Available online www.jsaer.com

***Journal of Scientific and Engineering Research*, 2018, 5(6):199-216**

Research Article

ISSN: 2394-2630
CODEN(USA): JSERBR

Movement and Traffic in the Main Axes of the City of Dhamar, Republic of Yemen - An Assessment Study of the Problem in the Light of References to Urban Planning

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Abstract The rapid growth and development as well as the improvement of the living and health conditions of the population in all the cities of the Republic of Yemen, including the city of Dhamar, the capital of Dhamar province, led to a significant increase in population numbers with a marked increase in the percentage of their ownership of vehicles and means of transport of all types and sizes which causes the devouring of more lands from various directions of the city to cope with the urban expansion that fled Which imposed by the process of urbanization rapid and continuous resulted in many of the problems, especially the problems of traffic system in the city. The aggravation of the problem of overcrowding and traffic jam on the streets of the city, especially at the main axes of the movement led to the low efficiency of the system of roads and sub-roads.

The study aims to study the problems of the movement system and traffic on the main movement axes through a methodology based on the analysis of the current situation from a serious reading of the references of urban planning of the city (Master plan) as a basis to help diagnose the problem.

The research concluded with a number of suggestions, solutions and general recommendations that help to solve the problems of the traffic system and traffic jams on the main axis of the movement inside and outside the city.

Keywords Urban planning, Master plan, Road network

1. Introduction

The city of Dhamar, like other major Yemeni cities, has witnessed great urban growth in various directions, especially in the northern and southern directions along the national artery Sana'a-Taiz-Aden road which links the capital Sana'a with the province Sana'a, Dhamar, Ibb, Taiz, Lahj and ending in the economic capital of Aden, and branching out of roads to connect the provinces of: Al-Bayda, Abyan and Dhalae.

Internal migration - both rural and other governorates - was a major factor in the urban growth of the city, especially after the unification of the north and south of the country on 22 May 1990. The average location of the city for the cities and governorates of the Republic, as well as the high rate of ownership and increase in the number of vehicles and means of private and public transport created pressure and burden on the road network and the city's traffic system and made it unable to meet the daily needs of the population and travelers.

The system of legislation, projects and development plans indicate that the official authorities were fully aware of the problems that would result from rapid urbanization and worked to avoid the effects and problems resulting from the urbanization that swept the Yemeni cities. The following is a brief description of the urban planning process in Yemen:

- Adopting the Urban Planning and methods of construction in what was known as the Arab Republic of Yemen by promulgating Law No. 1965, which includes building, planning and roads regulations.
- Work continued in this manner until the promulgation of the Urban Planning Law No. 20/1995 and its Executive Regulation No. 260/1997 and the Building Law No. 19/2002 and its Executive Regulation No. 351/2008.

- In 1978, the Master Plans of the five main cities in Yemen, Sana'a, Taiz, Hodeidah, Ibb and Dhamar were completed by Louis Burger and Camp Sachs Company at the request of the government represented by the Ministry of Public Works and Municipalities.
- As for what was known as the People's Democratic Republic of Yemen, it adopted the Urban Planning and the legislations regulating it by promulgating the Planning and Building Law No. 31/1948.
- In the 1980s, the master plans of the two main cities in what was known as the People's Democratic Republic of Yemen; were completed in Aden in 1984, by a group of Russian experts, and in Mukala in 1981, by the Lebanese Arab Company for Studies and Designs.

The historical background shows that the city of Dhamar grew spontaneously in the period before the promulgation of the city plan issued in 1978, which is regarded as the first and most important reference in this concern. Hence comes the importance of this study, specifically the study of the proposals of traffic and movement scenarios. The studies of the Master Plan for the city of Dhamar were then based on a database of information and data based on the official statistics for 1975, in addition to the field studies of the technical team assigned to prepare the master plan. According to these statistics and studies, the population of the city of Dhamar was not more than 20000 people and the city size was about 3 km2, while the city's population in 2015 exceeded 250000 and an area of about 37 km 2. Therefore, the city Master Plan has set the traffic and traffic scenarios in three time periods to take into consideration future expectations and factors of urban growth, traffic.

2. Research Problem

The problem is the aggravation of the overcrowding and traffic congestion within the city, particularly in the main axes of traffic flows, which reduces the efficiency of the system of main roads and sub-roads and makes them unable to provide an effective link between members of the community within each urban community, and other urban communities. The problem of movement and traffic in the city of Dhamar is due to several factors and reasons that can be summed up in the following:

- The city of Dhamar is located in the middle to the other governorates of the Republic and centers the passage of the road, the national and regional artery Sana'a-Taiz-Aden, which links the capital Sana'a with the economic capital Aden from the center of the city where most of the nodes and points of overcrowding and traffic congestion exist.
- The rapid urban growth and expansion in the four directions of the city, especially in the Northern and Southern directions.
- The failure of the official authorities and Urban Planning authorities to review, evaluate and update the master plan of the city since it was prepared in 1978 by Louis Burger and KambSachs to accommodate and keep abreast of developments and changes in the urban fabric of the city, including traffic flow.
- The severe shortage of parking, especially on the main traffic hubs.
- Improper use of road and confusion between vehicular traffic and pedestrian traffic.

3. Methodology of the Study

The methodology of the research was based on the extrapolation and analysis of the Urban Planning references of the General Plan of the city and the researches related to the field of this research, as well as the studies and information from the relevant authorities (the Executive Office of the Governorate, the Governorate Traffic Department and the Central Bureau of Statistics Branch). The research was also based on field photography and analysis of the current situation and ends with the setting of the appropriate proposals, solutions and recommendations.

4. Research Objectives

- To define the problem and its dimensions by studying and analyzing the current situation of the traffic system on its main axes.
- To study and analyze the traffic scenarios in the Master Plan of the city of Dhamar prepared in 1978.
- To suggest proposals for the problem of research in the most important intersections and nodes of traffic jams on traffic main axes.

5. Concepts and Reference of Urban Planning

5.1. Urban Planning

The American planner Olmsted said: "The truth is that we are interested in a thorny and complex issue which is the proper direction and supervision of the full natural growth of cities - a directive that will overcome all problems and reduce and alleviate the problem of overcrowding of population and transformation…etc [1]..

According to Goderitz, Urban Planning is to find a kind of acceptable link between the distribution of areas of population, work areas, entertainment, culture and traffic… etc [2]. And the International Conference on Modern Buildings concluded that Urban Planning is the organization of functions related to the common everyday life of the people, which consists of four basic functions: housing, work, recreation and traffic [2].

Dr. Ali Al-Haidari in his book "Urban Design - Structure and Field Studies" pointed out that Urban Planning takes into account the axes of movement, land uses and service problems and the obstacles of traffic and transportation…etc [3].

In the opinion of Dr. Saied Kareem "We must first know the basis of the problem and the reason for this problem. We cannot solve the traffic problem without examining the city planning it to determine the traffic relationship with the city itself" [4].

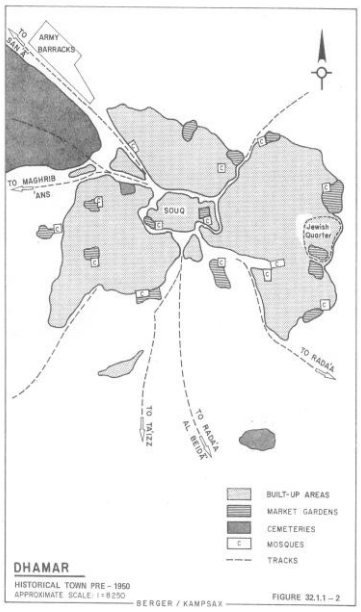


Figure 1: Historical Town Pre-1950

(Lois Berger international, 1978)

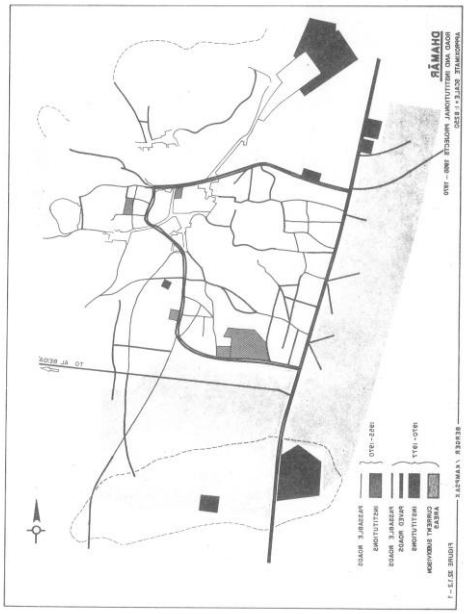


Figure 2: Road and Institutional Projects 1955-1970

(Lois Berger international, 1978)

5.2. Master Plan

Master plan is the plan which is meant to arrange and regulate the relationship between the components and functions of the city, and it is the legal means to guide urban growth, and to find solutions to the problems of housing and traffic.

Objectives of the Master Plan

- Improving the physical environment of the city and make it beautiful and healthy so as to achieve the elements of comfort, safety and safety of the population.
- Coordinating and regulating the relationship between land use in the city.
- Providing a network of roads, streets and transportation means to transport the population and meet their daily needs in an easy and convenient way.

- Providing a network of utilities and public services "water, electricity, sewage, telephone and internet" and with adequate spaces and suitable sites for the establishment of parks, kindergartens, schools, theaters, stadiums and others.

5.3. Scenarios of movement and traffic in the Master Plan of Dhamar city

The Master Plan and its annexes to the city of Dhamar [5] identified the scenarios and stages required for the establishment and expansion of the network of roads and streets. This was divided into three chronological stages as given in Table (1) below.

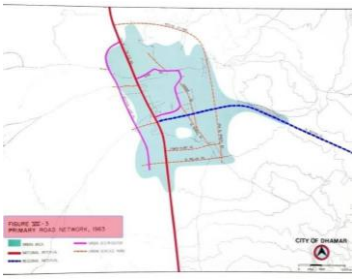
Table 1: Scenarios of movement and traffic in the Master Plan of Dhamar city

Phase I: 1983	*Phase II: 1990*	*Phase III: 2000*
1.Urban Distributor: a. Western Loop Road: This road, based on a proposal of the Ministry of Municipalities Planning office, will parallel Sana'a-Taiz Road and function as a minor bypass, providing relief to the main highway as a truck route. 2. Urban Service Road: a. Medina Bypass: a proposal of national Planning officials, this road will pass northeast of the city, connecting the Sana'a – Taiz and Al Baydah Roads. b. New Al Manzel Road: This new north – south route will extend from Al Nasr Road to cross Al Baydah Road and serve the Phse 1 city center and industrial project. c. Al Mellah Road: This east – west road will cross the Sana'a-Taiz Road and serve the two Al Manzel industrial areas in Phse 1. d. Al Baydah Road Extenion; road is proposed to connect with the Western Loop Road.	1. National Arterial: a. Sana'a-Taiz Road: Improvement would include pavement expansions within the existing right-of-way to accommodate four full lanes of traffic. 2 .Reginald Arterial: a. . Al Baydah Road: Improvement would include expansion to four full lanes between the Sana'a-Taiz Road and New Al Manzel Road. 3. Urban Distributor: a. Al Mellah Road: An extension east will carry the road through the Al Mellah sector to meet the Al Baydah Road near the Governorate complex. At this point in time the function of this road will change to that of an Urban Distributor. b. Western Loop Road: An extension to the south is proposed to serve Phase II industrial areas in the Ayzan sector. 4. Urban Service Road: a. New Al Manzel Road: This road will be extended south to serve Phase II industrial areas east of the San'a-Taizz Road. b. Ayzan Road: This new route will be developed in the Ayzan sector to serve Phase II industrial project.	1. National Arteries: a. Al Hudaydah Road: The recommended road from Al Hudaydah and Bajil is project for this Phase and is proposed to meet the Al Mellah Road While a spur from the Al Hudaydah-Ma'bar route to Dhamar is considered essential, it would be even more desirable for the train route to proceed directly to Dhamar, which is already established as the regional center, rather than terminating at Ma'bar. 2 .Reginald Arterial: a. Al Baydah Road: During this Phase, the road would be widened to four lanes between the new Al Manzel Road and Al Mellah Road. 3. Urban Distributor: a. Wadi Al Har Road: This Road will distribute traffic from the west to the many industrial zones around the city. b. Al Mellah Road: A further extension west is proposed to link with the Al Hudaydah Road and supplement the system of urban distributes. 4. Urban Services Road: a. Ayzan Road: The Ayzan Road will be extended west paralleling the Al Mellah Road and meeting the Wadi Al Har Road. b. Ayshaan Road: This route

will consist of an extension and improvement to an existing right-of-way to meet the Wadi Al Har Road.

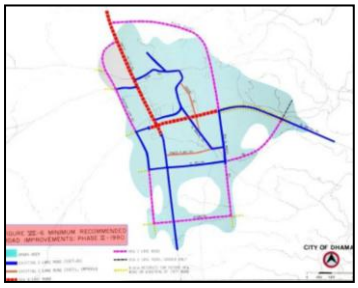
c. Magreb Ans Road: This route is also based on improvements to an existing right-of-way and will connect the Wadi Al Har Road and San'a-Taiz Road.

d. Al Baydah Road Extension: A spur from the Al Baydah Road will be extended west, paralleling the Al Hudaydah Road.



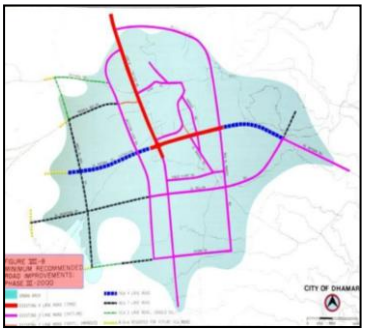
Phase I: 1983

[5]



Phase II: 1990

[5]



Phase III: 2000:

[5]

The first phase of streets network was implemented with some technical excesses during implementation.	The second phase of streets network was implemented except (4-b) Ayzan Road which was implemented by the time of third phase implementation.	(1-a and 3-b) were not implemented and the recommended section to be implemented, linking Al Mellah street and Hodiedah road (Eastern Ring) under construction.

The evaluation of the implemented of the scenarios in the three stages is linked to the extent of achieving the goals set for them and their ability to keep pace with the present time. It is clear enough that the reality has exceeded the goals set as a result of urbanization factors and others. Therefore, they must be reviewed in accordance with the changes and requirements in the present time. It is very useful to avoid and correct the technical excesses that accompanied the implementation of the first and second stages (street and sidewalk widths and some streets directions). For the third stage, there is a great possibility of review, evaluation and modification according to the current data and the problems not expected by the master plan of the city at that time. This will make the system of traffic able to keep up and achieve the acceptable level of efficiency.

5.4 . Causes and factors that aggravated the traffic problem

The researcher believes that the reasons that led to the aggravation of the problem of movement and traffic in the city of Dhamar, especially on the main axis of the movement can be divided into two parts:

A) General reasons: Dr. Shafak Alwakeel in her book "Urban Planning – Part II" [6] identified the reasons for the problem of traffic within the city in the following points:

- High population density
- High rate of car ownership
- Lack of space allocated for traffic

- Lack of parking spaces
- Misappropriation of land uses

B) Specific reasons:

- Failure to undertake a review and evaluation leading to the development of the master plan of the city in general, and scenarios of traffic and movement in particular, keeping pace with developments and the absorption of variables, including traffic and movement problems.
- The road, the national and regional artery Sana'a-Taiz-Aden, which connects the capital Sana'a with the capital city of Aden in the center of the city.
- The presence of many of the nodes and points of congestion and traffic congestion on the main traffic arteries of the network of the city's streets, which are mostly centered on the movement of the first axis (Sana'a-Taiz-Aden), which is currently, due to the process of urban development of the city, becomes part of the city's streets network.
- Narrow road network in many parts of the city (mostly starts from 5m-10m, as in the old city which may increase or decrease in some other parts).
- Increasing density of building in the city center and bypassing and altering the construction works of urban plans.
- The deterioration and bad condition of many sections and parts of the network of roads and streets due to almost complete cessation of maintenance and renovation and restoration.
- All road construction projects have been stopped, for example the construction of the Eastern Ring Road, which has not been completed since 2011.

6. Planning standards for the network of roads and streets

Roads are the vessel that contains traffic and arteries that link land use to each other. The road and street network is the main element of the urban assembly (city / village) and occupies about 30% of the urban area. The importance of the road is proportionate to the purpose designed for it in terms of service and traffic density. Therefore, it should have sufficient width to suit the current size and the future expectation of traffic and movement in order to achieve its optimal use and ease and flow of traffic.

6.1. Factors that regulate the relationship between the hierarchy of the road network and its width and speeds:

- The size of the urban assembly using the road.
- The expected traffic size.
- The rate of vehicle ownership and its development, which is a reflection of the standard of living of the population.
- The expected development of land use in the area in which it goes through [6].

6.2. Classification of roads and streets networks

The streets network can be classified according to the nature of their use, the size and type of traffic they are going through, and the importance of the connections they make. The researcher found that this classification differs from one author to another, and it seems that the political and cultural environment has an impact on it. According to local data, the researcher has been consistent with the ratings of both Dr. Shafak Al-Wakeel [6], Dr. Ahmad Allah [1], Dr. Salwa Sakal and Dr. Omar Martini [7]:

A) Highway streets (roads)

They represent the highest level in the hierarchy of roads and pass on the outskirts of cities and characterized by multiple traffic movements with the complete separation of traffic at intersections and full control of entrances and exits. The transfer of traffic from the outskirts of the city to the city and its urban communities is the main function of this type of road. It has many names such as:

Round roads: They are highways that surround urban communities with belts to prevent traffic transit by creating multiple entrances and exits leading directly to different areas of the city. The circular roads have more than one level around the city, each of which represents a stage of its growth, and each level in the downtown area is connected by a lower ranking road.

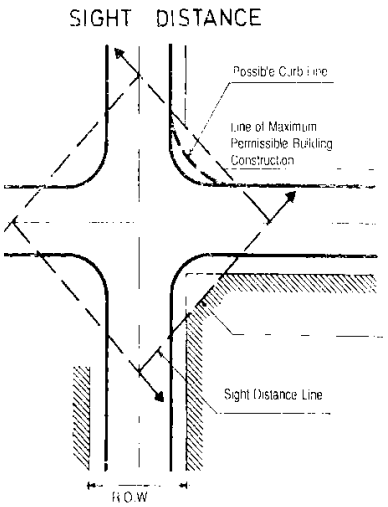


Figure 3: Siht Distance

B) Main streets

The second level in the hierarchy of the road network and its main function is the service of transit within cities, where it collects and distributes traffic to and from highways. It also distributes traffic to reach the main areas and components of the city. The movement is in both directions on several streets in each direction for public transport. There are two basic principles to consider when designing main streets:

Principle 1: The lengths of the main streets should be commensurate with the expected traffic size.

Principle 2: The main street network should be continuous without intersections in the form of a letter T in order to achieve a smooth flow of traffic and decrease the obstacles of movement that arise from the transfer of local traffic loads, and this is done by the assembly street.

C) Collective Streets

This is the third level in the hierarchy of the street network, whose main function is to transfer traffic from the streets of the local service to the main streets, as well as to serve the houses, plots and public facilities.

- **The importance of the collective street of residential neighborhood:** The collective street is the backbone of the residential neighborhood where it serves the local streets, as it collects traffic before it reaches the level of congestion and transport it either to the secondary or main traffic streets or to local attractions (commercial center or primary school). The width of the street is between 18 - 25m in residential areas and this offer is increasing in the commercial and industrial areas. Although the street width is not much more than the width of the local service street, the difference lies in the street design, where priority is given to the car on pedestrians, increasing the area of vehicular traffic and decreasing the width of the sidewalk of the pedestrian and island, and the track is straight with reducing the possibility of parking and waiting vehicles on both sides.

D) Local service streets

This is the fourth level in the hierarchy of the road network, which is dedicated to the access and service of residential groups. The infrastructure (electricity, water, telephones, gas, etc.) are under its territory. It can be classified into two types:

Streets with closed ends: The length of the street should not exceed 100-150m. The end must be rectangular or diameter at 18m.

Ring Streets: The minimum distance between the axes of the entrance street and the exit street should be 60m.

6. 3. Types of Intersections

Intersections are divided into two types:

Type I :one level intersection.

Type II: Multiple levels intersections.

The influencing and determining factors for its establishment:

- Road rank.
- Road classification.
- The importance of the road.
- Traffic intensity.

6.3.1. One Level Intersection:

One- level intersection is classified to:

- Triple intersection (three branches/ streets).

- Quadrangle intersection (four branches/ streets).
- Multiple intersections (branches/ streets).

It is preferable that the one level intersection to be direct and perpendicular, and if opposite directions are met, the angle of the intersection shall not be less than 60 degrees.

- **Conditions for achieving intersection competency:**

In order for one level intersection to achieve their objectives in the flow of traffic and avoiding accidents, the following conditions must be met:

A) Improving the viewing angles: with sufficient distance between 30 - 40m. the easiest way to secure a good angle of vision is to cut the corners of the buildings at the quadrilateral intersection, for example in line 45 on the axis of the road, Figure (3).

B) Reducing the number of collision points: At the intersection of the four-way street (orthogonal cross) there is a 16-point collision, which can be reduced and mitigated by turning the intersection into two intersections T-shaped to reduce the intersection points to only 3 points, (Figure 4). Whereas at intersections, where a group of streets converge in one point, the intersection is completely or partially eliminated by creating a square, rectangular or circular central square if the number of intersecting streets exceeds five (Martini, 1992), Figure (5).

C) The use of optical signals: The light signal and the middle island are used to regulate the traffic and achieve a smooth flow of traffic at one level intersection.

- **Defects:**
  - One level intersection does not provide smooth flow of traffic perfectly.
  - One-level intersections do not provide sufficient protection for pedestrian traffic.

6.3.2. Intersections at multiple levels:

Intersections are held at multiple levels at high traffic intersections and can be set up at intersections of main roads and streets.

- **Features and specifications:**
  - Multiple level intersections ensure - ease and smooth movement and traffic flow.
  - Multiple level intersections secure pedestrian levels and isolate their movement from vehicles.
  - The height between the intersection levels is between 4.5 - 5.6m.
  - The slopes suitable for linking the lower and upper levels are in the range of 3%, 5% and 8%, thus extending the lengths of those slopes between 80-250m.

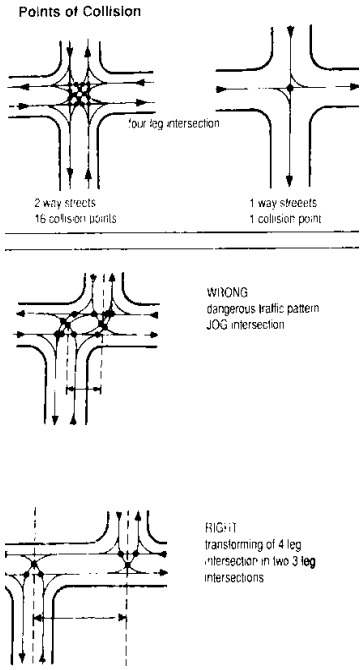


Figure 4: Point Collision

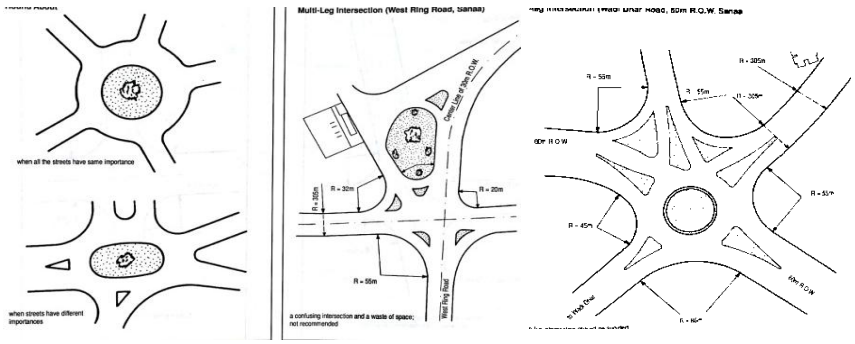


Figure 5: Multi Intersection

- **Defects:**
  - The costs of creating multiple level intersections are high.
  - The dissolving of the traffic contract needs large tracts of land.

6.4. Parking

Parking is an integral part of the city's road network, contributing to the worsening the traffic problem in Dhamar city.

- **The problem on the city's main traffic axes**

Parking of cars and the other types of vehicles on the main traffic arteries and in the city center are among the reasons that aggravated the problem of traffic, due to several factors, the most important of which are:

- All governmental, educational, commercial, banking, recreational and other services focus on the main traffic arteries and in the downtown area.
- The main axis of the movement is a destination for the working class as it is located in the central region on the one hand, and on the other to seek employment opportunities as the most public and private institutions are present on them.
- The rate of land use (the so-called utilization rate) and the high purchasing power on the main traffic arteries and in the central area contributed to the severe shortage of parking spaces for vehicles.
- Narrow road network in many parts of the city especially in the middle area (Old Town) contributed in the acute shortage of parking and vehicles.

- **Criteria for choosing parking areas**
  - Parking areas should be selected taking into consideration the degree of the road. They should not be placed on highways, except in locations designated and designed for this purpose.
  - Parking locations must be identified as part of a comprehensive traffic system in the city.
  - The distance between parking and waiting areas and places of service should be taken into account as such distance is between 50 and 150 meters.
  - Lanes must be constructed as entrances and exits for parking and waiting spaces in high speed streets and traffic densities.
- **Design of parking areas:**

It is necessary to provide the entrances and exits of the parking waiting spaces and for the ease and smooth movement. The following is an explanation of the methods of designing parking spaces. Figure (6):

- Parallel positions for pavement: suitable for narrow streets and in front of houses.
- Vertical positions on the pavement: It is preferable to use them in broad roads, and the most important disadvantages are the difficulty of entering and leaving the position because of continuous traffic.
- Sloping on the pavement at an angle of 45-60: This method is good in terms of space utilization and its easy entry and exit.
- Sloping on the pavement at an angle of 30: This method does not achieve a good use of space.

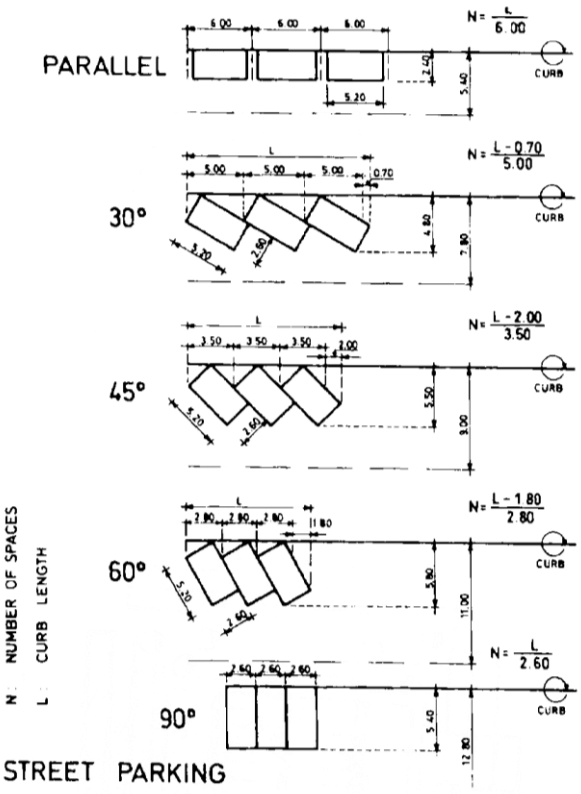


Figure 6: Street Parking – Parking Standards

7. Studying the current situation of movement and traffic on the main axes of the city

The traffic and traffic axes in Dhamar city are divided into three main axes as well as the western ring road as shown in Figures (7 & 8).

7.1. The first axis: Sana'a - Taiz– Aden Road:

This road is the national and regional artery of the movement, linking the capital Sana'a with the economic capital of Aden. It is the main axis of the movement in the city of Dhamar and extends from north to south and divides the city into two parts:

A) The eastern section: Its most important components are the old city and the urban expansions that followed the revolution of 26 September 1962. Until the mid-eighties of the last century. Almost, the center of the city and the government complex and a number of administrative and service buildings are the most important components of this section.

B) The western section: It includes the new neighborhoods of the city, which has grown since the mid-eighties of the last century, and the university is the most important components of this section, in addition to some new administrative buildings and services. From this section, there is the third axis of the movement, Dhamar–Husseiniya Road, which links the capital of the province with its western directorates and extends to Hodiedah Governorate on the Red Sea.

- **Advantages**
  - This axis is the main artery of traffic as being in the center of Dhamar city.
  - It is the tallest and most important street in the city and its network of branches.

- **Defects**
  - The passage of this axis in the center of the city exacerbated the problem of traffic and movement in the city, as it is still the main path of the regional movement.
  - On this axis there are many nodes and points of traffic congestion, especially on intersections with:
    - Western ring intersection.
    - Al-jamarik Intersection (tour) or what is currently known as Sawal tour.
    - Intersection at the entrance of Dhamar General Hospital (formerly Dutch Hospital).
    - Al-Taamoon Street Intersection.

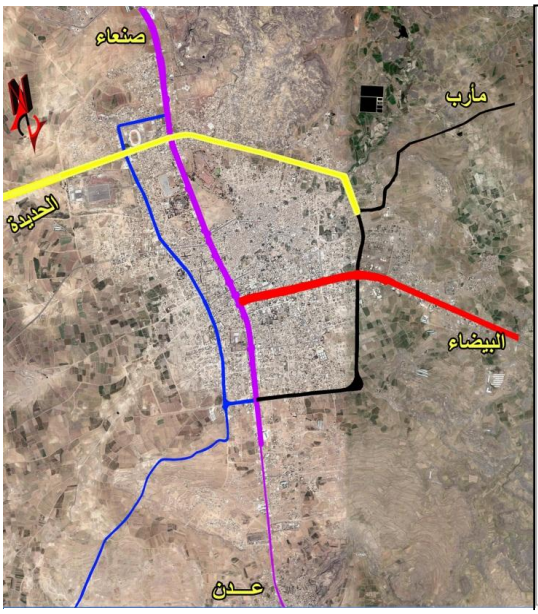


Figure 7: Movement and Traffic on the main axes of the city

Figure 8: Important Intersections and Nodes on the main axes of the city

- Al-Maghrib Street Intersection.
- Radaa Street Intersection.
- Kamran Intersection (Tour) (intersection with the western and southern ring)

- The random parking of vehicles on both sides of the road, especially from 9 am. to 3 pm. due to the presence of many facilities and government offices and service and lack of parking in those facilities, which helps to congestion traffic.
- The control of large areas of both sides of the road and the exploitation of the works of sale and purchase, which impedes the flow of traffic.
- Vehicle traffic mixed with pedestrian traffic in some parts.
- Neglect of the central islands and the non-exploitation of sidewalks side streets of pedestrian movement, as a result of its occupation with inappropriate billboards and unplanned planting.
- Mismanagement of traffic and failure to deal responsibly with the problem.
- Lack of traffic awareness among citizens and users of the road.

7.1.2. Most important intersections and nodes on the first axis

A) Al-Jamarik Intersection - what is known today (Sawal Tour)

This intersection is the meeting point of two important axes of the main traffic in Dhamar city: the first axis; Sana'a-Taiz-Aden road, and the third axis Dhamar-Husseiniya road, which extends to the province of Hodeida.

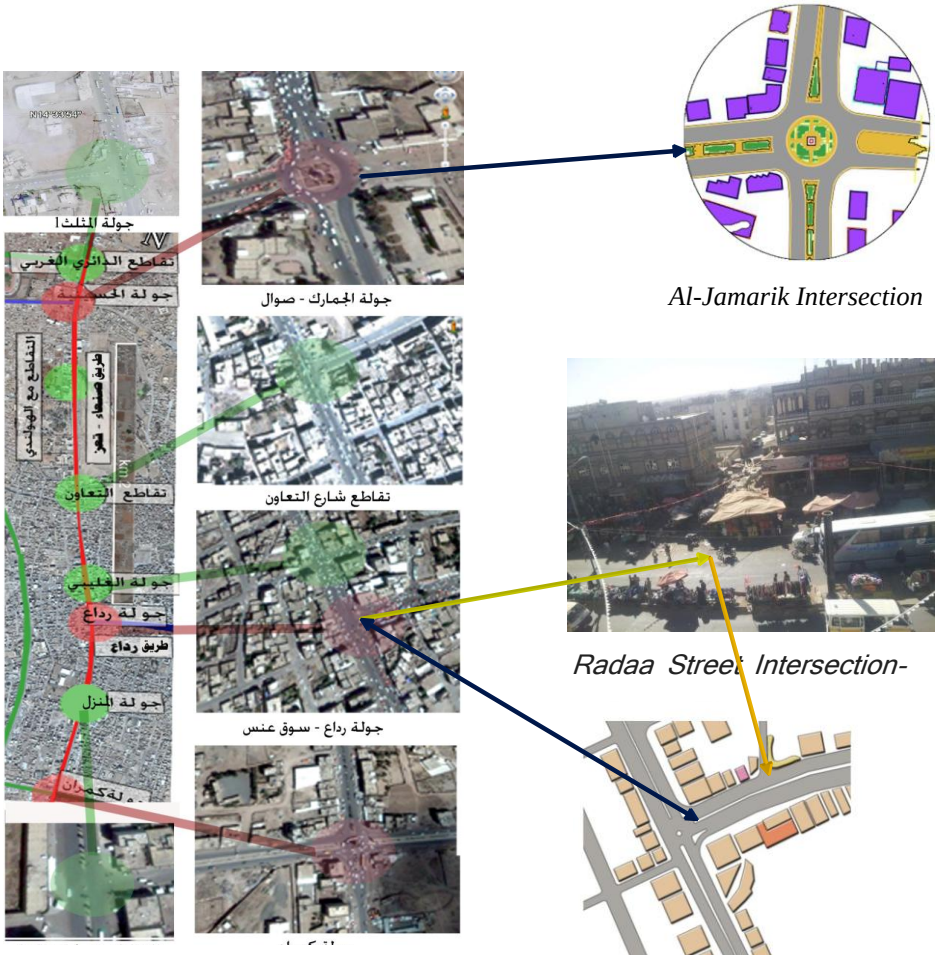


Figure 9: Important Intersections and Nodes on the first axis: Sana'a - Taiz– Aden Road

- **Land use around the intersection:**

Service-oriented buildings surround the intersection from all sides (Office of Finance, Office of Tax, hotels, residential buildings with ground floors for commercial purposes, market for sale of qat, restaurants. Hospital and Petrol Station) cause traffic problem that has been exacerbated by:

- The severe shortage of parking in buildings and service facilities surrounding the intersection.
- Using the intersection following the western intersection as station (Parking area) rental cars.
- Random parking of vehicles.
- Mixed vehicle traffic with pedestrian traffic.
- Mismanagement of traffic and failure to deal responsibly with the problem.

B) Radaa Intersection (tour) - what is currently known (Ans Market Tour)

This three-way intersection is a meeting point for two important axes of the main movement in the Dhamar city: the first axis Sana'a-Taiz-Aden road and the second axis Dhamar-Radaa-Al-Bayda road.

- **Land use around the intersection**

Service-oriented buildings surround the intersection from all sides (Office of Social Affairs and Labor, hotels, residential buildings with ground floors for commercial purposes, restaurants, Ans market for sale of qat) cause traffic problem that has been exacerbated by:

- Vendors control a large part of the road (about half the right side after the intersection) for sales and purchasing.
- The severe shortage of parking in buildings and service facilities surrounding the intersection.
- Random parking of vehicles.
- Mixed vehicle traffic with pedestrian traffic.

C) Kamran Intersection (tour)

This intersection is the meeting point of three axes of the city's main traffic arteries: the first axis; Sana'a-Taiz-Aden road, and the fourth axis; Western Ring Road and its extension, the Southern Ring Road.

- **Land use around the intersection**

The intersection is surrounded by residential buildings that use land floors for commercial purposes. Nearby are service buildings (post office, banks, hotels, restaurants). This intersection is an important point for the distribution of transit traffic outside the city. It should be noted that there are several factors that have aggravated the traffic problem in this intersection, the most important of which are:

- Intensity of traffic inbound and outbound.
- The intersection is not executed according to detailed plans and engineering designs.
- Mismanagement of the movement at this intersection and the lack of adequate traffic reference and guidance.
- Suspending the construction of the two sides of the road to the south – Dhamar Alkarn.
- The indiscriminate parking of heavy vehicles (trucks) on both sides of the intersection.
- Mixed vehicle traffic with pedestrian traffic.
- Mismanagement of traffic and failure to deal responsibly with the problem.

7.1.3. Proposed solutions to address the problem in the most important intersections and traffic nodes on the first axis

Through the study and analysis of the movement on this axis, some proposals can be developed to solve the problem as follows:

- Moving and turning the path of the movement coming from the northern side (Sana'a) and from the southern (Taiz and Ibb) crossing the center of the city through this axis to the parallel (alternative) route - the western ring as in Figure (10).

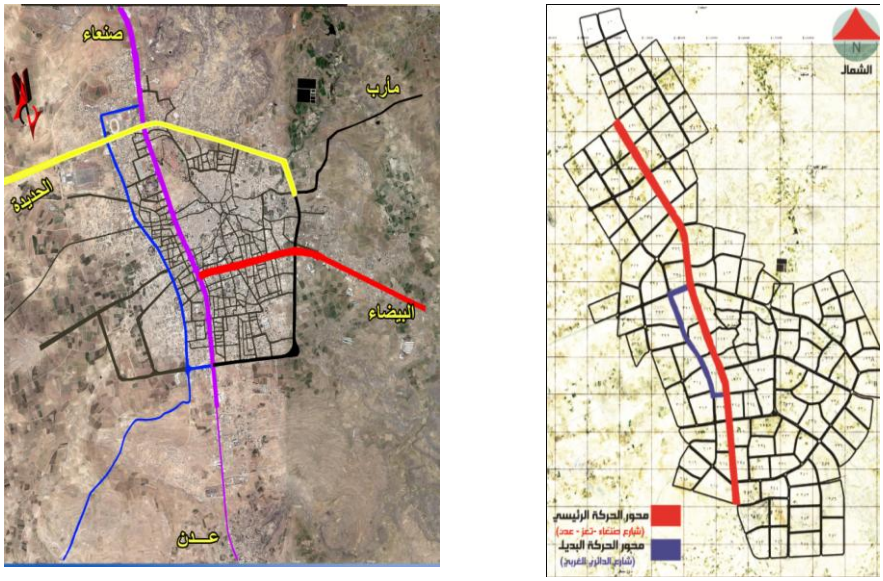


Figure 10: Proposal for moving and turning the first path to the parallel (alternative) route - the western ring movement

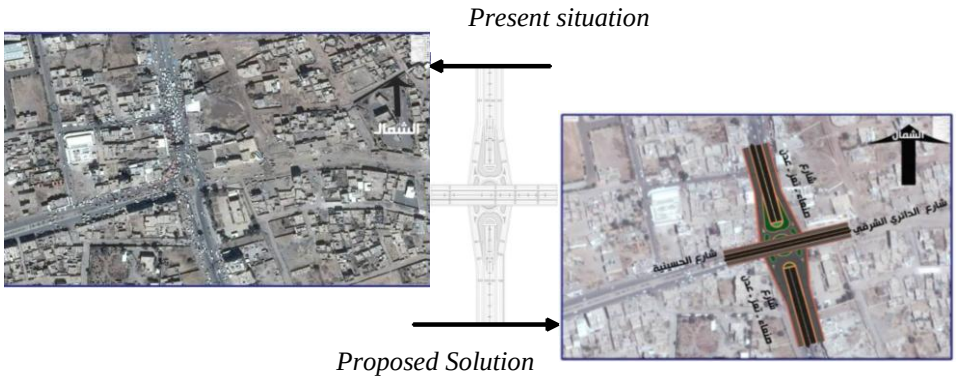


Figure 11: Proposed solutions to address the problem Al-Jamarik Intersection (tour)

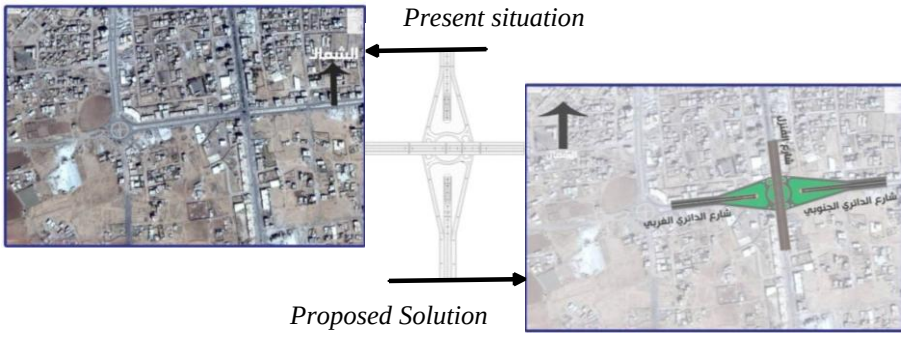


Figure 12: Proposed solutions to address the problem in Kamran Intersection (tour)

- Reducing the nodes, overcrowding points and traffic congestion on this axis (intersections of Customs and Kamran) through dividing these intersections at multiple levels to ensure the ease and flow of traffic and reduce the mixing of pedestrian traffic with vehicles as in Figure (11) and Figure (12).
- Transferring travelling stations to and from Dhamar to alternative areas and planning them according to established standards.
- Removing the obstacles that further exacerbate the problem (prostheses, workshops, qat markets, etc.).
- Prohibiting the use of sidewalks and marshes for non-purposes.
- Reorganizing the traffic at the intersection of Rada'a tour according to the requirements and engineering standards in order to achieve the smooth flow of movement and separation of traffic and pedestrians, Figure (13).

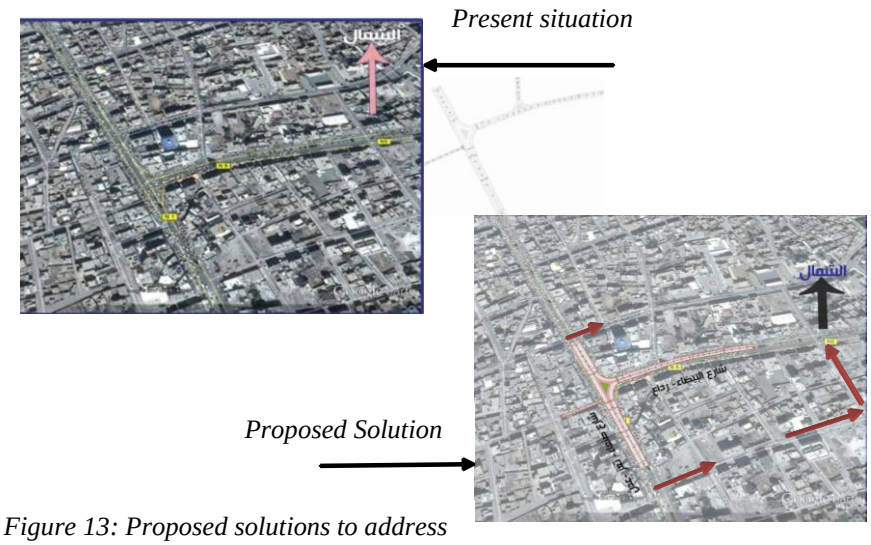


Figure 13: Proposed solutions to address the problem in Rada'a intersection

7.2. Second axis: Rada–Al-Bayda Road

Rada-Al-Bayda road is an important traffic artery in the city, where the eastern part of the city is almost intertwined. It runs from the first axis to the east and links between the capital's secretariat, the provinces of Al-Bayda and Abyan, and the eastern districts of Dhamar.

- **Advantages:**
  - This axis is an important artery for movement and traffic being the middle of the eastern part of the city of Dhamar.
  - It is one of the tallest streets in the city where the streets network of the eastern part of the city comes from.
- **Defects:**
  - The passage of this axis in the middle of the eastern part of the city is a factor aggravating the problem of traffic and movement in the city, being the main route of the movement to and from the eastern parts of the province and the province of Al-Bayda, although there is a possibility to guide the movement and traffic of vehicles, specifically the large and medium trucks coming from the eastern direction of the city to the Southern Ring road (street) and from it to the west.
  - On this axis there are a number of nodes and points of strangulation, especially on the intersections with:
    - Rada (Ans Market) Intersection (Tour).

- Al-Manzil Street Intersection.
- The intersection located in front of Al-Dairah market (a market for the sale of qat).
- Province Intersection (tour).

- The spread of qat markets on this axis, where the beginning of the road, there is a market, and almost in the middle there is Al-dairah market which causes traffic congestion, especially from 11am. To 2pm.
- Vendors control large parts of the road.
- Vehicle traffic mixed with pedestrian traffic.
- There is no separation between the movement of heavy vehicles and light vehicles.
- Traffic mismanagement and lack of responsibility for the problem.
- Lack of traffic awareness among citizens and users of the road.

7.2.1. Main intersections and traffic nodes on the second axis

a) Province Intersection (round):

This intersection is the meeting point of two important axes of the main traffic arteries in the city: the second axis; Rada-Al-Bayda road, with the Southern Ring Road (which is an extension of the fourth axis of the Western Ring Road)

- **Land use around the intersection:**

This intersection is surrounded from all sides by buildings of a service and administrative nature; the governmental complex from the north, the Faculties of Medicine and Dentistry of the University of Dhamar from the south. The intersection is also surrounded by residential buildings that use ground floors for commercial and service purposes, restaurants and a private hospital. This concentration of services surrounding the intersection causes a problem for the movement and traffic which has been exacerbated by the following factors:

- The intersection rotations were not performed according to the detailed plans and engineering designs.
- Using the sides of the intersection as a semi-permanent position for heavy vehicles (trucks)
- The expansion of the area immediately following the intersection to the east, and the deterioration of the old route were not completed.
- Mixed vehicle traffic with pedestrian traffic.
- Traffic mismanagement and lack of responsibility for the problem.

7.2.2. Proposed solutions to address the problem in the most important intersections and traffic nodes on the second axis

Through the study and analysis of the movement on this axis, proposals for solutions to the problems can be developed as follows:

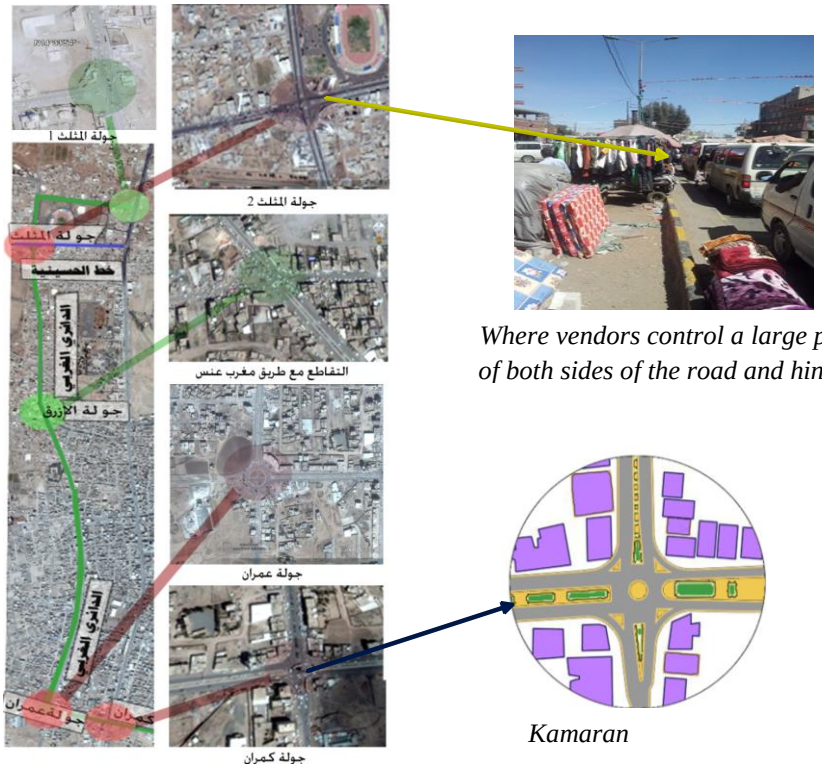
- The intersection of the province round intersects at levels to ensure the ease and smooth flow of traffic and reduce the mixing of vehicular traffic with pedestrian traffic as in Figure (15).
- Prohibiting the use of sidewalks and marshes for non-purposes.
- Finding planned traffic solutions for parking spaces according to the relevant standards.
- Removing the obstacles that further exacerbate the problem (vendors, workshops, qat markets, etc.).

7.3. The third axis: Dhamar - Husseiniya Road:

Dhamar-Husseiniya Road is one of the important traffic arteries in the city. It branches westward from the first axis Sana'a-Taiz-Aden road and links the capital's secretariat and Dhamar city with the western directorates of the governorate ending in the city of Husseiniya in Hodeidah Governorate on the Red Sea.

- **Advantages:**

- This axis is an important artery for traffic. The first section is a link between the first axes: Sana'a-Taiz-Aden road and the fourth axis; Western Ring Road (street). Its second section is the only street serving the new urban neighborhoods located on it.
- This axis is the main artery and the center of development for the population of the western districts of Dhamar governorate



Where vendors control a large part of both sides of the road and hinder

Kamaran

Figure 16. Important Intersections and Nodes on the third axis: Dhamar - Husseiniya Road

- **Defects:**
  - It is considered as passengers' terminal in the next section of the intersection of the road toward the west (Otomah Station) where vendors control a large part of both sides of the road and hinder traffic flow.
  - The existence of overcrowded points on this axis, especially on intersections with:
    - Al-Jamarik Intersection (tour) - what is currently known as Sawal Tour.
    - The intersection with the western ring - what is known as the Al-Muthallath Tour 2.
  - The market created on the road, in the area after the intersection of Al-Muthallath Tour 2 westward north of the Guard School is a suffocation point, traffic congestion and obstacle to movement.
  - Vehicle traffic mixed with pedestrian traffic.
  - Mismanagement of traffic and failure to deal responsibly with the problem.
  - Lack of traffic awareness among citizens and users of the road.

7.4. Fourth Axis: Western Ring Road:

The establishment of this axis contributed to reduce the pressure on the first axis Sana'a - Taiz - Aden and absorbing a large part of the traffic movement in addition to linking the residential neighborhoods, communities and public and services buildings on this axis with the rest of the city's axes The establishment of this parallel path to Sana'a - Taiz – Aden as response to the proposal of the Ministry of Public Works and Municipalities, in order to transport the movement and traffic of large and medium vehicles (trucks) through it.

- **Advantages:**
  - This axis was established as a parallel (alternative) route for the first movement axis Sana'a-Taiz-Aden road to transport the movement of large and medium vehicles (trucks) through it.
  - This axis is the main artery to link the urban communities and public and services buildings located on it.

- **Defects:**
  - This axis did not achieve the function and goal assigned to it in the master plan of the city.
  - On this axis there are many points of traffic congestion, especially on the intersections with:
    - The intersection with the western ring - what is known as the Al-Muthallath Tour 2,
    - The intersection with the road leading to Wadi al-Har and MaghribAns, at what is known as Al-Azrak Station,
    - Imran intersection (Tour),
    - Kamaran Tour intersection, which intersects the first axis of Sana'a-Taiz-Aden road and the Western Ring road and its southern circular extension.
  - The presence of workshops and some service shops located on this road are major factors to obstruct traffic.
  - Mixed traffic of vehicles with the movement of pedestrians in some parts, especially in front of the gates of the Faculty of Education and the Faculty of Arts of the University of Dhamar and also in front of the Office of Education of the province.
  - Mismanagement of traffic administration and the failure to deal responsibly with the problem.
  - Lack of traffic awareness among citizens and users of the road.

7.4.1. Proposed solutions to address the problems in the most important intersections and traffic nodes on the third and fourth axes:

Through the study and analysis of the third axis; Dhamar - Husseiniya and the fourth axis: The Western Ring Road and its extension South Ring Road, the following proposed solutions can be developed:

- Transferring and distributing of transit traffic (coming from different directions of the city) across these two axes to reduce the pressure on the downtown area (axes I and II).
- Reorganizing the four-way intersection - Al-Muthallath Tour in accordance with engineering standards and providing them with the necessary traffic guidance to achieve smooth flow and separation of traffic and pedestrians as in Figure (17).
- Find planning and traffic solutions for parking spaces and vehicle parking according to the relevant standards.
- Removing the obstacles that further exacerbate the problem (workshops, qat markets, etc.).

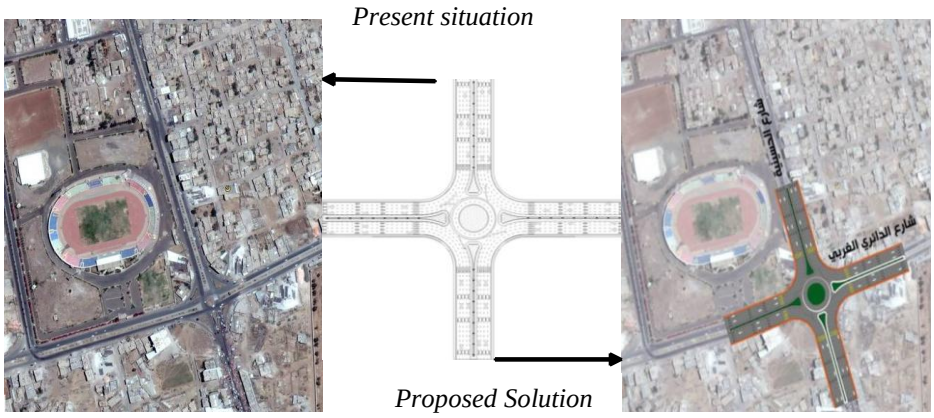


Figure 17. Proposed solutions to address the problem of Husseiniya intersection with Western Ring.

8. General Recommendations:

- Reviewing and reevaluating the city's master plan, so as to be updated and keep up with the pace of urban growth and to absorb all developments and changes, including traffic.

- Developing an integrated plan to address the traffic problem that takes into account the city and its regional environment in which all concerned parties (the General Authority for Land Surveying and Urban Planning, Ministry of Public Works and Roads, Local Authority, Traffic Department) will participate.
- Planning land use to make the hierarchy of the city's road network to allow the user to go back and forth from home, to the workplace, school or market easily and smoothly.
- Developing a diachronic plan for the partial unloading of the central area of the movement through the establishment and transformation of commercial, administrative and entertainment centers to the new urban expansion areas in the sides of the city and regulating traffic in the Old City through the development of a comprehensive traffic plan to solve the problem.
- Suspending the issuance of building permits contrary to the approved schemes and to ensure that the transfer of buildings located on the main streets to service centers (commercial, health, hotel, etc.) will not be possible in the future as they do not fit the technical requirements and do not have parking spaces according to standards.
- Reviewing and re-evaluating the use of traffic on the streets those are on the main axes to regulate the use at one-way or two-way routes.
- Finding alternative areas for passenger transport stations to and from Dhamar and planning them according to standards.
- Dividing One-Level quadrilateral intersections (at the shape of a cross) so that the collision points fall from 16 to 3 points only by turning each intersection into two intersections on the shape of T letter and providing them with traffic guidance and signals.
- Complete the work of paving and asphalting the eastern ring road to serve the eastern districts and neighborhoods of the city, and the transfer and distribution of the movement of Al-Jamarik tour (what is now known as Sawal Tour) to the province intersection (round) and vice versa to relieve the pressure on the downtown area and reduce the congestion in the traffic nodes on the main movement axes I and II.
- Obligating owners of real estate used as service facilities to provide parking spaces in accordance with the relevant standards.
- Finding alternative areas to transport qat markets located on or near the overcrowded areas and traffic nodes - such as Ans market, Al-Dairah market, Al-Furasi market and the traffic market to suitable areas that provide all the basic services and adequate parking.

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