Traffic on the Dhahran-Jubail Expressway in the Eastern Province in the Kingdom of Saudi Arabia: A Study in the Geography of Transportation Using Geographic Information Systems

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Abstract

The study of traffic on the Dhahran-Jubail Expressway is of great importance in transportation geography and in the field of geographical information systems. This study aims to identify the current situation of traffic in this area, in terms of vehicle movements, locations of congestion, the percentage of accidents and their spatial distribution. It also puts forward many future solutions and proposals which limit road problems. This study followed the descriptive analytical approach and the regional approach in which the entire study is based. The quantitative statistical method is also followed to use the study standards. The study also used the field and cartographic method. This study concluded the importance of the Dhahran-Jubail Expressway, which in turn connects vital cities that play an important role in raising the region's economy. The number of vehicles varies during the week, with the highest percentage reaching 17% on Sunday. The disparity varies during the hours. It increases during peak times leading to an increase in the accidents rate. As is the case in the city of Qatif, there are several reasons behind the increase in accidents, but the most important of them is the human element as a result of non-compliance with traffic laws and negligent use of vehicles. Congestion is concentrated on the bridges of the city of Dammam, as it is the headquarters of the emirate. Based on the road problems, the optimal solution was proposed, which is the suspended metro, which is 123.6 kilometers long and consists of 6 tracks and 7 stations.

Keywords: *Geographic Information Systems, Transportation, accidents.*

Introduction

Traffic is considered one of the most widespread phenomena in the world, especially in the developed world. The rise in the population's standard of living has had an impact on increasing the purchasing power of cars, which has led to an increase in the number of

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vehicles. As a result, the city's streets are flooded with more than they can accommodate. This highlights the disparity in traffic congestion on the roads, especially at peak times, which is difficult to control . This phenomenon negatively affects the streets and vehicles due to the difficulty of traffic there. The busiest roads radiate in the inner-city streets and highways. Congestion also plays a role in the decline of the economy [8].

The streets of the Eastern Province witnessed traffic congestion at certain roads. Congested road studies have shown that the Dhahran-Jubail Expressway is the second busiest road in Saudi Arabia as vehicle traffic stops at certain times when employees and students go to work and schools at the same time, especially in the morning and evening[9].

Vision 2030 in the Kingdom of Saudi Arabia, by the Ministry of Transport and Logistics, aimed for the success of sustainable development of the infrastructure of roads and means of transportation. It sought to launch an initiative to modernize transportation technologies and establish a steering committee for the future of transportation[10].

The study aims to identify the situation and suggest solutions to reduce the problems of the Dhahran-Jubail expressway .The importance of this study lies in determining the volume of traffic and the spatial and temporal variation of the areas where traffic congestion and accidents are concentrated. This study will contribute to finding solutions and proposals that can reduce the impact of the traffic congestion problem, the severity of accidents and increase road quality. This study dealt with many previous studies, the most important of which is the study of Abdul Wali Mohsen Al-Arashi (spatial variation of traffic accidents in the Yemeni Republic for the period from 2010-2014, 2020) . Traffic accidents in the Republic of Yemen in terms of their number, causes, occurrence, multiple effects, the development of the three elements over time, and their spatial distribution across the governorates, with the aim of highlighting the significant increase in their numbers, in order to reduce them, address their causes, and mitigate their negative effects. Among the most prominent recommendations are: The study comes up with proposals to limit the increase, address and reduce accidents, and compliance with traffic laws[11].

Study Area:

The study is located in the Eastern Province in the eastern part of the Kingdom of Saudi Arabia. Figure (1) , where the road extension is limited between latitudes °26'20"13.5 and °26'57"45.2 North, and is confined between longitudes °50'06"29.4

And °49'38"40.1 east, bringing the length of the road to 209.58 km. The study area represents the road extending along the group of bridges located between the end of the city of Dhahran and the beginning of Dammam, passing through the governorates: Saihat, Ank, Tarut, and Safwa, and through cities: Qatif and Ras Tanura until Jubail al-Balad. The Dhahran-Jubail expressway also feeds many bridges, exits, and secondary roads intersections.

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[9] News channel [alekhbariyatv]. (2020, 2, 2). The second largest road in terms of traffic density in the #Kingdom, those who use it suffer from daily accidents that hinder their work. #An-Nahar_Newsletter [Tweet]. Retrieved from:
https://twitter.com/alekhbariyatv/status/1488861925962403840?s=46&t=kh9yHFnv-_AA_9PFhGq_Zw

[10] Ministry of Transport and Logistics. (2022). The future of transportation. Retrieved from
http://spextesproapp01:2019/ar/AboutUs/FutureOfTransportation/Pages/default.aspx

[11] Al-Arshi, Abdel-Wali Mohsen. (2020). Spatial variation of traffic accidents in the Republic of Yemen for the period 2010-2014. Journal of Arts, No. 17, 479 - 517. Retrieved from http://search.mandumah.com/Record/1092088
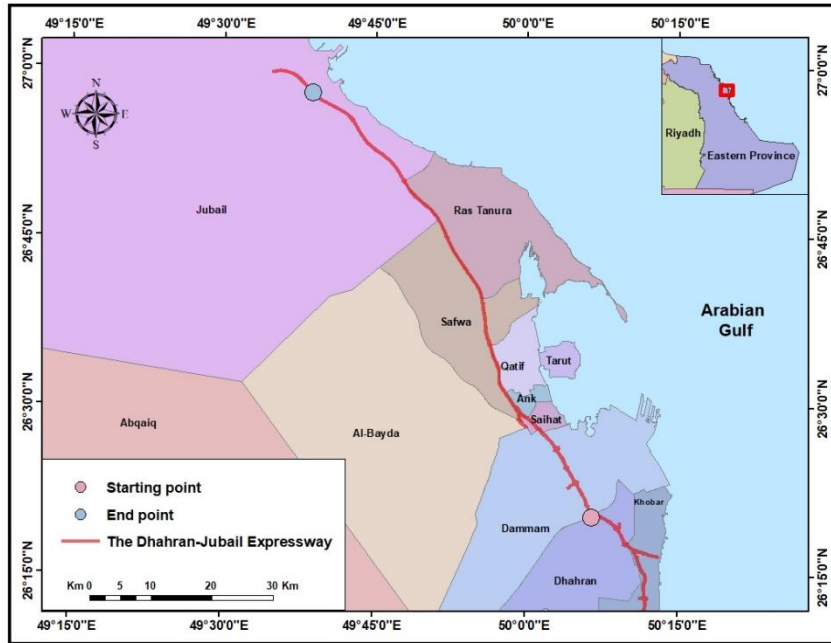
Figure(1), Dhahran-Jubail Expressway map.

Source: Prepared by Lulwah Barjas, based on:

- Branch of the Ministry of Transport and Logistics Services,(2023).Spatial data, unpublished, Dammam.

- Eastern Province Municipality,(2023). Spatial data, unpublished. Dammam.

Methodology and Methods

The study has relied on the descriptive analytical approach in terms of studying traffic movement on the Dhahran-Jubail Expressway in the Eastern Province, and interpreting the results of the methods used in this approach, such as the case study method, the correlational studies method, and the regional approach, which is based on studying the causes of traffic congestion and accidents, their impact on vehicle traffic, the results of this impact and the relationship between them.

The quantitative statistical approach was also used, where some statistical measures were used to estimate the percentage of the number of vehicles, accidents, congestion concentration areas, and the spatial distribution of accidents, and analyze them statistically to reach accurate results. The cartographic method, such as: the Euclidean distance tool, classification, and the weighted overlay tool, to produce the necessary graphs and maps to represent data, link it to descriptive data, and analyze it by using remote sensing and geographic information systems based on the following standards:

1.   Dhahran- Jubail expressway: away from the main road, 1000 meters.

2.   Vacant lands: Close to vacant lands, 500 meters.

3.   Residential plots: Away from residential plots, 500 meters.

4.   Agricultural lands: Away from agriculture lands, 500 meters.

5.   Commercial use: Close to commercial use, 500 meters.

A spatial suitability analysis model was created through (Catalog), then inserting (Toolbox), and choosing (Model) in whose window the tools will be listed in order, as the road standard was relied upon, which includes our study area in addition to Al-Khobar

Governorate, and land uses were also determined (vacant land, residential, agricultural, commercial use), and determining standards based on the road standard in meters. The analysis phase included the use of several tools, including:

1 .Euclidean Distance Tool: It is a Spatial Analyst tool for mapping distances measured in terms of other factors such as: slope, current road infrastructure, and land use. (Esri, W.D.), and the tool has been used to measure the distance of lands from the road as 1000 m and their distance from land uses as 500 m.

2 .Classification Tool: It is a tool for collecting certain values together and replacing them based on new information (Esri, W.D.). It has been used to collect the values and classify the resulting areas into three classifications: appropriate, inappropriate, and best appropriate.

3 .Weighted Overlay Tool: It is one of the appropriate modeling methods which is used to assigning the weight of each layer and reclassifying the values in the data to a common suitability measure (Esri, 2014). This tool has been used to determine and collect the weights of the various criteria and determine the most important ones to be classified according to degree and spatially appropriate to establish High-speed train stations.

After clicking on "run" in the "Model" window, the analysis process completed and resulted in spatial data representing the degree of spatial suitability, which was classified through the "Symbology" window, specifically "Unique Values" into 3 categories (unsuitable areas, suitable areas, best appropriate) and for unclassified areas that were not classified from the previous categories.

Based on spatial data that represents the degree of spatial suitability, the spatial distribution of stations and the metro route was done using the (Editor) tool to sign station points and draw path lines between stations, taking into account the land use layer to analyze the location and path of each station.
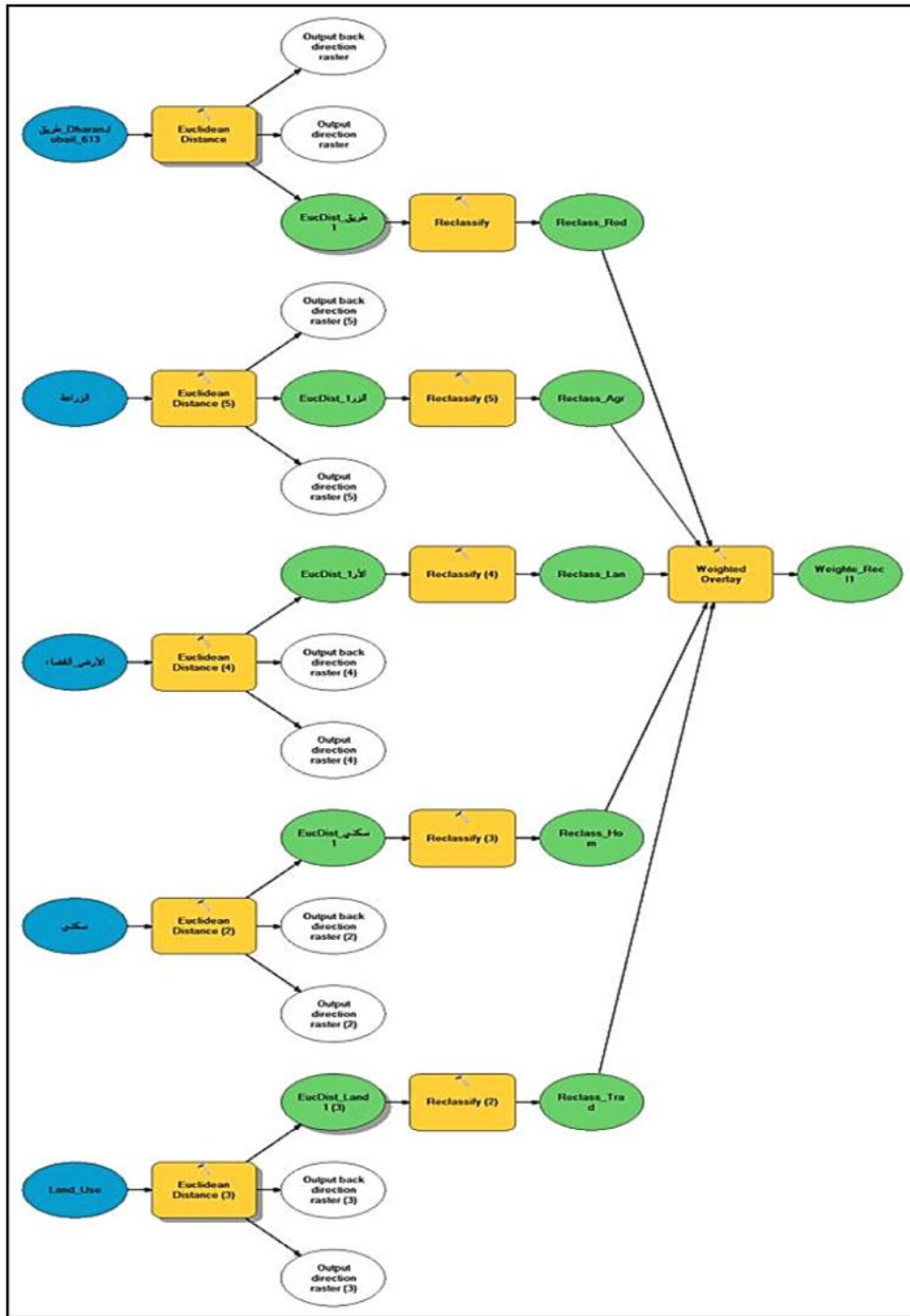
Figure (2) Map of suitable and unsuitable areas for building the suspended metro.

Source: Prepared by Lulwah Barjas, based on:

- Branch of the Ministry of Transport and Logistics Services,(2023). Spatial and non-spatial data, unpublished, Dammam.

- Eastern Province Municipality,(2023). Spatial data, unpublished, Dammam.

Field study: The use of the field study method was relied on during the road visit and the people concerned. Interviews are the most important field study methods that were used:

Interviews: The General Manager of Project Efficiency Raising , Abdul Rahman Al-Zahrani, and a number of engineers, were interviewed and discussed regarding transportation and roads, especially the Dhahran-Jubail Expressway , and the road

services, such as the bus and train project, and road signs, were the most important thing discussed with them. A phone call was made with Engineer Ahmed Al-Mutab regarding the uses of the land. And an interview with Ahmed Al-Yami, the director of human resources at the Ministry of Transport and Logistics Branch in the Eastern Region. The most important thing discussed with him was the traffic and vehicles movement on the road. Also, a virtual meeting was held with Engineer Abdul Rahman Al-Khorayef at the Ministry of Transport and Logistics Services in Riyadh, and several topics were discussed, the most important of which is vehicle traffic, its percentage on the road, and locations for monitoring it. Finally, Engineer Walid Al-Hamidi was telephoned in the Traffic Safety Committee about the causes of accidents, their daily, monthly, and annual numbers and their spatial distribution over the cities from 2018 to 2022.

Discussion and results:

■ Weekly vehicle movement by hour:

The number of vehicles varies during the week and even between hours during the day, which in turn affects the flexibility of vehicle movement on the road. The number of vehicles varies during working hours. It increases during peak times, which start from 5 a.m. until 8 a.m., and this is the morning peak time, so it coincides with work and school times. The second peak time starts from 12 noon until 3 p.m., which coincides with employees leaving their work and students leaving their schools. while the third peak time begins from 5 p.m. until 10 p.m. There is a lot of vehicle movement within the cities (Al-Ghazal, 1444 AH). We will discuss an example of the number of vehicles during a week from January 1 to January 7 in the year 2023, and find out what is the reason for the increase in the number of vehicles, and what its impact was on traffic.

Day	Number of moving cars	Road	%
Sunday	24824		17
Monday	22514		16
Tuesday	19888		14
Wednesday	21436	Dhahran - Jubail Expressway	15
Thursday	17252		12
Friday	17740		12
Saturday	20192		14
Total	143846		100

Table (1), Traffic from January 1 to January 7, 2023, on the Dhahran - Jubail Expressway.

Source: Prepared by Raghad Alshoshan, based on :

– Ministry of Transport and Logistics Services,(2023).Spatial data, unpublished, Riyadh.

– . Table (1) shows that the peak occurs on Sunday and Monday from 6 a.m. to 6 p.m., as these days are the school's days, and also employees go to work thier work. The period from12 noon to 6 p.m. which is considered an active period in which students leave their schools and universities, and employees leave their work. On Tuesday the percentage reached 14%, as movement is active from 6 a.m. when students and employees leave for work, vehicles number increase until 1 p.m. Table (1) and Figure (3) show that the percentage increases on Wednesday, which amounts to 15% of the number of vehicles on this day, and the peak time is from 6 am to 6 pm. The

percentage increased due to weather conditions, as it was raining in the morning, but there was a school day. At 8:30am., a message was sent to parents (suspension of studies) to collect their sons and daughters from school. At 1 p.m., the rain stopped and people began to go out to enjoy the beautiful weather, which resulted in an increase in the number of vehicles and resulted in an accident at 6:30 p.m., causing damage to four cars on the Dhahran - Jubail expressway. While Thursday and Friday were the lowest percentage in the number of vehicles, reaching 12% for each day, as the weather was rainy in the morning and studies were suspended in schools and most universities, which led to a decrease in the percentage on these two days , then the percentage returned to increase on Saturday, which reached 14 %, and the peak time was from 12 pm until 7 pm, as indicated in the previous table and figures, due to this period being active in visiting relatives and going out with the family.

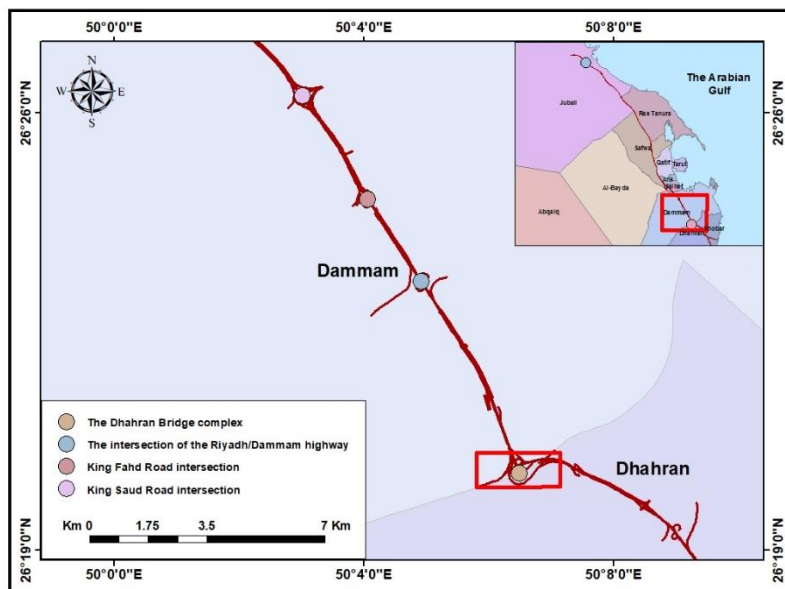■   Spatial analysis of congestion concentration locations:

Figure (3): Congestion location map on the Dhahran-Jubail Expressway.

Source: Prepared by Lulwah Barjas, based on :

–   Branch of the Ministry of Transport and Logistics Services,(2023). Spatial and non-spatial data, unpublished, Dammam.

–   Eastern Province Municipality,(2023). Spatial data, unpublished, Dammam.

Figure (3) shows the density and congestion on the Dhahran-Jubail Expressway that happens for many reasons. It is noticed that the most of the congestion points are located in the city of Dammam, as it is the capital of the Eastern Province and the headquarters of the emirate and its administrative center. It is also considered a link between Al-Khobar, Dhahran and Dammam and between Qatif and Ras. Tanura and Jubail . Congestion begins to be concentrated in the Dhahran Bridge complex due to the presence of exits, side roads, and the main Aramco building, which serves all its employees. Along the road, congestion is also concentrated in Dammam, specifically at the intersection of the Riyadh/Dammam highway, as there is only one intersection that serves users. There is also a congestion point at King Fahd Intersection because it is in an area that serves employees of government and private companies, and also an area in which there are many vehicles such as buses that serve users. There is another congestion point at the King Saud Road intersection, where there is a military zone close to the road that serves the employees and residents of the area. It is also considered an extension of the road

leading to Jubail Road, and it also serves users going to Khobar and Dhahran because it contains exits and side roads.

■ Spatial and statistical analysis of the number of accidents and their causes in 5 years from 2018 – 2022:
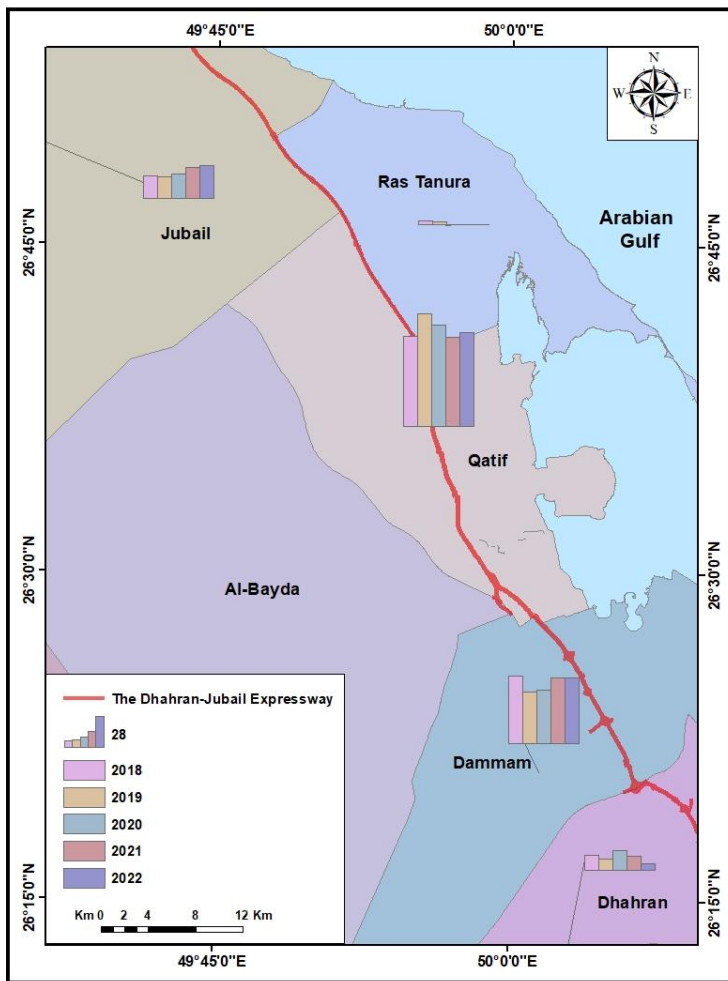
Figure (4): Spatial distribution map of accident rates in 5 years from 2018 - 2022.

Source: Prepared by Lulwah Barjas, based on:

- Branch of the Ministry of Transport and Logistics Services. (2023). Spatial and non-spatial data, unpublished, Dammam.

- Eastern Province Municipality. (2023). Spatial data, unpublished, Dammam.

- Traffic Safety Committee. (2023). Spatial data, unpublished, Dhahran.

Table (2) Number of traffic accidents in 2018 on the Dhahran-Jubail expressway.

Result	Accidents	%	Injuries	%	Deaths	%
Moving vehicle collision	16	36	20	36	3	27
Vehicle rollover	11	24	14	25	5	45
Fixed object collision	7	16	7	13	0	0

Stopped vehicle collision	5	11	6	11	1	9
Side barrier collision	3	7	6	11	1	9
Run over	2	4	1	2	1	9
Bicycle collision	1	2	1	2	0	0
Total	45	100	55	100	11	100

Source: Prepared by Batool Al-Tarouti, based on:

– Traffic Safety Committee,(2023). Spatial data, unpublished, Dhahran

Table (3) Types of accidents and their reasons in 2018 on the Dhahran-Jubail expressway.

Year 2018	
Accident Type	Reasons
Run over	Crossing in not pedestrians 'areas
	Sudden swerving.
Parked vehicle collision	Not keeping a safe distance.
	Sudden swerving.
Moving vehicle collision	Not keeping a safe distance.
	Sudden swerving.
	Driving distraction
	Reverse the traffic direction
Vehicle rollover	Over speeding.
	Sudden swerving.
	tire failure
Side barrier collision	Sudden swerving
Fixed object collision	the absence of safety sign
	Sudden swerving
Bicycle collision	traffic priority indiscipline

Source: Prepared by Batool Al-Tarouti, based on

– :Traffic Safety Committee, (2023). Non-spatial data, unpublished, Dhahran.

Tables (2) and (3) show the number of traffic accidents in 2018 on the Dhahran-Jubail Expressway, which totaled 45. There was a large number of accidents resulting from

moving vehicle collisions, with a percentage of 36%, while the injuries reached 36%, and the deaths reached 27%, for several reasons, including sudden swerving , distracted driving, reversing the traffic's direction, and not keeping a safe distance. The percentage of accidents resulting from vehicle rollovers was 24%, injuries were 25%, and deaths were 45%. This was due to several reasons, including over speeding, tire failure, and sudden swerving. The percentage of accidents resulting from the fixed object collision was 16%, the injured reached 13%, and the deaths 0%. The reasons for this type of accidents are summarized in the absence of safety signs and the sudden swerving. The percentage of accidents resulting from the parked vehicle collision was 11%, the injured also reached 11%, and the deaths 9%, due to sudden swerving and not keeping a safe distance. The percentage of accidents resulting from collision with a side barrier was 7%, the injured reached 11%, and the deaths reached 9%, and this was due to the sudden swerving. The percentage of accidents resulting from being run over was 4%, injuries were 2%, and deaths were 9%. This was due to crossing in not pedestrians areas and sudden swerving. The percentage of bicycle collisions was 2%, 2% were injured, and 0% were dead, due to traffic priority indiscipline.

Table (4), Number of traffic accidents in 2019 on the Dhahran-Jubail expressway.

Year	Result	Accidents	%	Injuries	%	Deaths	%
2019	Moving vehicle collision	40	56	52	57	11	52
	Vehicle rollover	10	14	17	19	1	5
	Run over	6	8	5	5	4	19
	Road fence collision	4	6	3	3	1	5
	Side barrier collision	3	4	8	9	0	0
	Fixed object collision	3	4	2	2	1	5
	Bicycle collision	2	3	1	1	1	5
	Motorcycle collision	1	1	1	1	0	0
	Utility pole collision	1	1	1	1	0	0
	Parked vehicle collision	1	1	1	1	2	10
	Total	71	100	91	100	21	100

Source: Prepared by Batool Al-Tarouti, based on:

- Traffic Safety Committee,(2023). Spatial data, unpublished, Dhahran.

Table (5) Types of accidents and their reasons in 2019 on the Dhahran-Jubail expressway.

Year. 2019	
Accident Type	Reasons
Run over	Crossing in not pedestrians 'areas.
	Driving distraction
	Rear-end collision
Moving vehicle collision	Parking indiscipline
	Not keeping a safe distance

	Traffic priority indiscipline
	Rear-end collision
Vehicle rollover	Sudden swerving
	Tyre failure
Side barrier collision	Over speeding
	Tyre failure
	Sudden swerving
Fixed object collision	Driving distraction
	Sudden swerving
Bicycle collision	Driving distraction
	Sudden swerving
utility pole collision	Sudden swerving
Motorcycle collision	Plying in streets

Source: Prepared by Batool Al-Tarouti, based on:

- Traffic Safety Committee,(2023). Non-spatial data, unpublished, Dhahran.

Table (4) and (5) show the accidents for the year 2019 on the Dhahran-Jubail Expressway in the Eastern Province, where the total number reached 71 accidents due to many causes.

The highest percentage of accidents resulting from moving vehicle collisions reached 56%, the percentage of injuries eached 57%, and the percentage of deaths reached 52%, and they resulted from more than one reason, including parking indiscipline , not keeping a safe distance, traffic priority indiscipline , and rear-end collision. It is followed by accidents resulting from a vehicle rollover at a percentage of 14%, the deaths reached 5%, and the injuries reached 19%. It also resulted from more than one cause, including a sudden swerving and a tire failure. The lowest percentage of accidents is for these three types, a motorcycle collision, a utility pole collision, and a parked vehicle collision, which amounted to only one accident, and the number of injuries for each of them was only one, while the accident resulting from a collision with a parked vehicle reached 2 deaths.

Table (6) Number of traffic accidents in 2020 on the Dhahran-Jubail expressway .

Year	Result	Accidents	%	Injuries	%	Deaths	%
2020	Moving vehicle collision	21	57	39	72	2	29
	Vehicle rollover	8	22	6	11	2	29
	Side barrier collision	3	8	5	9	0	0
	Road fence collision	2	5	2	4	2	29
	Fixed object collision	1	3	1	2	0	0
	Run over	1	3	1	2	0	0

Parked vehicle collision	1	3	0	0	1	14
Total	37	100	54	100	7	100

Source: Prepared by Batool Al-Tarouti, based on:

- Traffic Safety Committee,(2023). Spatial data, unpublished, Dhahran.

Table (7) Types of accidents and the reasons for their occurrence in 2020 on the Dhahran-Jubail expressway.

Year 2020	
Accident type	Reasons
Run over	Crossing in non-pedestrian's areas
Moving vehicle collision	Sudden swerving
	Not keeping a safe distance
	Reverse the traffic direction
	Rear- end collision
Vehicle rollover	Sudden swerving
	Tyre failure
Side barrier collision	Sudden swerving
Fixed object collision	Sudden swerving
Road fence collision	Over speeding
	Sudden swerving
Motorcycle collision	Sudden swerving

Source: Prepared by Batool Al-Tarouti, based on:

- Traffic Safety Committee,(2023). Non-spatial data, unpublished, Dhahran.

Tables(6) and (7) show the number of the accidents for the year 2020 on the Dhahran-Jubail Expressway in the Eastern Province, where the percentage of total accidents in 2020 amounted to 37% of the total accidents in the world as a result of multiple reasons, the highest of which was a moving vehicle collision , with a percentage reached 57%, and injuries reached 39%, while the percentage of deaths was 29%. In the second stage, a vehicle rollover , with a percentage of 22%, injuries 11%, and the deaths reached 29%. In the third stage, was the side barrier collision at a percentage of 8%, the injuries reached 9%, and the deaths reached zero. After that came the accidents resulting from a road fence collision with a percentage of 5%, the injured and affected reached 4%, and the deaths were 29%. The total percentage of accidents resulting from a fixed object collision reached 3%, with zero deaths and 2% injured. The percentage of accidents resulting from the run over reached 3%, with zero deaths and 2% injured. Finally, the percentage of

accidents resulting from collisions with a parked vehicle reached 3%, with 14% deaths14 and zero injuries.

Table (7) shows the types the reasons of accidents for the year 2020 on the Jubail - Dhahran Expressway, where the first type of accidents was run over, and one of its causes was crossing in the not pedestrians areas. As for the second type, it was a moving vehicle collision which happened due to a sudden swerving , not keeping a safe distance, reversing the direction of traffic, rear-end collision, or a tire failure. As for the vehicle rollover , it was due to a sudden swerving , or a tire failure . Also, a side barrier and a fixed object collisions were caused solely by the sudden swerving. The collision with a road fence was due to speeding and a sudden swerve. Finally, motorcycle accidents that were caused by a sudden swerving.

Table (8) Number of traffic accidents in 2021 on the Dhahran-Jubail expressway.

Year	Result	Accidents	%	Injuries	%	Deaths	%
2021	Moving vehicle collision	34	53	46	55	6	38
	Vehicle rollover	11	17	23	28	2	23
	Side barrier collision	8	13	6	7	4	15
	Run over	5	8	2	2	1	23
	Road fence collision	3	5	3	4	1	0
	Parked vehicle collision	2	3	2	2	1	0
	Motorcycle collision	1	2	1	1	0	0
	Total	64	100	83	100	15	100

Source: Prepared by Batool Al-Tarouti, based on:

- Traffic Safety Committee,(2023). Spatial data, unpublished, Dhahran.

Table (9) Number of traffic accidents in 2022 on the Dhahran-Jubail expressway.

Year	Result	Accidents	%	Injuries	%	Deaths	%
2022	Moving vehicle collision	29	48	37	50	6	40
	Vehicle rollover	9	15	15	20	2	13
	Run over	9	15	5	7	4	27
	Side barrier collision	3	5	3	4	1	7
	Parked vehicle collision	3	5	6	8	1	7
	Road fence collision	2	3	1	1	1	7
	Motorcycle collision	1	2	1	1	0	0
	Bicycle collision	1	2	1	1	0	0
	Fixed object collision	3	5	5	7	0	0
	Total	60	100	74	100	15	100

Source: Prepared by Raghad Alshoshan, based on:

– Traffic Safety Committee,(2023). Spatial data, unpublished, Dhahran.

Table (10) Types of accidents and their reasons in 2021, and 2011 on the Dhahran-Jubail expressway.

Years 2021-2022	
Accident type	Reasons
Vehicle rollover	Driving distraction
	Sudden swerving
	Over speeding
	Tires failure
Moving vehicle collision	Not keeping a safe distance
	Rear-end collision
	Traffic priority indiscipline
	Sudden swerving
	Wrong overtaking
	Driving distraction
	Tires failure
Run over	Crossing in not pedestrians areas
	Driving distraction
	The lack of safety signs
Side barrier collision	Driving distraction
	Over speeding
	Sudden swerving
Parked vehicle collision	Reverse traffic directions
	Not keeping a safe distance
	Sleeping
Road fence collision	Driving distraction
	Over speeding
	Sudden swerving
Fixed object collision	Tyre failure
	Driving distraction
Motorcycle collision	Sudden swerving
	Wrong overtaking
	Crossing in not pedestrians areas

Source: Prepared by Batool Al-Tarouti, based on:

- Traffic Safety Committee,(2023). Non-spatial data, unpublished, Dhahran.

Tables (8),(9) and (10) show the accidents for the years 2021 and 2022, on the Dhahran-Jubail Expressway in the Eastern Province. The total accident rate in 2021 reached 64% of the total accidents in the two years as a result of multiple reasons. In 2022, the accident rate decreased to 60% as a result of the state's traffic safety directives and some citizens' adherence to traffic laws .

The type of accidents which had the largest number in 2021 was the amoving vehicle collision with a percentage of 53%, and injures reached 55%, and deaths reached 38%. In 2022, accident rates decreased to 48%, with injuries reached 50%, except for the deaths , which rose to 40%, and are a result of many causes including not keeping a safe distance, traffic priority indiscipline , sudden swerving , and most of them are caused by over speeding.

The percentage of accidents resulting from vehicle rollovers in 2021 reached 17%, with injuries reached 28%, and deaths 23%. This was a result of driving distraction , tires failure, and over speeding. In 2022, the percentage of accidents reached 15%, with injuries reached 20%, and deaths reached 13%. Comparing the two periods, there are clear differences in the decrease in accidents. However, this type of accidents did not disappear, and there was also no commitment by some citizens to speeding and overtaking violations in order for accidents to decrease. This type of accident can occur due to strong sandstorms that unbalance the car .

The percentage of accidents due to run over in 2021 was 8%, with injuries 2%, and the percentage of deaths was nearly a quarter, reaching 23%. This was a result of crossing in not pedestrians areas, driving distraction, and the lack of safety signs. There was an increase in the percentage of this type of accidents in the year 2022, where it reached 15%, the injured reached 7%, and the deaths reached 27%, respectively.

This type is followed by accidents resulting from a side barrier collision due to over speeding, a sudden swerving , and driving distraction, in which the percentage of these accidents in 2021 reached 13%, the injured 7%, and the death 15%,. This percentages decreased during the following year, 2022 to 5 %, the injured 4%, and the deaths 7%. This type may occur when unqualified drivers fail to drive or do not adhere to the speed limit.

As for accidents resulting from a parked vehicle collision , their percentage reached 3% in 2021, the injured was 2%, and there were no deaths, while in 2022, the number of accidents increased to 5%, the number of injured was 8%, and the deaths were 7%. The reasons are attributed to falling asleep, reversing the direction of traffic, and not keeping a safe distance. The phone is the biggest cause of driving distraction, as it causes distraction and doubles the chances of traffic accidents.

The percentage of accidents resulting from road collisions in 2021 reached 5%, and the number of injured was 4%. There were no deaths from this type of accidents. In 2022, there was a decrease in accidents by 3%, injured by 1%, and deaths by 7%. Only the percentage of deaths has increased as a result of distracted driving and over speeding. This type of accidents is considered dangerous, and it may also occur due to failure to adhere to the designated path.

There are also other reasons for the accidents: sudden swerving, crossing in not pedestrians areas, and wrong overtaking that cause a type of motorcycle collision, the percentage of which in 2021 was 2% with injuries reached 1%, and no deaths were recorded during this year. The accident rate in 2022 reached 2%, with 1% injuries , and there were no deaths. This year there was one type of bicycle, 1%, 1% injuries , and no deaths. There was one type of bicycle accident during this year, and its percentage was 1%, the injures were 1%, and there were no deaths.

The percentage of accidents of the type of a fixed object collision, objects such as signs, directional signs, sidewalks, and other fixed object, this also includes camels, in 2022 reached 5%, and the injured, 7%, and there were no deaths. The majority of this type of accident occurs due to tires failure , over speeding, and being busy with the phone while driving. In 2021, this type of incident did not occur.

Table (11) Percentage distribution of traffic accidents on the Dhahran-Jubail Expressway by time of accident for the years 2018, 2019, and 2020.

Time of accident	2018	%	2019	%	2020	%	Total	%
Morning	14	38.89	32	42.67	12	31.58	58	38.93
Evening	22	61.11	43	57.33	26	68.42	91	61.07
Total	36	100	75	100	38	100	149	100

Source: Prepared by Batool Al-Tarouti, based on:

- Traffic Safety Committee,(2023). Non-spatial data, unpublished, Dhahran.

Table (11) shows the total percentages of accidents for the years 2018, 2019, and 2020, where morning accidents reached 38.93% and evening accidents 61.07%. The number of traffic accidents in 2018 reached 14 traffic accidents in the morning and 22 accidents in the evening, while in 2019 the number of traffic accidents increased. In the morning, there were 32 traffic accidents, and in the evening, there were 43 accidents. Then it decreased in 2020 where the number of morning accidents reached 12 accidents, and 26 traffic accidents in the evening.

Table (12) Percentage distribution of traffic accidents on the Dhahran-Jubail Expressway by time of accident for the years 2021, 2022.

Time of accident	2021	%	2022	%	Total	%
Morning	29	46.77	28	46.76	57	46.72
Evening	33	53.23	32	53.33	65	53.28
Total	62	100	60	100	122	100

Source: Prepared by Batool Al-Tarouti, based on:

- Traffic Safety Committee,(2023). Non-spatial data, unpublished, Dhahran.

Table (12) shows the percentage of total morning accidents in the Eastern Province on the Dhahran-Jubail Expressway, which reached 46.72%, and evening accidents, which reached 53.28%. The number of traffic accidents in 2021 reached 29 traffic accidents in the morning, at a rate of 46.77%, and 33 traffic accidents in the evening, at a rate of 53.23%. There was a slight relative decrease in traffic accidents in 2022, about 28 traffic accidents in the morning, at a rate of 46.67%, and 32 traffic accidents in the evening, at a rate of 53.33%. The percentage of traffic accidents on the Dhahran-Jubail expressway occurs to a greater extent in the evening than in the morning.

■ Future Outlook:

The ideal solution to the problems of the Dhahran-Jubail Expressway is the construction of the suspended metro, which will connect the cities through the electric train network covering the eastern region. This transportation system will provide an effective means for residents to move between cities in the Eastern Region efficiently and easily via trains equipped with the latest technology. The suspended metro will give a feeling of sophistication, add a

rea touch of modernity and change the face of the city. The growing population in the coming years will require providing a more effective alternative, which in turn will contribute to reducing the number of cars and will save a large amount of fuel daily, thus reducing the percentage of air polluting emissions. This will be applied to the study area, which is located between the cities of Dhahran and Jubail, crossing Al-Khobar, Dammam, Qatif and Ras Tanura.
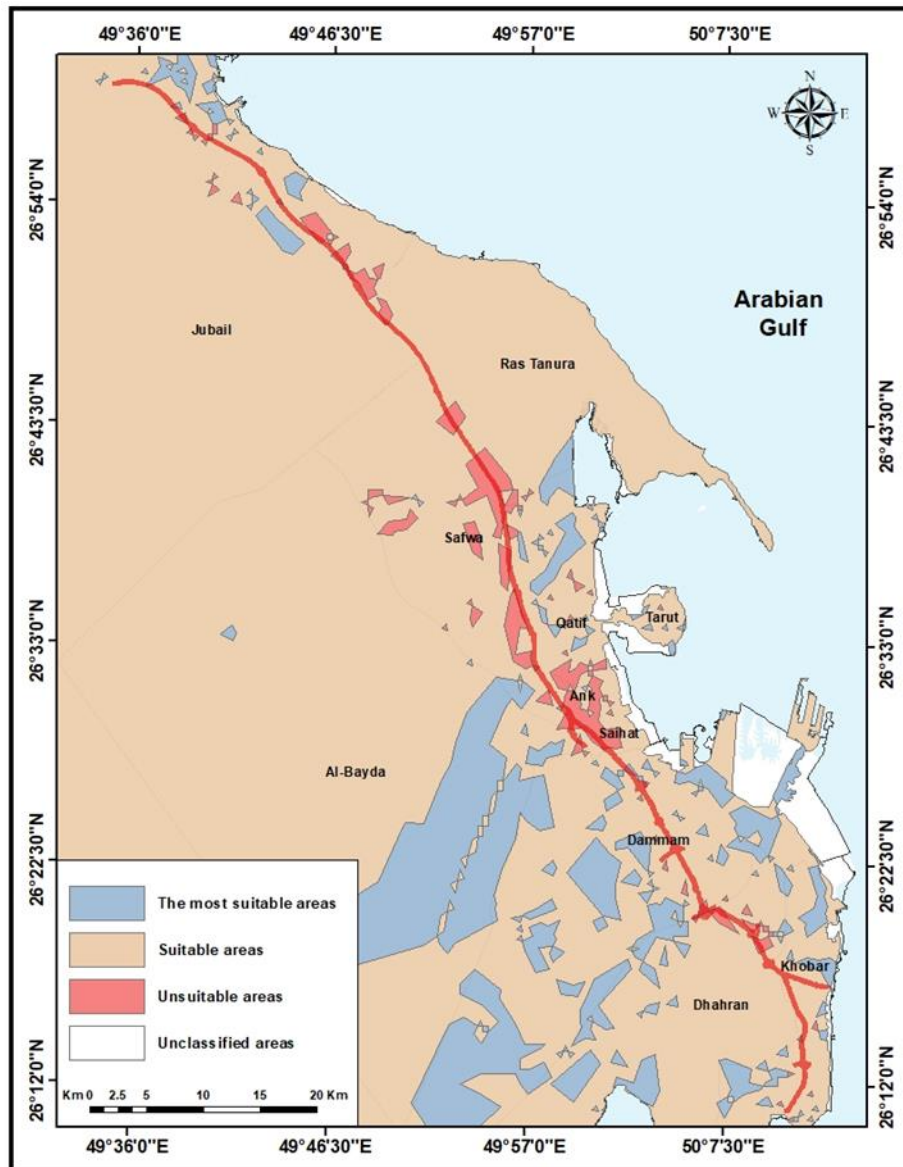

Figure (5) Map of suitable and unsuitable areas for building the suspended metro.

Source: Prepared by Lulwah Barjas, based on data in Figure (2).

Table (14) Degree of spatial suitability for building a high-speed electric train.

Degree of spatial suitability	Space (M^2)	%
Unsuitable areas	90725740	0.94
Suitable areas	9076736808	93.67
The most suitable areas	522443574	5.39
Total	9689906122	100

Source: Prepared by Lulwah Barjas, based on data in Figure (6).

Table (14) and Figure (5) show that the geographical distribution of the most suitable areas is concentrated in the southern region of the map, while it is dispersed in the central and northern region. Its percentage reached 5.39% and achieved 3 to 5 standers such as its distance from the road, 1000 meters, and proximity to commercial centers and the vacant lands. The suitable areas were distributed the most in the area of the study, reaching a percentage of 93.67%. The unsuitable areas were concentrated on both sides of the road due to the lack of standards such as their proximity to the road, residential areas, and agricultural lands such as the aquaculture farm in Safwa. The unsuitable areas were estimated at a percentage 0.94%, while the unclassified areas were concentrated in the east of the map, near the coast.

Table (15) Spatial and numerical distribution of suspended metro stations.

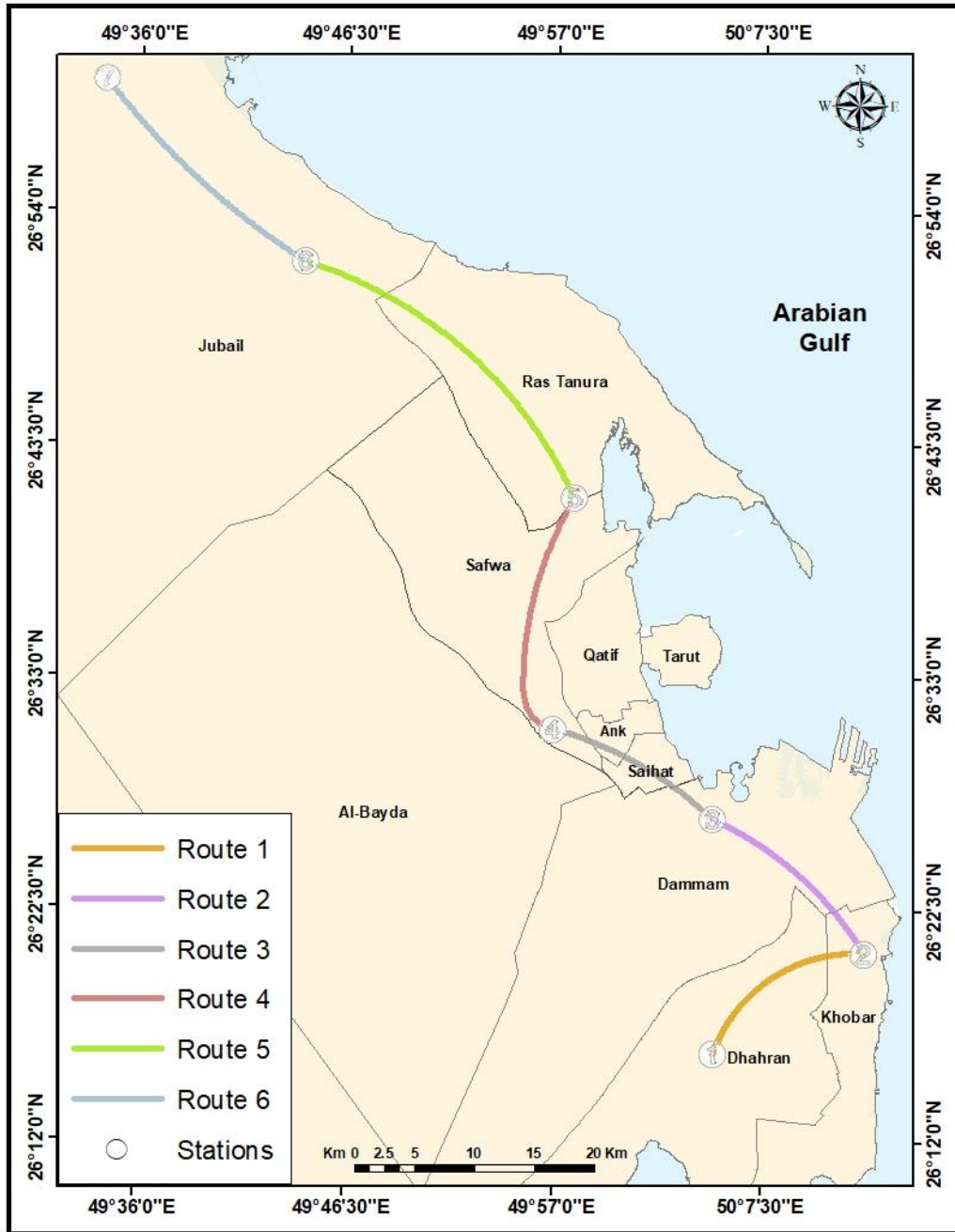| Stations	Cities	The distance from the road (Km)
Station 1	Dhahran	10.51
Station 2	Khobar	8.27
Station3	Dammam	3.57
Station 4	Safwa	2.40
Station 5	Ras Tanoura	5.03
Station 6	Jubail	2.22
Station 7	Jubail	1.16

Figure (6) Map of the suspended metro route.

Source: Prepared by Lulwah Barjas, based on data in Figure(6).

Table (16) Suspended Metro stations.

Routes	Stations	The distance (km)
Route 1	Stations (1,2)	16.3
Route2	Stations (2,3)	17.2
Route3	Stations (3,4)	15.5

Route 4	Stations (4,5)	21.2
Route 5	Stations (5,6)	30.9
Route 6	Stations (6,7)	22.6
The total length of the metro		123.6

Source: Prepared by Lulwah Barjas, based on: data in Figure (31).

Tables (16) and (15) and Figure (6) show that the total length of the suspended metro line is 123.6 km, and it consists of 6 tracks with 8 stations. The first route, which is 16.3 kilometers long, starts from the first station, which is 10.51 kilometers away from the road and located west of Dhahran.

Route 1 passes through Aramco and King Fahd University of Petroleum and Minerals, passing through the West Dammam neighborhood, and passes between the northern and southern Dana neighborhoods, then north of Doha, and also passes next to the National Guard in Dhahran until it reaches the city of Khobar, passing through the Qurtuba neighborhood and finally the southern Rakah neighborhood, where the station is located. The second is 8.27 km away from the road.

Route 2, which has a length of 17.2 km, passes from the second station from the beginning of the Al-Rakah Al-Janouby neighborhood, passing next to the National Guard, then passes through the Al-Rakah Al-Shamaliyah neighborhood, arriving in the city of Dammam, starting from the neighborhoods of eastern Dammam, which are Al-Safa neighborhood, then Al-Hussam neighborhood, Al-Khalidiya Al-Janoubiy, Al-Khalidiya Al-Shamaliyah, Al-Nasiriyah, then Neighborhoods in central Dammam, which are the Prince Muhammad bin Saud neighborhood, Al-Adamah, Al-Qazzaz and Al-Nakhil until it reaches the Al-Khaleej neighborhood, where the third station is located.

Route 3 of the metro, which is estimated to be 15.5 km long, passes from the beginning of the third station, which is 3.57 km away from the road, and crosses the Al Khaleej, Al Anoud, Al Aziziyah and Al Hamidiya neighborhoods in Dammam, then passes through Granada, Al Firdaws, Al Zuhur, Al Salam, Al Deira and Al Naqi in Saihat, then Al Rimal neighborhood in Anak. Until Safwa, where the fourth station is located, is 2.40 km from the road.

Route 4 starts from the fourth station. It crosses the Al-Rayhan, Al-Tilal, Al-Awjam, Al-Fayha, Al-Budur, Al-Orouba, Hazm and Al-Manar neighborhoods in Safwa, arriving at the beginning of the city of Ras Tanura, where the fifth station is located next to the Mangrove Ecological Park and is 5.03 km away from the road.

Route 5 crosses from the fifth station next to the Mangrove Ecological Park in Ras Tanura. The length of Route 5 reaches 30.9 km, and passes next to a number of public facilities such as a gas station, a resort, and rest houses, arriving in the city of Jubail. It passes through Al-Aziziyah and then reaches a vacant lot where the sixth station is located which is 2.22 km away from the road.

The length of the 6th and final route is 22.6 km. It starts from the sixth station, passing by the farms and Al-Khuzama neighborhood, then passes through the city's outskirts area, where companies and factories are located, until it reaches the final station. The seventh station is 1.16 km away from the road.

Conclusion

we can only thank Allah, by whose grace good deeds are accomplished. In this research, We have put in our maximum effort and put our utmost energy into it so that it is comprehensive and complementary to all axes and topics, asking Allah that this research be a guide and reference for every researcher interested in this topic. Through our research into this topic, we were keen to provide all information from official and reliable references, so we extend our highest expressions of thanks and appreciation to Imam Abdul Rahman bin Faisal University and to all faculty members in the Department of Geography and Geographic Information Systems in the College of Arts, especially Eng.Fatima Al-Mushaiti, Eng. Fatima Al-Fateel, and Eng. Alaa Al-Ghamdi for their cooperation and generous guidance, and thanks go to the Emirate of the Eastern Province for their cooperation and help. We also thank all the officials in the Eastern Province Secretariat, The General Manager of Raising the Efficiency of Projects, Abdul Rahman Al-Zahrani, and Eng. Ahmed Al-Mutab in the General Administration of Urban Planning and all the engineers in the Eastern Province Secretariat. We thank the Ministry of Transport and Logistics, Eng. Abdul Rahman Al-Kharif, Eng. Abdullah Al-Khudair and Eng. Muhammad Al-Qarni at the Ministry of Transport and Logistics Services in Riyadh, Eng. Ahmed Al-Yami and the manager of Human Resources at the Ministry of Transport and Logistics Services Branch in the Eastern Region, and many thanks to the Traffic Safety Committee in the Eastern Region Eng. Saad Al-Zaher, Eng. Walid Al-Hamidi for their generous cooperation, support and guidance. We deeply thank them all for their cooperation, answering our questions, and providing us with the required data. We also extend our sincere thanks to everyone who contributed an opinion or advice to the completion of our research.

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