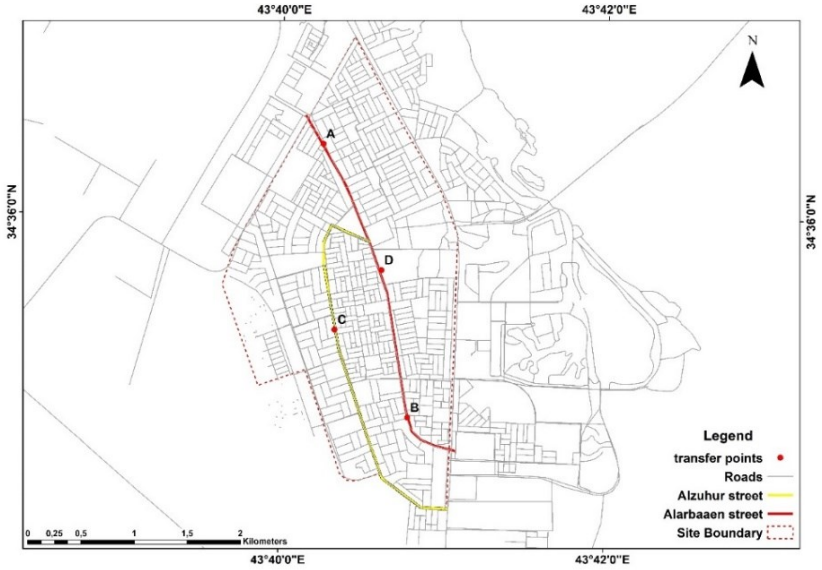

Fig. 9: Mechanisms of activating the transport points in Tikrit
Source: Author

This exercise shows that the activation of smart transportation mechanisms in the traditional city produces a solution to the problem of congestion and has the potential to reduce the traffic problems by sensing the journey and determining the paths from the start and finish including time taken. This is possible with modern technological means and mobile applications. The fact that the study area is a traditional city with a unique urban structure poses problems but they can be overcome.

The application of geographic information systems in the study and analysis of smart transportation ensures speed and accuracy in performance and efficiency in managing infrastructure, especially the transport sector. It provides a realistic picture for decision-makers and researchers, with quick alternatives and solutions for the reality of the situation.

The conclusion derived through the results of the study and maps is that the urban form and the urban environment of the city can be integrated with a transportation organization. Without doubt, transportation and road networks are affected by the nature and shape of the activities and uses of the land within which they are located. Linked to it is also the development of smart transport strategies and mechanisms within a basic plan of reality. This requires a study of the land uses first, and then developing proposals and solutions that are commensurate with the uses of the land within the study area. The activation of the systems including the geographic information systems, in monitoring and analyzing the transport network gives a clear and comprehensive understanding, with less time and cost. The designation of the starting points of the trip and linking them to phone applications and the use of GPS (geographical positioning system) help enormously. Most importantly, they make it possible to identify the location of the vehicle and the person who wants to travel. These mechanisms will reduce the pressure on the main streets in the city. In the case of Tikrit, this will ease the traffic issues on the Al-Arbaeen and Al-Zuhur Streets, by organizing trips, time and distance to reach the activities, events or places that the vehicle will take. In addition, it will also reduce the crowds and provide comfort to the people.

Conclusions

This paper thus makes the following conclusions.

1. Most cities suffer from traffic problems resulting from population increases, diversity in activities and services, as well as the routine requirements of their lives: going to and from places of work and shopping. These lead to pressure on roads.
2. The location of the city of Tikrit has an important role in defining the urban form, and the growth of the city and its expansion. This has a clear impact on the planning of the city and the pattern of its transportation network through the stages of its growth and the morphological stages addressed in this study. They involve the morphological conditions, urban form, and basic design.
3. The transportation network of the city of Tikrit consists of three patterns: an organic pattern characterized by torsion, zigzag, radial pattern, and quadrilateral grid pattern.
4. The large number of private vehicles on the road relate to the population increase and the fact that each family owns more than one vehicle, while the roads remain in their traditional manner. Thus, the roads become congested contributing to traffic jams.
4. The increasing and unplanned concentration of commercial activities and events towards the main streets has led to an increase in the attraction and turnout of the people. Thus, the streets will become more crowded, and therefore require the development of planning solutions that are appropriate to the reality of the situation.
5. The application of smart transportation methods and mechanisms in traditional cities is difficult, because within cities, it is not possible to develop new methods or other transportation methods that work on alternative means of energy due to the difficulty of changing the basic plans and developing new methods.
6. The city of Tikrit is a crowded commercial city, which is important due to it being the center of the Salah Al-Din Governorate, and therefore the service activities represented by the government administrative departments and other services are concentrated in it. As a result, there is tremendous pressure on the transport network.
7. The city of Tikrit includes multiple residential neighborhoods compared to the percentage of main streets that connect the neighborhoods. As a result, there is pressure on the main streets throughout the week.
8. Al-Arbaeen Street and Al-Zuhur Street are commercial centers due to the concentration of commercial activities on both sides of the two streets. Thus, they increase the

pressure on the neighborhoods and the residents. This leads to traffic congestion, especially during the peak hours.

9. The absence of any management techniques for the transport sector using geographic information systems to monitor the locations of nodes lead to bottlenecks. Unless solutions are developed that are commensurate with the basic design of the current plan that exacerbated the traffic problems, it will become difficult to manage the transport sector in Tikrit.
10. Developing strategies to activate smart transportation systems with the help of modern technologies will contribute to solving problems arising from crowding and pressure on roads at peak times and other times. They will provide comfort to residents and give them sufficient information on a journey, distance, time, and cost, so that they can take informed decisions.

This paper clearly demonstrates that it is possible to devise digitized smart systems that can address transport issues emanating in the modern world, as demonstrated in this exercise in Tikrit. The paper gave perception through the results of the study and maps that the urban form and the urban environment of the city are integrated with the transportation organization and linked to it, and that transportation and road networks are affected by nature and shape of the activities and uses of the land within which they are located, as the development of smart transport strategies and mechanisms within the basic plan of reality The case of the study area requires a study of land uses first, and then put forward proposals and solutions that commensurate with the uses of the land within the study area. The activation of systems, including geographic information systems, in monitoring and analyzing the transportation network gives us a clear and comprehensive vision, with less time and cost.

The recommendations for future research:

1. Paying attention to transportation planning, activating the smart transportation sector, and activating modern technology, due to its importance on the environmental, social and economic levels.
2. Using and activating geographic information systems in managing the transportation sector and monitoring nodes and crowded places, because these systems provide a comprehensive picture of the situation to be studied in a short time, less cost, and high accuracy.

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