Enhancing the Documentation Process of Traffic Accidents Registry in Gaza City Using GIS

Maher A. El-Hallaq

Abstract— Gaza City is the largest city in the Gaza Strip and the Palestinian territories. The city has a population about 700,000 inhabitants with an average population density of 12600 person/km^2. Documentation procedure of traffic accidents in the city is traditional and inefficient. It is not only based on paper formatting but also is not performed in the correct way since it misses the determination of exact position of occurrence of these accidents. Furthermore, documentation data do not involve appropriate level of details and need to be re-organized. This study aims to enhance the documentation process of the traffic accidents in Gaza City using GIS as well as developing appropriate recommendations that can raise the level of traffic safety in it. To enhance the documentation, a new mobile and desktop applications based on GIS Cloud are developed in order to automatically store spatial and descriptive data about traffic accidents in a computerized geodatabase. Many analysis using GIS of the accidents statistics of 2019 are performed. Results indicate that the hot neighborhood in the city is Northern Remal, the hot road is Salah Al-Din Str., the hot period is 12 – 14 O'clock, most accidents are caused by cars, and medium injuries are the dominant of these accidents. The study recommends to build a digital geodatabase that involves all necessary data associated with traffic accidents because it is the basis for planning, analyzing and making decisions. It is also recommended to establish a GIS department in Ministry of Transportation. There is a strong need to legislate binding laws to prevent the increase in the number of traffic accidents in addition to make field actions such as the necessity to set up traffic lights as much as possible near health centers, schools and other public places.

Index Terms— Documentation, Gaza City, GIS, Mobile Application, Traffic Accidents, Traffic Analysis

I INTRODUCTION

Traffic accidents is one of the most important and dangerous problems facing societies worldwide, as it leads to a large amount of human and physical damages. Statistics issued by the World Health Organization, WHO, indicate that the world annually loses about 2.1 million people, and a range from 20 to 50 million people are also injured. Annual losses of traffic accidents in the world are estimated to reach 518 billion dollars, which constitutes (1-3) % of the world's gross local income. Many countries have come to the conclusion that national traffic mechanisms and strategies are needed to meet the traffic safety challenges associated with many sectors and relevant authorities [1].

In developing countries, road accident fatality rates (deaths per 10,000 vehicles) are very high and often more than 5 times greater than those for countries of Western Europe and North America [2]. In 2007, traffic accidents were considered the second leading cause of death in Jordan. WHO [1] indicates that in Saudi Arabia, an average of 20 people die every day due to road crashes, which are the primary cause of death in males aged 16 to 36. If current trends continue, Saudi Arabia could have more than 4.0 million traffic accidents a year by 2030. Every year in Egypt, about 12,000 Egyptians lose their lives as a result of road traffic accidents. Many thousands are

non-fatal injury; some with resultant long-term disability [3]. Based on a World Bank study in 2006, the annual rate of increase in the number of crashes and fatalities in the Palestinian territories was about 5.0% in 1994. The percentage of pedestrians involved in the injury crashes was as high as 30%. The fatality rate increased sharply in 2003 compared to other years, where it was 16.5 fatality/10000 vehicles [4]. The available traffic statistics in Gaza City are disorderly and without good management. They are also limited to statistics conducted for solving a particular problem or for developing some roads. It is reported that road crashes in the Palestinian territories had been increased by 170% in the period (2007–2013), injuries increased by 120%, and deaths increased by 33% for the same period [5].

The traffic crashes in the Gaza Strip was 1985 in year 2000 and increased to 4046 in year 2012, then slightly decreased in 2013. There has been a remarkable rise in the number of victims due to unlawful use of motorcycles and disrespect for rules and laws concerning the speed limit and automobile standards. In 2011, 75 persons have died due to traffic crashes; 36 of them were in motorcycle-related [6].

II PROBLEM STATEMENT

Gaza City is the administrative center as well as being the main city in the Gaza Strip. It is the most populated area in the world, as its population reaches more than 700,000 over a small region (55.6 km^2) [5]. The city is suffering as the rest of the world from daily traffic accidents. The recorded traffic accidents are increased significantly resulting to a big number of deaths and injuries, which reflects the dangerous situation on its roads.

In the city, traffic accidents are paper documented and there is no use of detailed databases which can be a platform for an effective process of analysis. In addition to, location of those accidents are not properly documented in terms of their local coordinates. The success of any preventive action depends on the intensive analysis of traffic accident records. Thus, efficient and accurate analysis are consequently based on the descriptive documented data that are needed to understand which factors or causes are the most influential in traffic accidents, in addition to the spatial data that associated with location of those accidents. The location is one of the critical variables in the analysis process.

Standing on the main and most causes of traffic accidents will enable specialists to adequately prepare the best awareness and guidance programs aiming at directing the focus and targeting the real groups, whether they cause or affected by traffic accidents. This will make these programs more effective in performing their role. Determining the hot spots related to traffic accidents as well as knowing the influencing causes as they occur, will help planners and decision-makers in taking actions and creating laws with real effectiveness in reducing traffic accidents, and consequently human losses and economic implications.

Thus, this study aims to enhance the documentation process of the traffic accidents registery in Gaza City using GIS as well as developing appropriate recommendations that can raise the level of traffic safety in it. The technology of GIS is one of the important tools used globally for studying and analyzing traffic accidents in terms of their causes and consequences.

III MINISTRY OF TRANSPORTATION

Ministry of Transportation, MOT, is one of the ministries of the Palestinian Authority that was established since the arrival of the Palestinian Authority in 1995. Its main mission is to preserve human lives by minimizing traffic accidents on roads and setting the standards and conditions necessary for establishing transport facilities and services, in coordination with other relevant ministries. MOT is also responsible for [7]:

- Developing a comprehensive plan to rebuild the infrastructure of the land, sea and air transport sector to follow up programs and projects related to this sector.

- Preparing laws, regulations and instructions that regulate the various transport sectors and agencies affiliated to the Ministry.
- Preparing systems and safety standards for establishing service facilities in coordination with the ministries competent.
- Supervising all sectors of land, sea and air transport, and coordinating with all sectors; governmental and non-governmental entities in order to provide the best service to citizens.
- Preparing and organizing transport agreements between MOT and the sector companies regarding what ensures that this sector is run locally and internationally.
- Undertaking the necessary surveys of road networks and setting the standards and specifications necessary for their development, participation and supervision
- Supervising and taking over all means of government transport organization, operation, maintenance and follow-up.
- Regulating the issuance of licenses for vehicles, drivers, garages, spare parts, and driving education schools, institutes, training centers, rental companies, and travel agencies of car loans and payment of fees for all different types of licenses.
- Promoting the work of the land crossings, updating the working mechanisms in them and simplifying their procedures and organization of work.

The "Engineering and Traffic Safety Unit", ETSU, is considered one of the most important departments in MOT, as it falls under its responsibility setting the necessary standards and final approvals for licensing the facilities to be followed by MOT. Among the most important basic tasks of this Unit are; setting special and regulatory standards for parking lots, the use of safety barriers and islands, organizing traffic within the municipalities, preparing the necessary traffic studies such as (traffic volumes, peak hours, road intersections and their efficiency, levels of service) in addition to collecting and analyzing information about traffic accidents (places of occurrence, resulting damages, time, etc.) in order to stand on their causes and trying to find appropriate solutions.

Unfortunately, Gaza suffers from problematic and limitations in data, lack of accuracy, and the absence of statistical series that allows monitoring of traffic accidents. There are lack of sufficient information about different age groups, the absence of standardization and classification of traffic accidents, and lack of commitment by many of the relevant official departments to record accurate information about traffic accidents [8].

IV THE STUDY AREA

Gaza City is the largest city in the Gaza Strip and the Palestinian territories. The city is frequently termed "Gaza City" in order to distinguish it from the larger Gaza Strip. The history of Gaza, one of the oldest cities in the world, has been

shaped by its strategic location. The city is located on the Mediterranean coastal route, between North Africa and the greener lands of West Asia. The area of the City is about 55.6 square Kilometers and is located at 34⁰- longitude and 31⁰- latitude. The city has a population of about 700,000 inhabitants with an average population density of 12600 person/km^2 [9]. Figure 1 illustrates the charcteristics of the city regarding its geographic location, its neighborhoods, population density as well as its road network.

Gaza City participates borders with towns of Jabalya, Beit Lahiya and Beit Hanoun in the north while it is enclosed by the Mediterranean Sea in the west, Al-Zahraa City in the south, and the remaining border of 1978 is the restrictions of the City from the eastern border. It is divided into twenty one neighborhoods; El Daraj, Sheikh Radwan, El Awda City, Northern Remal, Southern Remal, Sabra, Al-Nasr, Tuffah, Ijdaida, East Ijdaida, Old City, Sheikh Ejleen, Zaytoun, Tal

El-Hawa, Beach Camp, Turkman East, Turkman, Murabteen, New East Extension and New West Extension. Zaytoun neighborhood involves the highest number of residents in the City, while Al-Shati Camp is the most dense regarding population [9].

In Gaza City, the transportation system relies on land transport. Roads are considered the only mode of transportation; where there is no rail lines, water or air transport facilities. Gaza City road network combines between the radial network system in the old part of the city and the grid system in the newer parts [10]. Salah Al-Din and Al-Rasheed Streets are considered the major arterial roads that cross the city in the east-west direction. The City also includes main roads such as Jamal Abdel Nasser, Al-Wihda, Al-Nasr, Omer Mukhtar and Al-Jalaa streets in addition to hundreds of other local streets.
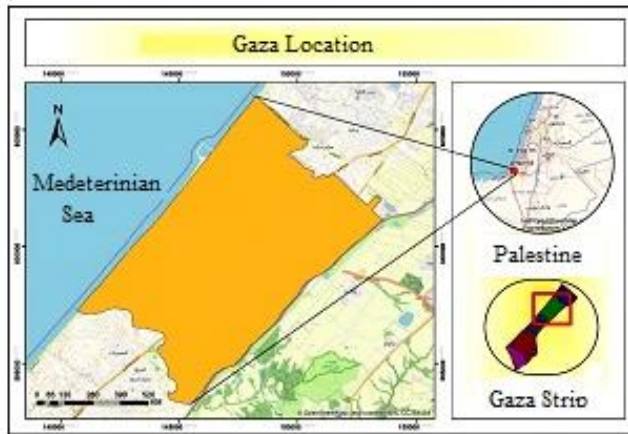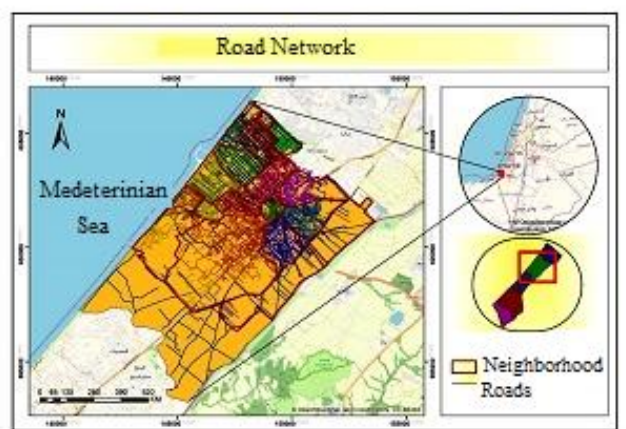

a. geographic location
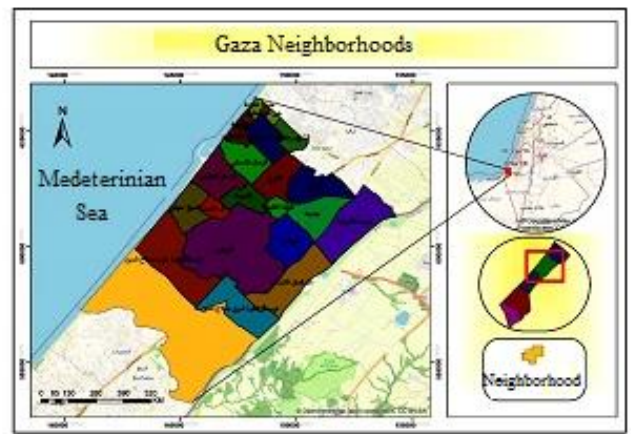
b. Gaza neighborhoods
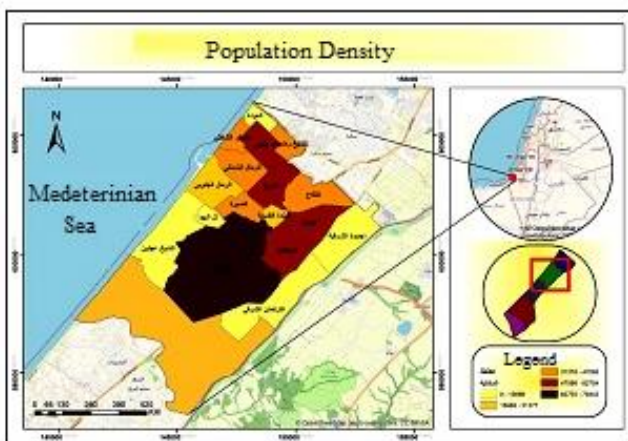
c. population density

d. Gaza roads

V NEW METHODOLOGY

Figure 2(a) shows the current documentation of traffic accidents [9]. Documentation procedure of accidents in the city is not only based on paper formatting but also is not performed in the correct way since it misses the determination of exact position of occurrence of these accidents. For example, it is written that an accident was occurred at Al-Rasheed Street, knowing that this street extends along over 45 km. Furthermore, documentation data do not involve appropriate level of details and need to be re-organized and enhanced for meaningful and effective analysis.

Figure 2(b) indicates the suggested methodology of the new developed system for traffic accidents documentation and analysis. This new system involves three basic stages; field accident data collection, accident data management and accident analysis stages. All tasks of each stage are automatically performed under the GIS umbrella.

The first stage includes the field collection of accident data. Such data involves both spatial and tabular data. Spatial data regard to the location of these accidents interms of thier coordinates, while tabular data concern with the descriptive attributes of those accidents such as injuries information, accident causes, accident time, etc. For this purpose, a mobile electronic computerized application is created to spatially sign traffic accidents in terms of their local coordinates and replace the inefficient current paper registration system. Here, an account on GIS Cloud and then an application on it are created to record and save accidents locations and attributes. Each new accident will be automatically signed with a unique primary key.

The second stage involves the management of the collected data of traffic accidents. Once accidents data are completed by the mobile field application, they are automatically stored and saved in a file geodatabase, so that data can be easily accessible and smoothly managed by any GIS software. Each accident will be geographically represented in a point feature format that is located on the map as the value of its coordinates and hold the corresponding tabular data of this accident. The file geodatabase has also other data layers associated with traffic accidenets such as, for example, Gaza City roads network (line vector format), Gaza Governorate and the city neighborhoods (area vector format), etc. Tabular data involves fields with text, numeric, code formats, etc. Storing data in a geodatabase will facilitate data retrieving, updating, sharing and performing quieries.

The third stage is next established in order to perform statistical and spatial analysis regarding traffic accidents. It is necessary to determine hot spots, hot neighborhoods, hot streets, hot hours, hot months, in addition to other statistics such as injuries statistics, accident causes, etc. These analysis can help to conclude recommendations and decide actions to avoid future traffic accidents.

the field, the application is turned on a smart phone and login

(a) The current documentation of traffic accidents
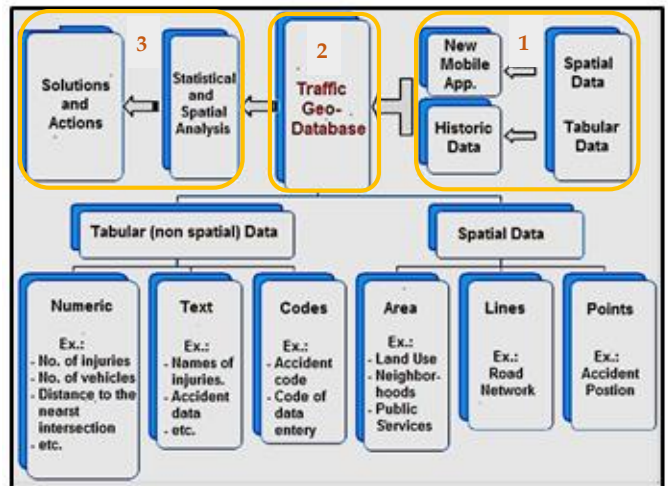
(b) The new methodology of documentation procedure

Fig. 2. The current and suggested methodologies for traffic accident documentation.

Figure 3 shows the main interface of the new desktop application on the central computer of the ETSU of MOT. It allows to control base map properties, add new data layers, import external traffic data tables in addition to export the existing database into other various formats. This application helps to electronically collect traffic accidents data in a single place and consequently enhance sharing, documenting, managing and analyzing it. It can also be set on a mobile smart phone in order to facilitate documenting accident data in the field.

The yellow coloured feature in Figure 3 represents an accident and similarly other documented accidents using the mobile application will automatically have the same appearance but with different location. Old paper documented data can be arranged in Excel or CSV files and directly imported into the main interface as well as being stored in the file geodatabase with the new data. To document an accident in to the GIS Cloud can be possible by either entering a defined

username and password or by using other ways such as Facebook or Google accounts.
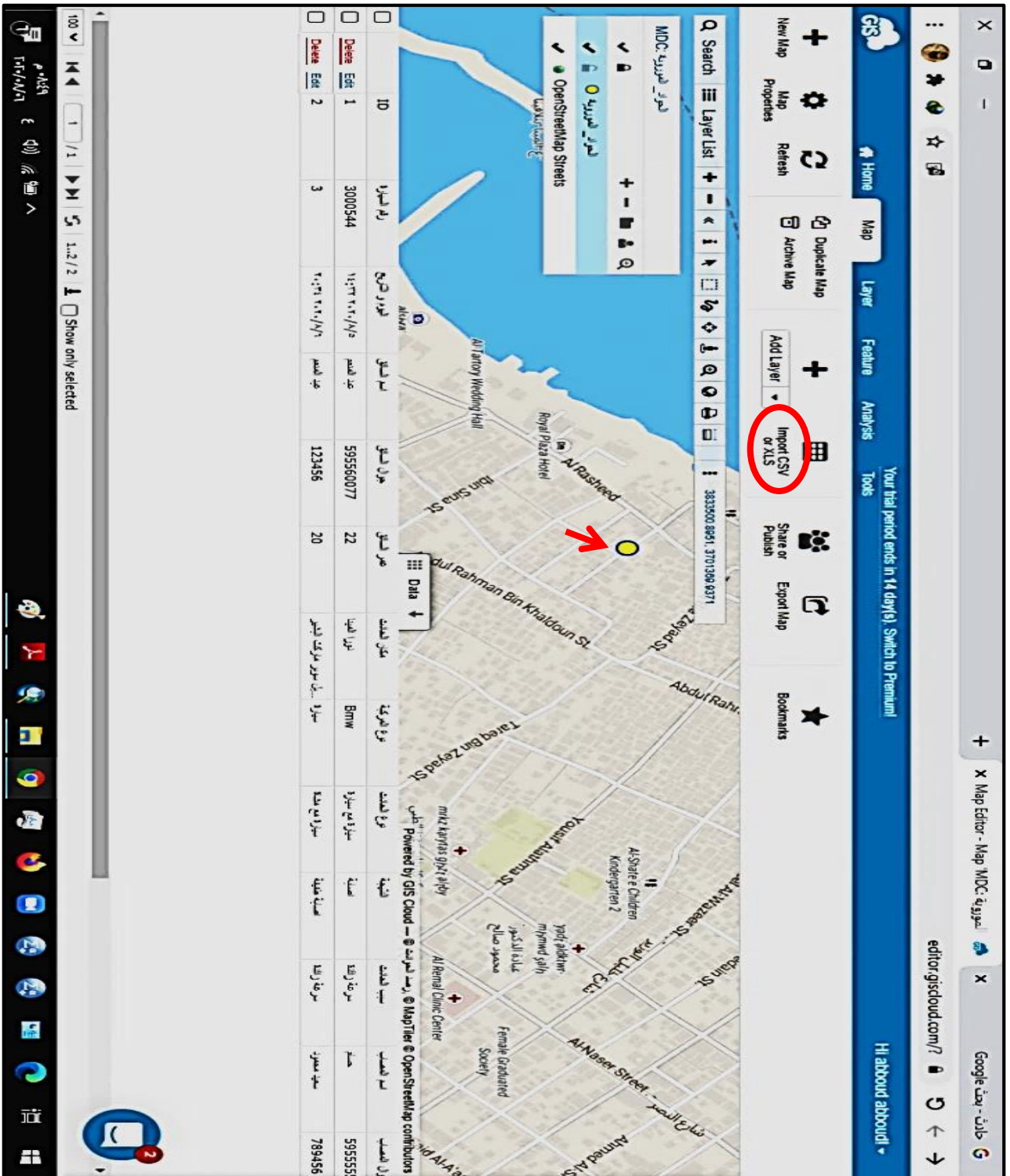

Figure 3 The main user interface of the new application.

A project concerning Traffic accidents is first selected and then a template is filled regarding the descriptive attributes about this accident. It also allows to locate the position of the traffic accident either by typing it manually on a map or using the GPS of the mobile phone. The application also allows to get many photos of the accident and save them in the database. When finishing, data is sent to the central computer by pressing the "Send" button. After sending the file from the mobile phone, all entered data can be automatically archived, accessed and managed by the specialists of ETSU. Steps to illustrate using this application as well as the required data to construct a template form within it are shown in the appendix.

VI ANALYSIS OF TRAFFIC ACCIDENTS

Since there is no enough information about traffic accidents and accidents history, analysis will be only limited to the documented statistics of 2019 as a case study to experiment the new developed application. Number of traffic accidents in Gaza Governorate in this year reached 513 distributed among 21 neighborhoods of the Gaza administrative governorate. Unfortunately, 374 accident of them have correct geographic location, knowing that this location is expressed in a descriptive manner and not in terms of the accident coordinates. Those accidents are transformed into Excel format according to the developed template detail instead of the paper registry condition and then imported by the new application.

Figure 4 shows the characteristics of the spatial phenomenon of these accidents. At first, descriptive data about accidents are linked to their geographical location using GIS software, and then a group of maps and graphs are produced in order to understand this phenomenon. Figure 4a shows the distribution of accidents in the city while Figure 4b indicates that the most neighborhoods exposed to accidents are; Al-Nasr, Northern and Southern Remal, due to the large traffic flow in these neighborhoods. Fig. 4c locates the distribution of hot and cold spots for accidents in the neighborhoods, where the hottest point is in the Northern Remal and the coldest point in the Old City neighborhood. Fig. 4d shows the five most hot streets in descending order; Salah Al-Din Street, Rasheed Street, Al-Jalaa Street, Omar Al-Mukhtar Street and Awn Al Shawa Street.

Figure 5 shows more additional analysis about the traffic accidents. It illustrates that most accidents occur in the daily time period between 12 and 14 o'clock, and the reason for this is due to the big movement of people at this time in particular school students, employees, workers, etc. April and October are the hot months. It is noticed that most of the accidents cause moderate injuries with 151 accidents, foll owed by damages with 102 accidents. The classification of accidents according to traffic composition shows that most of the accidents are caused by cars, with 260 accidents.
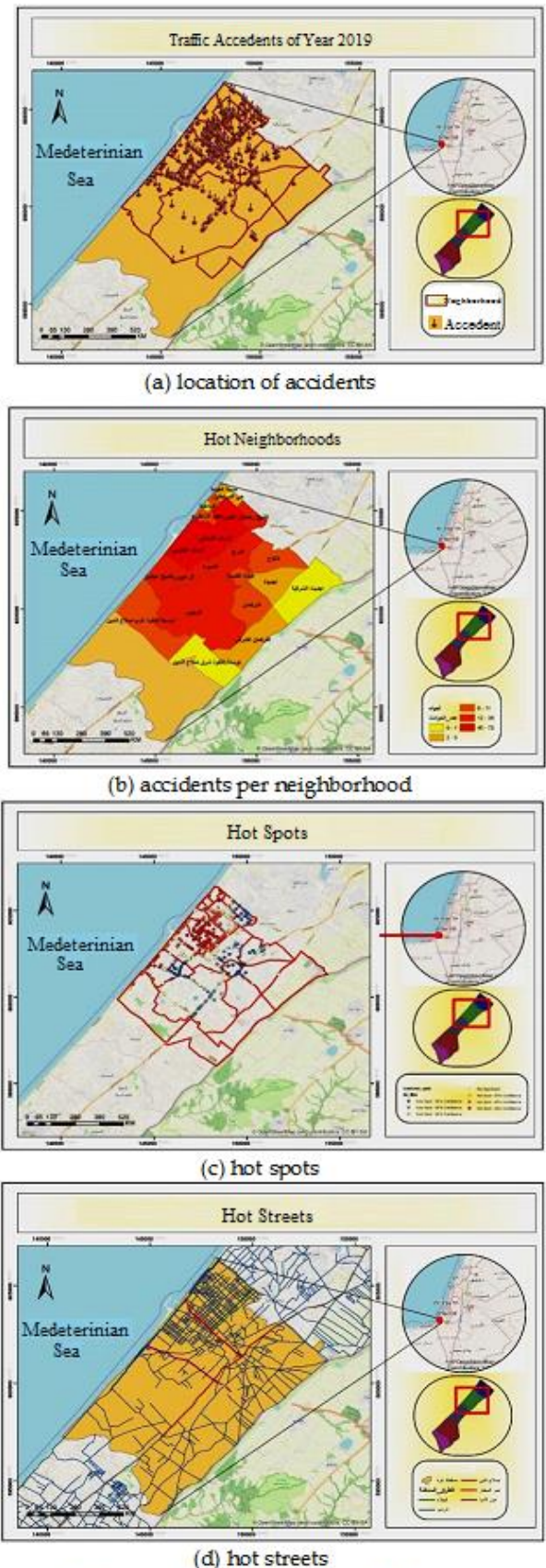

(a) location of accidents

(b) accidents per neighborhood

(c) hot spots

(d) hot streets

Figure 4 Analysis of traffic accidents.

(a) hot hours

(b) hot months

(c) type of injuries
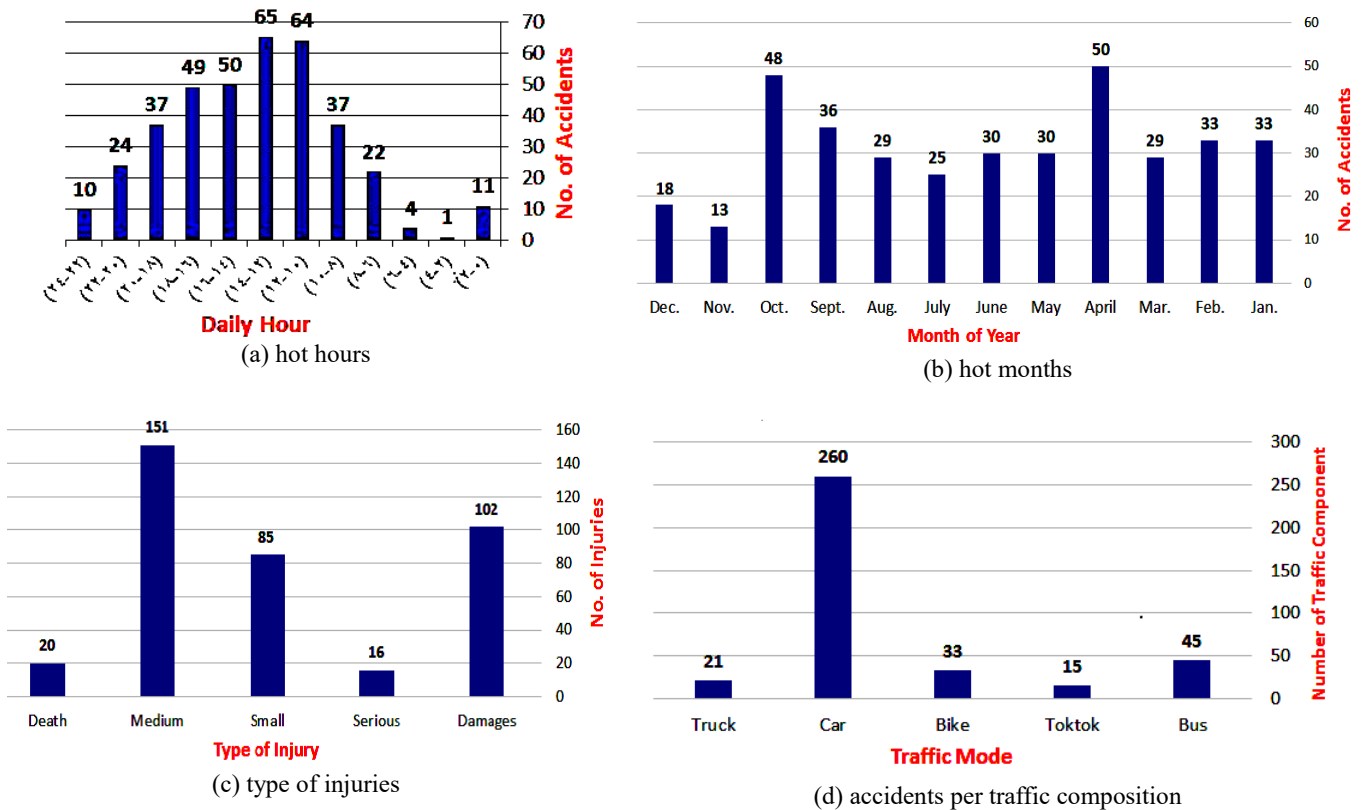
(d) accidents per traffic composition

Figure 5. Additional analysis of traffic accidents.

Analysis also indicates that:

- Most of the vehicles that cause accidents have no insurance.
- The average age of drivers who cause accidents is 40 years.
- Most of injuries occur among children and the elderly.

VII CONCLUSION AND RECOMMENDATIONS

This study shows that the documentation process of traffic accidents in Gaza City is traditional and inefficient since it depends on using paper registry documents. To enhance the documentation, a new mobile and desktop applications based on GIS Cloud are developed in order to automatically store spatial and descriptive data about traffic accidents in a computerized geodatabase. Many analysis using GIS of the accidents statistics of 2019 are performed. Results indicate that the hot neighborhood is Northern Remal, the hot road is Salah Al-Din Str., the hot time period is 12 – 14 O'clock, most accidents are caused by cars, and medium injuries are the result of these accidents.

Attention should be paid to build a digital geodatabase which can include all necessary data for roads and traffic accidents because it is the basis for planning and decisions making based on sound scientific foundations. It is recommended to establish a department for geographic information systems in MOT. There is a strong need to legislate binding laws to prevent the increase in the number of traffic accidents in addition to make field actions such as the necessity to set up traffic lights as much as possible near health centers, schools and other public places.

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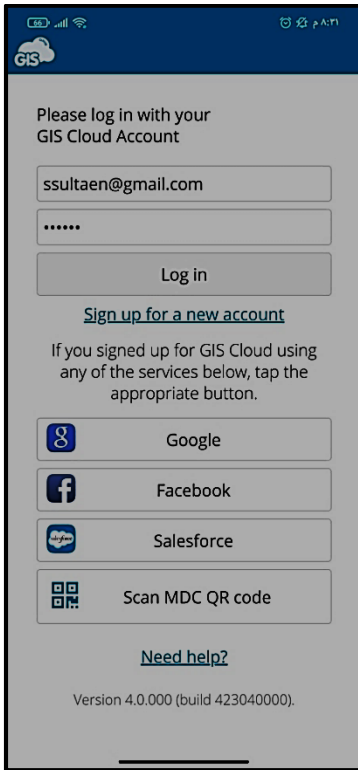
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APPENDIX

| |
|---|
| **A. Accident Time:**
 Date: Day: Hour: |
| **B. Accident Location:**
 Governorate: Municipality: Neighborhood: Street Info:
 Nearest Landmark: Nearest Intersection: Coordinates: |
| **C. Vehicle Type: (Repeated when there are more than one vehicle)**
 Ex.: ( ) Private   ( ) Public Taxi ( ) Public Bus   ( ) Heavy Truck
    ( ) rented Vehicle   ( ) Driving Education Vehicle
    ( ) Motorcycle   ( ) Agricultural tractor   ( ) Tactic
    ( ) animal drawn cart ( ) bicycle ( ) Year of Production   etc. |
| **D. Legal Status of Vehicle: (Repeated when there are more than one vehicle)**
 Licensed or not: Insurance Condition: Insurance Type:
 Driver License Status: Driver License Type: Driver age: |
| **E. Accident Type and Description:**
 ( ) A vehicle with one or more vehicles   ( ) A vehicle with a motorcycle
 ( ) A vehicle with a parked vehicle
 ( ) A vehicle with a bicycle   ( ) A vehicle with individuals
 ( ) Vehicle with road components
 ( ) A vehicle with an animal drawn cart
 ( ) Vehicles with tree/concrete barriers/guardrails   ( ) Others
 Accident Description: |
| **F. Accident Reason:**
 ( ) The driver does not comply with traffic signs ( ) Wrong cut-off of traffic lights ( ) Over speed ( ) Wrong overrun
 ( ) Go against the road   ( ) The driver is distracted from driving
 ( ) Driving under the influence of a drug
 ( ) For pedestrians, do not cross the road from the pedestrian area
 ( ) Failure to maintain the vehicle
 ( ) For pedestrians not to abide by the pedestrian traffic lights
 ( ) Bad road conditions
 ( ) Weather/ rain, fog or raised sand and dust, strong winds
 ( ) The use of bright lights   ( ) Others
 Description: |
| **G. Injuries: (Repeated when there are more than one injury)**
 Condition: ( ) Death   ( ) serious injury ( ) Medium injury ( ) Minor injury ( ) No injuries
 Injury data: Name: ....   Age .... Gender .... Mobile ....
 Injury Details: ( ) An animal-drawn cart user   ( ) A motorcycle rider
  ( ) The driver of the vehicle   ( ) The seat next to the driver
  ( ) A passenger in the back seat or in a public vehicle
  ( ) Walk on the side of the road   ( ) Walk across the road
  ( ) It is carried in the box of a transport vehicle
  ( ) A cyclist
 Use of Safety Factors: ( ) Seat belt ( ) airbag
  ( ) The Helmet
  ( ) A seat for children
  ( ) not use of any safety equipment |
| **H. Non Injuries:**
 Individuals who were in the interlocking vehicles in the accident and had no injuries:
 Number of these persons .... Did they use vehicle safety equipment .... its type .... |
| **I. Damages:**
 Damages Description: |

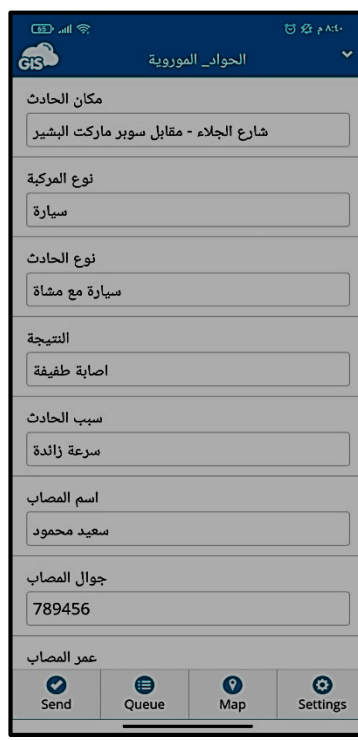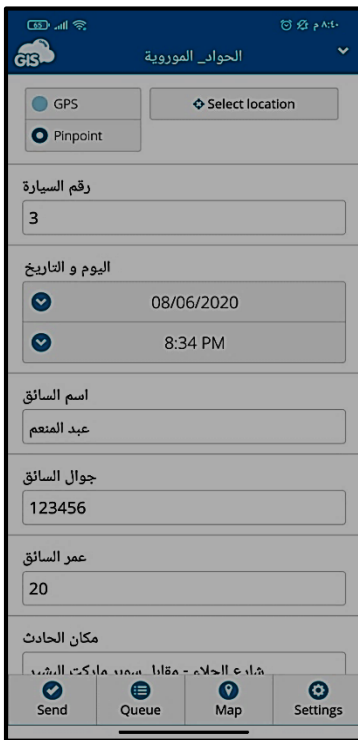A1: Data involved in the traffic accidents template form.

1. Login Mobile App.
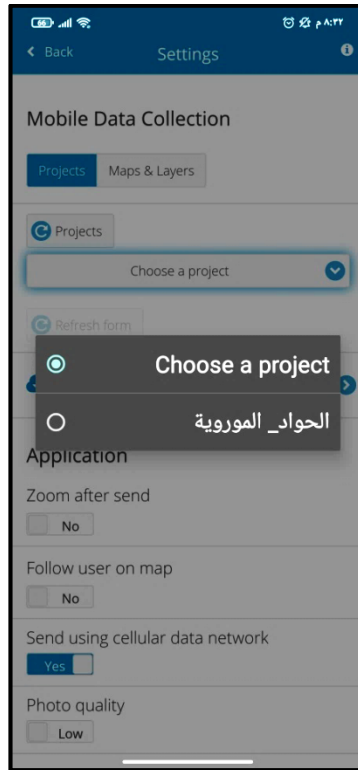
2. Choose a project
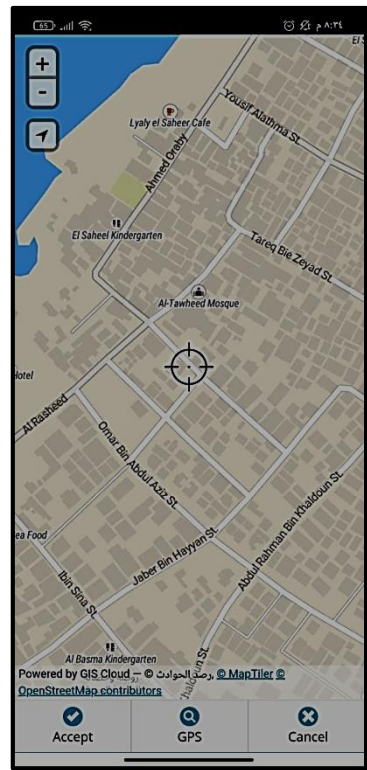
3. Locate an accident manually or by mobile GPS

4. Part of filling the template form and sending information to the central computer

A2: Steps to document accidents in field using the mobile application.