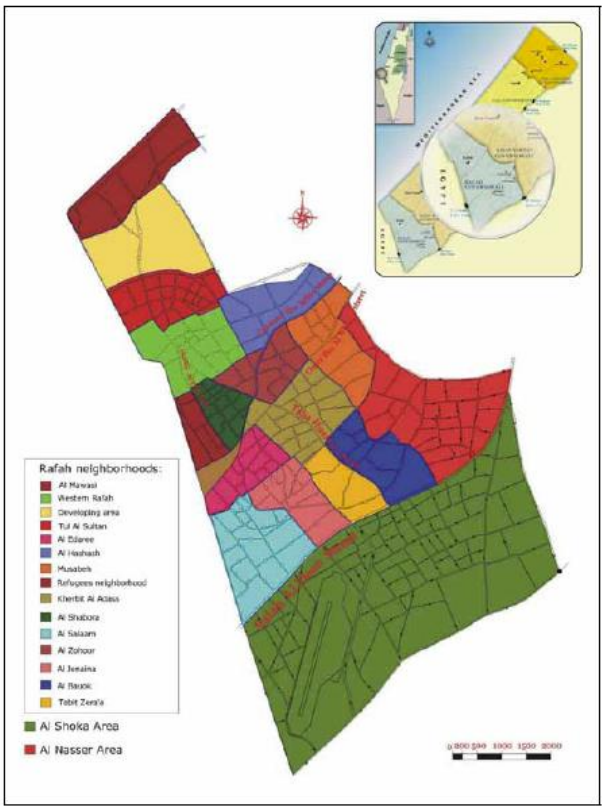
Development of Transportation Master Plan

Rafah Governorate, 2030



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1 Executive Summary

I. Introduction

In response to the Rafah Municipality request to conduct a strategic Plan for the traffic system in Rafah Governorate and to support projects that promote a long-term shift towards low emission and sustainable forms of transportation, the Global Environment Facility (GEF) contracted Natuf for Development (a Local Palestinian NGO) to conduct a traffic system management plan for Rafah Governorate. From GEF perspective, the project will support the measures that minimize climate change damage by reducing the risk, or the adverse effects, of climate change.

Rafah Transportation Master Plan 2030 (RTMP) aims to conduct and elaborate a consistent strategic plan for the traffic system and transportation facilities in Rafah Governorate. RTMP will try to enhance safety, ensure proper management of traffic network, solve the congestion and reduce delay in Rafah streets network up to year 2030.

This plan serves a variety of purposes. It is a framework document that serves as a comprehensive reference guide regarding transportation issues in Rafah Governorate. The plan identifies transportation issues that need to be solved under specific future development plans, provides a clear vision document that defines the long-term transportation system that Rafah needs in the future, and it also provides policy direction for how decisions regarding the implementation of the transportation system should be made. Accordingly, the plan incorporated the most recent demographic data and used the City's transportation demand model to test and evaluate the alternatives.

A proper methodology was used to develop the plan and several tools and techniques were utilized. The process of developing the RTMP-2030 includes four steps as listed below:

1. Data collection to review and assess the existing conditions. Several data collection techniques were used; traffic counts, questionnaires, photos, site visits, interviews, etc.
2. Data Analysis and Evaluation Phase depending on Modelling by using a dynamic traffic modelling software known as CONTRAM Software and expert opinion.

3. Planning phase, involving the identification of the criteria and standards of traffic planning, projecting future transportation demands using modeling software, formulating different planning options, evaluating the performance of the improvement plan, scheduling the proposed development projects and conducting cost estimation for the suggested projects.
4. Awareness plan targeting the local community was also prepared to ensure public acceptance and cooperation with the municipalities.

II. Planning Horizon

Depending on the analysis of collected data, current and future traffic demands, the nature of traffic problems and financial constraints, the proposed projects were classified into three phases. These are; (i) short term phase, that will be directly implemented after approving the proposed plan, (ii) intermediate term phase, that will be implemented within a period of 5 to 10 years period after approving the proposed plan and (iii) long term phase, which includes suggestions of major modifications and major reconstruction solutions that aim at providing long term objectives up to 2030.

III. Traffic Surveys

A comprehensive assessment of the prevailing traffic and road conditions in Rafah Governorate. The assessment was made through a series of surveys that were conducted during the months of February to April, 2007 and included:

a) Street network characteristics, which was identified by a review of secondary information resource, site visits, observations, photos, and about 200 questionnaires were distributed all over Rafah Governorate targeting all roads' users.
b) Traffic flow conditions, which was identified by traffic flow surveys (conducted on 25 selected stations in Rafah Governorate during different time intervals from 6 hrs to 24 hrs) and by spot speed surveys (conducted at 8 selected stations in the governorate).
c) Origin-Destination Survey to build, calibrate and validate the model .
d) Investigating the opinion of related stakeholders (Rafah community, pedestrians, drivers, Municipality of Rafah, Municipality of Al Nasser, Municipality of Al Shoka and the Ministry of Transportation) about the transportation network efficiency. This was identified by questionnaires, meetings and workshops.

IV. Traffic Analysis

Conducting the transportation management plan depends on identification of street network characteristics, network problems, public opinions and classified traffic movement counts. Several tools were used in the analysis phase included CONTRAM (Traffic Simulation Software), Excel Software, SPSS Software and experts opinions.

Tracking the traffic situation in Rafah Governorate lead to identify the City Center as the key problematic area in Rafah. In particular, Abu Bakre Street (the main street that connects the eastern and western side of the city), the main intersections with Abu Bakre Street and all related facilities, parking and markets are the major issues to be considered in the development process. The traffic problems in Rafah Governorate can be classified into:

- Traffic network problem such as traffic congestion in Abu Bakre Street.
- Unorganized parking spaces and taxi stations.
- The Central Market lies on the center of the city where it is considered as the main congestion point in Rafah.
- Absence of the power of law and enforcement.
- Lack of traffic control equipment and tools (signs, signals and safety measures).
- The lack of traffic awareness among road users.

V. Traffic Modeling and Forecasting

The dynamic traffic modelling software CONTRAM was used as a simulation software in this study. This model estimates trips, travel patterns, mode choices, and traffic volumes. This information is in turn used to estimate street congestion, air quality impacts, and other measures of transportation system performance. In order to perform modeling process it was necessary to predict the nature of trips in the next 25 years, and due to the instability of Palestine political and economical conditions, the population growth rate was chosen to be the reference of the projection process.

Two simulation peak hour periods were built, the morning peak (AM 6:00 – 9:00) and evening peak (PM 1:00 – 4:00). Both models were calibrated and validated to reproduce existing traffic conditions as observed in the various traffic surveys conducted during the base year (2007). The peak hour models were then applied in their forecast mode to estimate link volumes, turning movements, queue lengths

and delays across the simulation study area.

The output data that available for display in the link data boxes are total flow (veh), average flow (veh/hr), speed (km/hr), time (sec), queue (veh), delay (sec), capacity (pcu/hr), Rho (v/c) and blocking.

The results of the model effectively support the proposed development and management actions of the transportation system. Moreover, it clearly identified the future needs.

VI. Traffic Development Plan

After the evaluation of the existing conditions of traffic network performance in Rafah Governorate, the traffic improvement measures were articulated into specific plans that included:

- **Network Development:** In attempting to develop the transportation network several problems were discussed such as; congestion on Abu Bakre Street, entrances of Rafah Governorate, absence of ring roads in Rafah City, Al Shoka and Al Nasser Area streets network problems, and the structural and geometric problems in the network. The main proposed projects are converting part of Abu Bakre Street to one way street, activating Taha Husain street, activating Othman Ibn Affan northern entrance to Rafah City, paving other streets and rehabilitate damaged main roads in the Governorate.
- **Intersections Development:** lack of traffic control tools at road intersections is one of the most serious problems that was reported in this plan. Installation of specific control tools and measures at road intersections is suggested.
- **Markets Development:** RTMP studied the current situation of public markets and market booths and concluded that the existing conditions of the markets are not suitable either in location or concentration. Saturday Market problem is a main challenge for traffic on Saturdays in Rafah. Therefore Moving the Saturday market place gradually to Al Shuara market area and the activation of the governorate neglected markets is strongly suggested .
- **Taxi Stations Development:** the location of current taxi stations causes congestion at several locations particularly in the city center; therefore a taxi

station development plan is suggested in order to regulate Taxi services. The proposed actions include rearranging the existing taxi stations by removing some of them, relocating or expanding others, it is also proposed to improve facilities at some taxi stations and to make sure that traffic law and regulations are enforced.

- **Pedestrian facilities:** Encroachments on pedestrian sidewalks and school gates on Abu Bakre Street are the major problems in this regard. The main proposed actions to improve the pedestrian facilities include; removing encroachments of shops located on the main street, regulating and organizing peddlers and stalls, widening the sidewalks, moving school gates which are currently on Abu Bakre Street to minor streets if possible and converting some internal minor streets to be limited to pedestrians.
- **Parking :** The low number of available parking spaces in the Governorate causes a critical problem that lead to decreasing the efficiency of the network. A detailed parking development plan is suggested.
- **Regulation, control and enforcement**: Observations clearly indicated the lack of regulation and law enforcement in Rafah Governorate such as encroachment problem, lack of traffic control system, animal driven carts problem, etc. Several measures were suggested in order to activate the traffic policing on the road network. The proposed actions include reviewing the current enforcement practices and recommending the appropriate enforcement tactics, considering traffic fines and other methods that guarantee the promotion of police efficiency and regulations commitment.
- **Environmental Protection Measures**: The suggested measures included both o awareness and physical measures that ensures the improvement of environment in the Governorate. The main proposed actions include disseminating of the best practices regarding transportation modes and awareness on its related environmental issues, Planting trees, protecting residents from exposure to adverse traffic noise impacts and applying best practices to avoid and mitigate impacts on the environment.
- **Safety Measures:** Rafah Governorate is advised to give high priority to public safety through some suggested measures that will increase safety on its roads. The main proposed action includes hiring additional uniformed traffic law

enforcement officers, installing and maintaining road signs, signals, handrails and humps, enhancing the public awareness about traffic law enforcement officers rules, raising public awareness towards safety through internal outreach programs and presentations to schools and community groups, enhancing incidents reporting, and standardize related procedures with other traffic agencies and proper planning and safety audit.

Every suggested solution was evaluated by using simulation (CONTRAM Software) and questionnaires distributed to a sample of 720 individuals. CONTRAM results and public opinions supported strongly the proposed development actions.

VII. Economical Evaluation

The expected budget of each action proposed to improve the traffic conditions in Rafah Governorate was estimated. The entire estimated budget is about ($11,454,035) divided on three phases, short term about ($3,530,950), intermediate term about ($2,649,575) and long term about ($5,273,510).

VIII. Air Pollution Analysis

A number of 140 gasoline-fueled vehicles were tested by the Community College of Applied Science & Technology (CCAST) laboratories for 4 gases in exhaust emissions. These gases were carbon monoxide, carbon dioxide, hydrocarbons, and oxygen the air to fuel ratio was measured also. The distribution of the vehicles was made to represent all models and car ages working in Gaza Strip. The collected samples has been critically reviewed and analyzed to examine the quality of data where it showed consistency, reproducibility, and high precession.

When air quality is the concern, it is worth pointing out that most of tested cars exceeds carbon monoxide and hydrocarbons permissible emission limits. On the other hand, carbon dioxide emissions in the average are acceptable when compared with the emission limits. This situation emphasizes on the need for immediate interventions to bring innovative solutions of automobile emissions problem. The interventions might include; enforcing emission limits and regulations, maintenance plans of major highways, master planning of highway networks, etc.

The proposed traffic master plan has been evaluated using emission field data to examine its impact on the source emission rate of the road network of Rafah governorate. Results shows that the implementation of such plan will reduce the

rate of gases emission from the vehicles during peak hours by 10% in the 2007 to more than 50% by the end of the year 2030. These emission reductions are reflected positively on both the local environment when carbon monoxide and hydrocarbons are considered and the global environment when carbon dioxide emissions are considered.

IX. Awareness and Public Participation

The last phase of the project was increasing the traffic awareness of the local community. This Study dealt with this issue by suggesting awareness campaigns targeting most community sectors in Rafah Governorate. It included leaflets, public meetings, brochures, marketing slogans and awareness Posters.

X. Impacts

The implementation of Rafah Transportation master plan (RTMP) is expected to achieve benefits in different areas including natural environment (air quality, water quality, noise, and aesthetic values), transportation services by utilizing the existing road network at the best way, community life style that it will make Rafah community more liveable, public health , safety and funding issues

2 Introduction

2.1 The Transportation Master Plan

Throughout the world, the transportation sector is the fastest growing source of greenhouse gas emissions. In contrast with trends in other air emissions, greenhouse gas emissions from transportation continue to rise, in large part because travel growth has outpaced improvements in vehicle energy efficiency. So it is important to support projects that promote a long-term shift towards low emission and sustainable forms of transportation.

Responding to these principles, The municipality of Rafah proposed the preparation of Transportation Master Plan (RTMP) in accordance with the Municipality transit needs and plans. Rafah Transportation Master Plan (RTMP) outlines the City's strategic directions for the development of its transportation networks, programs and priorities. The RTMP is a critical policy document that is expected to influence trips made by residents and visitors to Rafah over the next 25 years. The plan also creates a comprehensive concept around which agencies responsible for traffic development can coordinate their individual efforts.

The RTMP is prepared by Natuf For Development (a Palestinian Non-Governmental Organization) and funded by the Global Environment Facility (GEF) - Small Grants Program (SGP) which is managed by United Nations Development Program (UNDP). several stakeholders were cooperated to ensure successful development and implementation of the RTMP. The key stakeholders were Natuf organization, Rafah Municipality, Al Shoka Municipality, Al Nasr Municipality and the local community.

2.2 Study Area

Rafah Governorate is located in the southern part of Gaza Strip (Figure 1), overlooking the Mediterranean, it is the main link between Palestine and Egypt. The total area of Rafah Governorate covered by the Master Plan of 1999 is approximately 26,000 dunums. It embodies seven localities as follows: Al-Mwasi (Rafah), Al-Qarya El-Suwaydiya, Tall Al-Sultan Camp, Rafah, Rafah Camp, Al-Bayuk and Shokat Al-Sufi. The total population of Rafah Governorate is 177,632 inhabitants (PCBS, Projected mid year population 2007), 60% of whom are refugees

living in refugee camps. Average household size is estimated to be 8.6 persons per household, and annual population growth rate is estimated to be 4.32%.

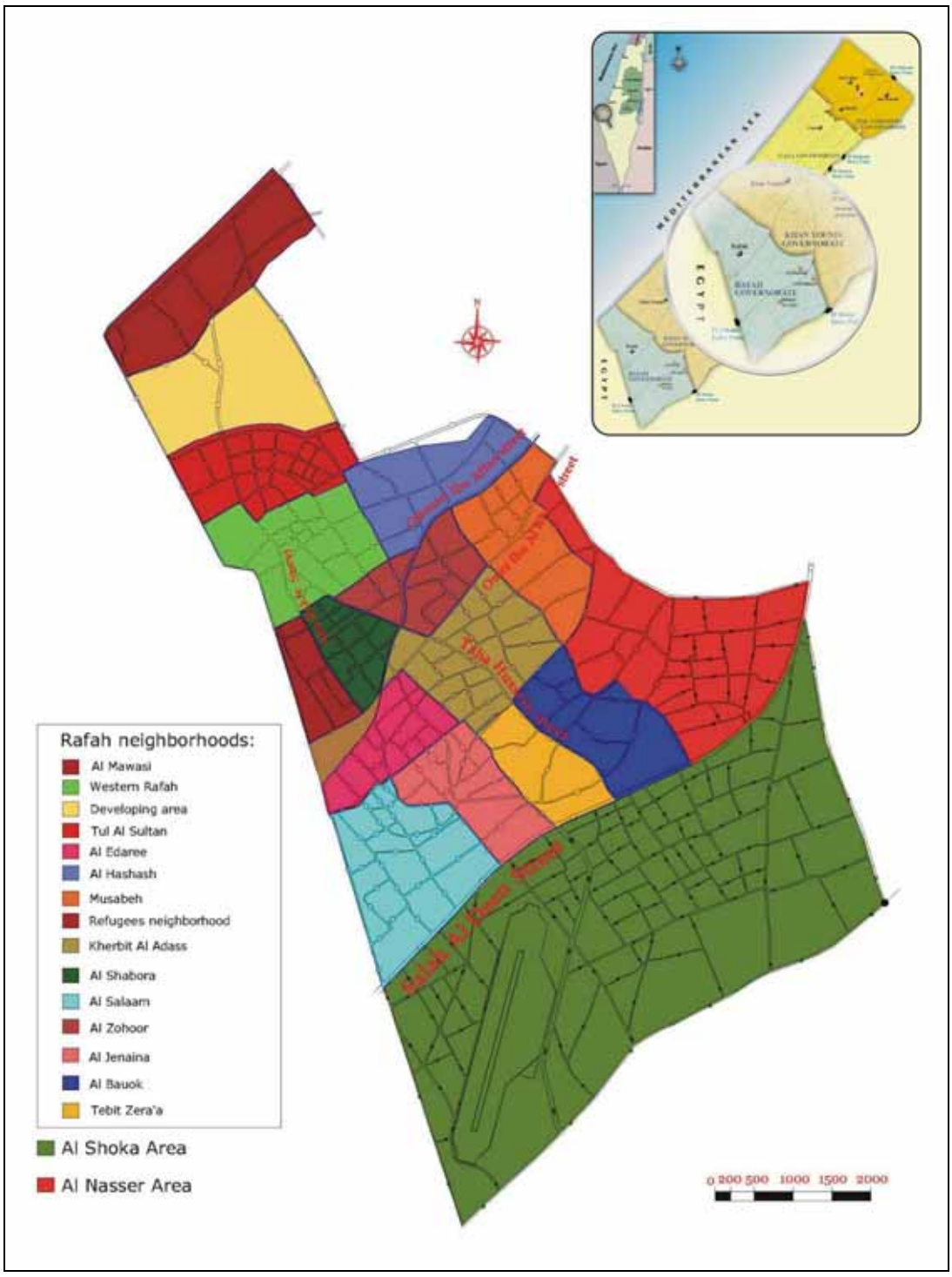


Figure (1) : Rafah Governorate

2.3 The Problem Statement

The traffic problem in Rafah Governorate is clearly visible in some areas and mainly in the city center. This problem increased substantially because of the continuous rise in population and in the number of vehicles. What makes the problem worse is the non existence of a transportation master plan or clear strategic direction for traffic management. The municipality lacks the guiding towards transportation development. Furthermore, there isn't a reliable numbering scheme for the roads in the municipality, which makes tracking the required investments and maintenance of roads difficult.

The traffic problems in Rafah are mainly detected at the city center of Rafah, principally on Abu Bakre Street , where the main popular market is found. The existence of the main market, onsite shops, medical clinic, parking and other multi-activities in the same area in addition to the high density of population in the vicinity contributed all to traffic congestion and formed bottleneck in the specified area particularly during the morning hours.

In addition to the main problem, the following are other contributing problems that affect traffic system in Rafah Governorate:

- Rafah lacks traffic control instruments.
- There is no obedience by citizens and drivers to the regulations that are imposed by the Municipality.
- Animal driven carts represent a very serious problem that causes congestion in general.
- There is a problem in Rafah storm water drainage system.
- There is a general problem in some customs of Rafah community that affects negatively the traffic system.

The following figures clarify some of the problem aspects:


Figure (2) : Transportation Problems Aspects in Rafah Governorate

2.4 Purpose of Rafah Transportation Master Plan (RTMP)

Rafah Transportation Master Plan 2030 (RTMP) aims to achieve the highest level of future transit usage that can reasonably be achieved and to protect the local community from unacceptable levels of transportation-related noise, pollution, delay and danger that are most likely to arise. Moreover, the RTMP aims to conduct and elaborate a consistent strategic Plan for the traffic system and transportation facilities in Rafah Governorate to enhance safety, properly manage traffic network, solve the congestion and reduce delay in Rafah streets network up to year 2030. More specifically, the RTMP was developed in order to:

- Coordinate the use of streets and providing high capacity routes to provide greater, and more convenient accessibility to all parts of the city and to the adjacent areas.
- Set projects and programs that provide better transportation services within the context of the broader community goals to protect the natural environment and enhance quality of life.
- Provide a sound structural framework for future growth and development.
- Establish right-of-way, pavement, recommended alignment, intersection standards based on forecasted future traffic volumes and economic development.

3 Methodology of the Transportation Master Plan Development

In order to achieve the RTMP aim, several tools and techniques were utilized. Figure (3) shows the main tools, techniques and steps of master plan development:

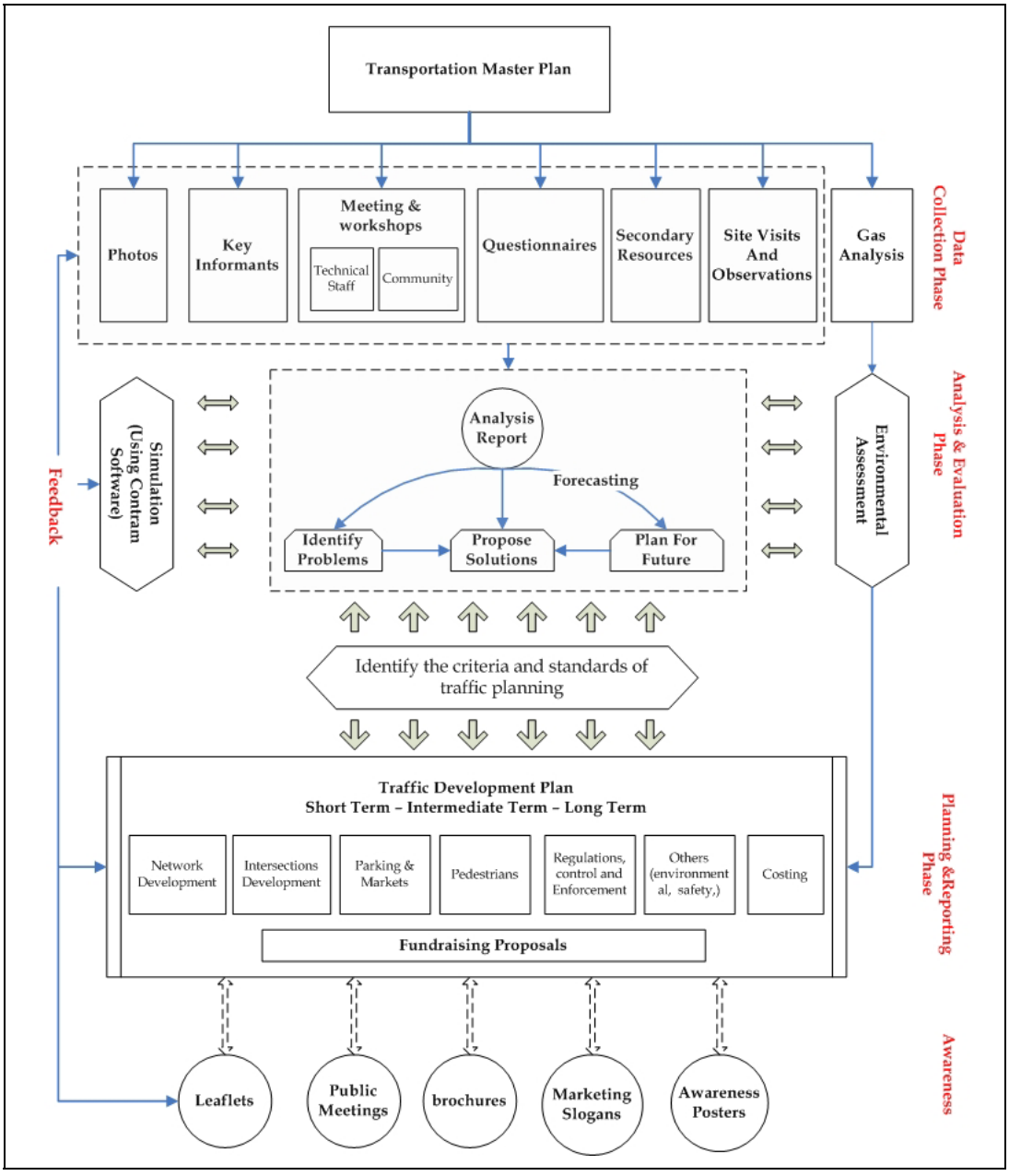


Figure (3) : Rafah Transportation Master Plan Methodology

The following sections detail the methodology of RTMP development :

3.1 Data Collection Phase

The development of the Rafah Transportation Master Plan - 2030 (RTMP) began with reviewing the existing conditions. In order to achieve this purpose a series of surveys were conducted:

e) Street network characteristics, which was identified through:
   1. Review of secondary information resource.
   2. Site visits, observation and photos.
   3. Questionnaires.

f) Traffic flow conditions, Which was identified through:
   1. Traffic flow survey: conducted on 25 stations covered the governorate, during different time intervals from 6 hrs to 24 hrs.
   2. Spot Speed survey: conducted on 8 stations distributed over the governorate.

g) Origin-Destination Survey to build, calibrate and validate the model.

h) The opinion of stakeholders (Rafah community, Pedestrians, Drivers, Municipality of Rafah, Municipality of Al Nasser, Municipality of Al Shoka and Ministry of Transportation) about the transportation network efficiency. Which was identified through questionnaires, meetings and workshops.

i) Environmental Analysis to assess the effects of traffic on the generation of pollutants.

3.2 Data Analysis and Evaluation Phase

The following are tools used to conduct the evaluation as:

a) **Analysis of Collected Data:** In order to summarize the collected data and extracts results, data analysis was conducted by using Excel and SPSS Software, And the document summarizing the analysis was prepared.

b) **Modelling :** By using a dynamic traffic modelling software known as CONTRAM Software. CONTRAM is designed to model the varying traffic demand and congestion that occurs during the day and will represent the peaks of congestion as well as off-peak conditions within a single model. These features are combined with a high quality graphical interface.

c) **Expert opinion :** the project staff includes specialist in traffic management , planning and environmental assessment.

The outputs summarized the analysis results of the collected data, and the results of the simulation process .They also evaluate the existing conditions by considering the analysis results and the transportation standards.

3.3 Planning Phase

In order to develop the plan the following activities were conducted:

a) Identify the criteria and standards of traffic planning that will be considered as references and Guidelines in this Plan.
b) Projecting future transportation demands using CONTRAM (Modeling software) that the plan is intended to serve, to express what that future transportation system might look like, and how it might benefit Rafah residents in twenty years.
c) Formulating different planning options and scenarios for an environmental-sound traffic system including detailed implementation plan for the scenario based on environmental and economic evaluation criteria.
d) Development of improvement Project list as Short term, intermediate term and Long term actions.
e) Evaluating the performance of the improvement plan by using of the simulation model and consideration of the identified design criteria.
f) Developing the implementation Plan to include:
    - Construction Costs
    - Prioritization of Improvements (rank projects by there Urgency and required funds)
    - Suggested responsible Agencies/Funding Sources

3.4 Awareness Components and Tools

The development of any traffic system will not be very beneficial as long as the traffic system is efficient while its users don't have the basic awareness of how to use it appropriately, especially that the human error is considered as the contributing factor in over 90% accidents as suggested by the latest traffic studies. So it is necessary to take in consideration the issue of traffic awareness of the local community. This Study dealt with this issue by suggesting awareness campaigns targeting all community sectors in Rafah Governorate and including:

- Leaflets.
- Public Meetings.
- Brochures.
- Marketing Slogans.
- Awareness Posters.

3.5 Structure of the Transportation Master Plan Report

According to the methodology and in order to produce a comprehensive report of the RTMP, the following is the proposed structure of the master plan report:

- **Part (A) :** Includes chapter (1) and chapter (2) that present an introduction and background about the study and the followed methodology to perform this study.
- **Part (B) :** Includes chapter (3) that presents the Transportation Master Plan Guiding Principles which includes the design criteria for the transportation master plan, the phases of implementation the suggested alternatives and the modeling process concept.
- **Part (C) :** Includes chapter (5) and chapter (6) that present the preparative phase that comes before the Planning process which includes data collection, data analysis and traffic modeling and forecasting.
- **Part (D) :** Includes chapter (7) that presents the planning process, and the serious transportation problems that the transportation in Rafah Governorate it also presents the suggested alternative solutions.
- **Part (E) :** Includes chapter (8) that presents the Economical evaluation for the suggested alternatives.
- **Part (F) :** Includes chapter (9) that presents the analysis of air pollutants generated from transportation sector , and the effect of the proposed master plan on the pollutants emission.
- **Part (G) :** Includes chapter (10) that presents the awareness and social activities required to support this study .
- **Part (H) :** Includes chapter (11) and chapter (12) that present the conclusions and recommendations.
- **Part (I) :** Includes annexes that contains all supportive data.

4 Transportation Master Plan Guiding Principles

The guiding principles of the RTMP are the design criteria, phases of development as well as the computer modeling assumptions and processes of analysis. The following sections elaborate the guiding principles of the RTMP.

4.1 Design Criteria

This section involves those elements and dimensions that have a direct effect on driver behaviour and traffic performance. The various design controls, criteria, and elements presented in this section shall be used to design roadway to accommodate the expected traffic volume and provide consistency in traffic operations.

4.1.1 Roadway Sections

The following parameters should be considered when designing roadway sections:

- **Lane Width**
  Driving lane widths are generally found to be in the range of (3.3 m -3.6m) Lane widths on a roadway section should not be less than 3.0 meters on local streets and 3.5 meters on major arterials. For distributor or collector streets, the lane width could be any value between the above mentioned lane widths. In any case, the lane width should not exceed 3.6 meters. However, The near side lane width is normally increased in order to accommodate for loading, bicycles, buses and pedestrians.

- **Sidewalks**
  The minimum widths of sidewalks should be 2.0 meters on local and distributor/collector streets, and 3.0 meters on major arterials. On narrow streets where the right of way width is limited and widening of the street is constrained by buildings or any other obstacles, a 1.0 meter of sidewalk should be provided. In any case all streets in urban areas should have sidewalks for safety considerations for pedestrians. Sidewalks can reach any width in areas where the flow of pedestrians is high. The recommended practice is to provide 1.0 meter of sidewalk width per 30 pedestrians/minute in total two-way directions.

- **Median Islands**
  Main arterials and some distributor/collector streets in urban areas are usually separated by raised islands in the center of the street. The purpose of this type of islands is to provide physical separation between the two directions of the street, in order to prevent drivers from attempting to drive on the opposite direction, to provide areas for utility poles (usually street light poles), to provide areas for installing traffic signs, and to provide refuge area for pedestrians when crossing a wide street. The minimum width for these islands is 1.20 meters. The width of medians will vary based on right-of-way limitations, future roadway expansion, and other such factors.

- **Median Openings**
  Each median opening should be evaluated based on roadway flow and capacity. Median openings need to be at least 180 m (600 feet) apart (nose to nose).

- **Pedestrian Crossings**
  Where a pedestrian study shows there is a considerable number of pedestrians cross a street section at a point, a zebra type pedestrian crossing should be considered in the roadway design. The minimum width of zebra pedestrian crossings is 3.0 meters. When the section of the street includes a median, the curbstone at the location of the pedestrian crossing should be low to allow for easy crossing of wheel chairs. The same measure should be taken for the sidewalk's curbstone. If the pedestrians crossing the two directions of the street at one time cause hazards and delay for vehicular movement, the crossing may be designed in a staggered way and allow pedestrians to cross in two stages.

- **On-Street Parking**
  Roadway design for streets in commercial areas should consider curb parking on the right side of the roadway section. The space available for curb parking is usually designed for longitudinal parking spaces. In this case the width of each parking space should be at least 2.5 meters. The length of each parking space should be at least 6.0 meters.. If the right of way of the roadway is relatively wide, an inclined parking spaces may be considered. The width of each parking space for inclined parking should be at least 2.8 meters and the length should be at least 5.2 meters.

- **Speed Reduction Devices**

  Sometimes, a street layout design encourages drivers to drive on a higher speed than it is intended for certain locations of a street section, especially where a school or playground is located, on which children cross the street frequently. In this case it is advisable to consider the installation of a speed reduction device. The most common used device for this purpose is the speed humps. When designing speed humps, the design consideration should be taken in a way not to cause any damage to vehicles. When installing speed hump, The proper traffic signs should be erected to warn drivers that they are approaching a speed hump in order to reduce their speed gradually before they reach the hump. Other traffic devices might be utilized for reducing speed.

- **Stopping Sight Distance**

  Stopping sight distance should be adequate at every point along a roadway for drivers to a safe stop before reaching the object:

Table (1): Stopping Sight Distance Relative to Vehicles Speed

Speed (kph)	Sight Distance (m)
30	38
40	45
50	60
60	90
70	115
80	130

- **Right-of-Way (R.O.W.)**

  Right-of-way width is generally determined by the pavement section required to perform the function and carry the traffic for which the street is designed to accommodate.

- **Design Speed**

  The design speed is the maximum safe speed maintainable over a specified section of street. It is a design standard based on geometric design elements, terrain, land use to be served, roadway type, anticipated traffic volumes and economic factors. Design speed does not reflect what speed should be used for a particular roadway type.

- **Vertical Grades**
  Maximum grades are determined by the effect of grades on truck speeds, design, functional classification of the roadway and general terrain of the area. Driving performance of vehicles with respect to grades varies greatly. Most cars are equipped with sufficient power to ascend grades up to 7 and 8 percent without noticeable reduction in speed. Trucks are more affected by grades and the maximum grades are established to address this concern.

- **Horizontal Curvature**
  Horizontal curvature of roadways requires the use of circular curves to form smooth transitions from one straight roadway section to another. Criteria for determining the maximum allowable limits of horizontal curves are based on the laws of mechanics and consider factors such as the practical limitations of super elevation and friction factors representative of pavement surfaces.

- **Vertical Clearance**
  Criteria of the State Department of Highways and Public Transportation require a minimum of 5.5m (16.5 feet) of vertical clearance. Consideration should be given to future roadway resurfacing which would decrease the clearance provided.

4.1.2 Intersections

When designing intersections, the following parameters should be considered:

- **Corner Radii**
  Curves at intersections should be designed in a way to accommodate the size of vehicles that use the intersection to make the right turn maneuver easily. For commercial areas, the curb radius should be at least 10.5 meters to accommodate commercial vehicles, while on residential streets, the minimum curb radius should be 6.0 meters.

- **Channelization**
  On intersections where the right of way provides a wide intersection areas, it is preferred to consider islands that may take different shapes. The main purposes of these islands are:
  - to separate conflicting traffic stream,
  - to guide drivers in taking the correct path,

- to reduce vehicle speed,
- to reduce excessive carriageway areas; and
- to assist pedestrians to use the islands as refuge areas.

Since these islands are raised islands, it is important to have street lighting and proper traffic signs at channelized intersections to improve visibility and reduce the possibility of confusion to motorists.

4.1.3 Off-Street Parking Areas (Taxi stations)

Preferably, Taxi stations should be rectangular with cars parked on both sides of aisles. They should be wide enough to provide two or more rows. The minimum width for Taxi stations should be 20.0 meters. Parking layouts may be designed in deferent ways concerning traffic circulation in the lot, and parking stalls angle. Parking stalls may be right angles (90 degrees) or angles parking (from 45 to 75 degrees). Aisles between parking spaces can be either one-way or two-way aisles.

4.1.4 The Level of Service (LOS)

Is a qualitative measure of traffic congestion that represents the collective factors of speed, travel time, traffic interruptions, freedom to maneuver, safety, driver comfort and convenience, and operating costs provided by a street under a specific traffic volume condition.

LOS designations typically go from A (best) to F (worst) At signalized intersections, LOS is an indication of delay, generally outlined in the Highway Capacity Manual as:

A ≤ 10 sec, B =10-20sec , c =20-35 sec, D=35-55 sec, E=55-80 sec, F> 80 sec.

Six Level of Service concepts are described below. Level of Service will be chosen to be acceptable to drivers and to be reached in the design and operation of the facility.

1) **Level of Service A:** The highest quality of service a particular thoroughfare can provide. It is a condition of free flow in which there is little or no restrictions on speed or maneuverability caused by the presence of other vehicles.

2) **Level of service B:** Even though this level is a zone of stable flow, operating speeds begin to be restricted by other traffic. Restriction on maneuvering is still negligible.

3) **Level of Service C:** This Level of Service still provides stable traffic flows, but at this volume and density level, most drivers are becoming restricted in their freedom to select speed, change lanes, or perform passing maneuvers.

4) **Level of Service D:** Unstable flow of traffic is approached at this level. Tolerable average operating speeds are maintained, yet are subject to considerable and sudden variation. Freedom to maneuver and drive in comfort is low. Most drivers consider this service level unsatisfactory.

5) **Level of Service E:** Traffic operations at this level are unstable, speeds and flow rates fluctuate, and there is little independence of speed selection of maneuvering. Driver comfort is low and accident potential is high.

6) **Level of Service F:** This level of service describes forced flow conditions. Speed and flow rates are very low, and may, for short time periods drop to zero.

4.1.5 Warrants for the use of traffic signals

A decision on the installation of traffic signals may be made on the basis of:

- Traffic flow
- Pedestrian safety
- Accident experience
- And the elimination of traffic conflict.

The Manual on Uniform Traffic Control Devices (MUTCD) lists several sets of conditions that warrant the installation of a traffic signal:

1. Traffic volume on intersecting streets exceeds values specified in the MUTCD.
2. The traffic volume on the major street is so heavy that traffic on the minor intersecting street suffers excessive delay or hazard in entering or crossing the major street.
3. Vehicular volumes on a major street and pedestrian volumes crossing that street exceed specified levels.

4. Inadequate gaps
5. Peak hour
6. School crossing
7. Coordinated signal system
8. Crash experience

4.2 Planning Horizon

Depending on the analysis of collected data, current and future traffic demands, the nature of traffic problems and time and financial constraints the proposed scenarios will be classified into three phases:

- **Short Term (< 5 Years) to year 2012**
  This phase includes activities that will be directly implemented after approving the proposed plan. The alternatives will be suggested in this phase will provide immediate solutions to the most congested areas and hot spots that do not require major modifications and/or major reconstruction particularly in the city center.

- **Intermediate (5 to 10 Years) to year 2022**
  This phase includes activities that will be implemented within a period of 5 to 10 years period after approving of the proposed plan.

- **Long Term (10 to 25 Years) to year 2030**
  The plan in this phase will suggest major modifications and major reconstruction solutions that aim at providing long term objectives.

4.3 Transportation Modeling

Transportation modeling is used to develop information that support decision makers and planners in the future development and management of transportation systems, Particularly in urban areas. Modeling is a vital part of the overall transportation planning process which involves a forecast of travel patterns into the future and an attempt to develop a future transportation system that will work effectively in the future. Transportation has significant effects on land use, mobility, economic development, environmental quality, government finance and the quality of life. Sound planning is needed to create high quality transportation services at

cost-effective with limited environmental impacts. Failure to plan can lead to severe traffic congestions, dangerous travel patterns, undesirable land use patterns, adverse environmental impact and wasteful use of money and resources. Significant transportation projects require a long lead time for their design and construction.

Transportation planning uses the term 'models' extensively. This term is used to refer to a series of mathematical equations that are used to represent how choices are made when people travel. Travel demand occurs as a result of thousands of individual travelers making individual decisions on how, where and when to travel. The mathematical modeling is done using computer programming. Some of the modeling software are VISSUM, AIMSUN, SATURN, Paramics, Dynasim, TSIS, TransModeler, and CONTRAM . CONTRAM software was used because its website offers a free version which is limited to a road network with maximum of 25 zones that is enough for Rafah Project.

5 Traffic Surveys

In order to evaluate the current situation and built, calibrate and validate the model, a series of traffic surveys were conducted in order to collect the necessary data. Several surveying techniques were utilized. These surveys were conducted during the months of February to April, 2007 and included the investigation of the following:

- Street network characteristics and problems
- Origin-Destination Survey (Roadside interview survey)
- Traffic flow survey :
  a) Manual Classified Counts and Turning Movement Surveys
  b) Spot Speed survey

The following sections detail these surveys.

5.1 Investigation of Network Characteristics and Problems

To review the existed network characteristics and problems, three strategies were utilized:

1. Review of secondary information resource which includes previous related studies, municipality report about the current situation assessment and expert opinions.
2. Site visits, observation and photos.
3. Questionnaires distributed over the governorate on a random sample involved about 100 of drivers and 93 of pedestrians.

These questionnaires were prepared by transportation experts in order to reflect the public views about the network status, hot spots, problem roots, development priorities and the possible alternatives of development. The distribution process was conducted by a team of qualified engineers along 15 days from 1/3/2007 to 15/3/2007. The questionnaires were distributed in the following different locations:

1. Moraj Intersection
2. Al Najma Intersection
3. Al Matafi intersection
4. Al Mashroo'o Intersection
5. Al Jawazat intersection
6. The eastern Barking lot
7. Al Awda Intersection
8. Palestine Bank intersection
9. Awed Tower Intersection
10. Kherbat Al Adas Intersection
11. Al Quds Street
12. Zo'rob Intersection
13. Keer Intersection
14. Yebna

The following figure clarifies the questionnaire distribution locations.

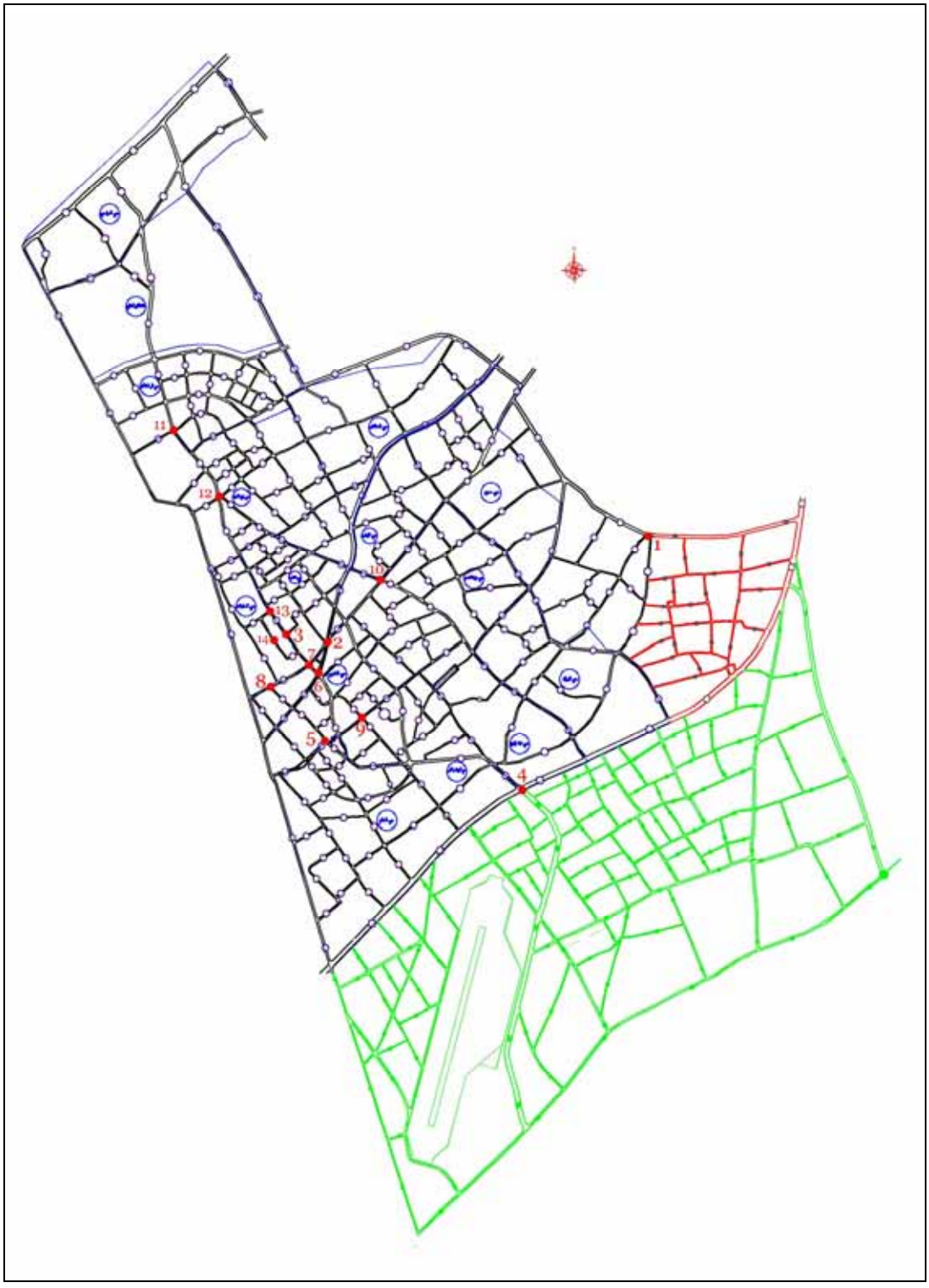


Figure (4) : Questionnaires Distribution Locations

5.2 Origin Destination Survey (Road Side Interview –RSI-)

Origin-Destination survey (OD) aims to determine the pattern of trips between the zones which is necessary for modeling process.

Roadside interviews were conducted on 12 stations as shown in Figure (5) with a sample of travelers during their trips (One of every 10 vehicles passing through, was selected as a random sample to conduct the RSI) in a single direction for 6 hrs a day from 6 to 9 AM and from 1 to 4 PM for two days from 2/4/2007 to 3/4/2007.

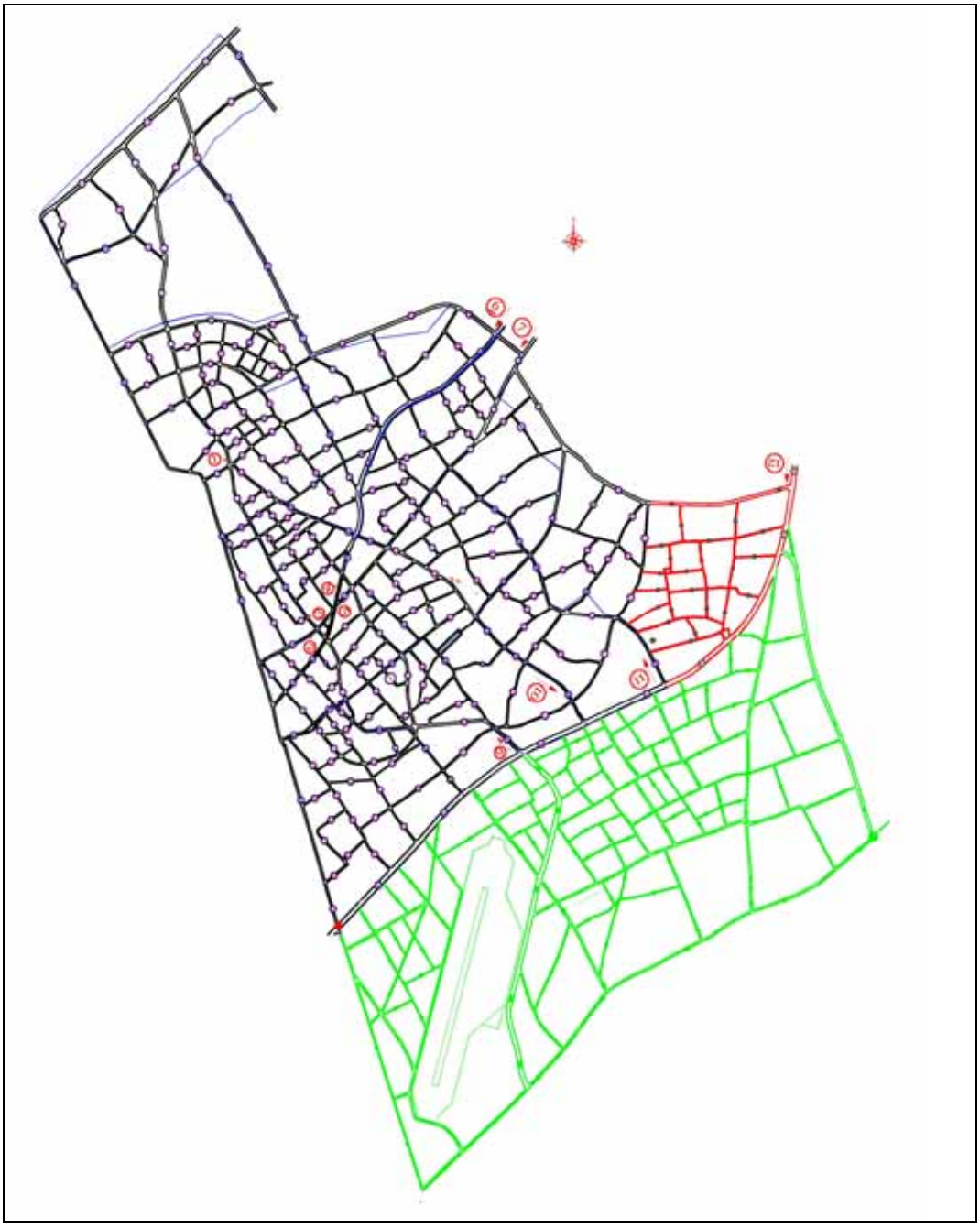


Figure (5) : Road Side Interview Stations

Each selected vehicles were stopped to answer three questions:

1- The location where it was come from (Origin).
2- The location where it will go to (Destination).
3- The route was utilized in the trip (route)

The Origin-Destination Survey Form is attached in annex (1). One sheet was used every 15 minutes. The following figures illustrate the team during the survey process:

Figure (6) : Road Side Interview Process

5.3 Traffic Flow survey

The Manual classified Counts (MCCs) were carried out in order to :

- Determine the average daily traffic, Turning movement, Traffic composition, and the Peak Hour at the major intersections in Rafah governorate.
- Assist in the model calibration process by adjusting the trip matrix.

The counts covered 25 intersections over the governorate (as shown in figure 7) which counted for different intervals that ranges (from 6 hrs to 24 hrs).

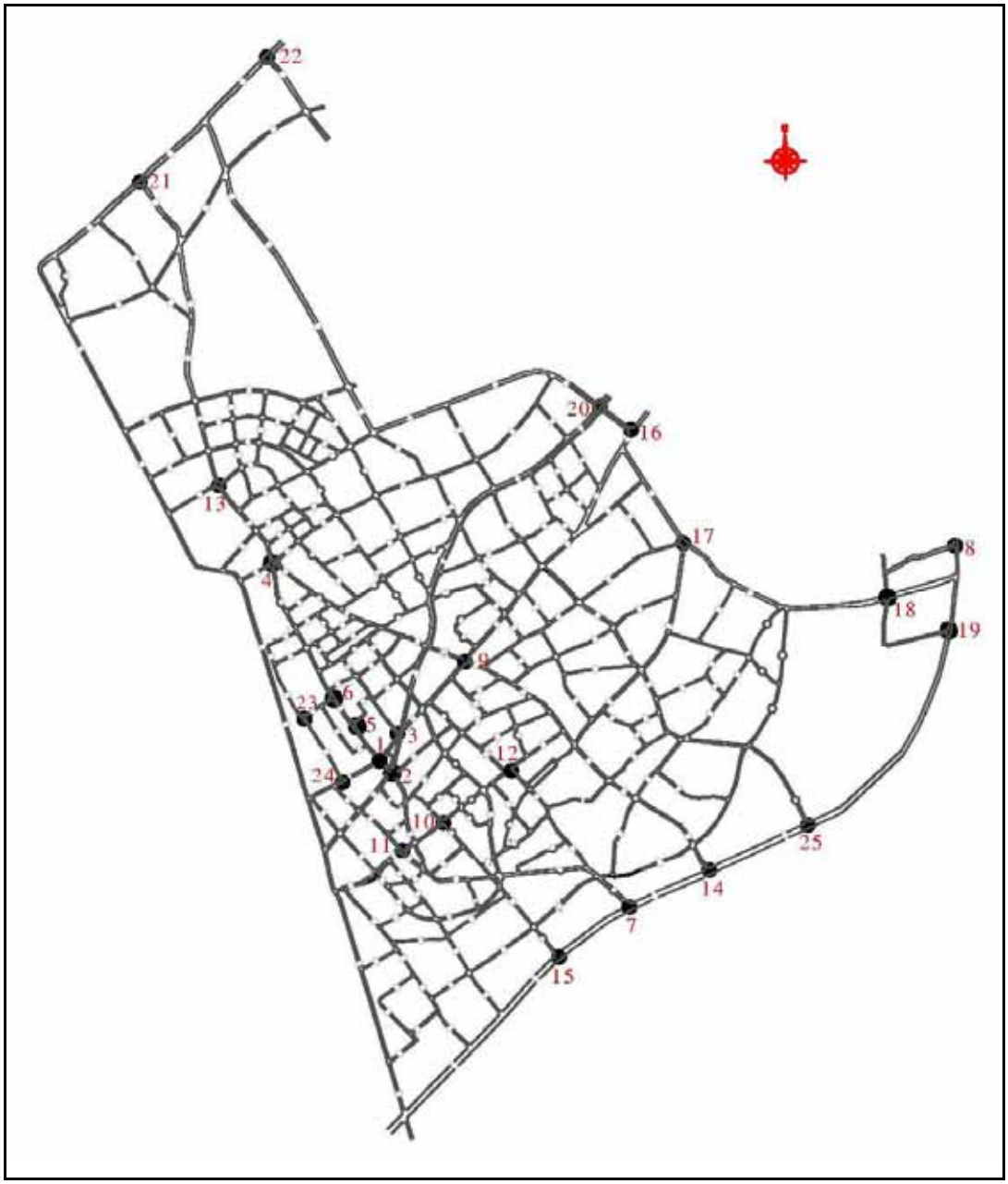


Figure (7) : Manual Classified Counts Stations

A team of 13 trained engineers carried out the counting process along 25 days from 17/2/2007 to 12/3/2007. The form which used in the counting process includes:

1- Counting period information.
2- The intersection layout.
3- Direction of flow.
4- Vehicles types were classified as follows:
   - Car: Including all types of passenger cars, jeeps and small buses with singular rear axis in addition to small pick ups.
   - Bus: Including all passenger buses of all types, form small buses with dual rear axis and even large size buses (50 Passengers).
   - Truck: Including all truck types
   - Bicycle
   - Motorcycle
   - Cart: Including carts driven by animals or peddlers.
   - Tractor : Including all tractor types.

U-Turns were considered during the count process. (Annex 2 shows the MCCs form).

5.4 Spot Speed Surveys

Spot speed is the instantaneous speed of a vehicle at a specified locations. It is used to determine the desired speed by motorists and it is hence useful for geometric design purposes on improved or new facilities.

Spot Speed Surveys were conducted at (8) stations selected far away intersections as shown in figure (9) with a sample selected at random (One of every 10 vehicles passing through) in a single direction along one day (4/4/2007). At each station 100 vehicles were observed.

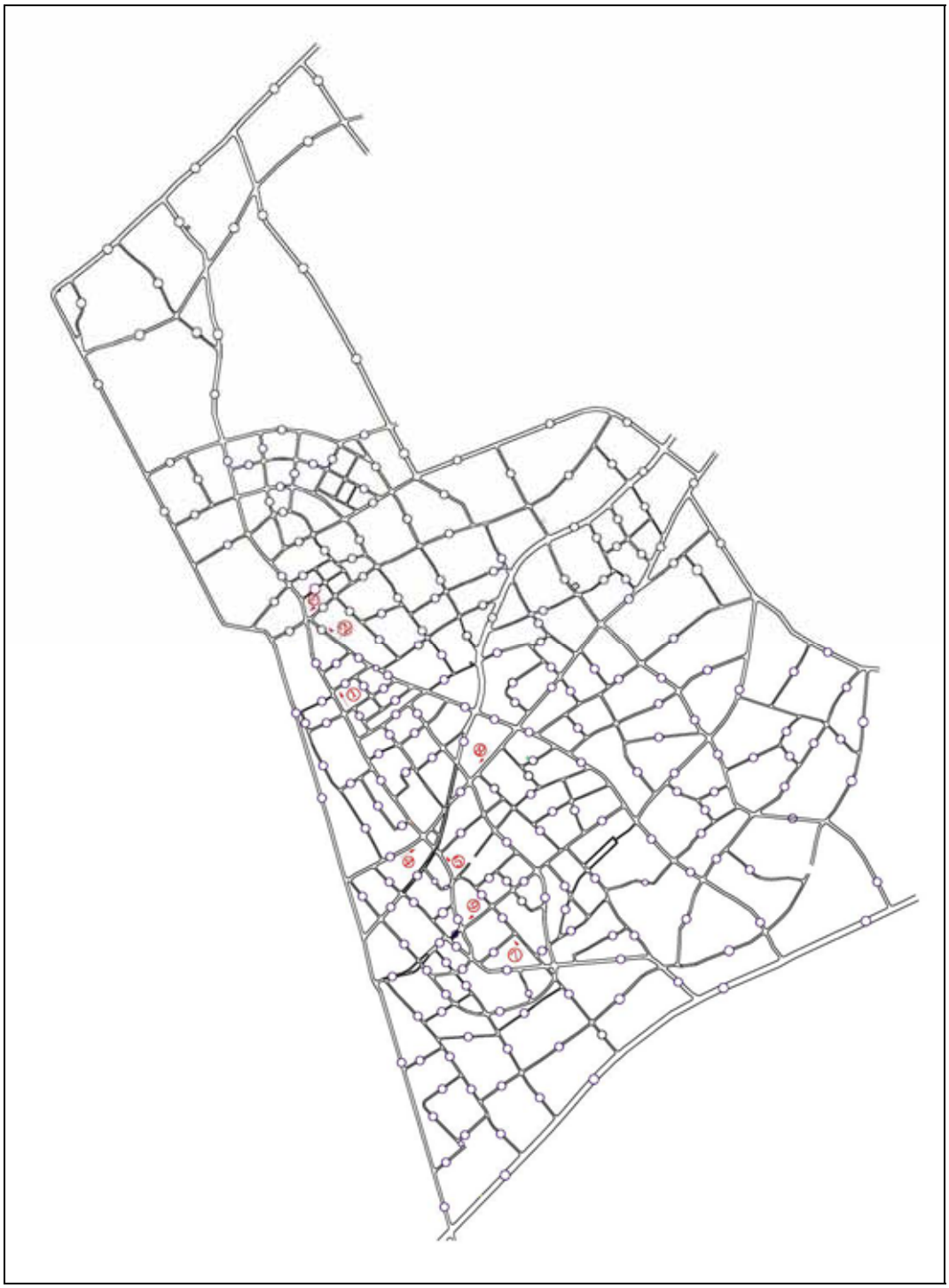


Figure (8) : Spot Speed Measurements Stations

The mechanism summarized as observing the time required by a vehicle to cover a short distance (40-50) m of the roadway. With taking into consideration that the observer and equipment should not be clearly visible to the drivers. The following figures illustrate the mechanism of spot speed measurement:

Figure (9) : Spot Speed Measurement process

Annex (3) shows the spot speed measurement form .

6 Traffic Analysis

In order to summarize the results of the collected data and simplify its application in the evaluation and modeling processes, the analysis has been carried considering the following surveys:

- Street network characteristics and problems survey.
- Traffic flow survey.
- Spot Speed Survey.
- Origin Destination Survey.

6.1 Network Characteristics and Problems

6.1.1 Network Characteristics

Rafah Governorate completely depends on road network as the only way of transportation it has. This makes the identification and evaluation of the current situation of the road network is very essential. As detailed in (Annex 4), the following are the main characteristics of the roads network in Rafah Governorate:

1. Rafah City has a total number of roads of 105 streets, with a proposed length of 160.58 km and an area of 3.54 km^2 , Only about %44 are paved . These roads were divided upon the pavement status as %44 are good, %33 are acceptable and %23 are in a bad condition. (the evaluation was conducted by the municipality's engineers)
2. Al Nasser City has a total of 8.36 km paved roads with a total area of 0.24 km^2.
3. Al Shoka City has only 7 partially paved roads.

6.1.2 Network Problems

The following issues were the main source of information about the current traffic problems in Rafah Governorate:

- Southern Governorate Municipalities report (Annex 5) which reflects the municipality engineers' evaluation for the current situation.
- Questionnaires for road users (drivers and pedestrians) in the targeted area (Annex 6). It targeted a sample of 193 road users (93 pedestrians and 100 drives).
- Observations of the traffic experts and opinions of community representatives.

The questionnaires were distributed in selected locations. These locations were selected in by the experts in cooperation with the municipal staff. This concluded to

consider hotspots as the most critical area where almost all traffic problems exist there.

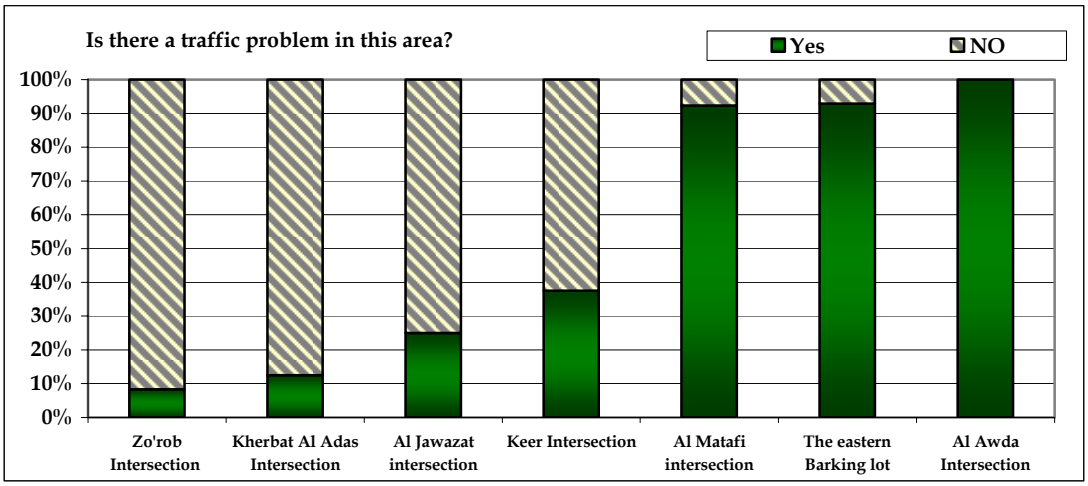


Figure (10) : Traffic Congestion Locations in Rafah Governorate

Annex 7 represents the results of the questionnaire analysis using SPSS program. Based on the analysis of this questionnaire and the reports made by experts from the local municipalities, the network problem can be specified on the following aspects:

I. Geometric Adequacy of Roads and Intersections:

The following points are identified by both road users and the municipality staff as the main problems of the traffic network:

Storm Water Drainage System

The municipality report clearly identifies the problem in the Storm water drainage system in the target area in general, but more obvious to be noticed in Al Huda Mosque Street, Abu Bakre Street and the intersection of the Open University Street with Street No. (67).

Geometric Design of Roads and Curve

The report highlighted the problem in Belal St. (which is proposed as an alternative option of Abu BakreSt.) where the width of this street is not adequate to overcome the traffic congestion in this area in addition to the presence of a local taxi station nearby the existing road.

The problem is even more complicated under the existence of geometric design faults in some curves. In addition, some other old buildings surrounding the intersections make vision constrains on the drivers' sight and lead to several road accidents.

This problem is mainly concentrated around the City Centre. This was demonstrated through the questionnaires where (Al Awda and Eastern Garage) roundabouts in the center of the city acquire the highest complains among road users whether in road width inadequacy or road intersections services.

Taxi Stations

lack of taxi station spaces available for vehicles had caused a congestion problem in the city center and contributed to the traffic delay in the streets. While (51%) of the drivers consider it as a main problem in their daily driving time, about (97%) of the road users in Al Awda, and (95%) in Eastern Garage and (96%) in Al Matafi roundabout areas complain about the unavailability of taxi station spaces most of the time.

Paving Condition

It was highly noticed during the preparing of this report that the majority of the streets in Rafah Governorate are unpaved while the paved ones varies in condition from bad to fairly good. The problem is even worse going south to Al Naser and Al Shoka areas where only 7 roads are paved. According to the questionnaire analysis, Al Awda and Yebna streets represent critical areas where the situation of unavailability of sidewalks presents a serious danger to the pedestrians and public movement.

II. Traffic Awareness and Drivers Commitment to Traffic Regulations

This problem was illustrated in the municipality report where several facilities in street has been ruined and put out of service because of the public ignorance to the importance of those street facilities. On the other hand, the childish violation against the traffic signs and the abusing of the streets open spaces by the public in their social occasions like weddings and so had caused a serious disruption in traffic movement.

On the other hand, the drivers commitment to traffic rules is essential in any development plan. Only (28%) of pedestrians believe that drivers obey the traffic rules while (67%) don't. It's essential to mention that (99%) of the drivers approved to enforce the power of the traffic police, increase supervision and affirm more fines on traffic mutiny.

III. Traffic Control Tools

A high resentment by the municipalities and the public in the target area was clearly observed toward the negligence of the police officers in controlling the

traffic movement and pedestrian crossing lines especially at the beginning of the months when employees head to the bank to receive their salaries.

The municipality report, as well, highlighted the lack of traffic control equipments and facilities such as traffic lights, street signs and light poles.

In addition to that, the high number of carts in the road also disrupt the vehicles movement. (73%) of the drivers consider carts as a major disturbance in the roads where also pedestrians agreed to them with about (80%) percentage.

IV. Sidewalks Encroachments

This problem affects the traffic movement as well as the pedestrian safety. Over 80% of road users agreed on that, these invasions to the sidewalk is unnecessary and considered to be abusing the public spaces.

V. Economic and Security Situation Affection on Traffic Condition

After the analytic study of the traffic problem and its consequences according to the municipalities experts and road users. It's important to notify the negative impact of the economic and security situation on traffic condition in the target area.

Hereinafter some main issues regarding to this problem:

c) Inability to take severe legal steps to eliminate carts problem because it is still considered as the only source of living for many poor families.

d) Unregistered taxies: The number of taxis has enormously increased during the past few years which came in parallel to the increasing number of unemployed people during the Intifada. This issue comes to a real disturbance when most of those unregistered cars has neither legal papers nor insurance which lead to irresponsible acts from its drivers.

e) Streets encroachments and booths invasion. Using these booths as an alternative sources of living in the presence of terrible economic situation make it hard to pursue the sellers to remove it.

f) Some random disturbing acts from some families as blocking the roads for personal purposes where lack of security forces controlling the area causes this problem.

g) Vehicles defects: The bad conditions for some vehicle make road accidents more likely to happen. Moreover, the unfiltered gas emissions dangerously affecting the surrounding environment. This problem obviously related to the retrogressive economic situation in Gaza Strip.

h) Illegal humps installed by citizens in front of their residences to provide more safety for them and for their children. These humps are not complied to the Geometric design of the roads and not authorized by the municipal.

6.2 Traffic flow

The traffic counting includes 25 points distributed on the main roads and intersections in Rafah, Al Shoka and Al Nasser Municipalities. The counting process lasted for 4 weeks and carried out by 13 well-trained engineers.

Data analysis

The analysis has been carried out for the following data:

- Average Traffic Flow during the counting period.
- Average Traffic Flow per hour from all approaches.
- Traffic Flow during peak hour from all approaches.
- Peak Hour period.
- Min. Traffic Flow from all approaches.
- Period of Min. Traffic Flow.
- Peak Hour Factor.
- Traffic composition.
- Traffic flow during the counting period.
- Turning movement.

(Annex 8) shows the results of the data analysis.

The Traffic counting was conducted for variable time intervals and converting factors was obtained to prepare a 24 continues counting hours and the Average Annual Traffic (ADT) was then obtained.

The following table clarify the intersections which were counted on, sorted upon the Average daily traffic flow:

Table (2): Manual Classified Counts Stations

Station number	Intersection	Average daily Traffic (veh./24hr)	Peak Hour		Peak Hour flow (veh./hr)
2	Othman Ibn Affan Street – Abu Bakre Street	17,753	10:45	11:45	1666
1	Omer Ibn Al Khatab Street - Abu Bakre Street	16,631	10:00	11:00	1366
3	Al Nejma Intersection	16,384	10:45	11:45	1634
5	Civil Defense Intersection	13,458	16:00	17:00	1075
6	CAIR Intersection	12,710	17:00	18:00	985
10	Sadam Street – Al Jama'a Street	12,007	10:30	11:30	931
4	Zo'rob Intersection	11,315	16:15	17:15	964
9	Taha Hussein Street – Omer Ibn Al Khatab Street	10,553	16:00	17:00	895
13	Al Quds Street – Abu Bakre Street	10,319	9:30	10:30	734
7	Al Oroba Street – Salah Al Deen Street	7,834	12:30	13:30	709
8	Moraj Street- Salah Al Deen Street	7,755	11:00	12:00	635
16	Moraj Street- Omer Ibn Al Khatab Street	6,920	7:15	8:15	528
11	Al Jawazat Intersection	6,755	11:00	12:00	549
25	Salah Al Deen Street- Street no. (11)	6,164	6:45	7:45	432
14	Salah Al Deen Street- Jenean Street	6,092	10:15	11:15	427
19	Salah Al Deen Street- Al Salaam Street	5,103	10:30	11:30	385

Station number	Intersection	Average daily Traffic (veh./24hr)	Peak Hour		Peak Hour flow (veh./hr)
12	Abu Usef Al Najar Street- Sadam Street	4,976	10:00	11:00	377
24	Al Shuara intersection	4,422	10:30	11:30	431
15	Salah Al Deen Street- Al Matar Street	3,242	6:00	7:00	293
18	Qhassan Kanafani Street – Moraj Street	2,685	11:00	12:00	205
17	Moraj Street- Street no. (13) - Street no. (14)	2,304	7:15	8:15	176
20	Othman Ibn Affan Street – Moraj Street	1,963	6:00	7:00	156
23	Street no. (22) - Street no. (53)	1,963	11:00	12:00	209
21	Abu Bakre Street - Street no. (16)	1,284	7:45	8:45	98
22	Street no. (16) - Street no. (32)	269	11:00	12:00	26

Note: Intersections numbers from figure (7)

According to traffic counts analysis, it was noticed that the flow in peak hour ranges between (8-12%) which is among the international standards.

Traffic composition: (According to the count)

It is noted that the percentage of cars is lower than which common in Gaza Strip which refers to the low level of living. And it is noted that the percentage of bicycles and motorcycles is semi high which refers to the using of bicycles by students to reach and depart from their schools.

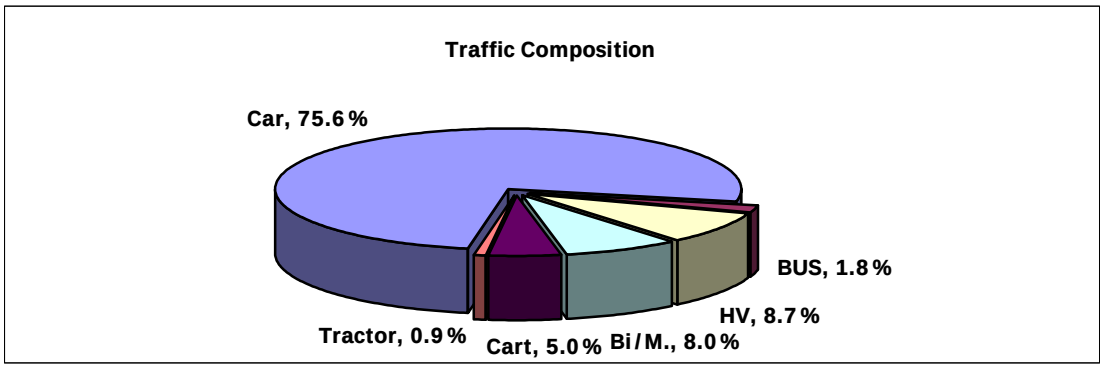


Figure (11) : Traffic composition

6.3 Spot Speed

Spot Speed is the instantaneous speed of a vehicle at a specified location. Detecting this velocity depends on measuring instruments installed aside from traffic movement and far from drivers' sight. A random sample of vehicles was chosen according to specified criteria.

The measuring process was manually conducted in 8 vital points in Rafah governorate for 100 cars randomly chosen. (Annex 9) shows the measuring stations and data collected.

The spot speed analysis shows that the speed in Rafah governorate ranges between 25 – 51 km/hr which complies to the national standards in urban areas.

6.4 Origin & Destination

The O&D survey aimed at providing information about road trip destinations whether interior trips or from/to the governorate itself. This survey was used in the simulation process to identify the (Demand Matrix = Traffic generation) – refer to section 6.1.6 .

This survey was conducted in 12 stations around the governorate using random sample (one over ten cars) using road side interview technique.

6.5 Results & Recommendation

Tracking the traffic situation in Rafah Governorate lead to identify the City Center as the key problematic area in Rafah. In particular, Abu Bakre Street , the main intersections crossing Abu Bakreand all what related to this street from facilities, parking and markets are the major issues to be considered in the development process. The traffic problems in Rafah Governorate can be classified into:

- Traffic Network problem presenting in traffic congestion in Abu Bakre Street as the main road connecting the eastern and western side of the city.
- Unorganized parking spaced.
- The Central Market lies on the center of the city where it is considered to be the most congestion point in Rafah.
- Absence of the power of law which lead to outrages on the sidewalks and street booths.
- Lack of traffic control equipment and tools.
- Problems related to the lack of traffic awareness for road users.

It's well cleared that the size of the problems are still increasing with the increasing number of road users. So it is necessary to start working on strategic plan to figure out the right solutions considering the current situation of traffic identified in this report. This plan should consider the following points:

- Working on developing the current traffic network.
- Parking spaces.
- Pedestrians.
- Drivers.
- Public Awareness.
- Proposed strategic projects in the target area.

7 Traffic Modeling and Forecasting

7.1 Traffic Modeling

7.1.1 General

This section of the report presents in details the development of the computer traffic model that was used to forecast traffic in the road network and provides the input for traffic development plan.

Two simulation peak hour periods were modelled, the morning peak hour (3 hours) and the afternoon peak hour period (3 hours). Both models were calibrated and validated to reproduce existing traffic conditions as observed in the various traffic surveys carried out during the base year. The peak hour models were then applied in their forecast mode to estimate link volumes, turning movements, queue lengths, and delays across the simulated Rafah network.

For the purpose of traffic assignment, the latest state-of-the-art traffic assignment model CONTRAM is used Annex (15) . CONTRAM provides the advanced dynamic traffic modelling features that are needed for applications such as congested networks with time varying traffic flows and fuel consumption and emissions statistics. CONTRAM has been the leading dynamic traffic modelling software used around the world for over 20 years. It has a wide range of modelling tools, which are continually being developed , for representing a variety of situations from congested urban networks to regional inter-urban areas.

CONTRAM is designed to model the varying traffic demand and congestion that occurs during the day and will represent the peaks of congestion as well as off-peak conditions within a single model. It is ideally suited to traffic management schemes and systems such as part time signals. Formulae built into CONTRAM provide detailed statistics on fuel consumption and emissions. These use results of European research as the basis for the calculations. Default pollutants include CO, HC, CO2, NOx and particulates.

For the network modelling of Rafah study area, it is enough to divide it into a small number of zones. Therefore, the free evaluation copy of CONTRAM is applied which can model up to 25 zones and no limits of links and nodes.

CONTRAM (CONtinuous TRaffic Assignment Model) was developed by the UK Transport Research Laboratory (TRL) in the late 1970s. It was originally developed to model urban traffic management schemes. It has been continuously developed over the years and is now widely used for many larger network models in the UK and worldwide.

In CONTRAM the day is divided into time slices which are used to model the build up and decay of traffic. Vehicles are assigned to their minimum cost routes, taking into account of traffic interactions and delays caused by other vehicles on the network. A journey can cover several time slices during which traffic demand and network conditions can vary and over-saturated conditions may occur temporarily, as in real life.

Key modelling features include:

- An unlimited number of time slices
- Up to 32 user definable vehicle classes
- Advanced junction modelling
- Link-based speed-flow relationships and tolls
- Left or right hand drive
- Dynamic matrix estimation

These features are combined with a high quality graphical interface. Building, running and analyzing models can be done from a single fully integrated program. The 32-bit software operates on Windows 95, 98, 2000, NT and XP platforms.

CONTRAM allows simple junctions to be coded in seconds, while complicated ones can be coded to a high level of detail and accuracy. The time-dependent

queuing relationships used are consistent with those in the TRL junction design programs ARCADY (roundabouts), PICADY (priority intersections) and OSCADY (signals).

Signal modelling features include:

- Multiple plans
- Part time signals
- Optimized cycle time
- Optimized stage lengths
- Opposed turns
- Approach flares
- Phase delays

CONTRAM 's functionality makes it very easy to use. Model networks may be built on-screen and edited by just a few mouse clicks. Templates guide the user through the input data required. To aid presentation a background map may be used so that junctions, zones and links are accurately located and networks easily recognized. Links can be shaped to reflect network topology and text can be added to provide roads and junctions with recognizable names.

A successful assignment model needs an accurate trip matrix. Matrix estimation is a technique for modifying a trip matrix so that, when assigned to a network, the modelled link flows are a closer match to observed link counts. Typically it is used to update an old trip matrix using a recent set of traffic counts. Time-dependency is at the heart of the way CONTRAM works so of course there is a facility to define counts by time slice or combinations of time slices. Weights can be applied to counts, reflecting that some counts may be less accurate or more variable than others.

7.1.2 Data Sources

- **Roadside Interview Surveys**

  Roadside interviews were carried out during two different periods, the first is 6:00-9:00 am and the second 1:00-4:00 pm . The traffic was intercepted at 12 stations as shown in Figure (12). At each of these stations, a sample of the traffic (10%) was stopped by police and interviewed.

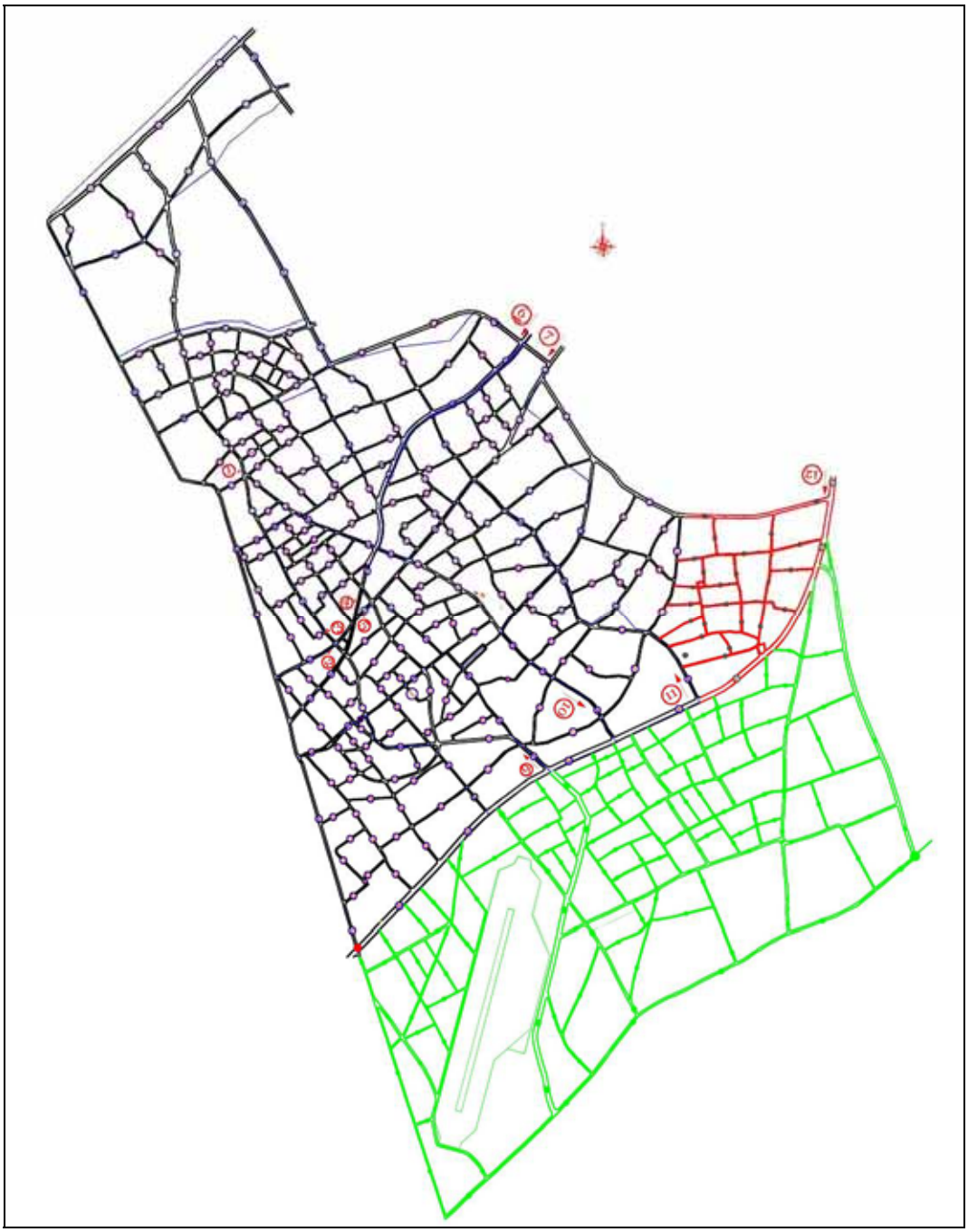


Figure (12) : Origin-Destination Survey Stations

The Origin-Destination Survey Form is attached in Annex (1). The origins and destinations recorded in the interviews were coded to traffic zones in the office and the interview data were entered into SPSS software.

- **Manual Classified Counts**

  At the same time as the interview survey, all traffic was counted at major intersections (25 intersections) in Rafah network. These intersections are presented in Figure (13) with dot plots. The traffic was counted each 15 minutes using 5 different vehicle classifications as described in section 4.

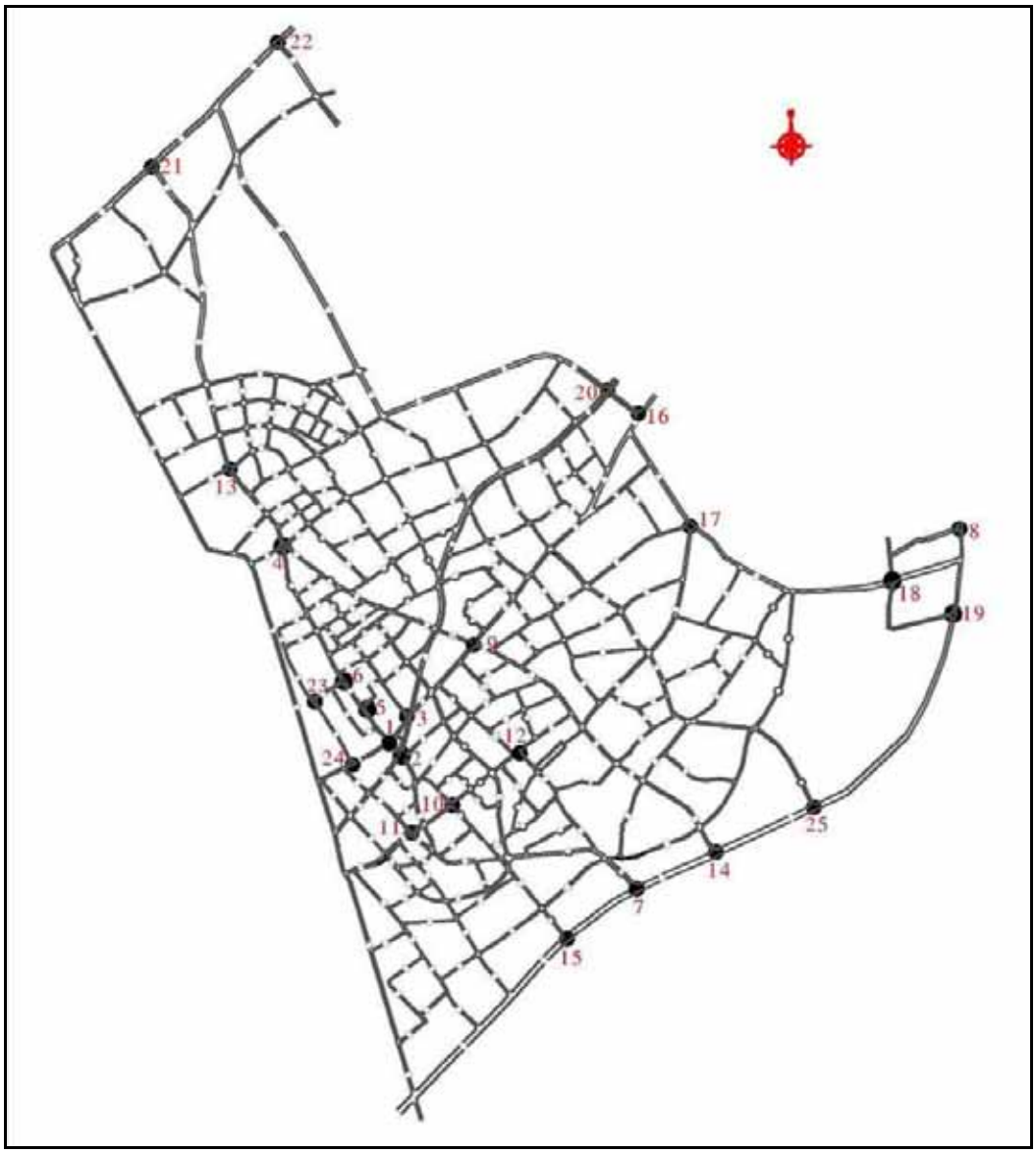


Figure (13) : The location of manual classification counts in Rafah network

7.1.3 Traffic Zones

The first stage of the study was dividing Rafah Municipality area into a number of traffic zones.

The selection of zonal boundaries was based upon the following criteria:

- Administrative boundaries within the municipality.
- Homogeneity of socio-economic parameters within individual zones.
- Primary and Secondary road network with and beyond the boundaries of the municipality.

Based on the above criteria, 21 zones were selected. The boundaries of these zones are shown in Figure (14) , and their names are presented in Table (3).

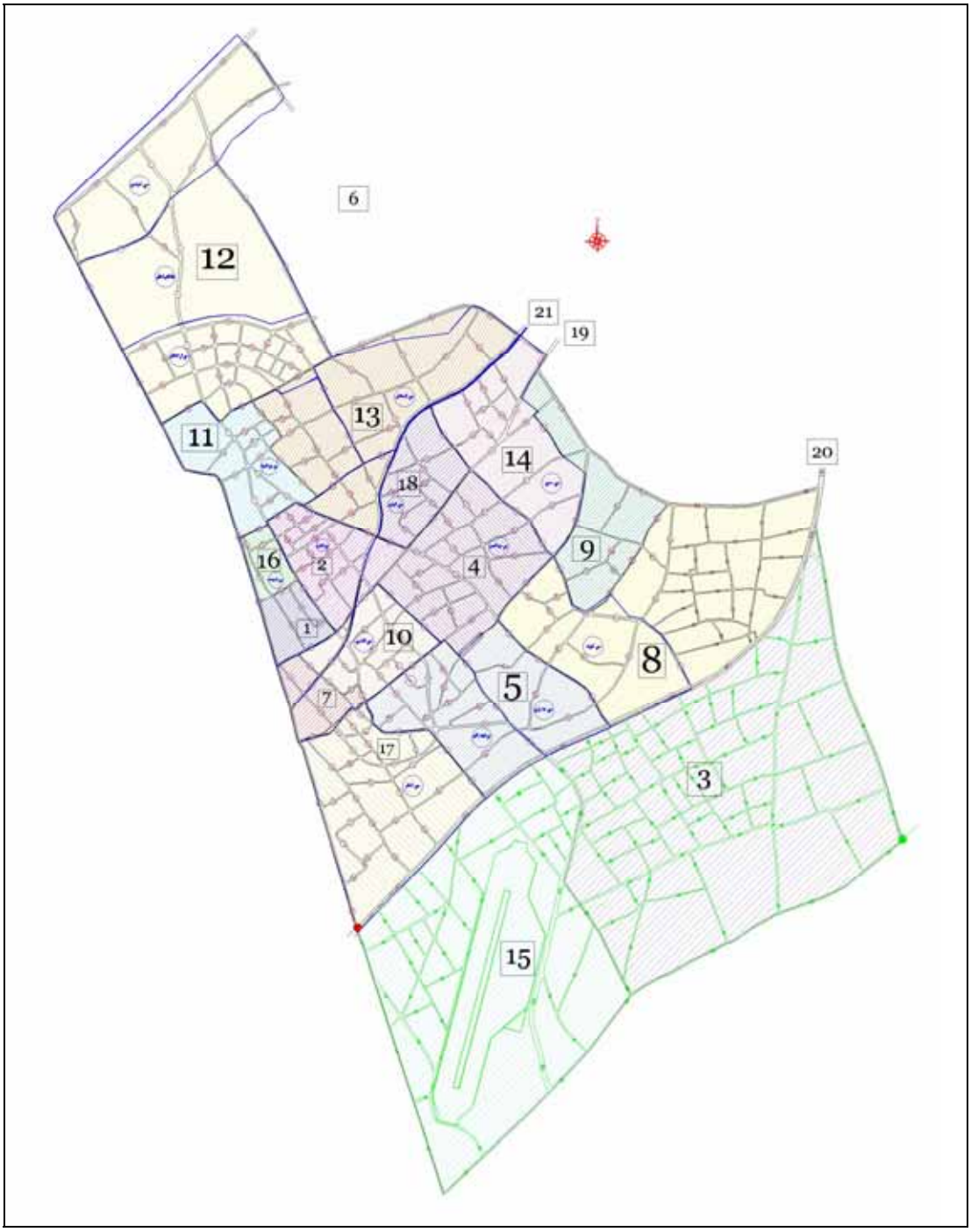


Figure (14) : Rafah zoning system

Table (3): Rafah Zones

Zone Number	Zone Definition	Zone Number	Zone Definition
1	Al Balad	**12**	Tul Al Sultan
2	Al Shabora	**13**	Western Rafah
3	Al Shoka	**14**	Mosabah
4	Kherbit Al Adass	**15**	Al Matar
5	Al Jinana	**16**	Al Mokhaimat
6	Al Mohararat	**17**	Al Salam
7	Al Brazil	**18**	Al Zohor
8	Al Nasser	**19**	External-Omer
9	Moraj	**20**	External-Abu Baker
10	Al Karaj Al Sherqi	**21**	External- Al Seca
11	Zo'rob	**-**	-

7.1.4 The Road Network Building

There are a number of fundamental modelling elements in any CONTRAM model.

Time Slices

Time slices are an integral part of the CONTRAM program, allowing variation in traffic demand to be accurately represented through the model period. A large number of time slices may be specified (a practical limit is currently set at 300); thus models ranging from minute-to-minute detail up to 24-hour periods can be accurately represented.

User Classes

32 user classes are available, each allowing a definable name and vehicle characteristic to be specified. Three default classes are given representing the usual values taken for cars, buses and lorries. These may be edited or deleted.

Nodes

In most cases, a node will be used to represent a junction. This may take the form of an uncontrolled, give-way or priority junction or a signalized junction. In addition roundabouts, merges and diverges can also be modelled by using single or multiple nodes. Nodes can also be used where a single link is separated into two or more links on the approach to a real junction.

Zones

A zone is a special type of node that is a source or sink of traffic for the network. Traffic cannot pass through a zone.

Links

Links are used to represent roads or in some cases lanes or even turning movements between junctions (nodes). All links are one-way. Left or right side driving may be coded.

Demand (Trips)

Traffic demand is provided for the model for pairs of zones – origins and destinations. Each OD pair of information is disaggregated by time slice and user class.

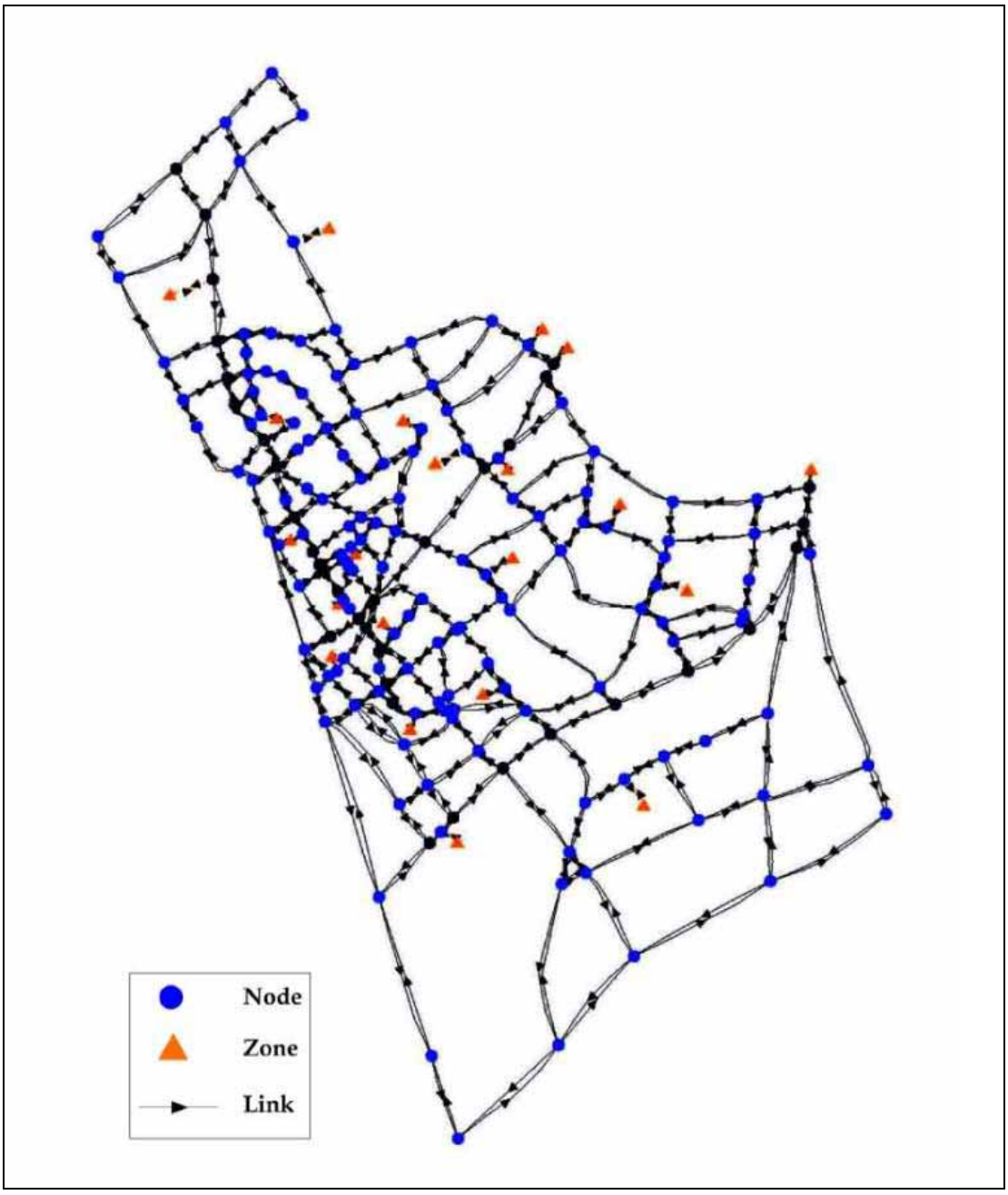


Figure (15) : CONTRAM Network Representation

7.1.5 Matrix Estimation

A successful assignment model needs an accurate trip matrix. Matrix estimation is a technique for modifying a trip matrix so that, when assigned to a network, the modeled link flows are a closer match to observed link counts.
Typically it is used to update an old trip matrix using a recent set of traffic counts.

Annex (10) Clarify the estimation process that conducted on the **Base Year Demand Matrix** based on data resulted from the Manual classified Counts (MCCs).

7.2 Projections and development trends

7.2.1 Introduction

The estimation of future demand for transport services in this project is imprecise – but necessary- task. Imprecise in that a number of assumptions have to be made on the nature and future actions of populations, over a 20 to 30 year period and necessary, in that economic analysis requires the estimation of the potential costs and benefits of that project over that period and design teams require parameters to which they can most cost effectively develop designs.

There are a number of ways to estimate future traffic demand, but for this project, given the amount of data available on the past performance of the economy, vehicle registration and population growth and other contributory socioeconomic parameters, forecasts are made primarily on the basis of an extrapolation from the past trends. Clearly such an approach needs to be used with care and adjustments made with some data sets. This section outlines the basic approach adopted and the adjustments and assumptions made in the forecasting process.

7.2.2 General Approach of projections and forecasting

Forecast Period

Growth of traffic has been estimated from the base year 2007 and three planned openings of the project packages as follows:

- The first opening is a short-term planning period between 2008 and 2012 over an horizon time of 5 years;
- The second opening is an intermediate-term planning period between 2013 and 2020 over an horizon time of 13 years; and
- The third opening is a long-term planning period between 2020 and 2030 over a horizon time of 23 years.

Areas of Study

Due to the lack of data about Rafah, the model developed for the study covers the entire area Gaza Strip with the assumption that this will reflect Rafah area.

Forecast approach

The end product of the passenger traffic forecasts developed here are estimates of the rate of growth in vehicle ownership over the project assessment period.

These are intended to be used as a proxy for the growth in vehicle trips expected in the future and are directly input to the modelling process as a value by which existing base year vehicle trip matrices are factored to develop future year trip matrices.

The assumption here is that the number of vehicle trips made is a function of the number of vehicle available. To derive such a value it is necessary therefore to forecasts both vehicle ownerships and population:

Vehicle Ownership **:** Estimated by direct projection of existing past Vehicle Ownership data.

Population : Estimated by direct projection of existing and past population data.

Results of Vehicle Ownership Estimation

The historical data of the number of vehicles registered yearly are presented in Table (4) according to PCBS (Palestinian Bureau of statistics) . The rate of growth between 1994 and 1995 is extremely different from other years. This is related to the jump of the economy at the year of the start of Palestinian Authority. However, the economy returned to be normal and stable after that. Because of that this period was excluded in regression analysis using EXCEL. Figure (16) presets the result equation of regression analysis. This equation is used as a basis for the estimation of the future vehicle registration.

Table (4): Statistics for Registered Vehicles in Gaza Strip (1994-2007)

Year	No. of Registed Vehicles	Rate of increment	Resource
1994	32,467		PCBS
1995	43,809	34.93	
1996	43,548	-0.60	
1997	46,427	6.61	
2000	49,014	5.57	
2001	49,836	1.68	
2002	50,624	1.58	
2003	51,758	2.24	
2004	53,310	3.00	
2005	55,948	4.95	
2006	56,724	1.39	Projection
2007	58,315	2.81	

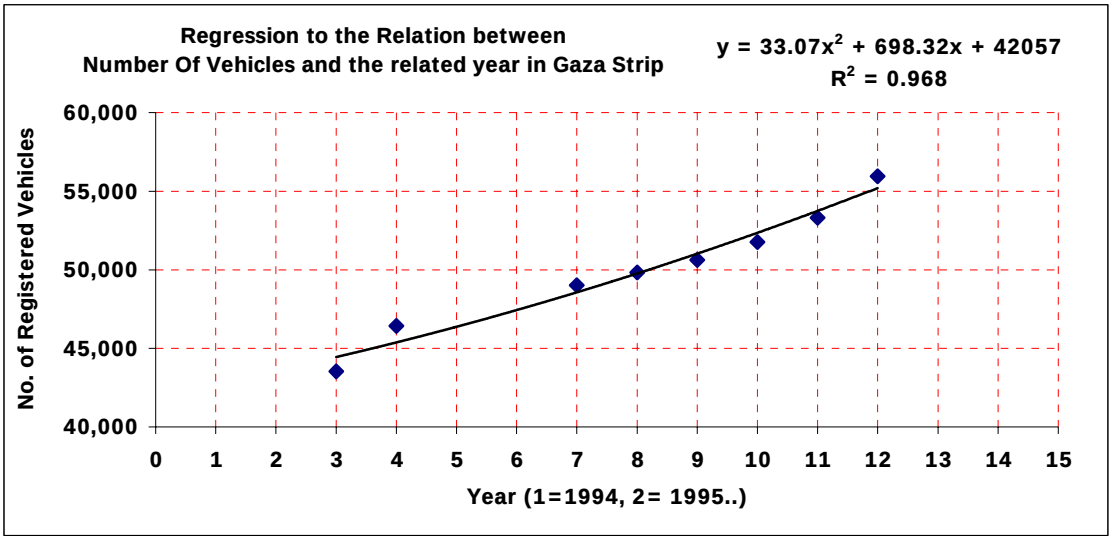


Figure (16) : Regression analysis of the historical data of vehicle registration in Gaza Strip

Table (5) presents the forecasted number of vehicles up to 2030. It is noted that the percentage of increase in the horizon years 2012, 2020 and 2030 are **15%, 46% and 94%** respectively.

Table (5): Projection for Registered Vehicle Numbers in Gaza Strip (2008-2030)

Year	No. of Registered Vehicles	Rate of increment	Resource
2008	59,973	2.84	Projection
2009	61,696	2.87	
2010	63,486	2.90	
2011	65,341	2.92	
2012	67,263	2.94	
2013	69,251	2.96	
2014	71,306	2.97	
2015	73,426	2.97	
2016	75,612	2.98	
2017	77,865	2.98	
2018	80,184	2.98	
2019	82,569	2.97	
2020	85,020	2.97	
2021	87,537	2.96	
2022	90,120	2.95	
2023	92,770	2.94	
2024	95,485	2.93	
2025	98,267	2.91	
2026	101,115	2.90	
2027	104,029	2.88	
2028	107,009	2.86	
2029	110,055	2.85	
2030	113,168	2.83	

Results of population Estimation

The historical data of the population until 2007 in addition to the estimated population up to 2015 are presented in Table (6) according to Central Beruo of Statistics. Figure (17) presets the result equation of regression analysis. This equation is used as a basis for the estimation of the future population.

Table (6): Projection for Population of Gaza Strip up to 2015:

Year	No. of inhabitants	Rate of increment
1997	995,522	4.30
1998	1,039,528	4.40
1999	1,086,970	4.50
2000	1,137,990	4.60
2001	1,188,130	4.00
2002	1,236,372	4.00
2003	1,286,109	3.90
2004	1,337,236	3.90
2005	1,389,789	3.80
2006	1,443,814	3.80
2007	1,499,369	3.80
2008	1,556,201	3.70
2009	1,614,018	3.60
2010	1,672,785	3.50
2011	1,732,438	3.50
2012	1,792,895	3.40
2013	1,854,353	3.30
2014	1,917,019	3.30
2015	1,980,825	3.20

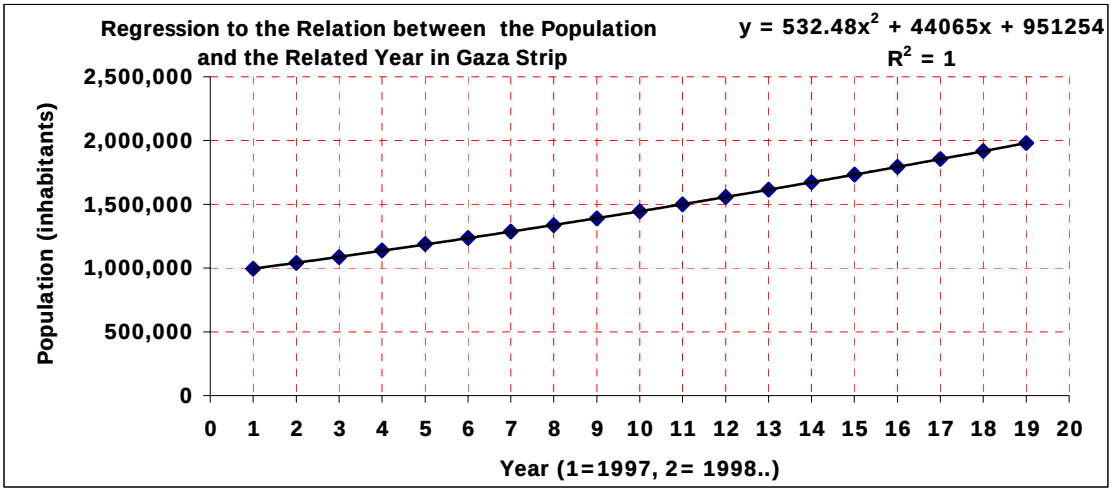


Figure (17) : Regression analysis of the historical data of population in Gaza Strip

Because the vehicle ownership is dependent on the economy, which is unstable in Palestine due to instability of political situation, and because of the stability of population, the forecasting of passenger trips will depend more on population. Table (7) presents the forecasted number of vehicles up to 2030. It is noted that the percentage of increase in the horizon years 2012, 2020 and 2030, which are relatively close to ones in vehicle ownership forecasting, are 20%, 54% and 104% respectively. These values are used as factors of multiplication for the origin-destination Matrices for forecasting future network traffic flow.

Table (7): Projection for Population of Gaza Strip (2015-2030):

Year	No. of inhabitants	Rate of increment
2016	75,612	2.98
2017	77,865	2.98
2018	80,184	2.98
2019	82,569	2.97
2020	85,020	2.97
2021	87,537	2.96
2022	90,120	2.95
2023	92,770	2.94
2024	95,485	2.93
2025	98,267	2.91
2026	101,115	2.90
2027	104,029	2.88
2028	107,009	2.86
2029	110,055	2.85
2030	113,168	2.83

7.2.3 Forecast Traffic Characteristics

To determine the behaviour of the existing unimproved traffic network in future years, the forecast-year matrices were assigned to the base year network.

A summary of the resulting traffic characteristics for the simulation area network is given in the following tables:

Do nothing Scenario (6-9):

Table (8): Simulation Process Results with Do Nothing Scenario (6:00 am -9:00 am)

Time		queuing time (veh-hr)				total distance (veh-km)				network speed (km/hr)			
From	to												
6:00	7:00	2007	2012	2020	2030	2007	2012	2020	2030	2007	2012	2020	2030
		5.7	7.3	25	56.2	13918.7	16569.4	21216.8	27466.4	44.2	44.1	42.8	41.2
		final queues				congestion				stops			
		2007	2012	2020	2030	2007	2012	2020	2030	2007	2012	2020	2030
		5.7	7.3	50.9	277.5	1.02	1.02	1.05	1.09	543	777	2603	3852

Time		queuing time (veh-hr)				total distance (veh-km)				network speed (km/hr)			
From	to	2007	2012	2020	2030	2007	2012	2020	2030	2007	2012	2020	2030
7:00	8:00	17.1	43.4	136.6	703.5	17740.1	20969.5	27231.4	33234.1	43.1	41.2	36.7	23.1
		final queues				congestion				stops			
		2007	2012	2020	2030	2007	2012	2020	2030	2007	2012	2020	2030
		106.5	229.6	472.1	1766.2	1.04	1.09	1.23	1.95	1594	3375	5234	8941
8:00	9:00	queuing time				total distance				network speed			
		2007	2012	2020	2030	2007	2012	2020	2030	2007	2012	2020	2030
		34.6	96.4	380.1	2167.6	17335.6	20248.3	25323.8	31434.1	41.3	37.1	26.9	11
		final queues				congestion				stops			
		2007	2012	2020	2030	2007	2012	2020	2030	2007	2012	2020	2030
		122.8	393.4	917.8	3067.4	1.09	1.21	1.68	4.11	2282	3466	6255	10083

Do nothing Scenario (13-16):

Table (9): Simulation Process Results with Do Nothing Scenario (1:00 pm -4:00 pm)

Time		queuing time (veh-hr)				total distance (veh-km)				network speed (km/hr)			
From	to	2007	2012	2020	2030	2007	2012	2020	2030	2007	2012	2020	2030
13:00	14:00	10.4	169.4	372.6	741.5	17553.9	25020	30714.9	38969.6	43.8	34.5	29.1	24.2
		final queues				congestion				stops			
		2007	2012	2020	2030	2007	2012	2020	2030	2007	2012	2020	2030
		10.5	664.6	1213.5	2040.3	1.03	1.3	1.55	1.86	1242	5462	8436	11278
14:00	15:00	queuing time				total distance				network speed			
		2007	2012	2020	2030	2007	2012	2020	2030	2007	2012	2020	2030
		8.5	349.4	1132.1	2347.1	15836.1	23616.5	28055.2	35973.7	44	27	16	11.4
		final queues				congestion				stops			
		2007	2012	2020	2030	2007	2012	2020	2030	2007	2012	2020	2030
		7.9	768.9	1679.5	3360.3	1.02	1.67	2.82	3.94	928	4808	6797	11977
15:00	16:00	queuing time				total distance				network speed			
		2007	2012	2020	2030	2007	2012	2020	2030	2007	2012	2020	2030
		8.6	691.6	1828.2	3581.1	17523.4	24187.4	30521.4	39396.1	44	19.7	12.2	8.8
		final queues				congestion				stops			
		2007	2012	2020	2030	2007	2012	2020	2030	2007	2012	2020	2030
		8.7	1200.2	2454.5	4536.8	1.02	2.29	3.7	5.09	993	4647	6862	11499

Note:

queuing time : The total time (in veh.-h) spent by vehicles in queues.
total distance : The total distance travelled by vehicles in the network (in veh.-km).
network speed : The average network speed for the time slice measured in kph.
final queues : The total number of vehicles queued at the end of the time slice.
congestion index : This is the ratio of total travel time on the link to its free-flow travel time. A congestion index of 1.0 indicates no queuing, whilst a value of 2.0 indicates that travel time is doubled due to junction delays.
stops : The total number of stops.

8 Traffic Development Plan

8.1 Actions to be considered

The objective of the **Rafah Transportation Master Plan (RTMP)** is to properly manage the traffic network, solve congestion, reduce delay and improve safety in the main and sub main local streets in Rafah City. As presented in the preceding chapters, this report discusses the current situation of the local network system in Rafah Governorate and presented the related issues of efficiency, effectiveness and safety.

The RTMP will be designed and developed to provide a sound structural framework for future growth and development. According to the evaluation of the existing conditions of traffic network performance in Rafah Governorate, the following issues are the most important issues:

- Network Development
- Intersection Development
- Markets Development
- Parking Policy
- Pedestrian Facilities
- Regulation, control and Enforcement
- Others (environmental, safety,)

The following sections detail the above issues.

8.1.1 Network Development:

The RTMP is designed to rehabilitate the deteriorated existing situation in terms of efficiency, effectiveness and safety. The current network suffers from reckless and negligence of the local authority and damage and disrespect by the local community due to the lack of awareness. Narrow, unpaved, Uncontrolled streets cause several problems and congestion to traffic movement in the governorate. This situation makes the RTMP essential to improve the traffic network.

Listed hereinafter the major problems that are related to the network in Rafah governorate as well as the suggested alternative solutions:

Problem (1) : Congestion on Abu Bakre Street as a vital street penetrating the town center and linking the governorate eastern side by its western side.	**Suggested solution:** *Scenario No.1:* Converting Abu Bakre Street to one way street *Scenario No.2*: Activate Taha Husain street that links the governorate eastern side by its western side. **(as an alternative to Abu Bakre Street).**

Problem Details:

The basic traffic problem is concentrated on Abu Bakre Street from CAIR Intersection to the Eastern Taxi station (ETS). The existence of the main market, onsite shops, medical clinic, taxi station and other multi-activities in the same area in addition to the high density of population in the vicinity contribute to traffic problems and congestion bottleneck in the specified area, particularly during the morning hours (Peak hour 10:00 – 11:00 am).

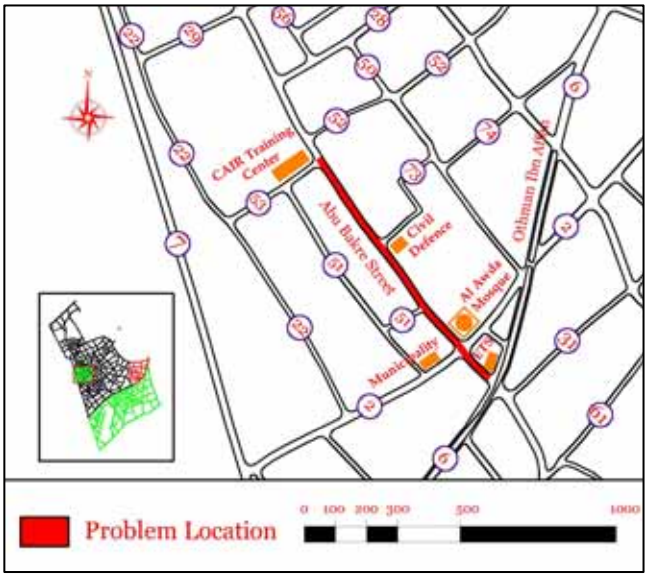


Figure (18) : The problem location

The problem aspects are identified as follows:

1- Traffic congestion particularly during the morning hours .
2- Encroachments on sidewalks by shops, peddlers and stalls.
3- Absence of traffic control devices.
4- There is a conflict between pedestrians and vehicles at the student's arrival and departure times, because of the existence of seven schools within the problem location.
5- A considerable number of heavy vehicles and carts usually use the street, the traffic count showed the composition of traffic utilizing this street as follows: 84.9% Cars, 2.7% Heavy vehicles, 0.8 % Buses, 0.3% Tractor, 3.5% Cart and 7.9% Bicycle/ Motorcycle)
6- There is very little obedience to traffic rules.
7- Taxi stations are randomly spread within the problem area.

As mentioned previously the problem is a combination between the network system, law enforcement , and traffic control measures.

Problem (1) : Congestion on Abu Bakre Street as a vital street penetrating the town center and linking the governorate eastern side by its western side.	**Suggested solution:** *Scenario No.1:* Converting Abu Bakre Street to one way street *Scenario No.2*: Activate Taha Husain street that links the governorate eastern side by its western side. **(as an alternative to Abu Bakre Street).**

Suggested solution Details:

The following suggested solution deals with the network development options. Other options that are related to other issues (Intersections Development, Markets Plan, Parking Plan, Pedestrian Plan, Regulation, control and Enforcement) will be discussed subsequently.

Scenario No.1

Converting Abu Bakre street (Starting From CAIR Intersection to the Eastern Taxi Station ETS) to one way street. (from East to West) and Using an alternative street to carry traffic in the opposite direction (from west to east).

Streets for west to east traffic

a) Bilal Street (Alternative –1) :

Bilal street represent the preferred alternative to Abu Barker street to carry flow from west to east and intersects with Uthman Ibn Affan Street which leads to the Eastern Taxi Station.

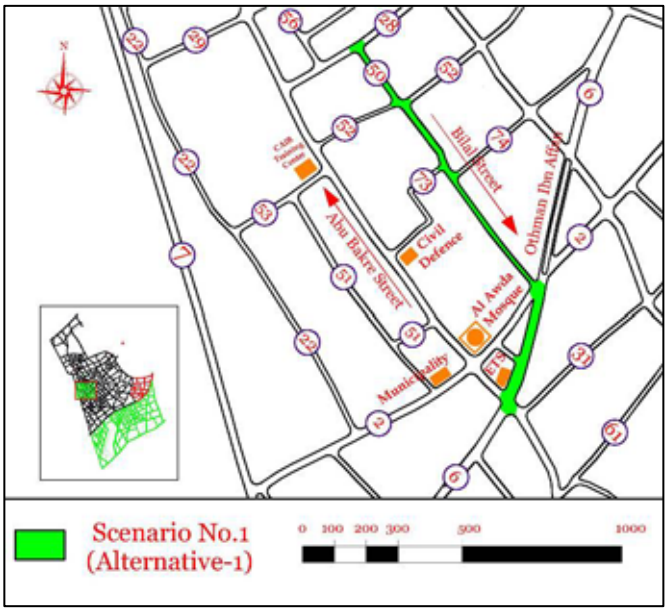


Figure (19) : Scenario no. 1 (Alternative-1)

This alternative (Bilal Street) has the following advantages :

1- Suitable width.
2- Possibility of future widening and upgrading.
3- The condition of pavement is good.
4- The street contains commercial activities that attracts users.

Problem (1) : Congestion on Abu Bakre Street as a vital street penetrating the town center and linking the governorate eastern side by its western side.	**Suggested solution:** *Scenario No.1:* Converting Abu Bakre Street to one way street *Scenario No.2*: Activate Taha Husain street that links the governorate eastern side by its western side. **(as an alternative to Abu Bakre Street).**

5- The walking distance between Bilal street and Abu Bakre Street is relatively short.

However it has some disadvantages :

1- The width of the Bilal street, in particular positions is narrow (about 8m wide), **therefore it is suggested to widen the street at the expense** of Al Khalideen Park.

2- The street penetrates a refugee camp that has a high population density**, therefore** awareness campaigns, Enforcing traffic regulations and laws are necessary.

3- The central public market on Abu Bakre Street reaches out to particular places on Bilal street . **Therefore** encroachments must be removed from this street.

4- Several random illegal humps are existed along the street, that must be removed and replaced by legal artificial humps.

b) Al Huda Mosque Street (Alternative –2) :

Al Huda Mosque Street is the second alternative to Abu Barker street to carry flow from west to east as follows:

- From west to east along Al Huda Mosque Street.
- Turn toward the south from the intersection of Al Huda street with Omar Ibn Al Khattab street, to the intersection of Omar Ibn Al Khattab street with Bier Quishta Street.
- Turn toward the east to the intersection of Bier Quishta street with Uthman Ibn Affan street.
- Turn toward the north to the intersection of the Eastern Taxi Station ETS.

Problem (1) : Congestion on Abu Bakre Street as a vital street penetrating the town center and linking the governorate eastern side by its western side.	**Suggested solution:** *Scenario No.1:* Converting Abu Bakre Street to one way street *Scenario No.2*: Activate Taha Husain street that links the governorate eastern side by its western side. **(as an alternative to Abu Bakre Street).**

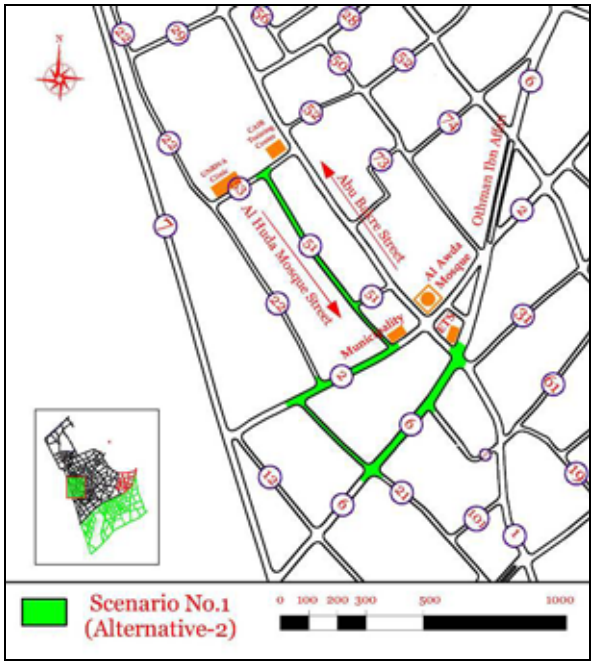


Figure (20) : Scenario no. 1 (Alternative-2)

This alternative has the following advantages :

1- The width of the street is considered enough for the expected traffic use.
2- Population density in the area along the street is relatively low in comparison with other areas.

However it has some disadvantages :

1- The distance from Al Huda Mosque Street to the Eastern Taxi Station (EST) is relatively long.
2- Bad pavement conditions, **Therefore** it is necessary to maintain the pavement.
3- There is a random Taxi station at the UNRWA clinic at the begging of the street. **Therefore** removing this random Taxi station and Enforcing traffic regulations and law application are necessary.
4- The street is narrow at its intersection with Omer Ibn Al Khatab street because of the existence of the municipality garage opposite to the Electricity company garage .
5- There is a storm water drainage problem along the street, **Therefore** a local drainage system is proposed.

Problem (1) : Congestion on Abu Bakre Street as a vital street penetrating the town center and linking the governorate eastern side by its western side.	**Suggested solution:** *Scenario No.1:* Converting Abu Bakre Street to one way street *Scenario No.2*: Activate Taha Husain street that links the governorate eastern side by its western side. **(as an alternative to Abu Bakre Street).**

Scenario No.2

Activate Taha Husain street that connects the governorate eastern side to it's western side is the second scenario. This is expected to reduce traffic congestions on Abu Bakre Street .

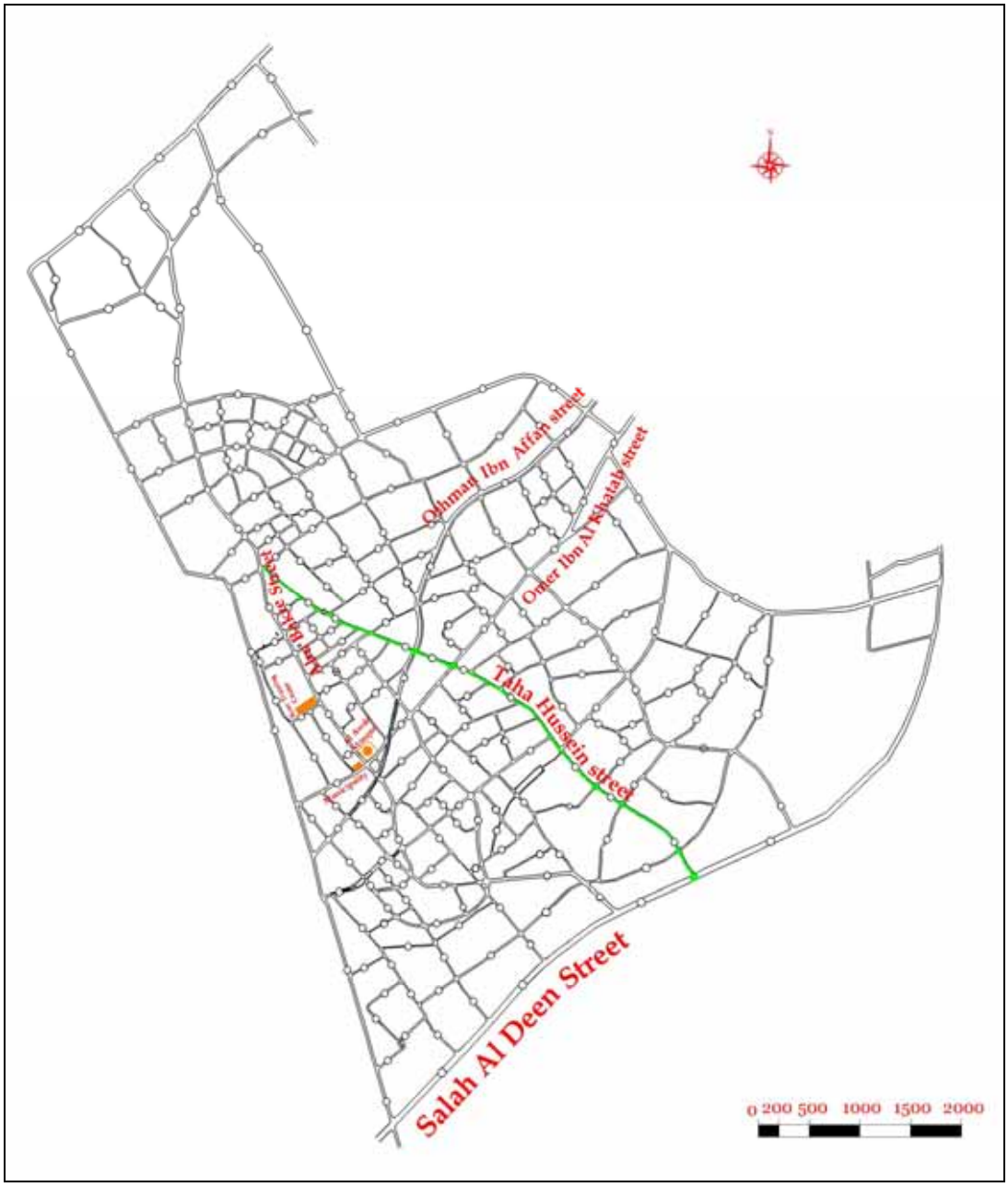


Figure (21) : Taha Husain street

Problem (1) : Congestion on Abu Bakre Street as a vital street penetrating the town center and linking the governorate eastern side by its western side.	**Suggested solution:** *Scenario No.1:* Converting Abu Bakre Street to one way street *Scenario No.2*: Activate Taha Husain street that links the governorate eastern side by its western side. **(as an alternative to Abu Bakre Street).**

The Scenario has the following advantages :

1- Drivers travelling to the western part of Rafah are encouraged to use Taha Husain street to reach their destination directly without crossing the town center. This can strongly ease traffic bottlenecks there.

2- In the case of activating Taha Husain street , it will be possible to move (Tul Al Sultan) Taxi station from the Civil Defense Center intersection to Taha Husain street itself, in order to alleviate congestion at the Civil Defense Centre intersection.

3- Activation of Taha Husain street will contribute in reviving the street surrounding area.

However it has some disadvantages :

1- No incentives or facilities are available on the street which is considered relatively far away from the town center, **therefore** Establishing a new commercial center, Establishing a health care center at the beginning of the street and Paving the sidewalks of the street are suggested in order to activate it.

2- There are two primary schools along the street, **therefore** it is recommended to move school gates to the minor streets.

3- High density of population along the street, **therefore** awareness campaigns, enforcing traffic laws and regulations and implementation of necessary legal artificial humps by Municipality according to specifications as needed are necessary.

Problem (1) : Congestion on Abu Bakre Street as a vital street penetrating the town center and linking the governorate eastern side by its western side.	**Suggested solution:** *Scenario No.1:* Converting Abu Bakre Street to one way street *Scenario No.2*: Activate Taha Husain street that links the governorate eastern side by its western side. **(as an alternative to Abu Bakre Street).**

In order to evaluate the suggested alternatives two strategies were considered:

Modelling:

By using *CONTRAM* software the results were:

Abu Bakre Street with Do Nothing option: V/C = 0.78 – 1.04 (From east to west)
0.53 – 0.99 (From west to east)

Convert Abu Bakre Street to one way street (From east to west) :
V/C for Abu Bakre Street = 0.25 – 0.43

Activate Taha Hussein street: V/C = 0.31 - 0.5 (From east to west)

Where V/C= (Traffic flow at the peak hour /Capacity)

Street users opinion:

Questionnaires were distributed to street users (Note Annex 11,12), the results were as follows:

Do you think that the conversion of Abu Bakre Street to one way street will alleviate the traffic congestion in the city center:

The Sample	The entire sample	Frequency of the sample that answered (Yes)	Percentage
Drivers	**184**	**122**	**% 66.3**
Pedestrians	**319**	**242**	**% 75.9**
Shop owners	**97**	**58**	**% 59.8**
Peddlers and temporary stall owners	**120**	**77**	**% 64.2**
Total	**720**	**499**	**% 69.3**

If the answer is (Yes) in which direction do you suggest traffic to travel on Abu Bakre Street:

Sample / **Suggestions**	Drivers	Pedestrians	Shop owners	Peddlers and temporary stall owners	**Total**
	184	**319**	**97**	**120**	**207**
	Percentage (%)				
East to West	**46%**	**58%**	**51%**	**51%**	**53%**
West to East	**20%**	**17%**	**13%**	**12%**	**17%**

Problem (1) : Congestion on Abu Bakre Street as a vital street penetrating the town center and linking the governorate eastern side by its western side.	**Suggested solution:** *Scenario No.1:* Converting Abu Bakre Street to one way street *Scenario No.2*: Activate Taha Husain street that links the governorate eastern side by its western side. **(as an alternative to Abu Bakre Street).**

If the answer is (East to West), what is the preferable alternative:

Sample / Suggestions	Drivers	Pedestrians	Shop owners	Peddlers and temporary stall owners	Total
	184	**319**	**97**	**120**	**720**
	Percentage (%)				
Al Huda street	**16%**	**19%**	**19%**	**14%**	**17%**
Al Eaida street	**3%**	**5%**	**1%**	**5%**	**4%**
Bilal Street	**27%**	**33%**	**30%**	**32%**	**31%**
Taha Hussein street	**0%**	**2%**	**1%**	**0%**	**1%**

If the answer is (West to East), what is the preferable alternative:

Sample / Suggestions	Drivers	Pedestrians	Shop owners	Peddlers and temporary stall owners	Total
	184	**319**	**97**	**120**	**720**
	Percentage (%)				
Al Huda street	**5%**	**6%**	**4%**	**5%**	**5%**
Al Eaida street	**3%**	**1%**	**2%**	**1%**	**2%**
Bilal Street	**11%**	**9%**	**7%**	**6%**	**9%**
Taha Hussein street	**1%**	**1%**	**0%**	**0%**	**1%**

Do you think that the activation of Taha Hussein street will alleviate the traffic congestion in the city center:

The Sample	The entire sample	Frequency of the sample that answered by (Yes)	Percentage
Drivers	**184**	**83**	**% 45.1**
Pedestrians	**319**	**191**	**% 59.9**
Shop owners	**97**	**42**	**% 43.3**
Peddlers and temporary stall owners	**120**	**61**	**% 50.8**
Total	**720**	**377**	**52%**

Problem (1) : Congestion on Abu Bakre Street as a vital street penetrating the town center and linking the governorate eastern side by its western side.	**Suggested solution:** *Scenario No.1:* Converting Abu Bakre Street to one way street *Scenario No.2*: Activate Taha Husain street that links the governorate eastern side by its western side. **(as an alternative to Abu Bakre Street).**

This evaluation leads to the conclusion that the conversion of Abu Bakre Street to a one way street from east to west and using Bilal street as an alternative to travel from west to east is the best solution.

This alternative is suggested for implementation in the short term phase. The other alternative "Activation of Taha Hussein street" is suggested to be implemented in the intermediate and long term phase, the results of the questionnaire sample indicates the followings:

- *About 23% support the improvement of the street geometric properties that include widening, patching, controlling, lightening and Taxi stations.*
- *About 16% support the construction of public facilities such as markets, petrol stations, places for entertainment and public institutions.*
- *The remained percentage had different suggestions such as vegetation, awareness and construction of housing projects.*

Problem (2): There are only two entrances for Rafah Governorate . This is expected to have adverse effect on the traffic system in future.	**Suggested solution:** Activate Othman Ibn Affan northern entrance as a third entrance to Rafah.

Problem Details:

Omer Ibn al Khatab and Salah Al Deen streets represent the main two entrances for Rafah Governorate. In future this is expected to cause delay and congestion of traffic.

Suggested Solution Details:

Activate Othman Ibn Affan northern entrance as a third governorate entrance is the proposed solution to be implemented in the long term.

In order to activate Othman Ibn Affan northern entrance as a third governorate entrance the following requirements should be achieved :

1- Paving the unpaved part of the street (about 1000 m) .
2- Place traffic signs indicating that this is an entrance to Rafah city.
3- Establishing incentives or facilities along this street.
4- The street penetrates a refugee camp with high population density. So awareness campaigns, Enforcing traffic regulations and law application are necessary.

Problem (2):	**Suggested solution:**
There are only two entrances for Rafah Governorate . This is expected to have adverse effect on the traffic system in future.	Activate Othman Ibn Affan northern entrance as a third entrance to Rafah.

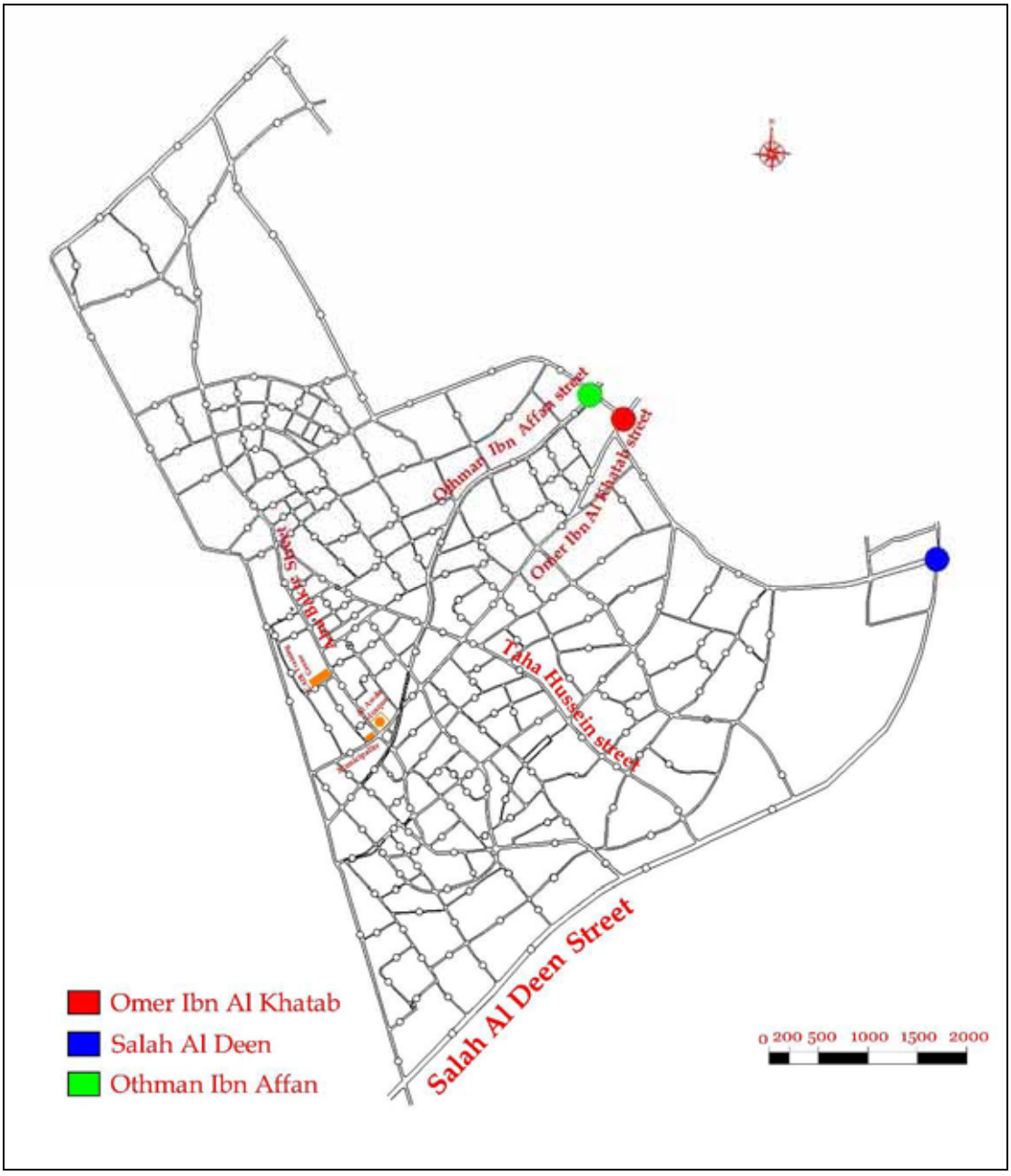


Figure (22) : Rafah entrances

Problem (3):	Suggested solution:
Absence of ring roads in Rafah Governorate.	Two actions should be considered in order to deal with this problem: a) Activate Taha Hussein Street. b) Maintain Streets No. (22,29,49).

Problem Details:

The road network in Rafah governorate consists of arterial and collector streets and there are no ring roads that help drivers to avoid the city center congestion .

Suggested solution Details:

Two actions should be considered in order to deal with this problem:

a) Activate Taha Hussein Street.

b) Rehabilitate and maintain Streets No. (22,29,49).

These streets form a ring road around the center, This can be illustrated as follows:

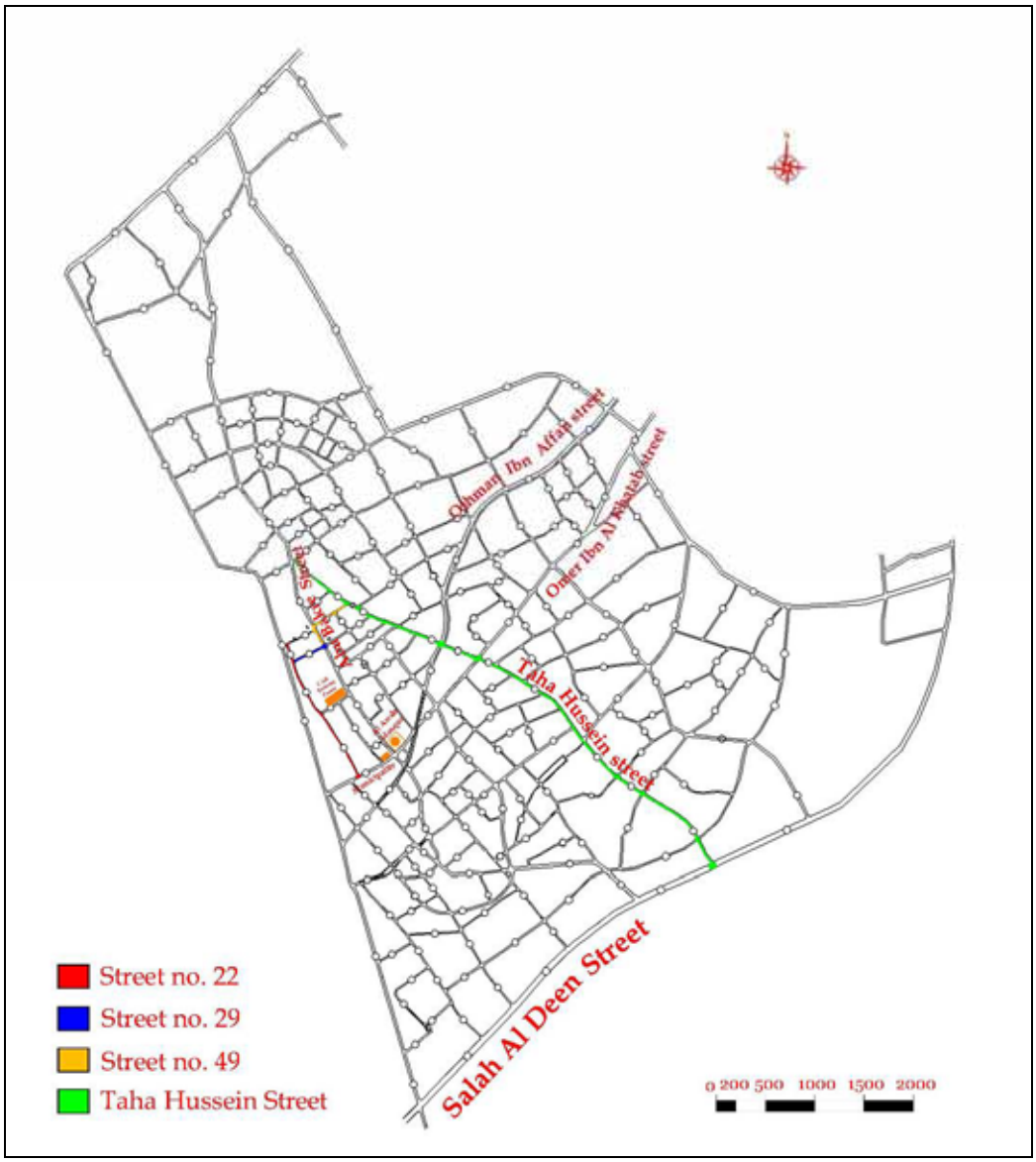


Figure (23) : Streets No. (22,29,49).

Problem (4) :	Suggested solution:
No existence of a paved road that links the northern side of Al Shoka region to its southern side.	Rehabilitate or construct the best alternative by coordination with Al Shoka Municipality. And that will be developed in the long Term phase.

Problem Details:

The road network in Al Shoka region consists of several unpaved (east-west) streets and no paved roads that links the northern side of the area to its southern side.

Suggested solution Details:

Rehabilitate or construct a north to south road by coordination with Al Shoka Municipality.

The Municipality proposed rout is illustrated in the following figure:

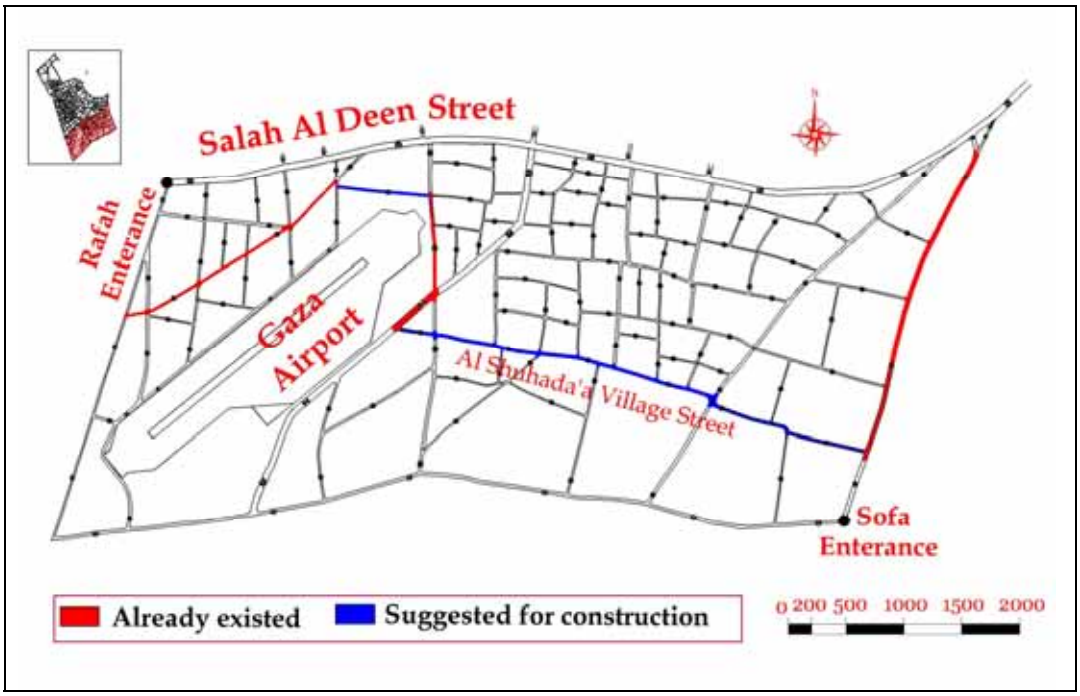


Figure (24) : road links the northern side of Al Shoka area to its southern side

Problem (5):	Suggested solution:
Structural and Geometric problems in the network	Network maintenance.

Problem Details:

There are a lot of Structural and Geometrical problems in Rafah network which cause confusion in the traffic system.

Suggested solution Details:

The following list clarify the urgent road rehabilitation needs for Rafah Governorate:

Road Resurfacing and/or patching

- Road (No 16) in Al Shoka area
- Road No. (1) in Al Shoka
- Road No. (66) in Al Shoka
- Mashro' Amer street
- Al Passateen Street (No. 15)
- Al Teena
- Al Rebat (in Al Nasser Area)
- Al Huda Mosque Street
- Street No. (53) in Rafah city
- Beer Qeshta

Rehabilitation of Drainage system

- Al Huda Mosque Street
- Abu Bakre(CAIR-Rab'a)
- Al Jam'a Intersection
- Abu Bakre(Al Berka)
- Abu Baker-Ibn Seena Intersection
- Abu Ussief Al Najaar

The following figures illustrate the urgent road rehabilitation needs for Al Nasser, Rafah and Al Shoka streets respectively:

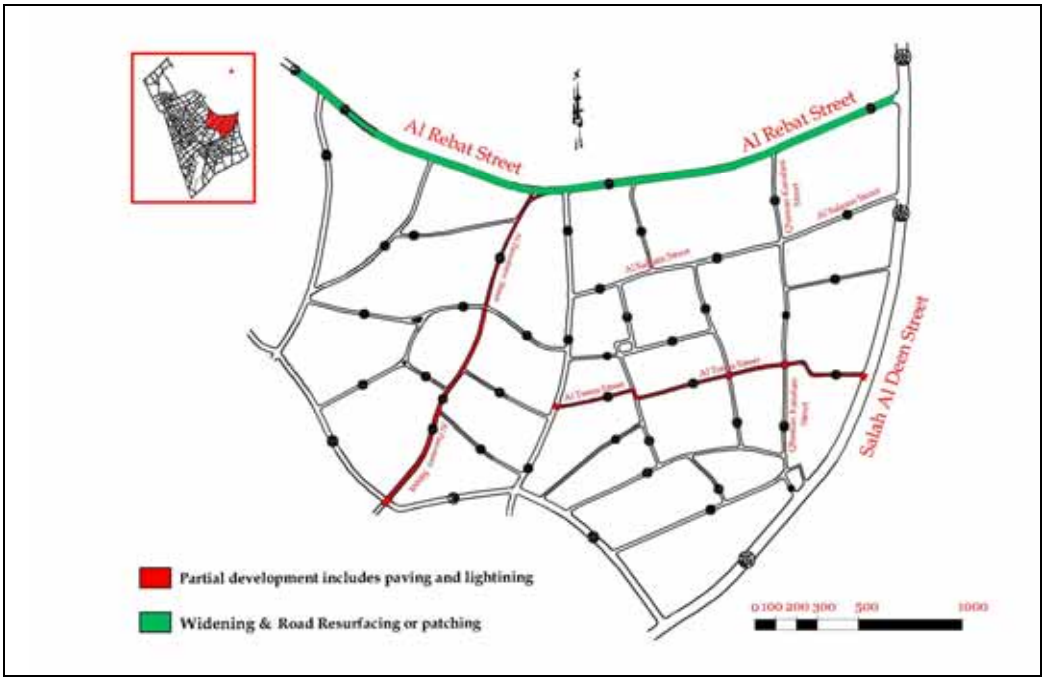


Figure (25) Al Nasser Area

Problem (5):	Suggested solution:
Structural and Geometric problems in the network	Network maintenance.

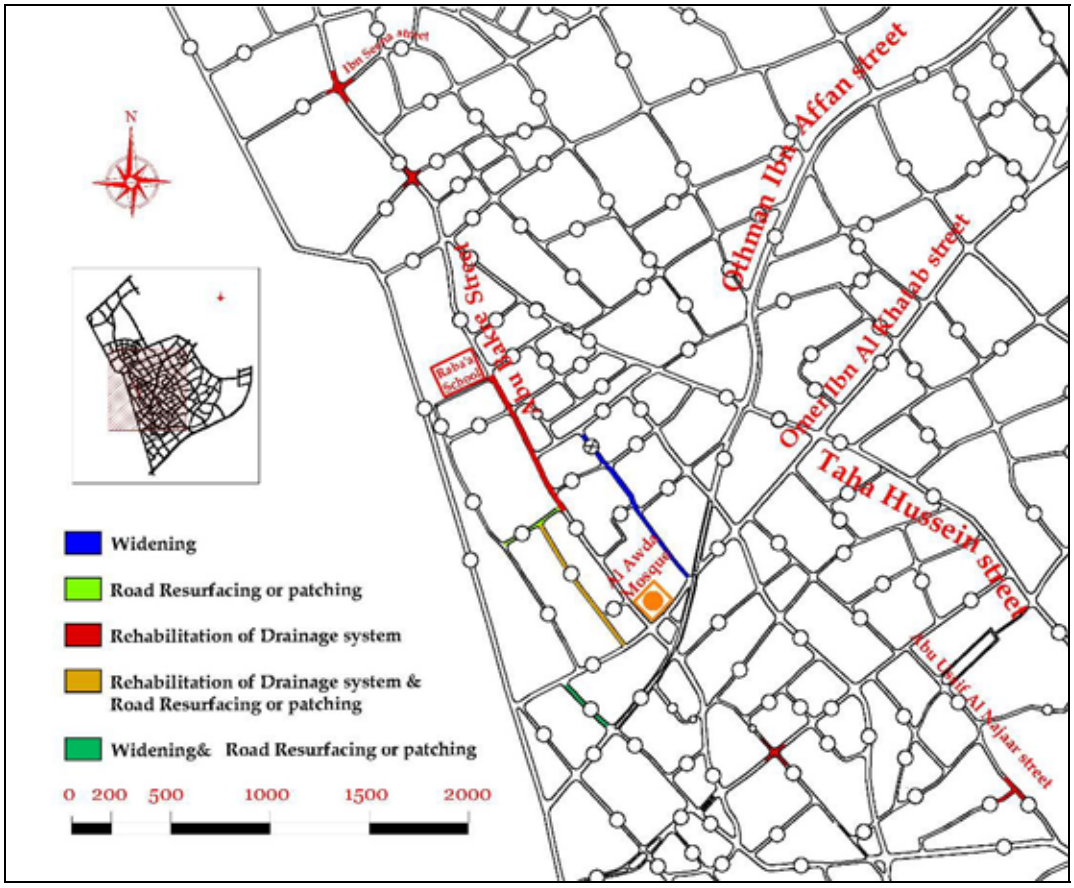


Figure (26) Rafah City

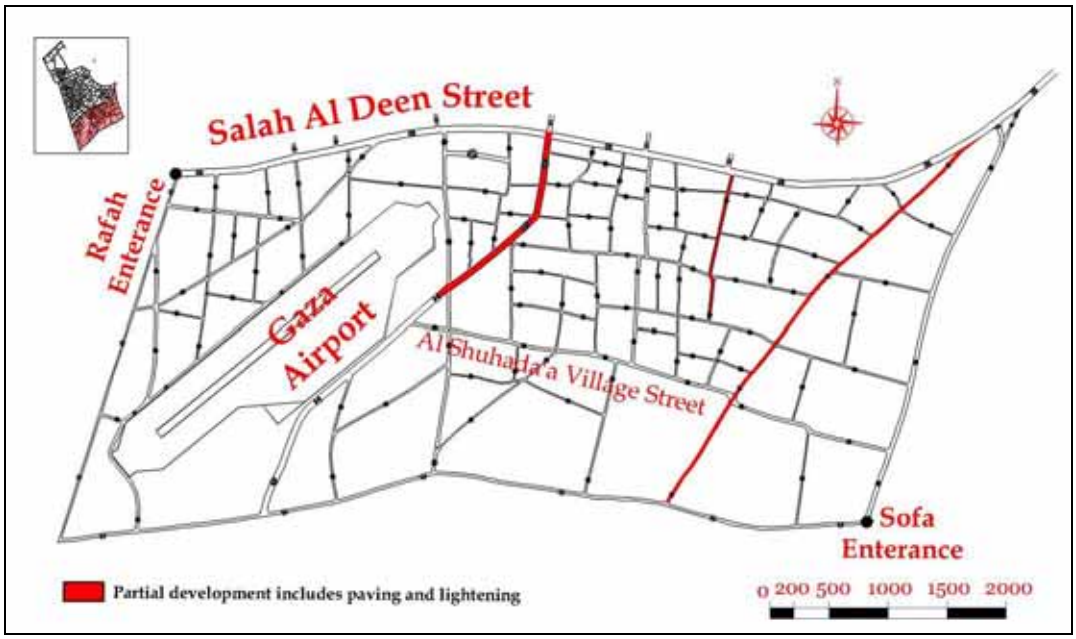


Figure (27) Al Shoka City

8.1.2 Road Intersection Development:

Intersections present the main problem in traffic congestion. The targeted area undergoes a sever problem in traffic control method which lead to huge delay at road intersections. Uncontrolled loading and unloading by taxies play an important role in increasing the size of the problem at intersections. Disruption of traffic movement and delay of traffic flow. Indeed, market booths invading road lanes had caused general disturbance for road users, drivers and pedestrians.

Installing new traffic signals and redesigning some of the existing intersections as roundabouts and adding auxiliary lanes is expected to help relieving some of the current congestion at peak hours, reducing potential conflict points and provide diverging lanes and waiting spaces for vehicles. Lighten

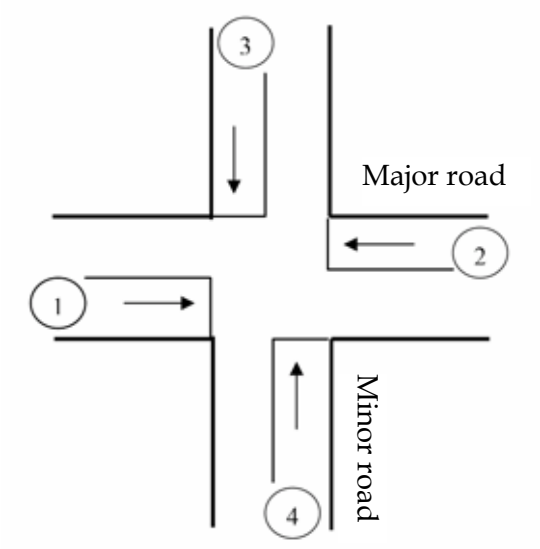
A decision on the installation of traffic signals may be made on the basis of traffic flow, pedestrian safety accident experience, and the elimination of traffic conflict.

For traffic flow:

Traffic signals are justified if the following traffic flow exists for eight hours on an average day:

Flow on the major road (①+②) ≥ 900 vehicles/hour and

Flow on the minor road ③or ④ ≥ 100 vehicles/hour.



For Pedestrian safety:

Signal control offers considerable assistance to pedestrian movements. The Department of Transport in the UK advises that a pedestrian stage is required:

- if pedestrians across any arm of the junction is ≥ 300 pedestrians/hour
- if turning traffic flow into any arm has an average headway of < 5 seconds and conflicting with a pedestrian flow of ≥ 50 pedestrians/hour.

The Manual on Uniform Traffic Control Devices (MUTCD) lists several sets of conditions that warrant the installation of a traffic signal:

- Traffic volume on intersecting streets exceeds values specified in the MUTCD.
- The traffic volume on the major street is so heavy that traffic on the minor intersecting street suffers excessive delay or hazard in entering or crossing the major street.
- Vehicular volumes on a major street and pedestrian volumes crossing that street exceed specified levels.
- Inadequate gaps
- Peak hour
- School crossing
- Coordinated signal system
- Crash experience

Intersections in Rafah Governorate do not have a good control system such as signals, roundabouts or priority system. The decision of the working team in preparing the RTMP for selecting a control strategy is done based on the flow counted in 2007 and on the flow estimated in 2012, 2020 and 2030.

For the flow counted in 2007: the flow on any major road does not exceed 900 veh/hr. Therefore the signal is not needed in the current situation. The Stop-Sign or Give-Way control system at all intersections in Rafah is needed for safety consideration. For safety consideration some measures should be conducted in order to avoid problems in specific location as follows:
It is needed to install a signal at Awad-Tower intersection for safety considerations (Horizontal site distance), Installing hump at the intersection of Abu Bakre Street with street No. (52),note annex (13) and Redesign of Zo'rob intersection by using Channelization, note Annex (13)

For future situation and based on the flow estimated using CONTRAM software in 2012 , In addition to the previous measures It is needed to install a traffic signal at both Abu Baker-Omar Ibn Al Khatab and Abu Baker-Othman Ibn Affan intersections. At all other intersections a Stop-Sign or Give-Way control system is suggested.

In 2020, the signal control is suggested at the same three intersections and at more two intersections; Abu Baker-Street with street No. (40) and Omar Ibn Al Khatab-

Taha Hussein intersections. For all other intersections priority intersection (Stop or yield signs) are proposed.

Finally, according to flow estimated in 2030, no more signal intersections are needed.

An example of signalized intersection design (Abu Baker-Omar Ibn Al Khatab intersection) by using SIDRA software is clarified in Annex (14) .

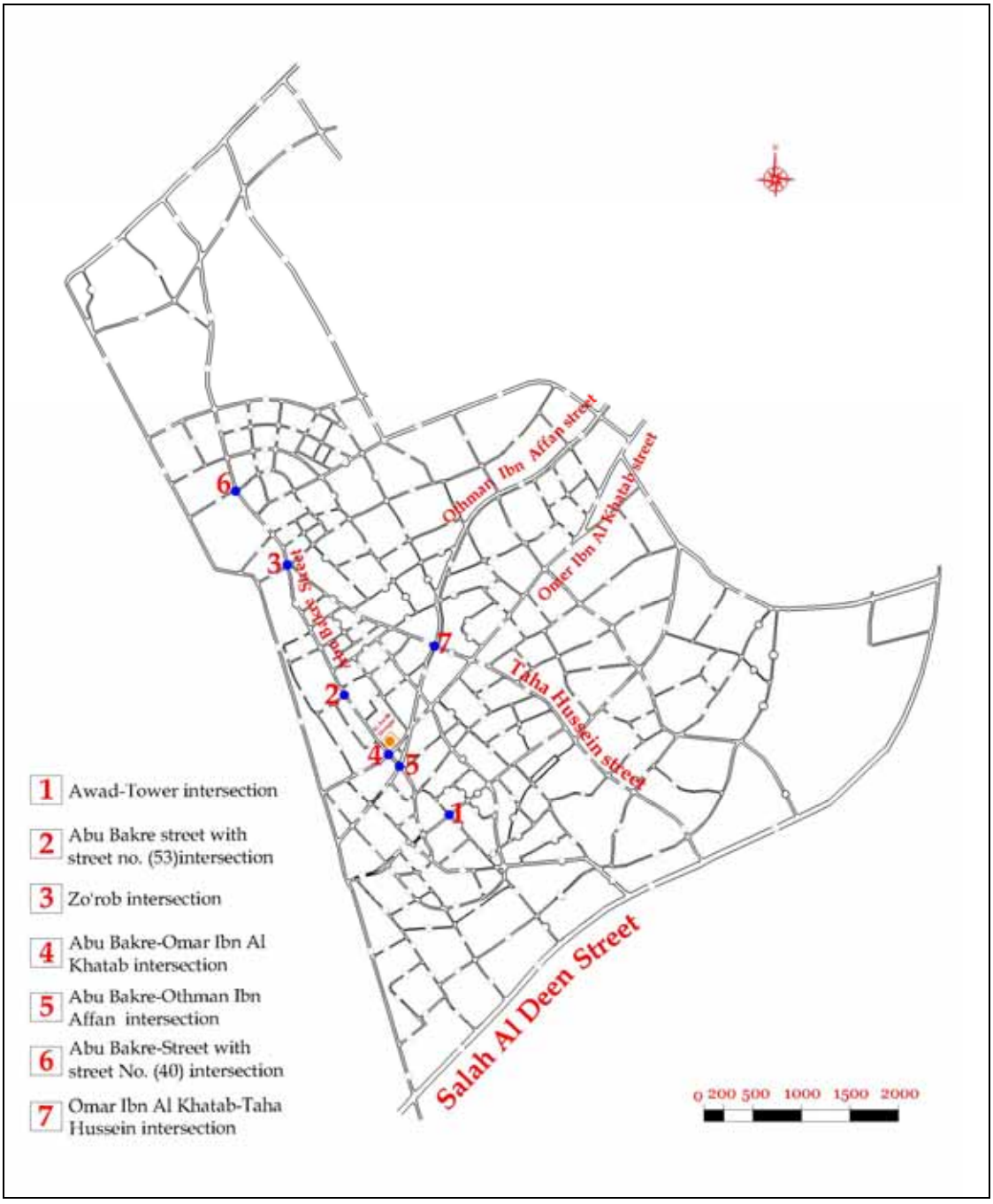


Figure (28) Intersections Development Plan

8.1.3 Markets

The RTMP studied the current public markets and market booths and concluded that the location of the markets is not suitable whether in location or concentration.

In this regard two problems were being faced:

Problem (1) : Saturday Market	**Suggested solution:** Moving the market to another suitable area.

Problem Details:

Every Saturday, encroachments of shops bordering the distance between Al-Awda intersection (Omer Ibn Al Khatab Arm) to Bier Quishta street, peddlers and temporary stalls established in the specified area, totally occupy the street.

These activities cause disruption in Al Awda intersection (Omar bin Al khattab – Bier Quishta Arm) and lead to:

- Disruption of public services located in the street.
- A very difficult bottleneck at Al Awda intersection, especially at the peak hour.

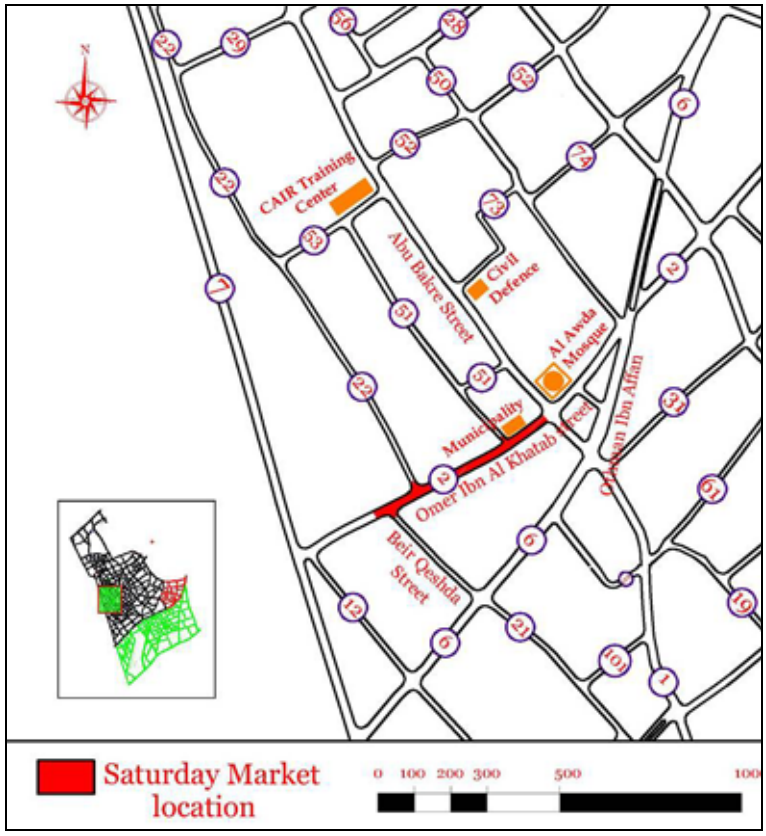


Figure (29) Saturday Market Location

Problem (1) :	Suggested solution:
Saturday Market	Moving the market to another suitable area.

Suggested solution Details:

Moving the market to another suitable location that has little adverse effect on traffic conditions in the town center.

Alternatives

Alternative (1): Othman Ibn Affan Street beside Beer Al Saba' secondary school.

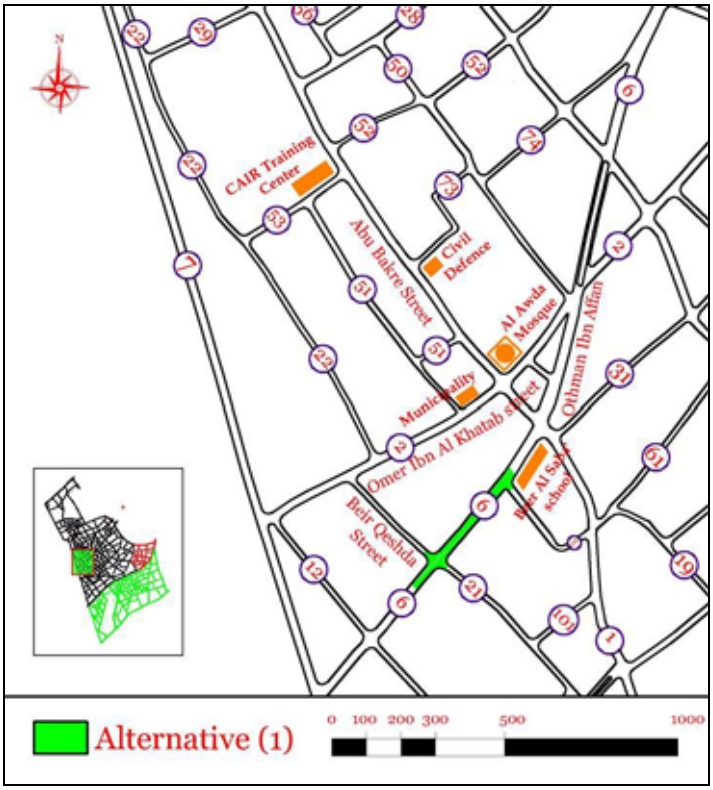


Figure (30) Saturday Market Alternative (1)

This alternative has the following advantages :

1- Othman Ibn Affan Street has a suitable width.
2- No public services located in the selected location.
3- The traffic flow in this location is low.
4- The selected area is not far from the current location of the Saturday Market, about 100m, which makes it easy for users to move to the new selected place.

However it has some disadvantages :

1- There is Al Saba' secondary school which overlook the specified area, **therefore** it is necessary to use the door overlooking Abu Bakre Street to the north of the eastern Taxi station instead of the door overlooking

Problem (1) :	Suggested solution:
Saturday Market	Moving the market to another suitable area.

the selected area.

2- Persuading sellers to move their stalls to the new selected area will be a difficult task. So it is necessary to Providing incentives at the new market and Enforcement laws and regulations.

Alternative (2): Al Shuara Market is the second proposed site as an alternative place for Saturday market.

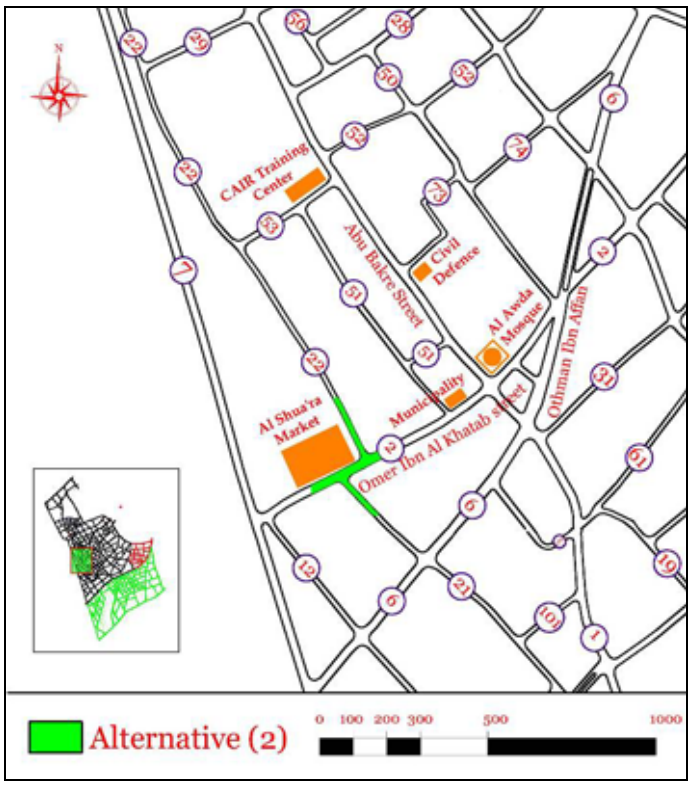


Figure (31) Saturday Market Alternative (2)

This alternative has the following advantages :

1- The market is already existing.

2- The selected site is very close to the current one.

However it has some disadvantages :

1- Al Shuara Market was damaged by occupation, therefore it is necessary to rehabilitate the site.

2- There is a probability that the encroachments may expand and reach to the current site, therefore it is necessary to implement measures to ensure the enforcement of laws and regulations.

Problem (1) :	Suggested solution:
Saturday Market	Moving the market to another suitable area.

In order to evaluate the suggested alternatives two strategies were considered:

Modelling:

Using of **CONTRAM** software the results were as follows:

Do Nothing option (Saturday market on Abu Bakre Street):

V/C = 0.94 – 1.14

On other days V/C = 0.78 – 1.04

Do Nothing option (Omer Ibn Al Khatab from Al Nijma intersection to the Eastern Taxi Station EST):

V/C = 0.47

On the remained week days V/C = 0.23

Where V/C= (Traffic flow at the peak hour /Capacity)

Street users opinion:

Questionnaires distributed to the street users (Note Annex 11, 12), had the following results:

Which place do you prefer Saturday market to be moved:					
Sample / Suggested place	Drivers	Pedestrians	Shop owners	Peddlers and temporary stall owners	Total
	184	319	97	120	719
	Percentage (%)				
No suggestions	2.7	3.8	6.2	11.7	5.2%
Al Najma	2.7	2.5	8.2	5.0	3.7%
The settlements	0.5	0.0	1.0	0.8	0.4%
Al Halal area	0.0	0.3	0.0	0.0	0.1%
Al Jawazat	0.0	0.3	0.0	0.0	0.1%
Al jenaina	0.0	0.9	1.0	0.8	0.7%
Al Hodood	9.2	8.2	12.4	7.5	8.9%
Al Sultan	1.1	0.6	0.0	0.0	0.5%
The eastern area	0.5	0.9	0.0	1.7	0.8%
Al Seca	35.3	23.8	16.5	24.2	25.9%
Al Shua'ra	47.3	56.4	53.6	48.3	52.4%
The western area	0.5	1.6	1.0	0.0	1.0%
Taha Hussein	0.0	0.6	0.0	0.0	0.3%

This evaluation lead to the conclusion that the best solution is to Move Saturday market gradually to Al Shuara market area.

Second Problem:	Suggested solution:
central market	Activate other markets in the Governorate

Problem Details:
The central market is existing in a congestion point on Abu Bakre Street which makes shopping difficult and increase the congestion.

Suggested solution Details:
The Activation process is to involve the following Markets:

Market	Location	Activation Mechanism
Al Sultan	Tul Al Sultan, at the beginning of Ibn Sina street.	- More municipality services, cleaning, vegetation, etc… - Adopt a new policy to reopen municipality stores at the market square .
Al Shua'ara	The intersection of Omar Ibn Al Khatab street with Bier Quishta street	- Rehabilitating the market . - Improving more services and facilities by municipality. - Enforcing laws and regulations.
Al Brazil	To the east of Bahloul towers beside the borders	- Rehabilitating the market . - Improving more services and facilities by municipality.

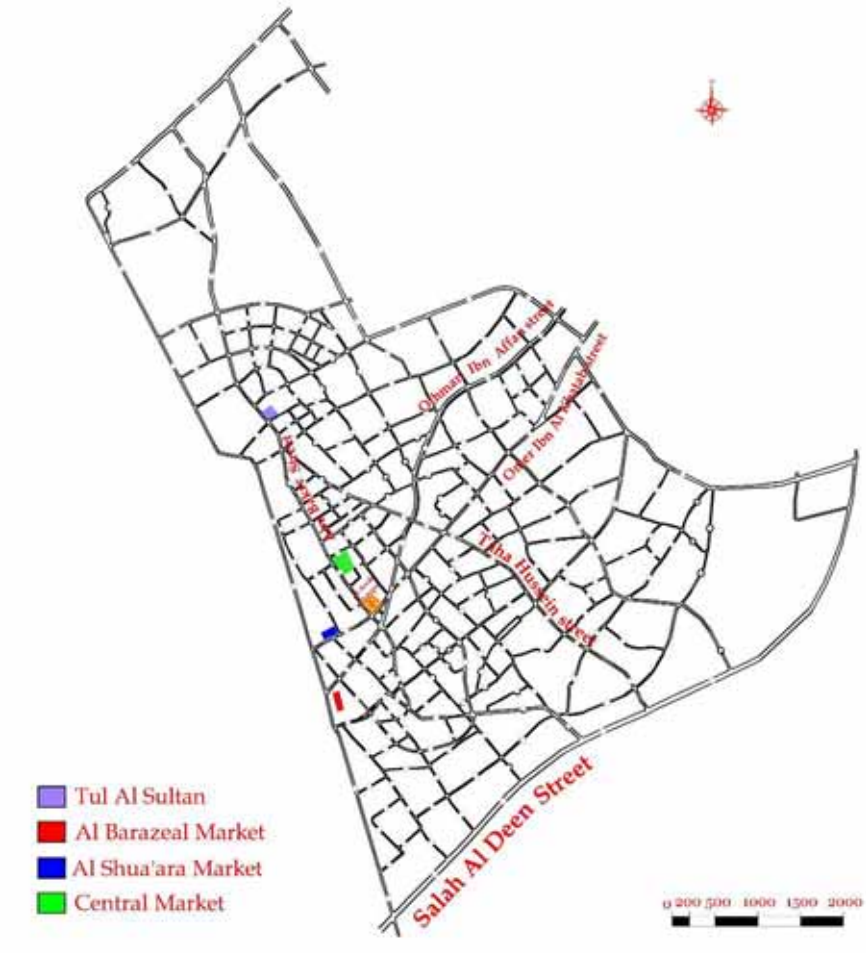


Figure (32) Rafah Markets

Second Problem:	Suggested solution:
central market	Activate other markets in the Governorate

And in the conducted questionnaire people were asked about the construction of a new market far from the city center, and the answers were as follows:

Do you support the construction of a new market far from the city center:			
The Sample	The entire sample	Frequency of the sample that answered by (Yes)	Percentage
Drivers	**184**	82	% 44.6
Pedestrians	**319**	162	% 50.8
Shop owners	**97**	48	% 49.5
Peddlers and temporary stall owners	**120**	47	% 39.2

If the answer is (Yes) in which place do you suggest to construct the new market:					
Sample / Suggested place	**Drivers**	**Pedestrians**	**Shop owners**	**Peddlers and temporary stall owners**	**Total**
	184	**319**	**97**	**120**	**719**
	Percentage (%)				
No suggestions	59.8	52.7	62.9	62.5	57.5%
Al Mauasi	0.0	0.0	1.0	0.0	0.1%
The Settlement	1.1	0.0	0.0	0.0	0.3%
Al Brazil	0.0	0.3	0.0	0.0	0.1%
Al Jawazat	2.7	3.8	2.1	2.5	3.1%
Al Jenaina	6.0	8.2	4.1	2.5	6.1%
Al Hodood	2.2	3.8	8.2	9.2	4.9%
Al Sutan	16.3	16.6	13.4	11.7	15.3%
The eastern area	3.8	6.6	3.1	5.0	5.1%
The Saudi area	1.6	0.3	0.0	0.0	0.6%
Al Shua'ra	0.0	0.0	2.1	0.0	0.3%
The Western area	1.1	1.9	2.1	0.8	1.5%
Taha Hussein	5.4	6.0	1.0	5.8	5.1%

8.1.4 Taxi Station :

This development plan (RTMP) made a survey to obtain the information required to make an assessment of the Taxi station problems in the target area. The survey concluded detailed information regarding the number of taxi spaces available .

The study showed that the location of current Taxi stations causes confusion in the main streets of Rafah Governorate , Therefore a taxi station development plan is suggested in order to regulate Taxi services, as follows:

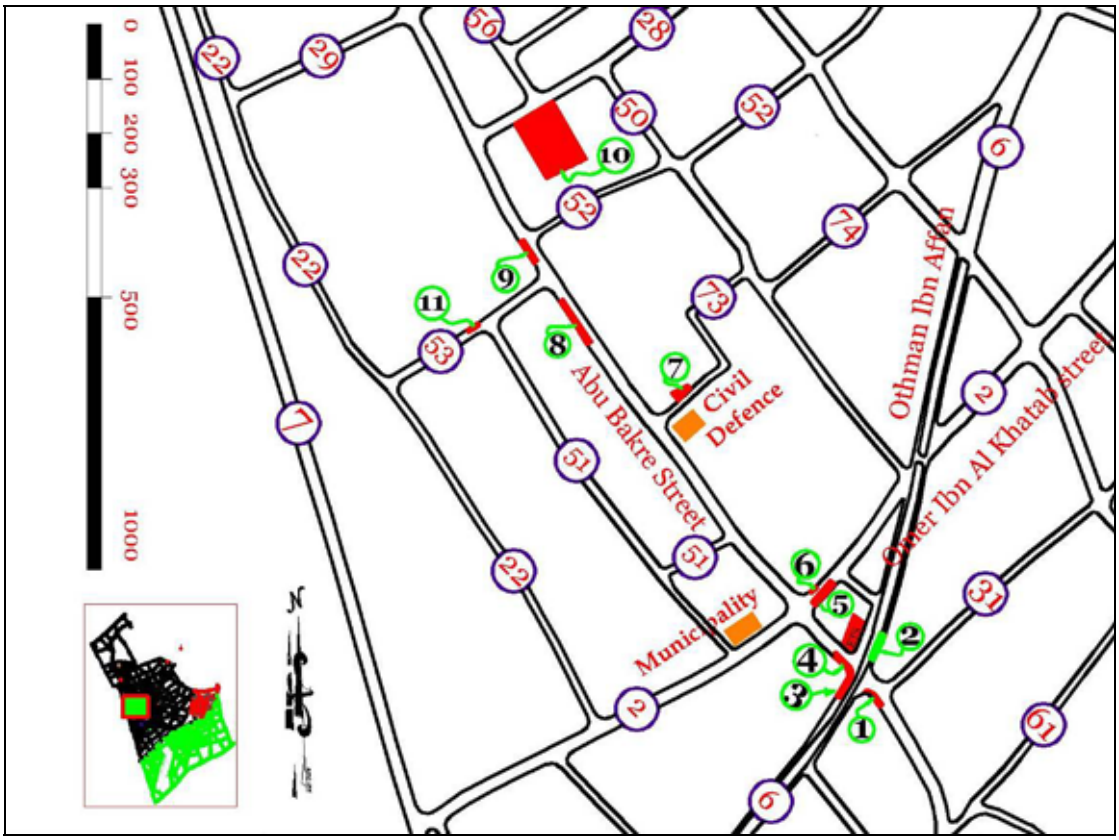


Figure (33) Taxi stations Development Plan

Table (10): Taxi Station Development Plan

Lot No.	Destination	Suggestions for Arrangement
1	European Hospital	Move to Taxi station No.3
2	Gaza	Move to the Eastern Taxi Station.
3	Eastern area (brazil , Jneina, Kherba localities)	- Improve facilities. - Make expansions. - Enforce laws and regulations
4	Khan Younis	- Move to Taxi station No. 5
5	Khan Younis	- Enforcing laws and regulations.
6	Al Kherba	- Move to Taxi station No. 3
7	Eastern area	- Remove
8	Gaza	- Move to the eastern Taxi station.
9	Buses Taxi station	- Enforcing laws and regulations .
10	Western area (Tal Al Sultan , The sea)	- Move to Bier Salem intersection connected with Taha Husain street. - Enforce laws and regulations.
11	City Center	-Remove.

To evaluate this suggestions questionnaires were distributed, and the feedback was:

Do you support the removing of Al Orobi and the eastern area taxi stations that located on front of Al Awda Mosque and move it to the Eastern Taxi Station where vehicles heading to the eastern area are stationed :			
The Sample	The entire sample	Frequency of the sample that answered (Yes)	Percentage
Drivers	**184**	156	% 84.8
Pedestrians	**319**	294	% 92.2
Shop owners	**97**	86	% 88.7
Peddlers and temporary stall owners	**120**	107	% 89.2

Do you support the removing of Gaza Taxi Station located on front of Al Qahera-Amman bank and moving it to the Eastern Taxi Station:			
The Sample	The entire sample	Frequency of the sample that answered (Yes)	Percentage
Drivers	**184**	139	% 75.5
Pedestrians	**319**	264	% 82.8
Shop owners	**97**	74	% 76.3
Peddlers and temporary stall owners	**120**	93	% 77.5

Do you support the removing of Khan Younis Taxi Station located on the Eastern Taxi Station and move it to the to Khan Younis Taxi Station that located on front of Al Awda Mosque:			
The Sample	The entire sample	Frequency of the sample that answered (Yes)	Percentage
Drivers	**184**	91	% 49.5
Pedestrians	**319**	153	% 48.0
Shop owners	**97**	47	% 48.5
Peddlers and temporary stall owners	**120**	69	% 57.5
Do you support moving the Eastern Area Taxi Station located on front of the central market and UNRWA Clinc Taxi Station to the Western Taxi Station:			
The Sample	The entire sample	Frequency of the sample that answered by (Yes)	Percentage
Drivers	**184**	96	% 52.2
Pedestrians	**319**	189	% 59.2
Shop owners	**97**	46	% 47.4
Peddlers and temporary stall owners	**120**	71	% 59.2

8.1.5 Parking :

Parking control is now in many countries the key to proper traffic control and transport policy implementation. A survey was conducted to obtain the information required to design an assessment of the parking problem in the targeted area. The survey concluded detailed information regarding the low number of parking spaces available taking into consideration the rate of increment in vehicle numbers.

The study suggests a Parking Development plan, as follows:

- Develop a Parking Management Strategy that Supports the City's strategic parking objectives.
- Identify candidate locations for new parking lots owned or operated by the Municipality, for monitoring and analysis
- Establish central parking lots within a reasonable walking distance of several destinations, where required.
- Provide on-street parking that does not compromise the achievement of targeted service level.
- Provide short-term parking to be owned or operated by the Municipality.
- Encourage the private sector to build and operate parking places especially in the city center.
- Consider the use of a multi story car park in the city center.

8.1.6 Pedestrians:

Pedestrians are the major road users. When the system fails, they are the major victim. An objective of this study is to provide the proper safe and convenient facilities for pedestrians. The pedestrian facilities in Rafah Governorate are suffering from partial damage and encroachments of shops bordering the streets, peddlers and temporary stalls. Some sidewalks are fully occupied to the extent that neither the driver nor the pedestrian can distinguish the road boarder. This plan aims to provide an adequate solution to the pedestrian safety in Rafah city by paving sidewalks and install special facilities such as traffic signs and road markings.

Listed hereinafter some actions to be considered in the **Pedestrian** planning development:

First Problem: Encroachments on pedestrian's Sidewalks	Suggested solution: *Scenario No.1:* Remove encroachments of shops bordering the street, peddlers and stalls. *Scenario No.2*: Change Abu Bakre Street to one way street, widen the pedestrian's Sidewalks and remove the road medians.

Problem Details:

Most of sidewalks and essential parts of pavement in the City Center (Al Awda -CAIR) are lost because of the encroachments of shops bordering the street, peddlers and stalls.

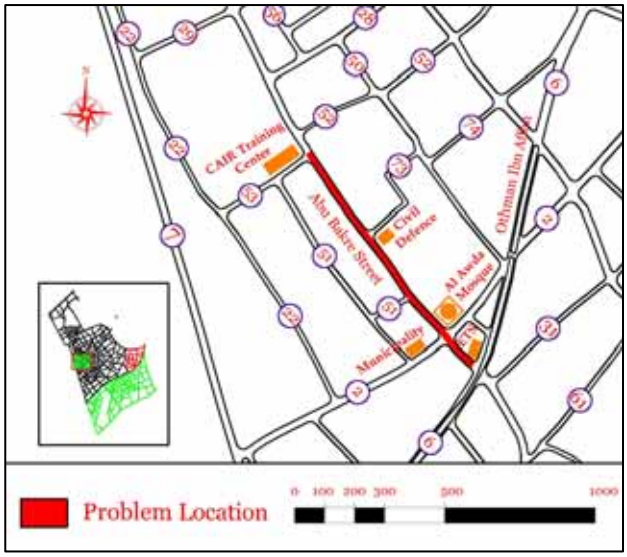


Figure (34) Problem Location

Suggested solution Details:

Scenario No.1: Remove encroachments of shops bordering the street, peddlers and stalls. Which needs awareness campaigns, Enforcing traffic regulations and law application.

Scenario No.2: Change Abu Bakre Street to one way street, widen the pedestrian's Sidewalks and remove the road medians. Which was discussed in details previously (see page 49) .

To evaluate this suggestions questionnaires were distributed, and the feedback was:

Do you support removing the encroachments of shops bordering the street:

The Sample	The entire sample	Frequency of the sample that answered by (Yes)	Percentage
Drivers	**184**	173	% 94.0
Pedestrians	**319**	296	% 92.8
Shop owners	**97**	87	% 89.7
Peddlers and temporary stall owners	**120**	79	% 65.8

Second Problem: Schools gates on Abu Bakre Street .	**Suggested solution:** Move the School gates which are currently on Abu Bakre Street to minor streets if possible.

Problem Details:
Many schools are located on Abu Bakre Street. This result in a conflict between students and vehicles at the time of arrival and departure of students.

Suggested solution Details:
Listed hereinafter Suggestions for schools on Abu Bakre Street:

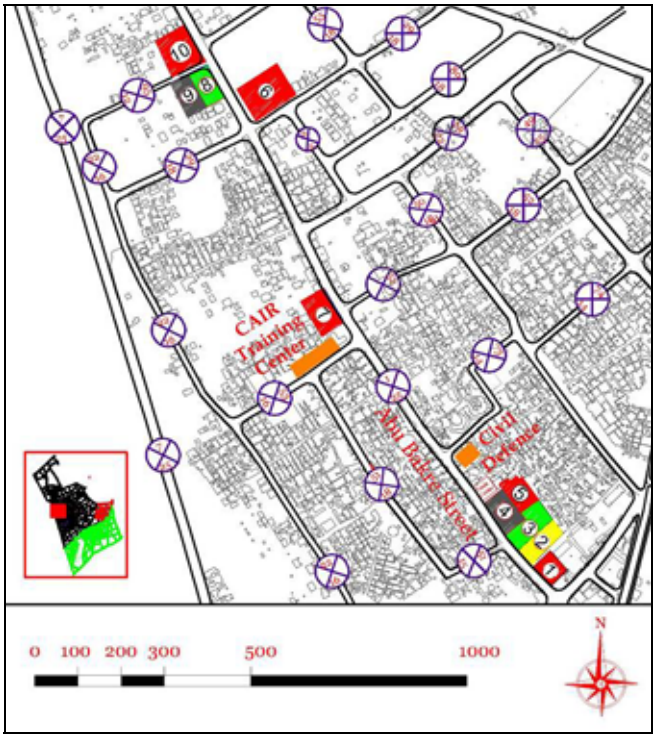


Figure (35) Schools Location

1. **Girls Preparatory E :** Move the main entrance to Al Nady street (Paved – 7m wide)
2. **Al Shuhada:** Move the main entrance to Al Nady street (Paved – 7m wide)
3. **Al Amirieah:** No change.
4. **Amna Bint Wahb:** Move the main entrance to the minor street bordering the school form the west opposite to the commercial center. (Paved – 7m wide)
5. **Al Khansa:** No change
6. **Girls Preparatory B:** Move the main entrance to the minor street bordering the school from the east opposite to Ali Mosque (Paved – 6m wide)
7. **Khawla:** No change
8. **Boys Elementary A:** Move the main entrance to the street bordering the school from the west (Paved- 6m wide)
9. **Elementary Co. C:** No change
10. **Raba'a:** Move the main entrance to the minor street bordering the school from the east (Paved -6m wide), or move the main entrance to the street located behind the school (Unpaved – 4m wide)

Third Problem: Encroachments on Al Eyada street's Sidewalks. *Note* : Al Eyada street = street No.(53)	**Suggested solution:** Convert the street to be limited to pedestrians only.

Problem Details:

Al Eyada Street is crowded by shops, peddlers and stalls which make the pedestrians movement difficult especially with traffic movement on the street. The street is narrow and is not suitable to carry traffic and pedestrians as well as the active shopping area.

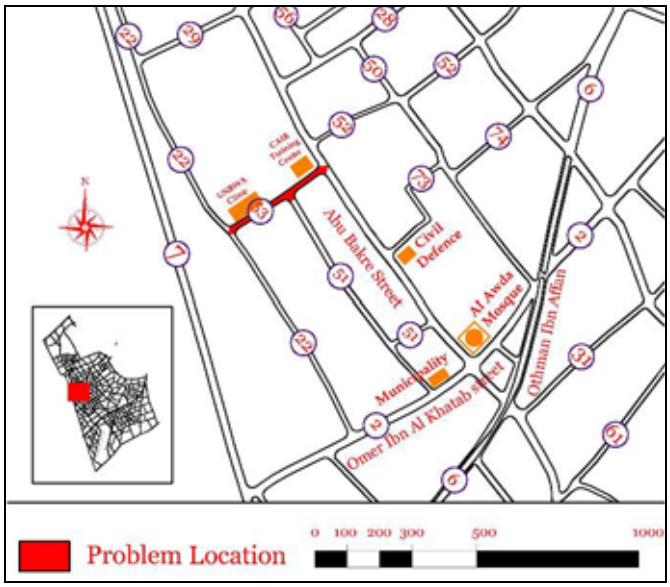


Figure (36) Al Eyada street's problem location

Suggested solution Details:

Convert the street to be limited to pedestrians is the proposed solution that is expected to solve this problem.

8.1.7 Traffic Regulations and Law Enforcement

Regulations and law enforcement are needed in order to enhance the efficiency of the transportation system. The best designed transportation system will be inefficient if the users break the laws that govern the use of the system. The application of enforcement measures in Rafah Governorate will contribute substantially in improving the traffic capacity at the intersections.

There are a lot of indicators for the lack of regulation and law enforcement in Rafah Governorate such as encroachment problems, lack of traffic control system, animal

driven carts problem, etc. Several measures should be carried out in order to get an efficient transportation system. The measures would include the following:

- Review of current enforcement practices and activities and recommend the appropriate enforcement tactics, methods and techniques suitable for use in Rafah. This will improve the effectiveness of traffic policing on the road network.
- Consideration should be given to traffic fines designed to make drivers more aware of the offense committed.
- Review the traffic Police capabilities in enforcement and conducting training courses to promote the traffic Police efficiency.
- Enforce all traffic regulations at all locations and at most of the times.
- Enforcement of proper driver behavior to control speeding, careless driving, not yielding and careless overtaking.
- Traffic police have to work closely with implementation agencies and have an important role in advising or enforcing the operational plans.
- Coordinate with the police on enforcement initiatives against unsafe behaviors by road users.

8.1.8 Environmental Protection Measures

The natural environment faces real and increasing risks arising from the community's continued expansion. The importance of dealing with growth in ways that minimize environmental impacts is vital, and transportation represent a particular challenge to the environment.

This plan intends to help minimizing the energy and land consumption as well as improving air and water quality and traffic safety. Rafah Governorate has many immediate opportunities to demonstrate environmental leadership through progressive transportation practices, such as:

Awareness Measures

- Promoting energy-efficient travel modes like walking and cycling.
- Giving priority to transportation programs and projects that encourage energy efficiency and reduced air emissions.
- Approving development actions that encourage residents, employees and customers to make travel choices that minimize their automobile use (use of public transportation or energy-efficient modes).

- Minimize the possible consumption of valuable agricultural and natural resource lands by transportation infrastructure expansion, by maximizing the efficient operation of existing facilities before adding new ones.
- Aware the community with the best practices regarding transportation modes.
- Involve, inform and educate the public in order to foster awareness of atmospheric change and of local initiatives to reduce air pollution. Working with other interested partners (local and international) towards achieving this purpose is strongly recommended.
- Promotion proper vehicles maintenance and driving habits.

Physical Measures

- Planting trees. Different types of trees could be planted according the purpose (for aesthetic features, shadow, pollution reduction, grounds, etc.). Species of trees to be planted include Drummond willow, Douglas hawthorne, alder, and red osier dogwood.
- Protect residents from exposure to adverse traffic noise impacts.
- Minimize area that prevent water from soaking into the ground.
- Apply best practices to avoid and mitigate impacts on the environmental resources.
- Lighting of streets and intersections would improve safety conditions specially during night hours.
- Maintenance or construction of sidewalks will improve safety and the aesthetic features.

8.1.9 Safety Measures

The fast development of roads network is accompanied with increase in the number of accidents and fatalities. In order to ensure safety on roads, all related partners must work together through engineering, enforcement and education techniques.

In developing and managing its transportation system, Rafah governorate must give high priority to public safety through progressive measures, such as:

- Increase transit system safety by hiring additional uniformed Transit Law Enforcement Officers .
- Enhance the public awareness about Transit Law Enforcement Officers rules in order to allow them to perform their duties more effectively and efficiently .
- Encourage and maintain partnerships among transit staff, police, school officials and community groups, and participate in joint initiatives to address the common concerns of traffic management and traffic safety.

- Raise customer and employee awareness towards safety through internal outreach programs and presentations to schools and community groups.
- Enhance incidents reporting, and standardize related procedures with other transit agencies.
- Install and maintain road signs, signals, handrails and humps to improve traffic management and safety conditions.
- Roads rehabilitation and maintenance.
- Proper planning and safety audit.
- Road safety promotion through media.
- Promotion of proper routine vehicles maintenance and driving habits.
- Increase funding to support enforcement of existing transportation laws and regulations.
- Increase the use of technology to improve safety in all transportation modes.

8.2 The Proposed Implementation Schedule of the Plan

As mentioned previously, the proposed scenarios will be classified into three phases:

- Short Term (< 5 Years): This phase includes the activities that will be directly implemented after approving the proposed plan.
- Intermediate (5 to 10 Years): This phase includes the activities that will be implemented within a period of 5 to 10 years period after approving the proposed plan.
- Long Term (10 to 25 Years): The plan in this phase will suggest major modifications and major reconstruction solutions that aim at providing long term objectives.

Listed hereinafter the proposed actions classified upon the phases of implementation as follows:

Table (11): Implementation Schedule of the Plan

<table>
<tr><th colspan="2" rowspan="2">Item</th><th colspan="2">Short Term Planning (2008 – 2012)</th><th>Intermediate Term planning (2013-2022)</th><th>Long Term Planning (2022 – 2030)</th></tr>
<tr><th>Action (1st priority)</th><th>Action (2st priority)</th><th>Action</th><th>Action</th></tr>
<tr><td rowspan="4">Network Development</td><td rowspan="4">Rafah</td><td>Convert Abu Baker Street (Starting From CAIR Intersection to the Eastern Taxi station) to one way Street. (from East to West) and Using an alternative Street to carry traffic in the opposite direction (from west to east).</td><td></td><td>Improve facilities at Taha Hussein Street including sidewalks, traffic signs, lightening and taxi stations.</td><td></td></tr>
<tr><td>Widen the pedestrian sidewalk of Abu Baker Street</td><td>Remove road medians of Abu Baker Street</td><td colspan="2" rowspan="3">Activate Taha Husain Street by one or more of the following:
▪ Vegetation
▪ Conduct Awareness Campaign.</td></tr>
<tr><td>Pave the unpaved part of Bilal Street.</td><td>Install traffic signs</td></tr>
</table>

Item		Short Term Planning (2008 – 2012)		Intermediate Term planning (2013-2022)	Long Term Planning (2022 – 2030)
		Action (1st priority)	Action (2st priority)	Action	Action
Network Development	Rafah	Rehabilitate Al Huda Mosque Street by: ▪ Resurfacing /patching. ▪ Rehabilitating the storm water Drainage system. Conduct awareness Campaign.	Resurface /patch Street No. (53)		
					Rehabilitate and maintain Streets No. (22,29,49).
					Activate Othman Ibn Affan northern entrance to serve as additional governorate entrance: ▪ Open the closed part of the Street and pave the unpaved part of the Street (about 1000 m long). ▪ Widen the existing part of the Street ▪ Install Signs that guide traffic to this entrance to Rafah city. ▪ Encourage Vegetating along the Street. ▪ Conduct awareness Campaign.

Item		Short Term Planning (2008 – 2012)		Intermediate Term planning (2013-2022)	Long Term Planning (2022 – 2030)
		Action (1st priority)	Action (2st priority)	Action	Action
Network Development	Rafah	Resurface /patching Beer Qeshta Street.			
		Rehabilitate the storm water drainage system in: ▪ Abu Baker Street (CAIR- Rab'a) ▪ Al Jame'a Intersection ▪ Abu Baker Street (Al Berka) ▪ Abu Baker - Ibn Seena Streets Intersection			
	Al Shoka		Partial development for road (No. 39) includes paving and lightening.	Conduct Maintenance	Conduct Maintenance
			Partial development for Mashro' Amer Street includes paving and lightening.	Conduct Maintenance	Conduct Maintenance
			-	Partial development for road (No 16) includes paving and lightening.	Conduct Maintenance
			-	-	Partial development for road (No. 5) includes paving and lightening.

Item		Short Term Planning (2008 – 2012)		Intermediate Term planning (2013-2022)	Long Term Planning (2022 – 2030)
		Action (1st priority)	Action (2st priority)	Action	Action
Network Development	Al Shoka		-	-	Partial development for road No. (1) includes paving and lightening.
	Al Nasser		Conduct Maintenance for Al Rebat Street	Conduct Maintenance for Al Rebat Street	Partial development for Al Rebat Street includes widening and resurfacing .
			-	Partial development for Al Teena Street includes paving and lightening .	Conduct Maintenance
			-	-	Partial development for Al Passateen Street includes paving and lightening.
Intersection Development	Rafah		Install traffic signal (vehicle actuated system) at Awad-Tower Intersection.	Conduct Maintenance	Conduct Major Maintenance
			Install Stopper or yield signs at the intersection of Abu Baker Street with Street No. (40)	Install traffic signal (vehicle actuated system) at the intersection of Abu Baker Street with Street No. (40)	Conduct Maintenance

Item		Short Term Planning (2008 – 2012)		Intermediate Term planning (2013-2022)	Long Term Planning (2022 – 2030)
		Action (1st priority)	Action (2st priority)	Action	Action
Intersection Development	Rafah		Install Stopper or yield signs at the intersection of Omar Ibn Al Khatab Street with Taha Hussein Street.	Install traffic signal (vehicle actuated system) at the intersection of Omar Ibn Al Khatab street with Taha Hussein Street.	Conduct Maintenance
			Install traffic signal (vehicle actuated system) at the intersection of Abu Baker Street with Omar Ibn Al Khatab Street.	Conduct Maintenance	Conduct Major Maintenance
			Install traffic signal (vehicle actuated system) at the intersection of Abu Baker Street with Othman Ibn Affan Street.	Conduct Maintenance	Conduct Major Maintenance
		Redesign Zo'rob intersection by using Channelization technique.		Conduct Maintenance & Modification	Conduct Major Maintenance
		Install speed hump at the intersection of Abu Baker Street with Street No. (53).		--	--

Item		Short Term Planning (2008 – 2012)		Intermediate Term planning (2013-2022)	Long Term Planning (2022 – 2030)
		Action (1st priority)	Action (2st priority)	Action	Action
Intersection Development	Rafah		Study existing hump, remove illegal ones and install slandered humps where necessary.	Introduce traffic calming measures	Introduce traffic calming measures such as zone 30.
		Install traffic signs mainly in the city center including guiding signs, arranging signs and warning signs.		Install traffic signs in all arterial roads.	Install traffic signs on collector and local roads.
Intersection Development	Al Shoka		Install traffic signs mainly in the city center including guiding signs, arranging signs and warning signs.	Install traffic signs in all arterial roads.	Install traffic signs on collector and local roads.
	Al Nasser		Install traffic signs mainly in the city center including guiding signs, arranging signs and warning signs.	Install traffic signs in all arterial roads.	Install traffic signs on collector and local roads.

Item	Short Term Planning (2008 – 2012)		Intermediate Term planning (2013-2022)	Long Term Planning (2022 – 2030)
	Action (1st priority)	Action (2st priority)	Action	Action
Markets	Move Saturday Market toward Al Shua'ara Market. Rehabilitate Al Shua'ara Market, Enforcing laws and regulations in the area and Improving municipal services, i.e. cleaning, environmental health, vegetation ..etc.		Conduct Maintenance	Conduct Major Maintenance
		Al Sultan Market (located in Tal Al Sultan, at the beginning of Ibn Sina Street) need to: ▪ Construct a latticework over an area of 1000m2 as a vegetables market next to the market. ▪ Improve municipal services, i.e. cleaning, environmental health, vegetation, etc… ▪ Encourage Merchants to open closed stores in the market square	Conduct Maintenance	Reconstruct a commercial central market.
		Al Brazil Market (located to the east of Bahloul Tower next the Egyption border) need to: ▪ Rehabilitate the market . ▪ Improve municipal services, i.e. cleaning, environmental health, vegetation, etc…	Conduct Maintenance	Conduct Major Maintenance

Item	Short Term Planning (2008 – 2012)		Intermediate Term planning (2013-2022)	Long Term Planning (2022 – 2030)
	Action (1st priority)	Action (2st priority)	Action	Action
Taxi Station (See Figure 33)	Move the (Rafah-European Hospital) Taxi Station (No. 1) from its current location to Taxi Station (No.3)		Introduce regulations to manage the taxi station .i.e. fees and etc…	Introduce public transportation facilities
	Move the (Rafah - Gaza) Taxi Station (No. 2) from its current location to the Eastern Taxi Station (ETS)			
	Improve the design and facilitation at taxi Station No. 3 located at the southern arm of the intersection of Othman Ibn Affan and Abu Baker Street and Enforce laws and regulations.			
	Move the (Rafah - Khan Younis) Taxi Station (No. 4) from its current location to the Taxi Station No.(5)			
	Enforce laws and regulations at the eastern taxi Station (no. 5)			
	Move the (Rafah - Al Kherba) Taxi Station (No. 6) from its current location to Taxi Station No. (3)		Introduce regulations to manage the taxi station . i.e. fees and etc…	Introduce public transportation facilities

Item	Short Term Planning (2008 – 2012)		Intermediate Term planning (2013-2022)	Long Term Planning (2022 – 2030)
	Action (1st priority)	Action (2st priority)	Action	Action
Taxi Station (See Figure 33)	Remove taxi Station (No.7) which located in front of the civil Defence.			
	Move the (Rafah - Gaza) Taxi Station (No. 8) from its current location to the to the Eastern Taxi Station (ETS)			
	Enforce laws and regulations at the Buses Station (No. 9) that located to the west of CAIR training center.			
	Move the (City Center - Tal Al Sultan) Taxi Station (No. 10) from its current location to Bier Salem intersection connected with Taha Husain Street in addition to Enforcing laws and regulations.			
	Remove the (UNRWA clinic – City Center) Taxi Station (No. 11) .			
Parking		Develop a Parking Management Strategy that Supports the City's strategic parking objectives.	Establishes centralized parking lots within a reasonable walking distance of multiple destinations, where required	--

Item	Short Term Planning (2008 – 2012)		Intermediate Term planning (2013-2022)	Long Term Planning (2022 – 2030)
	Action (1st priority)	Action (2st priority)	Action	Action
Parking		Identifies candidate locations for new parking lots owned or operated by the City, for monitoring and analysis	Providing parking to be owned or operated by the City.	--
			Providing on-street parking that does not compromise the achievement of targeted service level.	--
Pedestrian & School Gates		Introduce pedestrian facilities such as zebra crossing and side walks where required	Improve & develop pedestrian facilities	Introduce traffic calming measures to protect pedestrians.
	Remove the School gates which located on Abu Baker Street to minor Streets where possible:			
	Girls Prep. E: Move the main entrance to Al Nady Street (Paved – 7m wide)			

Item	Short Term Planning (2008 – 2012)		Intermediate Term planning (2013-2022)	Long Term Planning (2022 – 2030)
	Action (1st priority)	Action (2st priority)	Action	Action
Pedestrian & School Gates	**Al Shuhada:** Move the main entrance to Al Nady Street (Paved – 7m wide)			
	Amna Bint Wahb: Move the main entrance to the Street bordering the school form the west against the commercial center. (Paved – 7m wide)			
	Girls Prep. B: Move the main entrance to the Street bordering the school from the east against Ali Mosque (Paved – 6m wide)			
	Boys Elementary A: Move the main entrance to the Street bordering the school from the west. (Paved-6m wide)		Improve & develop pedestrian facilities	Introduce traffic calming measures to protect pedestrians.
	Raba'a: Move the main entrance to the Street bordering the school from the east (Paved -6m wide) (OR) Move the main entrance to the Street located behind the school (Unpaved – 4m wide)			
		Enforcing laws and regulations to protect pedestrian		

Item	Short Term Planning (2008 – 2012)		Intermediate Term planning (2013-2022)	Long Term Planning (2022 – 2030)
	Action (1st priority)	Action (2st priority)	Action	Action
Regulation, control and Enforcement	Review of current enforcement practices and activities and recommend the appropriate enforcement tactics, methods and techniques suitable for use in Rafah.		Create a public committee to help police enforcing law.	Enforce all traffic regulations at all locations and at most of the time.
	Review the traffic Police capabilities in enforcement and conducting training courses to promote the traffic Police efficiency.		--	Enforce proper driver behavior to control speeding, careless driving, not yielding and careless overtaking.
		--	--	Traffic police have to work closely with implementation agencies and have an important role in advising or enforcing the operational plans.
		--	--	Coordinate with the police on enforcement initiatives against unsafe behaviours by road users.
		--	--	Consideration should be given to traffic fines designed to make drivers more aware of the offense committed.

Item	Short Term Planning (2008 – 2012)		Intermediate Term planning (2013-2022)	Long Term Planning (2022 – 2030)
	Action (1st priority)	Action (2st priority)	Action	Action
Awareness	Conduct Awareness campaigns			
Environmental	Aware the community with the best practices regarding transportation modes.			
	Planting of trees. Different types of trees could be planted according the purpose (for aesthetic features, shadow, pollution reduction, grounds, etc.). Species of trees to be planted include Drummond willow, Douglas hawthorne, alder, and red osier dogwood.			
	Apply best practices to avoid and mitigate impacts on the environmental resources.			
	Lighten streets and intersections .			
	Maintain or construct of sidewalks that improve aesthetic features.			
Safety	Enhance the public awareness about Transit Law Enforcement Officers rules in order to allow them to perform their duties more effectively and efficiently .			
	Enhance incidents reporting, and standardize related procedures with other transit agencies.			
	Install and maintain road signs, signals, handrails and humps to improve traffic management and safety conditions.			
	Rehabilitate and maintain Roads where required.			
	Promote road safety through media.			
Studies	Annual statistics about traffic flow, speed and accidents			

This plan simulated by CONTRAM software and the results were:

Implementing the entire Plan (6-9) :

Table (12): Simulation Process Results with Implementing the Entire Plan (6:00 am -9:00 am)

Time		queuing time (veh-hr)				total distance (veh-km)				network speed (km/hr)			
From	to	2007	2012	2020	2030	2007	2012	2020	2030	2007	2012	2020	2030
6:00	7:00	5.6	7.2	10.7	19.6	13994.7	16658.5	21366.6	28186.8	48.6	48.5	48.4	47.9
		final queues (veh)				congestion (index)				stops (veh)			
		2007	2012	2020	2030	2007	2012	2020	2030	2007	2012	2020	2030
		5.6	7.2	10.8	20	1.02	1.02	1.02	1.03	526	752	1261	2196
7:00	8:00	queuing time (veh-hr)				total distance (veh-km)				network speed (km/hr)			
		2007	2012	2020	2030	2007	2012	2020	2030	2007	2012	2020	2030
		9	12.4	25.7	150.3	17791.4	21201.4	27385.7	35923.6	48.3	48.1	47.3	41.1
		final queues (veh)				congestion (index)				stops (veh)			
		2007	2012	2020	2030	2007	2012	2020	2030	2007	2012	2020	2030
		9.1	12.6	27.3	243.8	1.02	1.03	1.05	1.21	967	1393	2343	6159
8:00	9:00	queuing time (veh-hr)				total distance (veh-km)				network speed (km/hr)			
		2007	2012	2020	2030	2007	2012	2020	2030	2007	2012	2020	2030
		9.3	13.2	31.9	357.8	17217.1	20609	26538.4	34388.9	48.2	48	46.8	32.7
		final queues (veh)				congestion (index)				stops (veh)			
		2007	2012	2020	2030	2007	2012	2020	2030	2007	2012	2020	2030
		9.3	13.3	34.3	424.6	1.03	1.03	1.06	1.52	999	1409	2294	5688

Implementing the entire Plan (13 - 16) :

Table (13): Simulation Process Results with Implementing the Entire Plan (1:00 pm -4:00 pm)

Time													
From	to	queuing time (veh-hr)				total distance (veh-km)				network speed (km/hr)			
13:00	14:00	2007	2012	2020	2030	2007	2012	2020	2030	2007	2012	2020	2030
		9.7	74.7	190.4	429.4	17622.9	26382.1	33903.8	43853	48.2	43.4	38.8	33.4
		final queues (veh)				congestion (index)				stops (veh)			
		2007	2012	2020	2030	2007	2012	2020	2030	2007	2012	2020	2030
		9.8	119.5	338.3	1150.8	1.03	1.14	1.28	1.49	1136	3335	5685	10389
14:00	15:00	queuing time (veh-hr)				total distance (veh-km)				network speed (km/hr)			
		2007	2012	2020	2030	2007	2012	2020	2030	2007	2012	2020	2030
		7.2	36.6	338.4	899.9	15796.1	23041	29423.8	41072.7	48.4	45.9	31.6	23.8
		final queues (veh)				congestion (index)				stops (veh)			
		2007	2012	2020	2030	2007	2012	2020	2030	2007	2012	2020	2030
		7.2	15.2	350.7	1173.5	1.02	1.08	1.57	2.09	748	2024	5489	9757
15:00	16:00	queuing time (veh-hr)				total distance (veh-km)				network speed (km/hr)			
		2007	2012	2020	2030	2007	2012	2020	2030	2007	2012	2020	2030
		8.4	22.1	418.1	1144.4	17519.8	25856.1	32653.6	43446.3	48.4	47.5	30.3	21.5
		final queues (veh)				congestion (index)				stops (veh)			
		2007	2012	2020	2030	2007	2012	2020	2030	2007	2012	2020	2030
		8.5	23.9	487.5	1363.6	1.02	1.04	1.63	2.31	956	1816	3688	7129

Note:

queuing time : The total time (in veh-h) spent by vehicles in queues.

total distance : he total distance travelled by vehicles in the network (in veh-km).

network speed : The average network speed for the time slice measured in kph.

final queues : The total number of vehicles queued at the end of the time slice.

congestion index : This is the ratio of total travel time on the link to its free-flow travel time. A congestion index of 1.0 indicates no queuing, whilst a value of 2.0 indicates that travel time is doubled due to junction delays.

stops : The total number of stops.

The results of the Do–Nothing scenario at peak hour show that the performance of the traffic will become bad in 2020 and dramatically it will be worst in 2030.

As an example, the queuing time is estimated to be 34.6 veh.hr in 2007; whereas, it is forecasted to be 380 veh.hr in 2020 and 2167.7 in 2030.

In other words, the percentage of increment through 2030 in the queuing time is forecasted to be % 6,156 .

For these reasons actions and improvements have been proposed in the previous section. When simulating the suggested actions by CONTRAM Software, a large improvement in the network performance is occurred, for example, the queuing time is decreased from in 2030 from 2167.6 veh.hr to 357.8 veh.hr

And that emphases the majority of implementation the suggested plan in order to promote the street network efficiency in Rafah Governorate.

9 Cost Estimate

The cost of a specific project is the one of the most significant projects selection criteria. The municipalities identify the projects according to their initial cost estimates. According to the limited available financial resources, the municipalities are interested more with small projects or those matching the criteria of funding agencies. The availability of the traffic comprehensive plan will provide the municipalities with the necessary justifications and details that will make the projects

This section of the plan aims to figure out the expected budget of each action of those proposed to improve the traffic conditions in Rafah Governorate. The estimates cover the three phases of the plan; short, intermediate and the long terms.

In order to simplify the process and get the most accurate estimation of the proposed projects, the unit prices were studied thoroughly. The budget of each proposed action was estimated considering these prices. The estimates consider the future inflation rates, currency changes rate, as well as the local taxes.

The following table (**Table 14)** summarizes the costs of the proposed actions, the total of each phase and the total cost of the plan.

Recommended long term projects

These projects came in the context of the road network development which suggested to promote the network services and efficiency, and these projects are:

Rafah :

Project	Estimated Cost ($)
Rehabilitation and maintenance of Salah Elddine road	500,000
Rehabilitation of roads in the city center area	385,000
Rehabilitation and maintenance of internal roads in Al Junaina area "phase II"	500,000
Rehabilitation of internal roads Al Junina area	500,000
Rehabilitation of Tel Al Sultan access road "phase II"	350,000
Rehabilitation of road No."4"	352,000
Construction of Abu Baker road No"1" (phase III)	900,000
Construction of Taha Hussian road No"3" (phase II)	400,000
Construction of Omar Ben Al Khatab (phase I)	1,000,000
Construction of AL Shaheed area	450,000
Reconstruction of Abu Baker road "phase 4"	800,000
Reconstruction of omer ben Al khatab street (No.2) phase I	1,500,000
Reconstruction of omer ben Al khatab street (No.2) phase II	1,350,000
Construction of road (No. 24)	550,000
Construction of Hamza road (No. 61)	500,000
Construction of Jemaizet Al Sabeel street	400,000
Construction of Jafar Al Tayar Street	950,000
Retaining walls in different side walks in Rafah city	200,000
Construction of Al Ouroba side walks	250,000
Construction of Tal Sultan side walks	200,000
Construction of Al Nedjar side walks	200,000
Development of main roads in the city center	400,000
Development of internal roads in weastern Rafah	400,000
Development of internal roads in norhten Rafah (phase I)	1,000,000
Development of internal roads in norhten Rafah (phase II)	1,000,000
Development of Al Tanour neighbohood (phase II)	700,000
Development of Al Mawassi area (phase I)	1,000,000
Development of Al Mawassi area (phase II)	700,000

Project	Estimated Cost ($)
Development of internal roads in Ankar El Khaima neighborhood (phase I)	850,000
Development of internal roads in Ankar El Khaima neighborhood (phase II)	450,000
Development of Musabaih neighborhood	850,000
Development of Kherbit Al Addass internal roads	800,000
Development of Beer Eskandar main road	800,000
Development of internal roads in Al Junaina neighborhood	1,000,000
Development of internal roads in northen eastern of Rafah	1,000,000
Construction of othman ben afan street (phase I)	850,000
Construction of othman ben afan street (phase II)	1,000,000
Construction of road No. 11	1,000,000
Construction of road No. 12 (phase I)	1,000,000
Construction of road No. 12 (phase II)	1,000,000
Construction of Taha Hussain street (phase II)	800,000
Construction of road No. 13	1,700,000
Construction of main roads in Al Mawassi area	1,000,000
Total	**31,537,000**

Al Shoka:

Project	Estimated Cost ($)
Construction of road (No. 39) (phase II)	625,000
Construction of Mashro' Amer Street (phase II)	9,850,000
Construction of road (No 16) (phase II)	890,000
Construction of road (No. 5) (phase II)	2,645,000
Construction of road No. (1) (phase II)	2,850,000
Total	**16,860,000**

Al Nasser:

Project	Estimated Cost ($)
Developing of Al Rebat Street (phase II)	2,810,000
Developing of Al Teena Street (phase II)	270,000
Developing of Al Passateen Street (phase II)	650,000
Developing of Al Salam Street	900,000
Developing of Al Qadissia Street	1,300,000
Total	**5,930,000**

10 Air Pollution Analysis

10.1 Introduction

The Changing Climate

Human activities have substantially added to the amounts of potentially harmful gases and particles emitted into the atmosphere. These gases can cause health and environmental problems affecting both developed and developing countries around the world. Among these gases are those who are capable to increase the heat-trapping capacity of the atmosphere (greenhouse gases). The burning of fossil fuels and biomass has also resulted in emissions of aerosols that absorb and emit heat and reflect light. The addition of greenhouse gases, aerosols have changed the composition of the atmosphere that have likely influenced the climate of the earth.

NASA studies indicate that the Earth's average surface temperature has increased by about 0.67 to 0.78^{o}C in the past century. For the next century, climate models predict that the average temperature at the Earth's surface could increase from 1.78 to 4^{o}C above 1990 levels provided that greenhouse gases continue to increase. Scientists are certain that human activities are changing the composition of the atmosphere, and that increasing the concentration of greenhouse gases will change the planet's climate. Other aspects of the climate such as rainfall patterns, snow and ice cover, and sea level are also changing.

Health and Environmental Effects

Changes in the world environment have already been observed due to climate change. Observed effects include sea level rise, shrinking glaciers, changes in the range and distribution of plants and animals, trees blooming earlier, lengthening of growing seasons, ice on rivers and lakes freezing later and breaking up earlier, and thawing of permafrost. Some parts of the world will become wetter or drier. Human health can be affected directly and indirectly by climate change in part through extreme periods of heat and cold, storms, and climate-sensitive diseases such as malaria, and smog episodes.

Air Pollution Sources

Air pollutants come from several sources and vary considerably according to their origin. The combustion of fuels in automobiles and trucks produces several primary pollutants: nitrogen oxides, hydrocarbons, carbon monoxide, and particulate matter. In the presence of sunlight and other suitable conditions some of these pollutants combine to form a secondary class of pollutants (e.g. ozone). In cities, air may be severely polluted not only by transportation but also by the burning of fossil fuels in generating stations, factories, office buildings, and homes and by the incineration of garbage. Every industrial process exhibits its own pattern of air pollution.

Emissions from an individual car are generally low, relative to the smokestack, but in numerous places, the personal automobile is the single greatest polluter, as emissions from thousands of vehicles on the roads add up. According to Palestinian environmental strategy, transportation sector contributes to 50% of air pollution in Gaza Strip. The only mode of transportation in Palestine is on the road movers comprising any form of combustion-engine vehicles, e.g. light duty gasoline-powered cars, light and heavy-duty diesel-powered vehicles, and motorcycles.

Excessive amounts of pollutants are the by-product of engines operating under something other than ideal conditions. In theory, a perfectly running engine would create only these non-toxic by-products - carbon dioxide (CO2), water vapor (H2O), and heat. But even under the best of circumstances, even the newest of engines don't operate under ideal conditions.

Gaza strip Air Pollution

Gaza strip is one of the most crowded areas in the world with approximately 1.48 million Palestinians living over 360sq km. This large population over a small area have created many environmental problems including deterioration of air quality. Air pollution is mainly caused by the high density of traffic, the average old age of the cars, and lack of appropriate licensing systems that are based on emission testing prior allowing cars on the road. The problem is exacerbated by the bad conditions of the roads and lack of appropriate planning of the Palestinian cities.

Emission testing and pollution monitoring are required to determine the types and amounts of air pollutants emitted by a variety of emission sources. Information gathered from emission tests may be used for several purposes including: enforcing emission limits, issuing permits, evaluating pollution control systems, and determining emission inventories.

10.2 Purpose

In this chapter, the importance of the proposed master plan in reduction of gaseous emissions from motor vehicles. Cars emission data is used to estimate the amounts of carbon dioxide, carbon monoxide, and hydrocarbons loading from Rafah governorate. Those parameters are direct measures of air quality and global worming precursor. It provides full description of the sampling protocol and field methods and percussions to have quality assurance. Presentation and analysis of different parameters are also provided.

10.3 Scope

These field measurements were conducted to represent a grab sample representing the cars registered in Rafah Governorate. The Rafah Governorate is an administrative district of the Palestinian National Authority in the southernmost portion of the Gaza

Strip. Its district capital is the city of Rafah located on the border with Egypt. According to the Palestinian Central Bureau of Statistics the governorate had a population of 171,363 in mid-year 2006. It contains the closed down Yasser Arafat International Airport. It is consisted of four major localities that are al-Bayuk, al-Mawasi, Rafah (includes Rafah and Tell as-Sultan camps), and Shokat as-Sufi. The socio-economic indicators of Rafah is available in the previous chapters of this report.

10.4 Sampling Program

The study was conducted at two different phases in summer 2007. In the first phase, 75 gasoline-fueled vehicles were tested in three different localities in Gaza Strip. The first place was the workshop owned by the Community College of Applied Science & Technology (CCAST) laboratories. The two other places were licensed auto shops in the Middle and Northern Governorates. The first phase was conducted in summer 2007 starting in the 10th of July to one month period. The second phase took one week in October 2007.

After considering the time and funding available for this study, the number of vehicles to be tested was set at 140 gasoline-fueled in both testing phases. The distribution of the vehicles was made to represent all models and car ages available in service. Initially, sampling program was designed to have equal distribution of diesel and gasoline derived vehicles. But the unavailability of diesel exhaust sensor has shifted the sampling program towards gasoline only. Table (15) below outlines the car age distribution. The division was before 1980, 1980-1990, 1990-2000, and after year 2000. Engine size was set as an important selection criteria for picking up the cars for testing. In this respect, the sample cars were chosen to represent the diversity in the cars used in the target area.

Table (15): Tested Cars Distribution in the Two Phases of Testing

Age Category	First phase	Second phase
age ≥ 27 years	2	1
27 > age ≥ 17	19	21
17 > age ≥ 7	48	42
7 > age	6	1

The testing process was carried out according to the procedures provided by the MGA-1500-S manufacturer. The tests were carried out the staff of CCAST who were well trained to perform this test. Testing were conducted under identical circumstances and procedure to ensure that the test results consistent and reproducible. The vehicles were driven to the lab and allowed to worm up for 30 second before hanging the probe in the exhaust tube. Two readings were taken; the first one at idle speed or (motor speed =800 Rev/sec) and the second reading at typical cruise speed (motor speed =2500 Rev/sec). All the field data has been compiled and presented in the excel sheet in

Annex (17) . Hydrocarbons concentrations in the exhaust were relatively sparse, they were reported in parts per million (PPM). On the other hand, the other constituents are available in large quantities (CO, CO_2, O_2) so their concentrations were reported as percentage (1% = 10000 PPM).

10.5 Modular Gas Analyzer (MGA)

The MGA 1500 S modular gas analyzer is designed to meet the performance requirements of OIML Class 0 and ISO 3930. The apparatus is manufactured by Sun Electric Europe located in the Netherlands. The standard software supports the measurements of up to 5 gases in the vehicle exhaust emission. Carbon monoxide, carbon dioxide, and hydrocarbons are measured infrared adsorption techniques. Oxygen is measured using an operator changeable electrochemical cell. In addition to the gas measurements, the unit is also capable of measuring the fuel/air ratio Lambda together with a clock-calendar feature, engine speed in rpm and, oil temperature.

The measurements are displayed on 6, very bright, 20mm LED display elements. A print-out can be made with the on board printer. The RS 232 connection provides you with the possibility to interface with other equipment like the Sun test lanes and the Diesel kit. The simple controls of the MGA 1500 S, thumbwheel, right/left arrow key, function, print and mode/cancel buttons, allow easy navigation through the test program. RPM measuring, on all types of ignition systems, is no problem for the MGA 1500 S. Engine speed, rpm, can be measured by an inductive pick-up clamp on ignition secondary cables, by capacitive pick-up on a primary cable or an injector wire, or via a direct connection to a square wave from the engine management system. This enables rpm measurement on conventional, wasted spark and direct ignition systems. The gas analyzer used in this sampling program has been used in previous studies to test the emission of approximately 80 different of vehicles in Gaza strip. The calibration process was carried out each time as per the recommendation of manufactures and procedures outlined in the equipment catalogue.

10.6 Results and discussion

General Discussion

The MGA 1500 S modular gas analyzer has the capability to monitor continuously the regulated gaseous emissions, carbon monoxide (CO), total hydrocarbons, (HC), carbon dioxide (CO_2), molecular oxygen (O_2), and air to fuel ratio (lambda). The CO_2 measurements is also used to determine if there are any major exhaust leaks. The results from all of these measurements, for both the first and second phases, are given in Annex (17). The data of the two phases were tested to determine whether the data should be treated separately or they should be treated together. Analysis of the Variance (ANOVA) was conducted to test whether each pollutant measured at the first phase was

statistically the same as that was measured in the second phase. The confidence value (□) was set 0.025. The results of ANOVA analysis is presented in Table (16) below. Table (16) shows that F values are less than the critical value for all measured values except for hydrocarbons emission at the cruise speed. It is concluded that except hydrocarbons, all the measured parameters has the same mean value at the first and second phases from statistical point of view. The variation in hydrocarbons emissions in the two phases during the cruse can be explained by high sensitivity of hydrocarbons emissions to the vehicle motor speed which is difficult to control or to reproduce. In general, ANOVA test showed that the data has been reproduced after three months lag indicating the high level of precision in the data collection. It also shows that the measured parameters were independent of the weather and climatic conditions and place of measurement. This analysis also justifies pooling the two phases together and treat them as if they were collected at the same time.

Table (16): Summary of ANOVA Analysis for the Two Phases of the Study

	Idle					Cruise				
Parameter	**CO**	**CO_2**	**O_2**	**HC**	**Lambda**	**CO**	**CO_2**	**O_2**	**HC**	**Lambda**
Phase 1	3.49	10.09	4.26	1161.14	1.05	3.86	10.84	2.76	914.69	0.99
Phase 2	2.40	10.54	3.83	674.35	1.13	3.05	11.41	1.95	478.80	0.99
F	4.71	0.81	0.53	4.83	3.70	2.00	1.38	2.93	5.79	0.00
Fcrit	5.14	5.14	5.14	5.14	5.14	5.14	5.14	5.14	5.14	5.14

The type and quantity of exhaust contaminants from an internal combustion engine depend on inter-alia air-fuel ration, engine speed, and type of fuel. The mean and the 95% confidence intervals of results for the measured emissions, CO, CO2, O2, HC, and air to fuel ratio (lambda) for both idle and cruise modes of the motor are presented in Table(17). According to Table (17), there is no significant difference in the mean values of carbon monoxide, carbon dioxide, and hydrocarbons emissions measured in the course of this study. It is also worth pointing out that the mean values of lambda and oxygen emissions are significantly different at idle and cruise operation modes. The statistical tests are done at 95% confidence level. Table (18) represents the mean, maximum, and minimum of measured pollutants in the exhaust gas.

Table (17): Measured Exhaust Constituents as a Function of Driving Mode

mode	CO %	CO_2 %	O_2 %	HC (PPM)	Lambda
Idle	2.91±0.49	10.33±0.48	4.03±0.57	901.99±218.01	1.09±0.04
Cruise	3.43±0.56	11.14±0.47	2.33±0.46	682.63±178.86	0.99±0.03

Effect of Car age

Field data has been used to make scatter diagrams of the measured emissions as a function of the tested cars ages (Figures 37, 38, 39, 40). These plots shows that the concentrations of the pollutants measured were independent of the cars ages for both

modes of motor operation. The observed independence can be explained by two facts. First, most of the tested cars are older than the theoretical age of the engine that corresponds to about 10 years. This made the emissions dependent on the mechanical status of the motor rather than the age of the motor. Secondly, the large diversity of models and makes used in the study so that the variation in emissions from different models overshadows the variation in emissions due to the cars age.

Table (18): Mean, Maximum, and Minimum of Measured Exhaust Constituents

Mode of Operation	Idling					Cruising				
	CO (%)	CO_2 (%)	O_2 (%)	HC (PPM)	Lambda	CO (%)	CO_2 (%)	O_2 (%)	HC (PPM)	Lambda
Average	2.91	10.33	4.03	901.99	1.09	3.43	11.14	2.33	682.63	0.99
Maximum	11.93	15.22	18.40	8330.00	2.01	12.17	15.19	14.32	6244.00	1.81
Minimum	0.00	2.06	0.02	4.00	0.71	0.00	1.17	0.01	1.00	0.64

The plots show that the rate of both carbon monoxide and carbon dioxide emissions at the idle speed is lower than their emissions at the high cruise. The opposite situation is happening for oxygen and hydrocarbons emissions. Theoretically, the rate of emission of carbon monoxide and hydrocarbons is expected to decrease during cruising mode of operation. The increase of carbon monoxide is on the expense of that of carbon monoxide and vice versa. In reality, accurate trends can be shown if the cars models and makes have been unified.

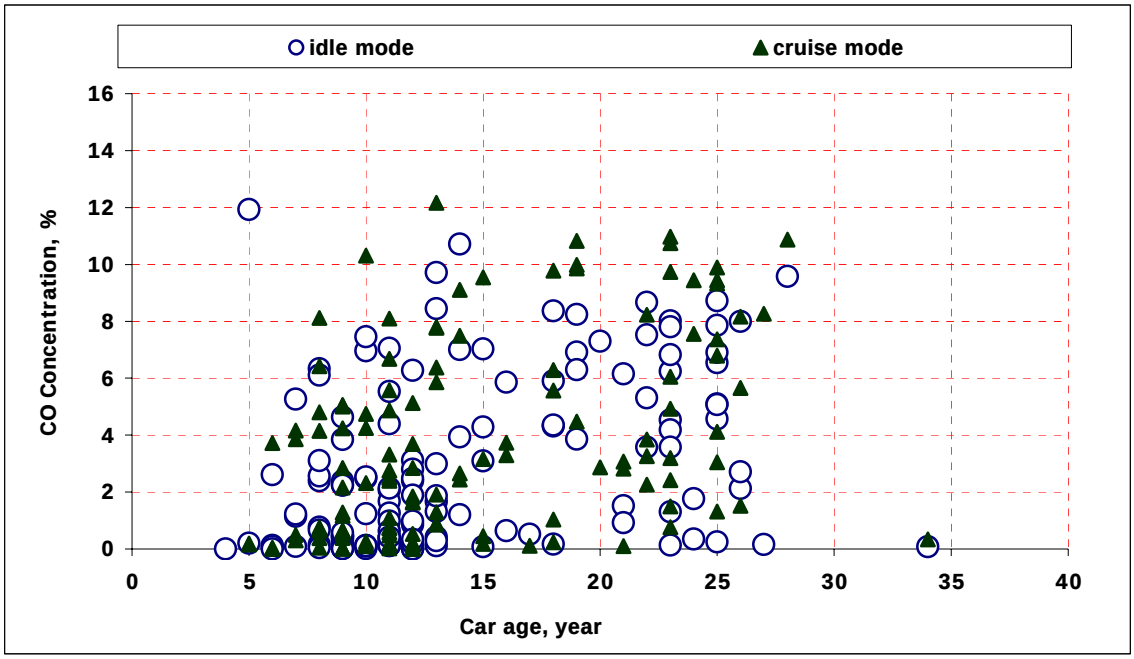


Figure (37) : Scatter Diagram of Carbon Monoxide Emissions as a Function of the Car Age

Referring to Figure 37 and Table 18, the mean and maximum of the carbon monoxide emission rates were higher for the cruise mode than for the idle mode. The average

values were 2.91 percent for the idle mode and 3.43 percent for the cruise mode. The maximum values were 12.17 percent for the cruise mode and 11.93 percent for the idle mode. The minimum value was observed to be zero for both modes of operation. These emission rates came from the same cars make which is Honda while the maximum at the idle was from Accord model and the maximum at the cruise was from Civic model. The measured values shows uniformity around the mean value and the Figure 37 reveals no outlier.

The mean and maximum of the carbon dioxide emission rates were higher for the cruise mode than for the idle mode as shown in Figure (38) and Table (18). The average values were 10.33 percent for the idle mode and 11.14 percent for the cruise mode. The maximum values were almost equal for both modes with 15.19 percent for the cruise mode and 15.22 percent for the idle mode. The minimum value was observed to be higher in the idle mode (2.06%) than that of the cruise mode (1.17%). These maximum emission rates came from the Kia cars make for which the corresponding idle emission was 15.2% . The car has highest CO2 emission was manufactured in 2003 that was the youngest in the tested sample. The law measurement of carbon dioxide is associated with early models.

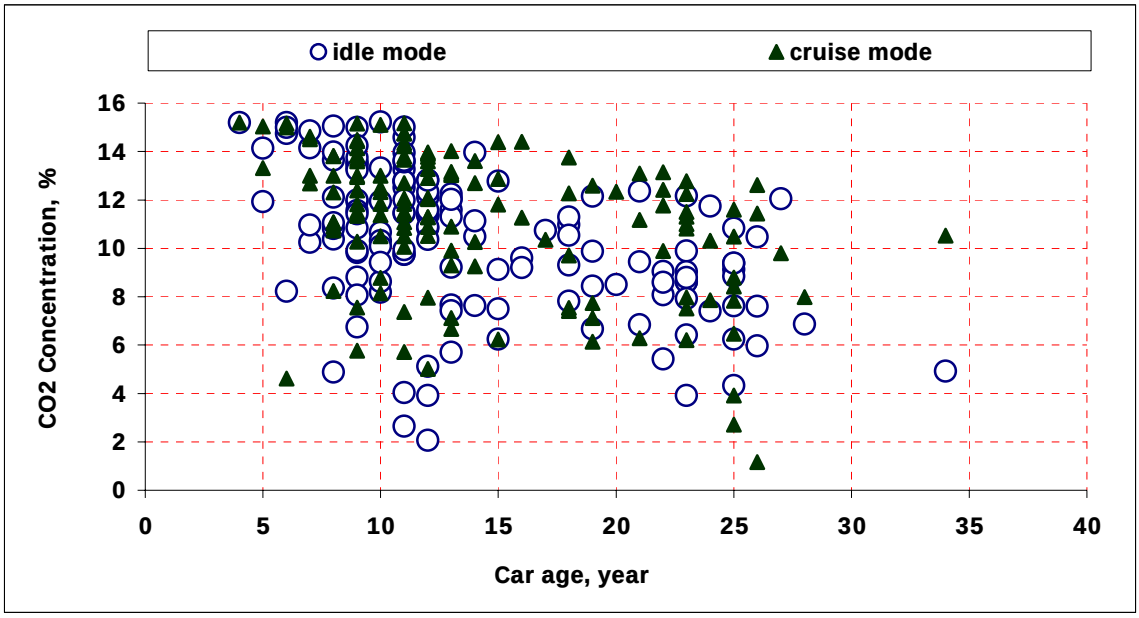


Figure (38) : Scatter Diagram of Carbon Dioxide Emissions as a Function of the Car Age

The mean and maximum of the oxygen emission rates were higher for the idle mode than for the cruise mode Table (18). The average values were 4.03 percent for the idle mode and 2.33 percent for the cruise mode. The maximum and minimum values were higher for the idle mode (18.40%, 0.02%) than the corresponding ones in the cruise mode(14.32%, 0.01%). Comparing these results with that of carbon dioxide shows that

high oxygen emission at the same time as low carbon dioxide. The maximum carbon monoxide emission rates came from the Kia cars at the cruise mode have the lowest oxygen emission (0.01%) at the same mode.

The mean and maximum of the hydrocarbons emission rates were higher for the idle mode than for the cruise mode (Figure 40, Table 18). The average values were 901.99 PPM for the idle mode and 682.63 PPM for the cruise mode. The maximum and minimum values were higher for the idle mode (8330, 4 PPM) than the corresponding ones in the cruise mode (6244, 1 PPM). The values in Figure (40) shows some values that are very high compared with the average value at both operation modes. High hydrocarbons emission in the exhaust indicates incomplete combustion of the fuel. In general, the hydrocarbon emission is associated with increasing the ratio of surface area of the combustion chamber to its volume. Based on this theory, relatively cool cylinder walls inhibit complete combustion within the layer, thus contributing significantly for exhaust hydrocarbons.

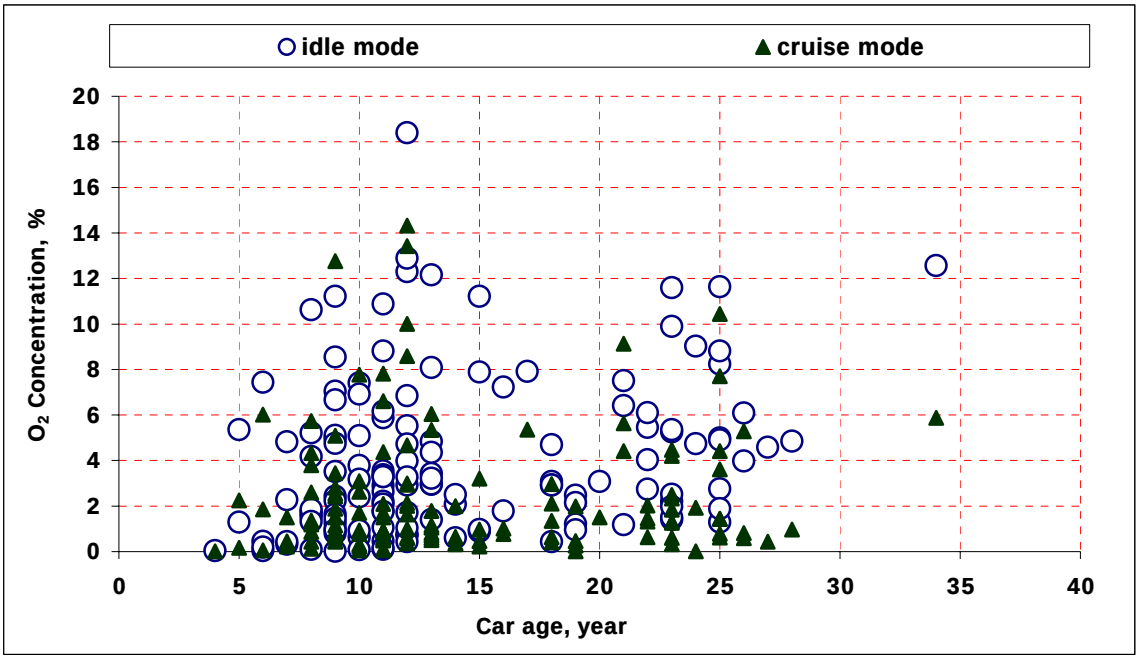


Figure (39) : Scatter Diagram of Oxygen Emissions as a Function of the Car Age

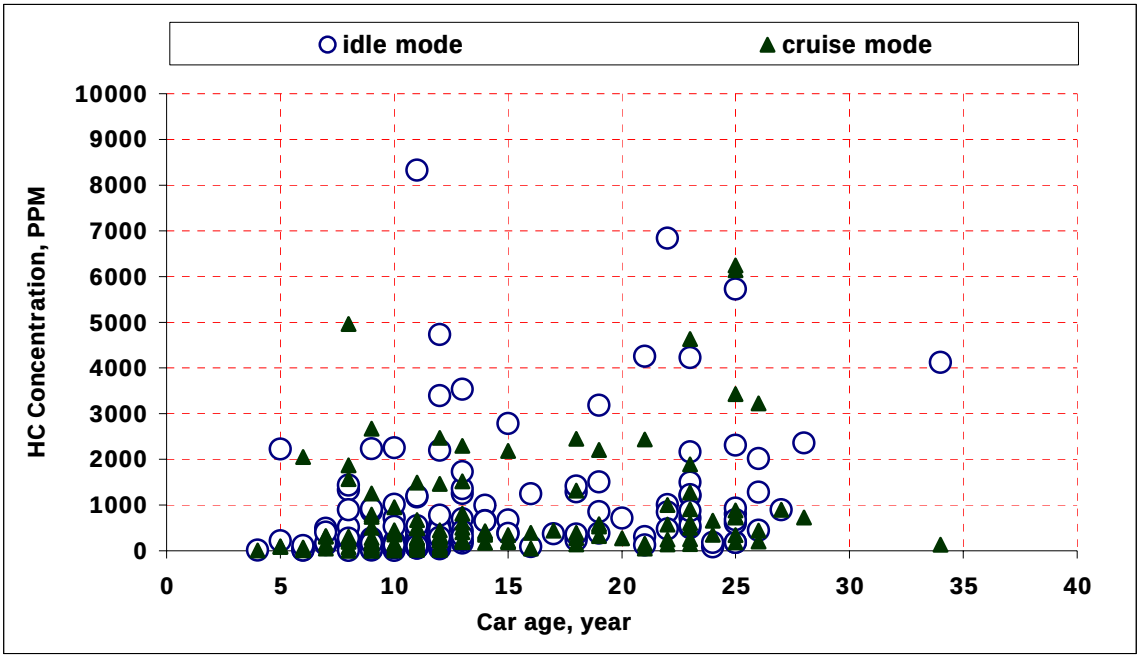


Figure (40) : Scatter Diagram of Hydrocarbons Emissions as a Function of the Car Age

Effect of Air to Fuel Ratio

The carburetor fuel-air mixture is characterized by the ratio of the weight of the air to the weight of the fuel which is called air to fuel ratio. Mixtures with low ratio are referred to as rich whereas those mixtures with high ratio is called lean. When the weight of air drawn to the carburetor is exactly the same as the theoretical amount required to have complete combustion of fuel, the stoichiometric air to fuel ratio is reached. The ratio of carburetor air to fuel ratio to the stoichiometric one is the measured by the MGA 1500 S as lambda (λ).

Figures (41, 42, 43,44) shows the relationships of combustion products to air-fuel ratio, the single most important factor in determining emissions. Combustion of rich mixtures (little oxygen) leads to CO formation as well as to the presence of residual fuel in the exhaust either unburned or partially burned (Figures 41, 44). Lean mixtures, on the other hand, produce considerably less CO and unburned hydrocarbons. However if the mixture was too lean (λ above 1.3) the mixture might not ignite properly leading to large amounts of fuel passing through unburned.

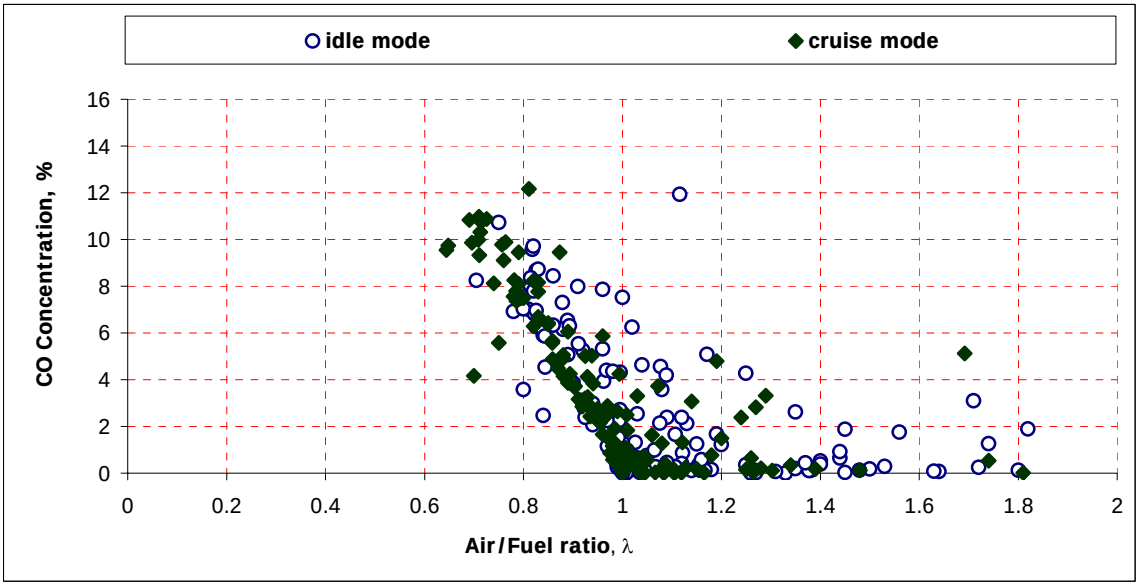


Figure (41) : Scatter Diagram of Carbon Monoxide Emissions as a Function of λ

Examination of Figure (42) reveals that carbon dioxide emission increases until the value of λ reaches one where carbon dioxide emissions attains its maximum value. The observed decrease in carbon dioxide when λ is above than one is attributed to lower fuel combustion efficiency and increased emission of unburned hydrocarbons.

Rich mixes where λ value is less than one, the oxygen is less than the required amount to burn the fuel resulting in lower amount of oxygen in the exhaust emission (Figure 44). On the other hand, lean mixes have high oxygen than the amount required to have complete combustion of the fuel resulting in increasing the amount of oxygen in the exhaust.

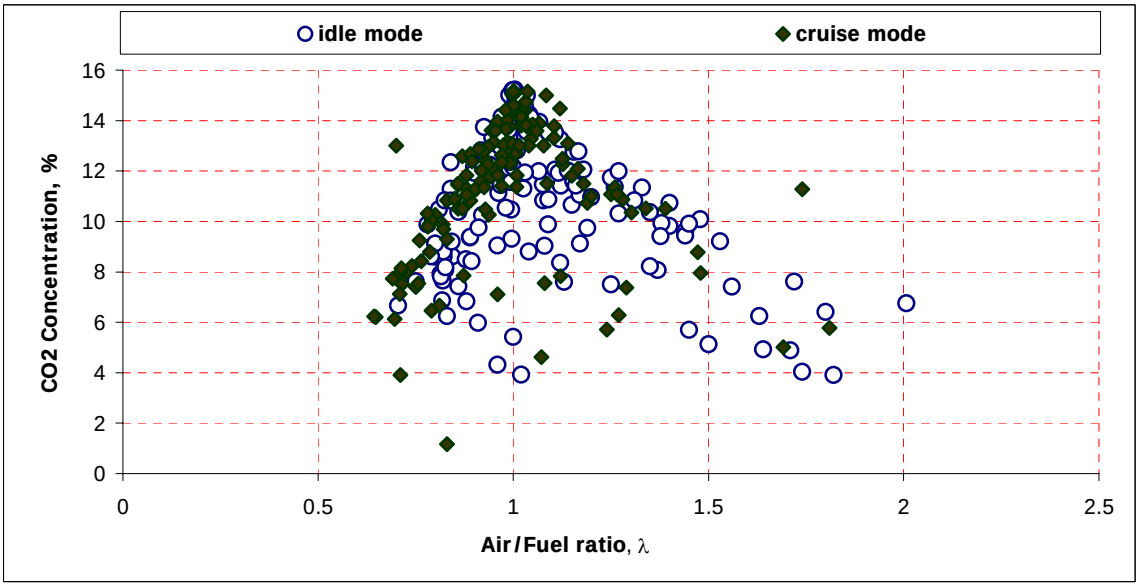


Figure (42) : Scatter Diagram of Carbon Dioxide Emissions as a Function of λ.

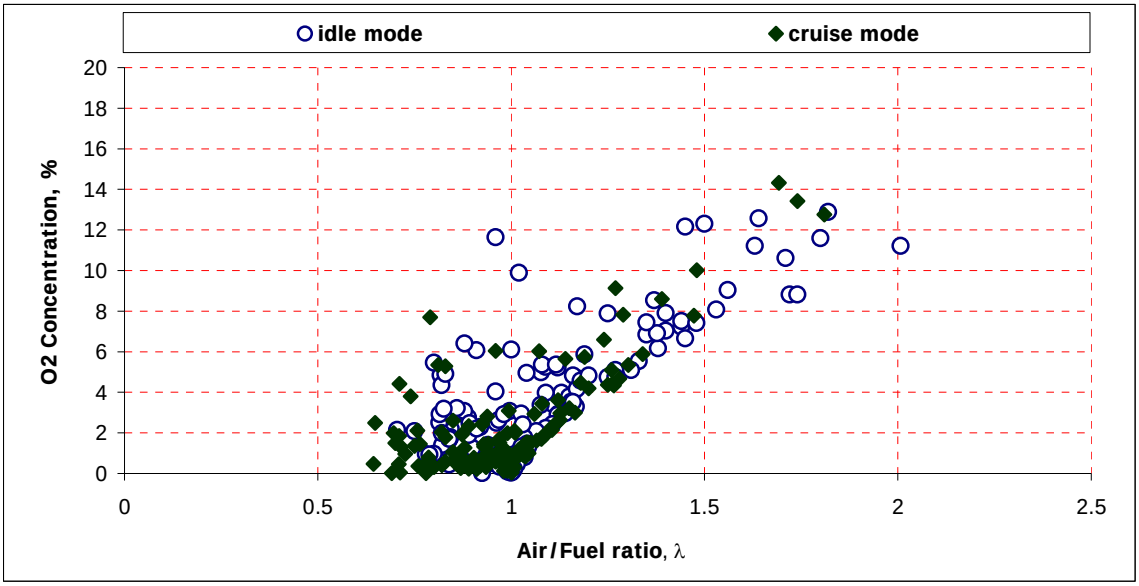


Figure (43) : Scatter Diagram of Oxygen Emissions as a Function of λ

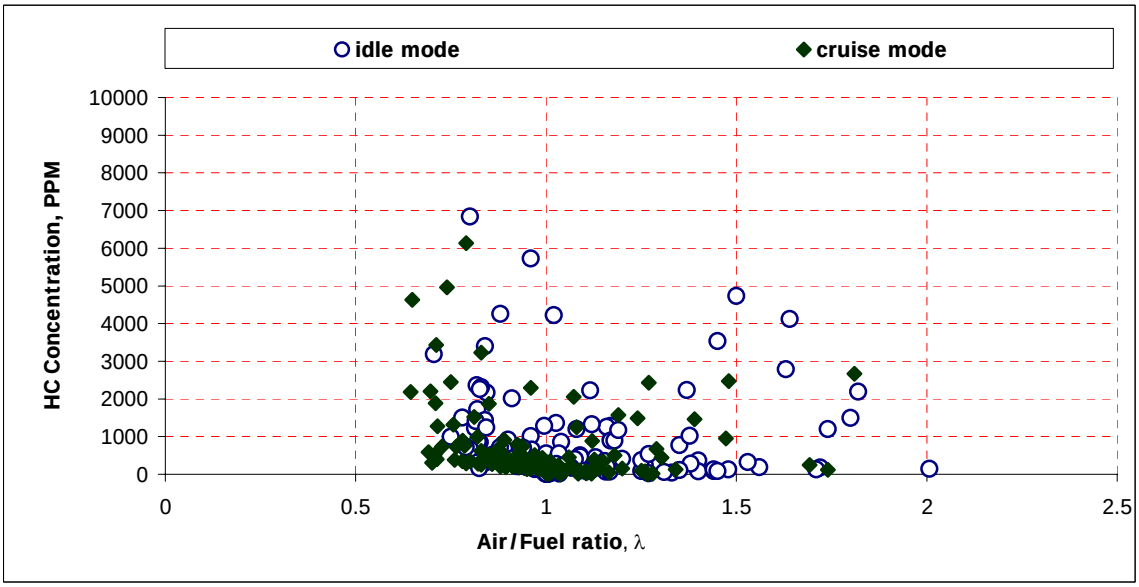


Figure (44) : Scatter Diagram of Hydrocarbons Emissions as a Function λ

The air to fuel ratio is function of the driving speed. Thus, exhaust emissions is expected to vary depending on the driving mode. Table (19) gives typical exhaust gas constituents from uncontrolled vehicle as a function of the driving mode. The mean values obtained during this study are in good agreement with the values presented in Table (19) . In general, the pollutants emission in the idle mode is higher than cruising mode. During idling, most engines require rich mixtures to compensate for residual combustion products in the cylinder. Thus carbon monoxide emissions are high during the idling mode.

Table (19): Typical Exhaust Gas Constituents as a Function of Driving Mode

Pollutant	Idling	Acceleration	Cruising	Deceleration
Carbon monoxide %	4-9	0-8	1-7	2-9
Hydrocarbons, PPM	500-1000	50-800	200-800	3000-12000

10.7 Diesel Versus Gasoline Engine

Diesel exhaust is composed of a mixture of many different toxic chemicals. Diesel engines rely on heat, generated during the compression cycle, for ignition rather than an electrical spark as in gasoline engines. Because of this needed compression, diesel engines are heavier and bulkier than gasoline engines. They operate with less highly refined fuel and consume less fuel per horsepower per hour. Gasoline engines and diesel engines produce similar materials in their exhaust although the relative proportions are different. Similar to the gasoline engine, the emission of diesel engines varies considerably depending on the operation mode. Gasoline engines emit fewer particulates in their exhaust than diesel engines, so the exhaust looks "cleaner." Table (20) shows representative composition of the exhaust gases in both gasoline and diesel engines at different operation modes. Direct comparison of emissions is difficult task but compared with equivalent gasoline engine, CO and hydrocarbons emissions are orders of magnitude lower in diesel engine under urban driving conditions.

Table (20): Representative Composition of the Exhaust Gases in Gasoline and Diesel Engines.

Fuel	Pollutant	Idling	Acceleration	Cruising	Deceleration
Gasoline	Carbon monoxide %	6.9	2.9	2.7	3.9
	Hydrocarbons, PPM	5300	1600	1000	10000
Diesel	Carbon monoxide %	Trace	0.1	trace	trace
	Hydrocarbons, PPM	400	200	100	300

A diesel engine, running at the correct fuel-air ratios (0.04) would have oxygen concentration of 1.5% and carbon dioxide of 13.5% in the exhaust gas. When the engine operate at higher fuel-air ratio of 0.094, oxygen concentration is lowered to reach of 0.3 %, a carbon dioxide concentration of 10.2 %, and carbon monoxide would abruptly increase to reach 6% in the exhaust gas.

Minimization of automobile emissions is achieved by enforcing the appropriate legislations and emission limits. Table (21) shows comparison between allowable emission limits and averages measured in during this study. Its clear from Table (20) that the carbon dioxide emissions in the average are acceptable when compared with the emission limits. This case is not achieved for the hydrocarbons where less than 50% of the total number of cars have hydrocarbons emission exceeds 300PPM. Similarly, about

50% of the cars have carbon monoxide emissions beyond the emission limits in Table (21).

Table (21): Allowable Emission Rates and Averages Obtained in This Study.

Pollutant	Allowable concentration	This Study
Hydrocarbons (max)	300 PPM	791 PPM
CO (max)	2.00 %	3.17 %
Carbon dioxide (min)	7.00 %	10.74%
Oxygen	9.00 %	3.18

10.8 Atmospheric Loading

The automobile atmospheric loading depends on the traffic volume on the road, its composition, and operation mode of the vehicle. The emission rate calculations are simplified by two assumptions. First, it has been assumed that gasoline and diesel engines emit equal amount of carbon monoxide. Secondly, single factor, vehicle speed was chosen to represent the engine operating mode. The following expression has been developed using field data from the USA and has been used the calculate the emission rates, Q:

$Q=1.031\ T\ S^{-0.795} \times 10^{-4}$ g/m. s

Where; T is the total traffic flow (veh/h), and S is the mean traffic speed (km/h).

This equation has been used to examine the impact of the developed transportation master plan on the air quality and carbon dioxide load. The master plan has improved the mean traffic speed, but has no control over the total traffic volume. This facilitates the use of the above equation to make qualitative comparisons between the proposed scenarios. When both sides of the above equation are divided by $1.031\ T \times 10^{-4}$ the left hand side of the equation will be $S^{-0.795}$. These calculations are shown in in Annex (18) . The $S^{-0.795}$ value is plotted against the time during peak hours as shown in Figure (46). This Figure shows that for all the times the traffic master plan will reduce the emission compared with the "do nothing" scenario.

The ratio between the source emissions in case of plan implemented and source emissions in case of "do nothing" scenario is plotted against the peak hour times for the planning period in Figure (46). Examination Figures (46) shows that when the plan is implemented peak hours emissions will be reduced more than 10% in the year 2007 and will continue to increase to exceed 50% by the end of the planning period.

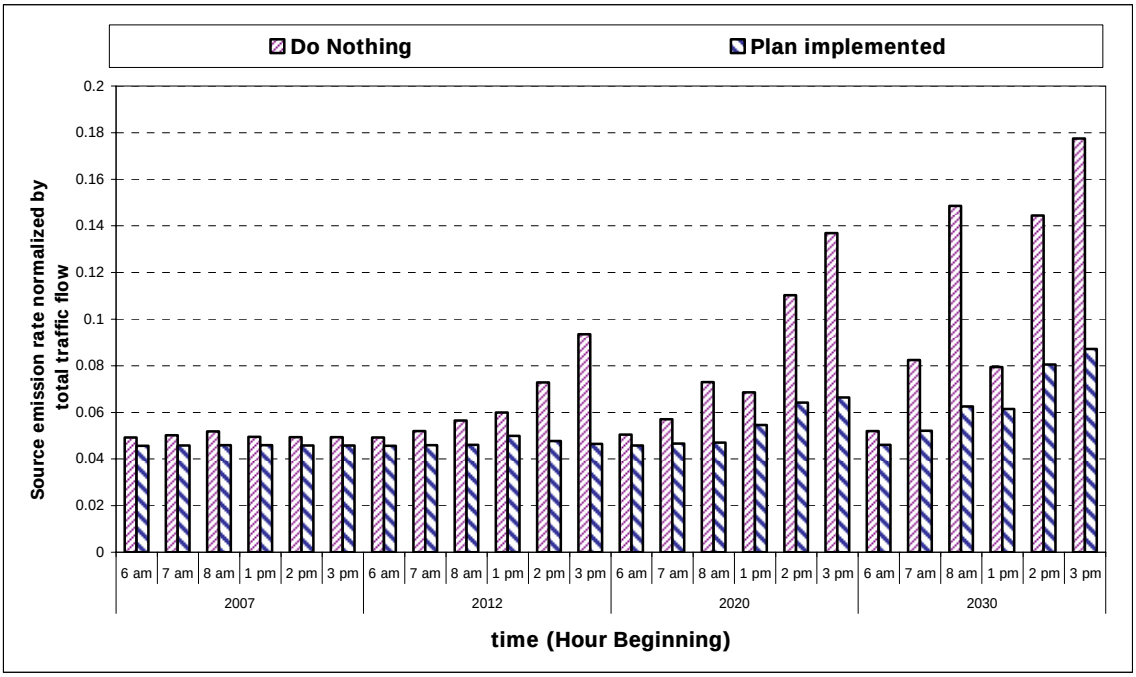


Figure (45) : Emission Loads When the Plan is Implemented Compared to Do Nothing Case

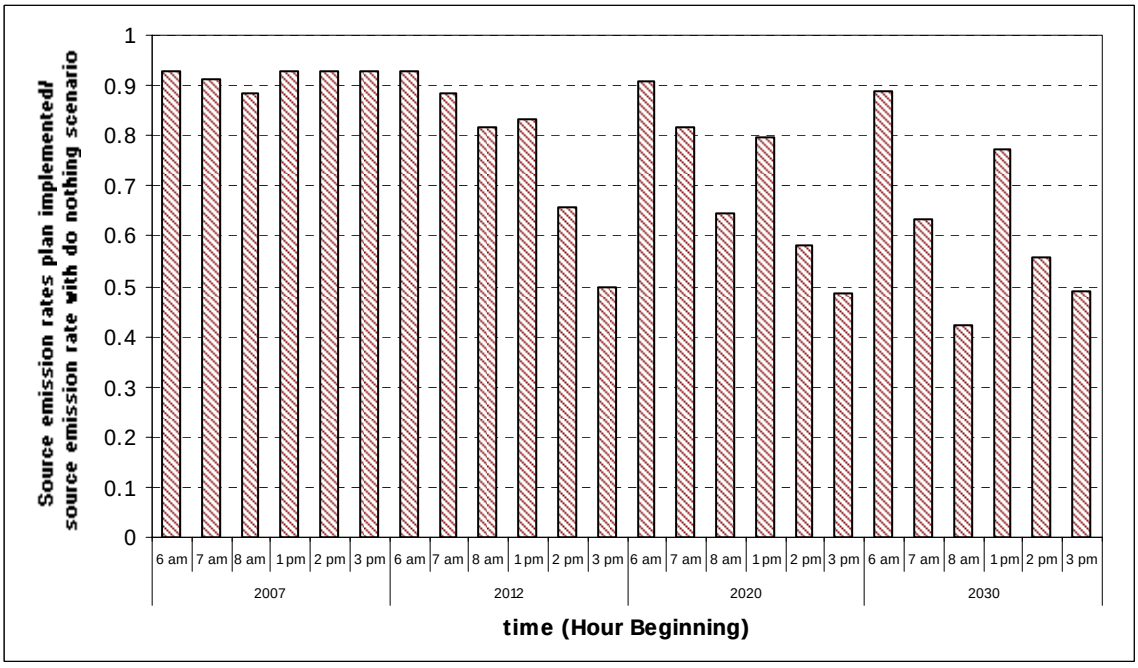


Figure (46) : Ratio of Source Emission in the Case of Plan Implemented and Do Nothing Scenario

10.9 Concluded Remarks

In this study, a number of 140 gasoline-fueled vehicles were tested by the Community College of Applied Science & Technology (CCAST) laboratories for 4 gases in exhaust emissions. These gases were carbon monoxide, carbon dioxide, hydrocarbons, and oxygen the air to fuel ratio was measured also. The distribution of the vehicles was made to represent all models and car ages working in Gaza Strip. The collected samples has been critically reviewed and analyzed to examine the quality of data where it showed consistency, reproducibility, and high precession.

When air quality is the concern, it is worth pointing out that most of tested cars exceeds carbon monoxide and hydrocarbons permissible emission limits. On the other hand, carbon dioxide emissions in the average are acceptable when compared with the emission limits. This situation emphasizes on the need for immediate interventions to bring innovative solutions of automobile emissions problem. The interventions might include; enforcing emission limits and regulations, maintenance plans of major highways, master planning of highway networks, etc.

The proposed traffic master plan has been evaluated using emission field data to examine its impact on the source emission rate of the road network of Rafah governorate. Results shows that the implementation of such plan will reduce the rate of gases emission from the vehicles during peak hours by 10% in the 2007 to more than 50% by the end of the year 2030. These emission reductions are reflected positively on both the local environment when carbon monoxide and hydrocarbons are considered and the global environment when carbon dioxide emissions are considered.

The analysis in this chapter depends on emission data from huge diversity of cars and models which was proven very useful. The usefulness would be expanded in future studies if the emission data were collected coupled with dynamometer readings. It also worth to make more studies that the diversity of the cars has been organized and more cars are being tested.

11 Awareness and Social Activities

11.1 The Need for Awareness Plan

Prior to the commencement of the development of any traffic system over an area, the issue of traffic awareness that the local community has, should be taken in consideration. This will not be very beneficial as long as a road is adequately designed and served while its users don't have the basic awareness of how to use it appropriately, especially that the human error is considered as the contributing factor in over 90% accidents as the latest traffic studies assume.

This fact is consolidated as the suggestion of performing awareness campaigns for the street users wholly, is a one of the first priority options adduced by street users covered through a questionnaire previously distributed in Rafah governorate, as well as awareness campaigns are among the most important outputs of the RTMP according to the design criteria consideration, therefore, it is necessary to work on such campaigns.

The desired expected action of such a traffic awareness plan is not limited to the traffic system purposes only, but exceeds to include other important aspects such as:

Environmental Aspect:

Air and noise pollutions as the most pivotal impacts of traffic movement onto environment locally and globally, are expected to be declined significantly through efficacious traffic awareness campaigns. It won't be complicated to convey messages carrying the harsh truth about environmental pollution impact to the local community individuals in Rafah governorate to gain their cooperation.

Health Aspect:

Both air and noise pollution has its tremendous influence to human health. The control and minimization of impacts will traditionally improve health conditions. Following-up the regulations, traffic laws, and the traffic signs will ensure healthy environment, safe people and minimize the injuries and deaths resulted from traffic accidents.

Social Aspect:

Getting red of noise pollution, and bad, aggressive and irresponsible traffic practices through awareness campaigns concentrating on the issue of "Social inclusion", is actually considered as a pivotal goal deserves concerned bodies' efforts and attention.

The problem that the traffic system in Rafah governorate faces can be summarized in the following points:

- The culture and the costumes of the local community in Rafah affect the traffic system in it adversely.
- Due to the paucity in traffic awareness campaigns resulted from the difficult economical situation dominating Gaza strip, the level of traffic awareness of the local community in Rafah governorate gradually goes worse.
- The implementation of inadequate geometrical design & characteristics and traffic control system in the vast majority of Rafah streets.
- The lack of commitment of laws and regulations.

11.2 Objectives of the Awareness Plan

The basic aim of this traffic awareness plan is to promote the traffic awareness of street users in Rafah governorate throughout pointed lectures, brochures and signboards. In addition, it aims to burnish the related engineers in Rafah municipality and traffic police officers skills through performing a group of workshops including lectures that will be accomplished in cooperation with concerned bodies so as to create a thorough traffic awareness state over Rafah governorate.

Finally, Clarifying the seriousness and the importance of such awareness plan for donor representatives and neighborhoods committees members so as to secure an accepted level of interaction of the local community with the plan, in addition to encourage conducting other studies aiming to the same purposes.

The more specialized expected impact of this program can be described as follows:

- Improve road safety.
- Reduce road danger.
- Reduce fuel consumption and CO_2 emissions.
- Reduce noise.
- Encourage walking, cycling and public transport.

11.3 Awareness Mechanism

To ensure the success and the effectiveness of the intended Traffic Master Plan proposed for Rafah governorate, a set of traffic awareness activities should be accomplished concurrently with the implementation of the projects suggested by the RTMP.

This can secure an acceptable literacy in traffic awareness of road users in Rafah, which, in turn, provides an atmosphere of positive and responsibility that ensures a greater chance of the success of the plan.

To achieve the aim mentioned above, the awareness mechanism will be approved in this plan, comprises three tools are expected to be sufficient, as follows:

11.3.1 Workshops

A group of workshops will be conducted in order to disseminate the plan findings and suggested actions. Each workshop has a specific objective according to the target group. These workshops and awareness campaigns are intended for the following groups:

- Street users: pedestrians, drivers and shops' owners and even interested local community individuals wholly.
- The related municipality engineers, interested neighborhood committees' members and financer representatives.

The following are the main proposed workshops.

Workshop	Target group	Objective
Presentation of the draft plan	Municipal representatives (20 persons)	To present the findings, conclusion and recommendations. The recommendations and comments of the municipal staff will be considered in the final plan.
Training program (workshop)	Municipal Engineers	To burnish their experience and introduce the planning principles, modeling, forecasting, data collection and data analysis methodology and techniques. A training material will be prepared.
Awareness workshop (replaced by visits for the schools)	Specific groups (school headmasters, teachers and students)	To summarize specific actions and report their recommendations concerning the awareness programs and dealing with local community.
Public campaign	Community and community committees (200 persons invited and about 70 attended the meeting)	Awareness campaign (traffic management and safety)
Presentation of the final plan	Municipal representatives and selected representative from local community, NGOs, funding agencies and police. (20 persons)	To present the findings, conclusion and recommendations

11.3.2 Brochures

The use of brochures is an effective action to be conducted within the approved work mechanism in this program for two reasons:

- Firstly, the beneficiaries of this mechanism are not confined to those interested and willing to attend public meetings and lectures, but can reach them without costing them any effort, consequently, it could reach the largest possible segment of the local community.
- Secondly, allowing road users to have fast, deep, concentrated information through abridged articles, is professional to let them have the most pivotal points in mind.

The brochure included fast and concentrated instructions related to the adequate traffic practices as well as special instructions for drivers with regard to their behavior and precautions they have to take on their vehicles.
The design of the brochure was simple, readable for all community categories, and included figures and massages. The developed brochure was shaped as a vehicle. This shape make it more popular and attractive.

Massage: Reduce the impacts of emissions

Massage: Kill your speed

Figure (47) Awareness Brochure

The brochure include ten pages with ten massages. The "Decalogue" – the ten massages were as follows:

Massage 1: Traffic police works for community safety
Massage 2: Kill your speed
Massage 3: Keep proper driver behavior
Massage 4: Reduce the impacts of emissions
Massage 5: Reduce noise pollution
Massage 6: Don't run on red light
Massage 7: Support the regulation to improve the level of service on roads
Massage 8: Make children safe to cross

Annex (16) shows the design of the brochure

11.3.3 Street Signboards

By experiment, traffic signboards can affect road users positively. A peculiar, abridged and meaningful slogan written and designed in a way touches directly driver's mind, can leave a deep positive impression on him, which leads to push him to deal wiser and more responsibly, especially at dangerous streets and intersections. Two massage were selected, they are:

Figure (48) Street Signboard-1
The necessity of cooperation with traffic police for community safety

Figure (49) Street Signboard-2
The bad effects of global warming on our environment and how we can alleviate this dangerous

The following massages were also covered during the workshops and public campaigns.

- " It's better to lose one minute of your life than your life in one minute".
- "Don't let your kids drive if they are not old enough - or else they never will be..!"
- "The lives of so many are dependent on you".
- "Come on, shut this evil and act responsibly".
- "Arrive Alive".
- " The Car is a means of transportation, don't make it a mean of death".

- Speed=death and disability
- please back safe.
- Other religious massages related to human health and safety:

11.4 The Manual

In order to simplify the plan report and make it accessible and readable for public and representative of international agencies, local agencies, local community, NGOs, and others, a manual was designed and published. The manual is in both Arabic and English. It is supported with photos, figures and slogans. The manual included mainly summary of the following:

- Planning Horizon
- Traffic Surveys
- Traffic Analysis
- Traffic Modeling and Forecasting
- Traffic Development Plan
- Economical Evaluation
- Air Pollution Analysis
- Awareness and Public Participation
- Impacts

Moreover, the manual is designed in a manner that shows the importance of plans and its proposed actions and projects in improving the local environment as well the global environment. About 500 copies were published and distributed in Gaza Strip.

12 Benefits of the RTMP Implementation

The overall goal of RTMP 2030 is to maintain and improve environmental conditions, while having an efficient transportation system. This Master Plan aims to minimize the unacceptable implications for Rafah's quality of life in terms of delay to persons and goods, air pollution and danger that are most likely to arise. Implementation of RTMP 2030 is expected to achieve the highest level of future transit usage. Moreover, the plan will enhance safety, properly manage traffic network, solve the congestion and reduce delay in Rafah streets network up to year 2030. More specifically, the RTMP impacts is expected to include multi- issues such as:

- Natural environment (air quality, water quality, noise, and aesthetic values).
- Transportation services.
- Community life style.
- Public health and safety.
- Funding issues.

12.1 Natural environment

The health of our natural environment — local, regional and global — is vitally important to the people of Rafah. However, the plan will minimize transportation system effects on the natural environment as follows:

Air quality: it ensures the minimization of vehicles gas emission. Transportation choices that can improve health, like walking and cycling, will be encouraged.

Water quality: it reduces the size and number of lots and reduces parking requirements for some land uses. The driveways and taxi stations prevent water from soaking into the ground and increase storm water volumes in the drainage system.

Noise: proper management of traffic systems will protect all neighborhoods from traffic noise.

Aesthetic values; streets and walkways will be planned, built and maintained as attractive public spaces. Planting of trees is highly recommended to improve the aesthetic features, improve the air quality and provide shade and wind protection. Reduction of noise, pollution and danger will improve the aesthetics.

Land consumption: minimize the possible consumption of valua0ble agricultural and natural lands to construct new transportation infrastructure, by maximizing the efficient operation of existing facilities before developing new ones.

12.2 Transportation services

Transportation services will be delivered cost-effectively by guiding the proposed plan , since this plan was taken into consideration the performance of the existing road and transit systems which will be optimized before building new facilities.

12.3 Community life style

Transportation facilities and services will make communities more liveable. The recommended facilities and services such as sidewalks and new roads will support and enliven the communities they pass through. Residential areas will also be protected from the undesirable impacts of transportation activity like congestion, noise, pollution and poor driver behaviour.

The economical conditions are proposed to be improved as a direct result of the proposed planning. The access to shops and commercial locations will be more accessible. The value of commercial assets will be much improved. Establishing new commercial facilities and markets is expected at the near future as direct impact of the proper traffic management.

12.4 Public health and safety

Rafah residents will enjoy sidewalks, roads and transit facilities that considers safety of people as a priority. Transportation choices that can improve health, like walking and cycling, will be encouraged. The city will also educate people about safe walking, cycling and driving behaviours for their own protection, and for their families and others.

12.5 Fund opportunities:

The plan will provide the municipalities (Rafah, AL Soka and Al Nasser) with the necessary tools and arguments that required to justify the proposed projects for donors. The plan provides comprehensive solutions of existing problems as well as development alternative to meet future requirements. Considering the impacts on people and natural environment will be highly appreciated by donors. Providing solutions and proposals for short, intermediate and long terms will increase funding opportunities.

13 Conclusion

In this report a Transportation Master Plan (RTMP) for Rafah Governorate was prepared. The RTMP outlines the City's strategic directions for the development of its transportation networks, programs and priorities. The RTMP is prepared by Natuf for Development (a Palestinian Non-Governmental Organization) and funded by the Global Environment Facility (GEF) - Small Grants Program (SGP) which is managed by United Nations Development Program (UNDP). Several stakeholders were cooperated to ensure successful development and implementation of the RTMP. The key stakeholders were Natuf organization, Rafah Municipality, Al Shoka Municipality, Al Nasr Municipality and the local community.

The main traffic problem in Rafah is located at the city center of Rafah, principally on Abu Bakre Street , where the main popular market is found. The existence of the main market, onsite shops, medical clinic, parking and other multi-activities in the same area in addition to the high density of population in the district contribute all to traffic congestion and form bottlenecks in the specified area particularly during the morning hours.

In addition to the main problem, there are other contributing problems that affect traffic system in Rafah Governorate. One is that Rafah lacks traffic control instruments. A second is that there is no respect by citizens and drivers to the regulations imposed by the Municipality. Thirdly, animal driven carts cause serious congestion in the area. Furthermore, a bad Rafah storm water drainage system causes a severe congestion problem especially in winter.

Given this context, the main purpose of RTMP is to propose solutions (projects and programs) to the mentioned problems, which results to protect the local community from unacceptable levels of transportation-related noise, pollution, delay and danger that are most likely to arise. Furthermore, the RTMP aims to conduct and elaborate a consistent strategic Plan for the traffic system and transportation facilities in Rafah Governorate to enhance safety, properly manage traffic network, solve the congestion and reduce delay in Rafah streets network up to year 2030.

In order to achieve the objectives of the RTMP, the work was divided into different phases. The first and the second phases ware traffic surveys and analysis to review the existing conditions. In order to achieve this purpose different surveys were conducted as follows:

- Street network characteristics and problems survey, which was done by reviewing the secondary information resource which includes previous related studies, municipality report about the current situation assessment and expert opinions. Moreover, by site visits, observation, photos and questionnaires.

- Origin-Destination survey (OD), which aims to determine the pattern of trips between the zones which is necessary for modeling and forecasting process. This was done using Roadside Interviews, which were conducted on 12 stations. One of every 10 vehicles passing through was selected as a random sample in a single direction for a period of 6 hrs. Each selected vehicles were stopped to answer three questions. These are (1) the location where it was come from (Origin); (2) the location where it is going to (Destination); and (3) which route was utilized in the trip (route).
- Traffic Flow Survey, was carried out by the Manual Classified Counts method. This survey was done in order to determine the average daily traffic, turning movements, traffic composition, and the peak hour at the major intersections in Rafah governorate. Furthermore, it aims to assist in the model calibration process by adjusting the trip matrix when applying the modeling software.
- Spot Speed Survey, which was conducted to determine the desired speed by motorists and hence it is useful for geometric design purposes on improved or new facilities. Moreover, it was an input to network traffic modeling software.

The third phase of RTMP was the traffic modeling and forecasting. The modeling was carried out using a dynamic traffic modeling software known as CONTRAM Software. CONTRAM is designed to model the varying traffic demand and congestion that occurs during the day and will represent the peaks of congestion as well as off-peak conditions within a single model. These features are combined with a high quality graphical interface.
The forecasting of future demand for transport services in this work was done for three planned periods of the project packages as follows. The first one is a short-term planning period between 2008 and 2012 over a horizon time of 5 years. The second period is an intermediate-term planning period between 2013 and 2020 over a horizon time of 13 years. And, the third one is a long-term planning period between 2020 and 2030 over a horizon time of 23 years.

The fourth phase of RTMP was the planning phase. In this phase different planning options and scenarios were formulated for an environmental-sound traffic system including detailed implementation plan for the scenario based on environmental and economic evaluation criteria. Moreover improvement project list was developed and listed as short term, intermediate term and long term actions. The developed projects were in the network, intersections, parking, markets and pedestrian facilities. Beside that projects were developed related to regulations, control, enforcement, environment and safety.

Furthermore, implementation plan was developed considering construction cost, prioritization of Improvements and suggested responsible Agencies/Funding Sources. In

addition to developing a plan for one year period consists of the urgent measures which need to be implemented as soon as possible.

The last phase was increasing the traffic awareness of the local community. This Study dealt with this issue by suggesting awareness campaigns targeting most community sectors in Rafah Governorate. It included leaflets, public meetings, brochures, marketing slogans and awareness Posters.

14 Recommendation

In addition to the necessity of implementing the Suggested projects by the RTMP to solve the current and predicted traffic system problems in Rafah Governorate until 2030 , there are several recommendations to support these suggested projects and to promote the efficiency of Rafah traffic system.

The following recommendations are suggested to be taken into consideration:

14.1 Rafah City Center traffic management:

Rafah Accessibility to City Center

There should be a hierarchy of streets to efficiently move vehicular traffic into and through the City Center.

Traffic control

It is recommended to use vehicle actuated traffic signals that employ detectors on all legs of the intersection and changes the timing of the signals to maximize traffic flow so that the delay will be minimized as much as possible.

Create Multi- Centers for Rafah City

It is recommended to create other centers for Rafah City that ensure the minimization of traffic congestion in the existed one, and the proposed location is at AL Kherba intersection (The intersection of Omer Ibn Al Khatab Street with Taha Hussein Street).

Pedestrian and Bicycle Friendly Environment

Rafah City Center is recommended to be pedestrian and Bicycle friendly in the long term, where walking become the primary mode of transportation. So it is recommended to:

- Make sure that transportation within the City Center will not require an automobile.
- Encourage people who live in the City Center to move around without the need to own a car.
- Create new pedestrian routes in order to make walking distances shorter, safer, and more appealing.
- Create new sidewalks and rehabilitate existing sidewalks and crosswalks.
- Identify street sections with excess lane capacity that can be used for improvements to the pedestrian environment.
- Create bicycle network to balance between transport modes.
- Encourage and protect vulnerable road user such as pedestrians and bicycle riders.

14.2 Parking

- Develop a comprehensive parking strategy for the Central Business District (CBD) that addresses how adequate parking can be provided for customers, employees and residents.
- The availability, visibility and accessibility of parking should be managed to achieve efficiency and to reduce congestion.
- Introduce paid on-street parking facility to match the parking demand.
- Develop and distribute maps that clearly indicate the location of off-street parking, how the parking is accessed, the cost of parking and the hours of operation.
- Provide annual reports showing statistics for parking use and rates.
- Provide bicycle parking areas throughout the CBD.

14.3 Taxi Stations

- Provide Taxi Stations at several locations in Rafah Governorate. Taxi Stations are recommended to have noticeable traffic signs indicating the origin and destination .
- Ensure enforcing traffic regulations related to the operation of taxies.

14.4 Schools

- Increase the presence of traffic police at school locations especially at primary schools
- Coordinate between schools and traffic police to disseminate traffic awareness among students.
- Conduct a separation between male and female schools to annihilate loitering.

14.5 Disabilities Serving

The City should improve the accessibility of its conventional services to better serve people with disabilities.

14.6 Environmental considerations

- Ensure proper vehicle testing before issuing a vehicle license to reduce exhaust pollution.
- Apply design guidelines that maximize greening opportunities for roads.

14.7 Traffic Calming

Traffic calming measures reduce speed but do not reduce traffic, so it is very strongly recommended to create Zone 30 (Zone with speed limit of 30 km/h) especially surround schools by the following measures:

- Volume control measures: Volume control measures consist of modifications that reduce the quantity of vehicles that use a specific roadway. Typical measures include

full street closures, half street closures, forced turn islands, and diverters, the following figures illustrate some of these measures:

Figure (50) Traffic Calming - Volume control measures

- Vertical speed control measures: Vertical speed control measures are elevated segments of roadway that require vehicles to slow down. Typical measures include speed humps/bumps, speed tables, raised crosswalks, and raised intersections, the following figures illustrate some of these measures:

Figure (51) Traffic Calming - Vertical speed control measures

- Horizontal speed control measure: Horizontal speed control measures alter the typical straight-line travelled way of a specific roadway in an effort to reduce speed. Typical measures include traffic circles, roundabouts, lateral shifts, and chicanes, the following figures illustrate some of these measures:

Figure (52) Traffic Calming - Horizontal speed control measure

- Narrowing: Typical narrowing include neckouts, chokers, and island or median narrowing. Narrowing can slow traffic and provide pedestrians with shorter crossing distances if utilized at crosswalk; they may also reduce cut through and volume, the following figures illustrate some of these measures:

Figure (53) Traffic Calming - Narrowing

14.8 Public Transport

It is recommended to create reliable and comfortable public transport services to help in reducing congestion.

14.9 Public awareness

- Develop new strategies for informing the public before implementing any new action concerning the traffic system in Rafah governorate.
- Provide better communication between Rafah Municipality and its stakeholders.

14.10 Public Participation

Ensure the participation of the local community by inviting them to meetings and workshops to integrate the needs and opinions of the public in the planning and implementation of actions which will be introduced to the transportation system.

14.11 More studies

It is recommended to conduct a before and after evaluation study for every action implemented in the traffic system.

14.12 Detailed Design for suggested projects

Prepare detailed design for the suggested actions and projects to facilitate the budget Provision, tendering, and implementation for these projects.

14.13 Transportation Statistics

It is recommended to continue conducting traffic counts at the important links and junctions at least once a week per year. In addition to conducting automatic traffic counts when it is feasible and possible.

14.14 Recommended long term projects

There are several recommended projects came in the context of the road network development which suggested to promote the network services and efficiency (Refer chapter 9) , and these projects estimated budget is:

City	Projects Cost ($)
Rafah	**31,537,000**
Al Shoka	**16,860,000**
Al Nasser	**5,930,000**

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Annexes