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# TOWARDS PUBLIC TRANSPORTATION AND INTELLIGENT TRANSPORTATION SYSTEM: NAJAF CITY AS A CASE STUDY

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## ABSTRACT

**Najaf-Kufa road suffers from high congestion, especially at morning peak hour in the direction coming from Al-Najaf city towards Al-Kufa city (for 95% from its length) in addition to the other major roads in the city. This could be easily attributed to high trips coming to different destinations (i.e universities, schools, hospitals, courts, etc) distributed along the road without using modern public transportation such as scheduled buses, Bus Rapid Transit (BRT) and light train or tram. Furthermore, the other roads also suffer from congestion such as Airport road, Garage Shamalee, Najaf-Abu Skher, etc. This study aims to investigate the merits of using public transportations and suggest new means of public transportation in Al-Najaf city in accordance with the fundamental design for the city. The GIS program has been adopted to determine the suggested major routes for scheduled buses, BRT and tram with new network for public transportation. Different trip generation and distribution have been investigated such hospital, schools and universities using GIS. Moreover, the suggested intelligent transportation system also has been included in this study.**

***KEYWORDS:*** BRT, Public transportation system, Tram, Intelligent transportation system

## 1. INTRODUCTION

Generally, two types of congestion have been recognized, recurrent and non-recurrent congestion (Papageorgiou and Kotsialos, 2002). The recurrent congestion could be described as the congestion occurs due to lack of road capacity at the time of peak hour; whereas the non-recurrent congestion is due to other issues such as special events, bad weather, roadwork and accidents.

In the study area (Al-Najaf City), the causes of congestion according to the field observations are due to bottleneck sections, recurrent congestion, along main roads such as Kufa-Najaf Road, Najaf-Kerbala and Airport Road (Al-Jameel, 2017). Therefore, this study aims to suggest some means of public transportation such as schedule bus, Bus Rapid Transit (BRT) and light train. In addition to the investigating the location of trip generation and distribution in the city such as health and educational institutions. This study also indicates where these transportation facilities may be according to the fundamental design for the city. The GIS tool will be used in this study. The GIS provides several options to deal with and analyze spatial data which could be used for evaluating public transportation. The benefits from using the GIS are information retrieval, query language and optimum decision (Maguire, 2009). Information retrieval which helps the user to get all information for each feature in the map. Whereas, query language enables the system in selecting the specific information element and ability to conduct operation relations and mathematic operations. Finally, the best information leads to the best solutions.

## 2. MERITS AND DEMERITS OF PUBLIC TRANSPORTATION

Traffic congestion, noise and air pollution lead to encourage the public to leave private vehicle and taking public transportation in order to save energy and reduce greenhouse gas emissions (Zhang, 2014). In this regard, the FHWA (2004) suggested some possible solutions to reduce traffic congestion; one of these suggestions is to make people travel using fewer

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vehicles by encouraging public transportation.

It is worthwhile indicating that public transit saved 646 million hours of delays and 398 million gallons of gasoline in USA in 2007 (Zhang, 2014). Consequently, the public transit saved costs of $13.7 billion in 2007 over using private automobiles. In addition to that, the $CO_2$ emissions would be minimized by 37 million metric tons annually.

Other merits could be here addressed for public transportation such as providing important mobility for poor and elderly riders (Rittner and Kirk 1995). Besides that, it offers access for those who prefer not to drive to education, jobs and medical services.

Public transportation seems to be necessary to be adopted. In doing so, many challenges should be investigated by conducting rider/non-rider surveys and analyzing feedback from respondents (Zhang, 2014). Several studies were conducted in order to know the major concern which was time performance on-time performance. Non-on-time buses was listed as the top problem within transit services of 42% of riders experienced in the 2006 King County Metro survey (Zhang, 2014). Similarly, 51% of the Chicago Transit Authority was targeted improvement of reliability and scheduling in 2001 by the survey report had experienced non-on-time problems such as late and early buses (Zhang, 2014). Lawson and Mallia figured out that 34% of Capital District Transportation Authority buses were arriving at stations earlier than the scheduled time as reported by Zhang (2014). Buses arriving early and leaving early may cause riders to have to wait another 20 minutes in the station during weekdays and even longer during weekends.

With respect to the available literature, it is useful to diagnose the most important factors affecting public transportation which are (Zhang, 2014):

- Travel time: is the common challenge and second problem as ranked by investigated riders of public transit. At the University at Albany, 42% of students and faculty refused public transportation because of longer travel time.
- Multiple destinations & waiting time when transferring: it was found that people had multiple stops or destinations refuse to use public transit because of vague transfer wait times.
- Distance to station: is one of the motivations to use public transit if the the tolerable walking distance to a bus station is between 0.25 and 0.3 miles. Otherwise, the people tend to select private vehicles.
- Personal safety: it was found that safety, especially after dark, is an important factor in the literature to determine whether people will take buses or their own vehicles.
- Frequent Service: in some areas, people required more frequent services such as bus service each 15min rather than 30min.
- Park and ride system: It was found that a lack of park-and-ride systems also participates in preventing potential people from benefit of public transportation, especially in metropolitan areas.
- Bus fares: the effect of such factor is to a certain degree. It could be a minor effect.
- Bus environment, station environment and facilities: These factors would attract more people. It was reported that 5% of respondents refused to use public transportation in California because of uncomfortable environment in vehicles and stations.

## 3. ALTERNATIVE PUBLIC TRANSPORTATION

Different public transportation alternatives could be used according to environment and available financial. These are schedule buses, Bus Rapid Transit (BRT) and light train.

### 3.1 Buses network

Network design for buses is a critical element in transit since it affects the decision and later planning steps. The effective design of transit routes and service frequencies can decrease the overall cost of providing transit service (Beilli et al. 2002, and Ngamachai & Lovell 2000).

### 3.2 BRT

It could be defined as a rapid mean of public transportation that utilizes a rubber-tired vehicle to transform passengers from station to another one within a network of bus lanes that make up a system using

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technologies such as: dedicated running ways, uniquely designed bus stations, improved method of fare collection, and distinctive system branding (Ulloa, 2015). The characteristics of advanced BRT systems are intelligent Transportation System (ITS), queue jumps, electric/hybrid vehicles, and high-frequency service. BRT system is less expensive and easier to implement than light rail system. The average cost per mile for BRT is $13.5 million; whereas for light rail is $34.8 million (Ulloa, 2015). Moreover, this cost mainly relays on the location of the bus route, right-of way, construction of station structures, etc.

In spite of BRT being less popular than other transport systems, it is slowly gaining interest in the United States. There were 66 BRT bus routes operating in the United States during 2012 (Zhang, 2014). As of 2013, there are 130 BRT systems worldwide (Suzuki, 2013). A lot of studies found that property values close to BRT stations were higher than those were farther away.

**3.2.1 Characteristics of BRT**

BRT is, different from regular bus services, it has many distinguishing characteristics. According to (Lee, 2007), the main characteristics of BRT systems include the following:

●Dedicated (bus-only) running ways
●Accessible, safe, secure, and attractive stations
●Easy-to-board, attractive, and environmentally friendly vehicles
●Efficient fare collection
● ITS applications to provide real-time passenger information, signal priority, and service command/control
●Frequent, all-day service
●Distinctive system identity, these characteristics enable BRT to resolve the challenges of current public transportation to a certain degree.

BRT vehicles, which have better facilities than regular buses, are typically large capacity and stylized vehicles with low-floor boarding and different degrees of ITS integration, such as Automatic Vehicle Location (AVL), Traffic Signal Priority (TSP), Automatic Passenger Count (APC), next-stop annunciators, surveillance systems, and driver-assist systems (Lee, 2007; Barr and Danaher 2006). These new technologies, especially AVL and TSP, improve the on-time performance of transit services. The TSP reduced red light delays by 16%; in Toronto, a TSP system demonstrated a 32% to 50% reduction in signal delay for various bus routes (Chang et al., 2004). Off-vehicle fare collection and Park-and-Ride systems could be installed in certain full-size stations, where the major ridership is located (Vincent 2006). In order to collect more passengers in surrounding areas and transport them to the BRT stations in the main corridor, feeder bus services are normally integrated within BRT systems (Levinson and Younger, 2014).

**3.2.2 BRT Station Selection Criteria**

A number of principles can be generalized as follows (Levinson and Wu, 2005):

●Station Distances – The separation between BRT stations should be greater distances than bus stops serviced by regular bus routes. The separation distance is 0.4 miles, as an average, was used for urban areas and of 2.0 miles for the intervening suburban area.
●Demonstrated Demand – The location of BRT stations should be in areas that have the highest current ridership on the local service.
●Good Pedestrian Accommodation – The access should be safe and easy for the riders in order to reach the station location from other side of streets.
●Park and Ride – locations that have the potential for significant park-and-ride capacity are preferred, especially in suburban areas.
●Feeder/Cross Town Connections – locations where feeder routes or crosstown routes intersect the corridor will be preferred for the BRT stations.
●Station Pairing – stations will be provided at locations where it is feasible to have bi-directional stations directly across the street from each other.
●Existing Facilities – significant facility investments have been already made at some bus stops. These stations should receive priority consideration as stations.

In order to continue the services and save on budget, transit agencies develop BRT systems based on certain regular bus routes in the local area, as current bus stations may already have sufficient space, pedestrian routes, shelter, and parking (Zhang, 2014).

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According to current literature on the optimization of public bus systems, the optimization of bus routes can be classified into three categories: 1) optimization of stop spatial coverage (Shammout, 2012); 2) determining bus stop locations based on existing bus stops, population distribution, land use pattern, local transportation network, and so on (Wei, 2010); and 3) concentrating on temporal demand when optimizing a bus system (Zhang, 2011). In an optimization model, local population, commuting pattern, geographic settings and transportation network primarily determine passenger demand (Zhang, 2014). On the basis of maximizing the number of travelers, Abbas-Turki et al., (2004) used the Petri net Model to optimize a bus system (Abbas-Turki et al., 2004 and Zhang, 2014). Wei (2010) did a GIS project, optimizing bus stop locations in Wuhan, China, according to local population data, road networks, existing bus stops, and land use pattern. Optimization models are generally applied in planning a new bus service by sufficiently considering the stop space, population, and land use development (Wei, 2010). Therefore, the optimization model does not normally emphasize passenger demand, which is a key role in upgrading a regular bus service to a BRT system. It is wasteful to collect and archive traffic data, passenger data, and other data without making significant use of them. In addition, the optimization model cannot evaluate station usage and performance at different times and in different weather conditions. Last but not least, the optimization model does not analyze whether topography plays a role in determining the location of BRT stations and whether absolute distances between two continuous stations are considered in selecting the best location for BRT stations.

### 3.3 Train and Tram

Rail transport consists of moving goods or passengers using railroads or railways. Railroads provide the most energy efficient and cost-effective transportation services over land, compared to vehicles on paved roads, railcars make much less friction when moving over rails. As a result, trains typically use less energy than road vehicles to transport a given tonnage of freight or a given number of passengers over a given distance. Nevertheless, rail is still a capital-intensive means of transport (Janic, 2014).

The Tram is a comfortable, environmentally friendly, accessible, quick and safe mode of transport. It can carry up to 200 passengers or more (Tram, 2017). It is also from direct access and no need for stairs and connection corridors. If the Tram stations distribute well it helps more in transitions between urban transportation (Tram) with high speed transportation or transportation out of the cities (train stations).

## 4. METHODOLOGY OF THIS WORK

The main important part of this work has been summarized by using GIS program to represent the existing major roads in the city and then doing field surveys to the public transport lines in the city. Then, different types of trip generation and distribution will be investigated such as universities, schools and hospitals. These centers of activates will be determined on the map using the GIS program. Another important stage has been achieved by investigating the main garage for public transport in the whole city (i.e. Najaf and Kufa) and drawing that using GIS program.

After determining the main routes for current public transport in the city, the major trip generators and distributors have been located for the whole city by GIS. Finally, new public transport routes have been suggested to fit with the requirements of the community.

## 5. REPRESENTING THE REQUIRED INFORMATION USING GIS

The first step was to collect the necessary information about the major roads in the city as indicated in Figure 1. Then, public transportation lines for both Kufa and Najaf cities have been presented on the GIS map as demonstrated in Figures 2 and 3. Furthermore, main garages, educational institutions and health centers are also indicated in Figures 4, 5 and 6. Accordingly, this information has an important effect on suggestion the suitable public transportation lines as discussed in the next section.

In addition to this information, several points for collecting data have been selected

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on the major busiest roads such as airport ring road and Kufa-Najaf road

## 6. THE CURRENT AND SUGGESTED PUBLIC TRANSPORTATION SYSTEM IN AL-NAJAF CITY

As mentioned before, Al-Najaf city suffering from high congestion in most of major roads as indicated in Figure 1. These streets include ring roads, arterials and collectors only. However, the current public transportation system is represented by just little troops of minibus which serve just few quarters in the city. Furthermore, these minibuses follow unplanned lines, for example, most these vehicles intend going from Kufa to Najaf or vice versa use mostly only Kufa-Najaf road. The same is for northern and southern quarters as indicated in Figures 2, 3 and 4.

In addition, the motivation to use the public transportation is so high according to the specific study conducted by Al-Jameel and Kamel (2016). They found that more than 64% from all trips coming to the main campus of University of Kufa were implemented by public transport (min-bus) and taxi and just only 34% using the private car. This mainly proves that 64% of all-trips may use public transportation with other increment coming from the others who may prefer to use public transportation to their private cars depending on the facilities expected to offered by such suggested system.

According to Al-Jameel and Yahya (2017), there is a lack in the road hierarchy. The number of arterials and ring roads is not enough to facilitate both accessibility and mobility in the city.

Moreover, the current public transportation is so poor in its distribution among all quarters. Other important things are absence of timetable for these public transportation lines. In fact, no suitable stations are available through the city. In addition, all these vehicles used as public transportation are for private sector (each vehicle has private owner not belong to the government). Consequently, no control on the public transportation could be imposed.

Knowing the major trip generators and distributors in the city provides the best guidelines to suggest the new public transportation lines. Educational institutions in the city represent the main trip generators and distributors there. Figure 5 demonstrates the location of these institutions. Heath centers are also from important trip generators and distributors in the city as indicated in Figure 6.

The proposed tram lines for both Al-Najaf and Kufa cities have been suggested and implemented using GIS to satisfy with the preliminary design plan for the city as indicated in Figure 8. Four lines have been suggested to cover all the major trip centers in the city such as Kufa University, Al-Najaf airport and the centers of both Kufa and Al-Najaf city centers. These lines (1,2,3 and 4) have been suggested to cover all the city as indicated in Figure 8. These lines have been put in the most major roads within the city. For example, Line2 connects Al-Najaf city where Imam Ali Holey shrine and the city center with Kufa city where Kufa University, Kufa Mosque and Kufa city center are located there. This road suffers from high trips and traffic congestion as reported by Al-Jameel and Kamel (2016). Moreover, Line 1 also represents the busiest traffic road in the city because it links the city center with southern and northern quarters in addition to trips coming from other cities such as Kerbala, Baghdad, Hilla and Basrah.

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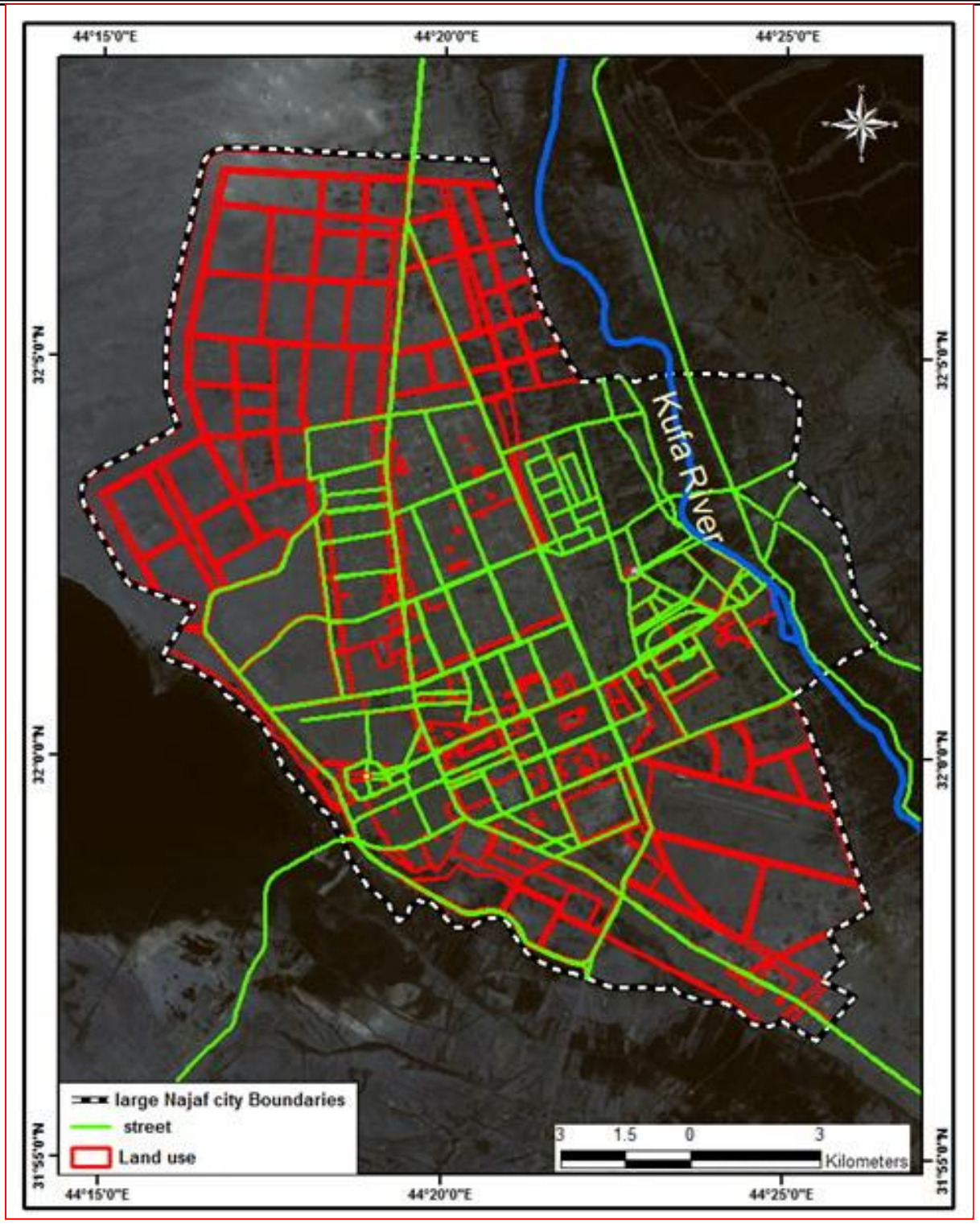


**Fig. (1):** Major streets in Al-Najaf city.

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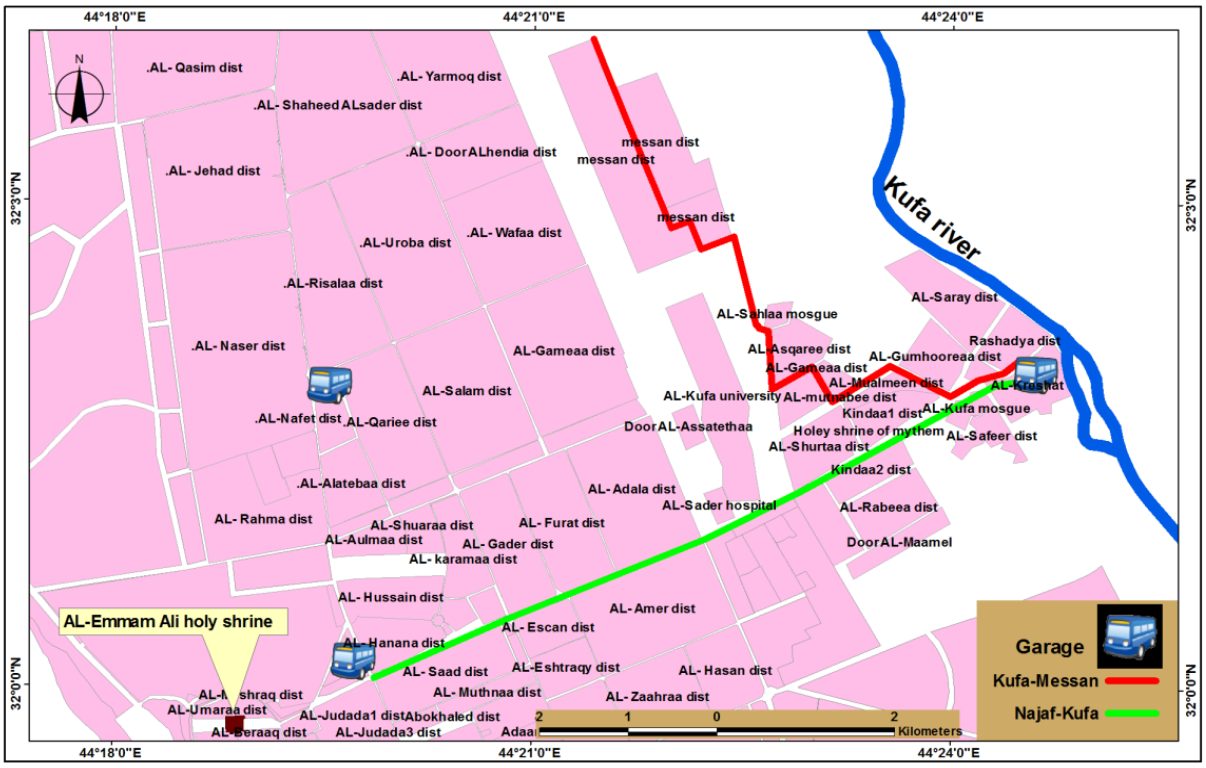


**Fig. (2):** Public transportation lines in Kufa city

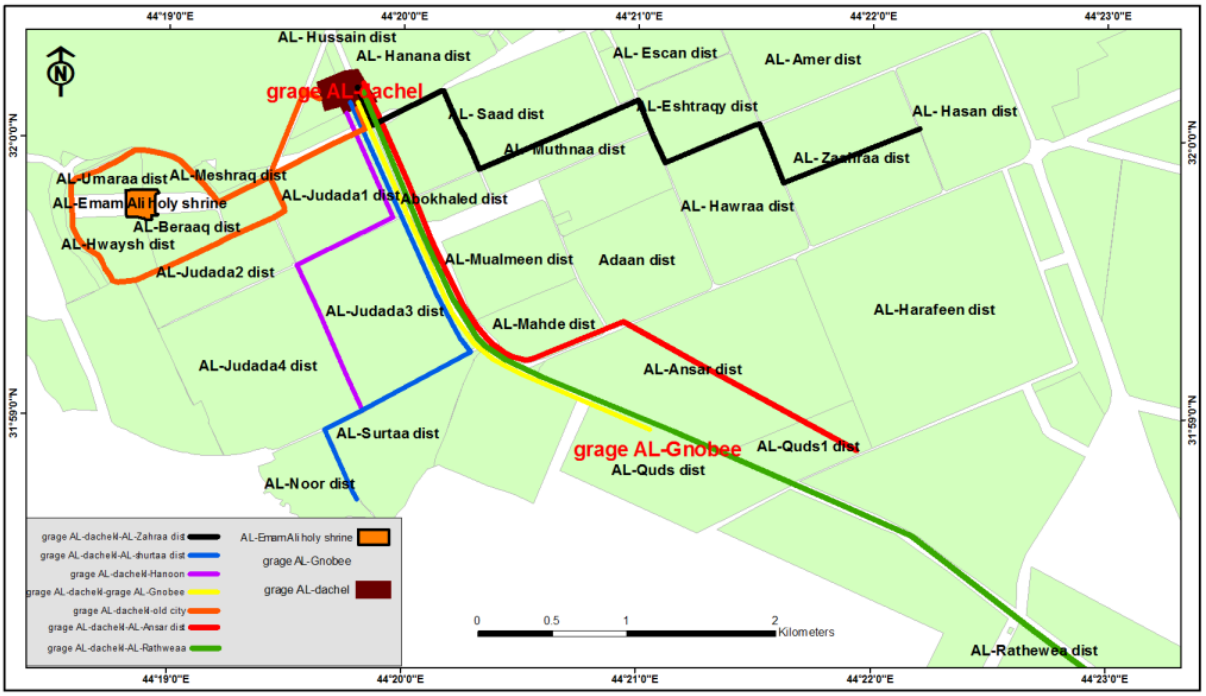


**Fig. (3):** Public transportation lines in Najaf city.

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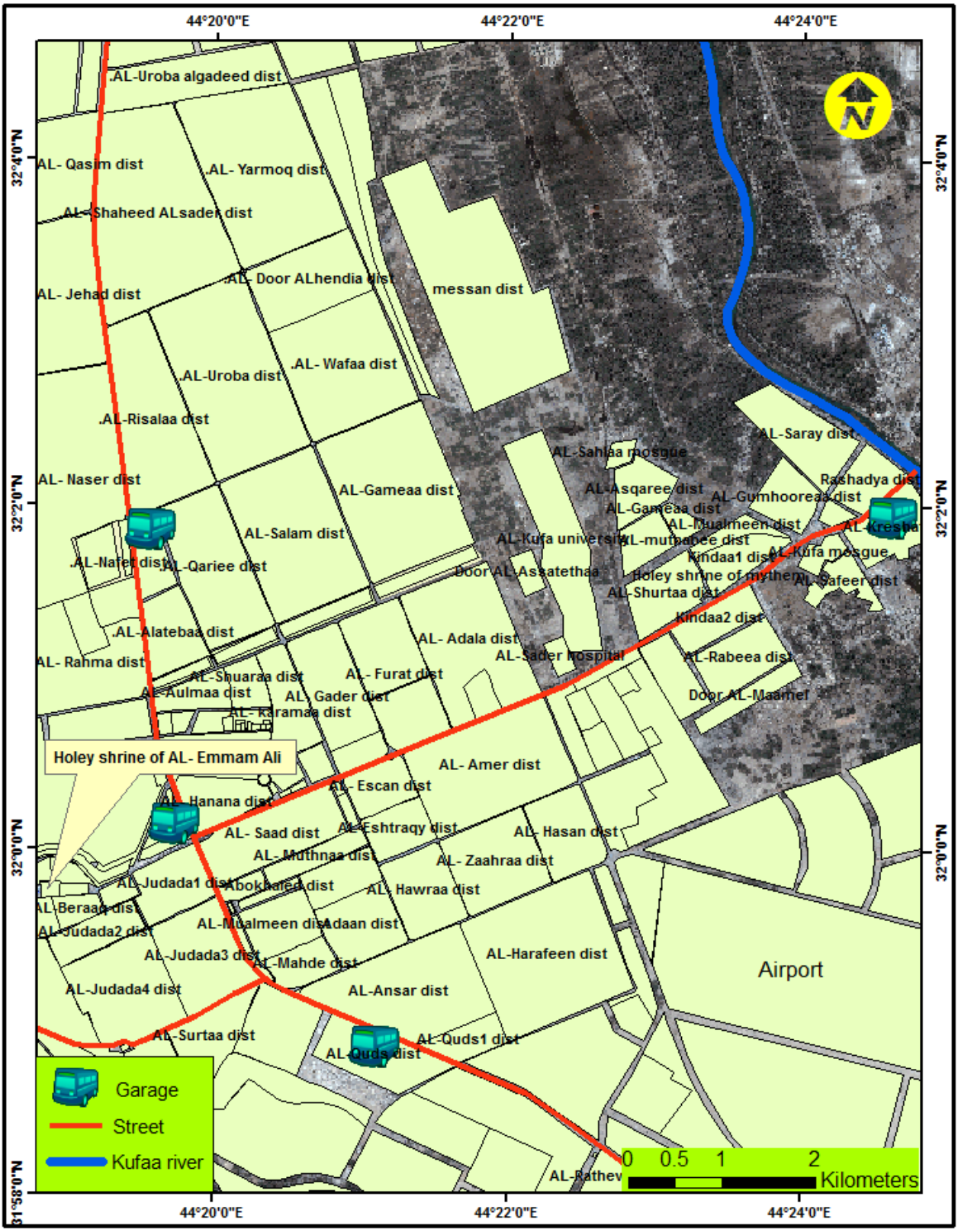


**Fig. (4):** Garages for public transport sites in the large city of Al-Najaf.

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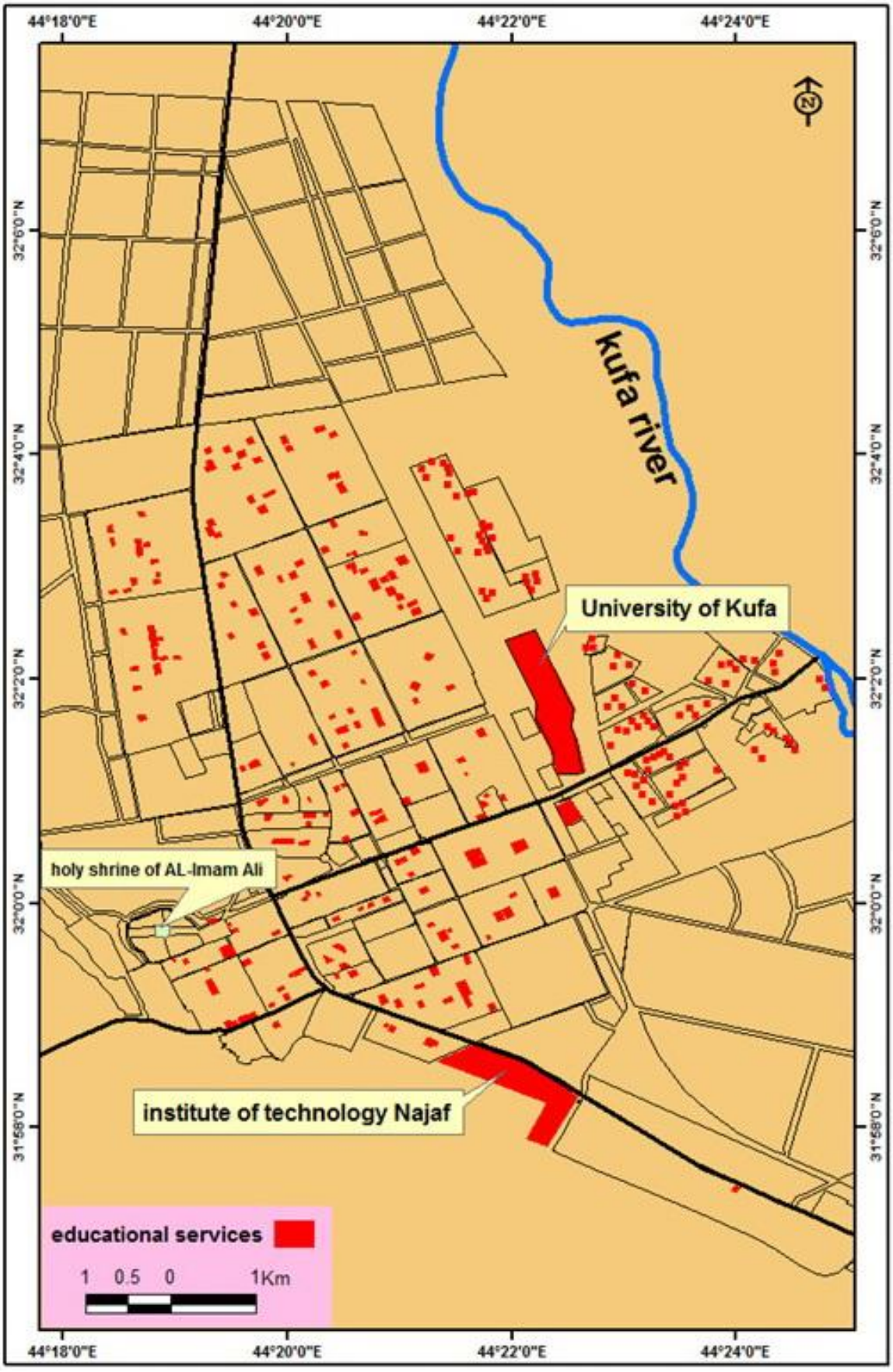


**Fig. (5):** Educational institutions in Al-Najaf city.

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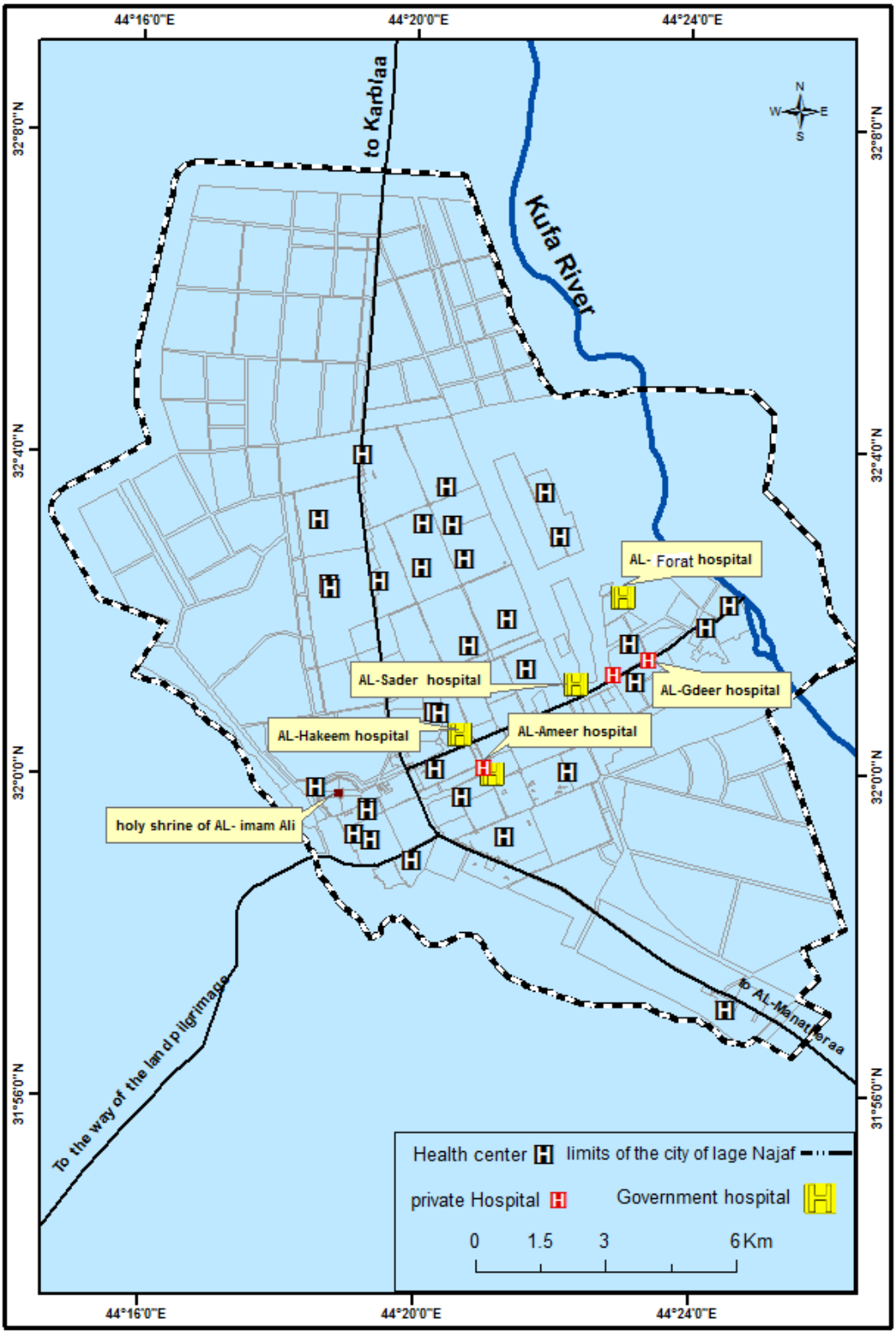


**Fig, (6):** Health services in the city of large Najaf for 2017

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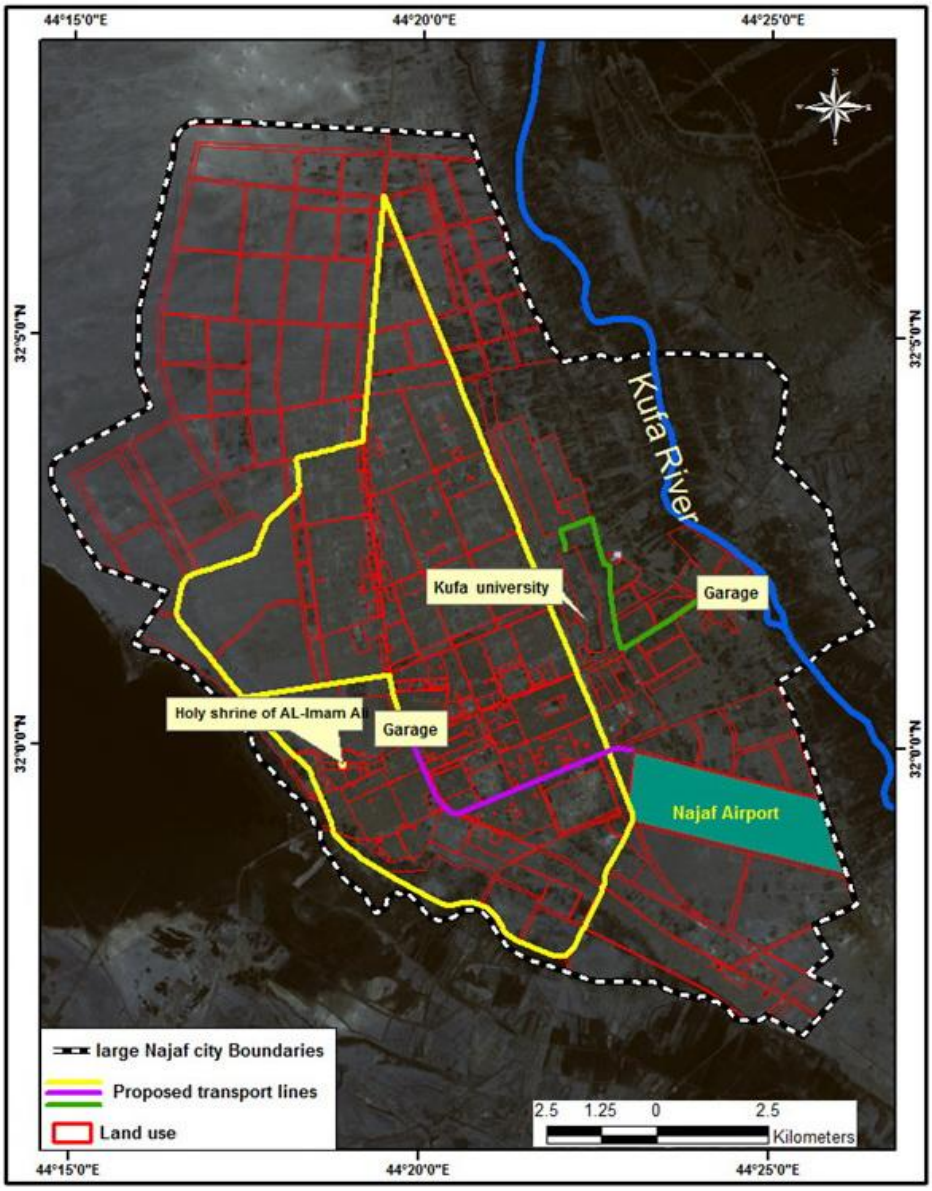


**Figure 7 Proposed transport lines.**

## 6. THE SUGGESTED IMPROVEMENTS FOR PUBLIC TRANSPORT

Referring to the current public transport as indicated in Figures 2, 3 and 4, the public transport facilities suffer from lack of covering the major trip generators or distributors such as educational institutes and health services as demonstrates in Figures 5 and 6.

Four-point data have been chosen to collect flow at peak hour by a group of engineers from 7:30AM to 9:00 AM. The count stations have been collected data for just the heaviest direction of flow. These points are distributed as count station No.1 on Kufa-Najaf road facing the main gate of Kufa University on Route No.2, the second count station on Route No.3, the third count station on Route No.4 and the fourth one is on Route No.1. The number of lane per direction for the stations 1and 2 are three; whereas for the third and fourth stations are two-lane sections. The flows at peak hour are 4200 veh/hr at station 1, 3800 veh/hr for the second station, 2500 veh/hr for the third one and 3900 veh/hr for the fourth station. The percentage of mini-buses for stations 1, 2 and 3 is around 18%; whereas for the fourth is 15%. On the other hand, the percentage of buses (from 24 seats and above) is around 2.5% which is very low comparing with the mini-buses. Therefore, the suggestion of Tram or BRT may be good solution for such traffic mix.

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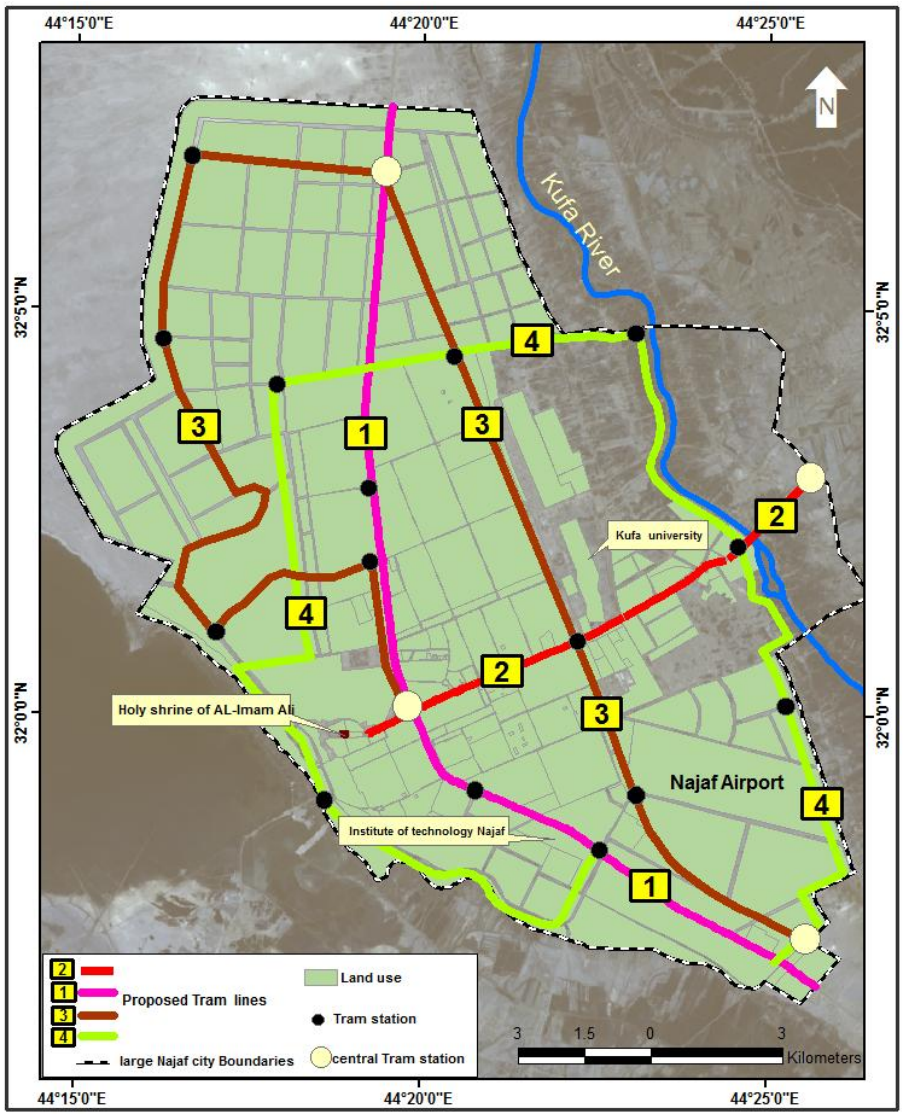


**Fig. (8):** Proposed Tram lines in the large Najaf city.

In addition to the above, the public transportation also suffers from lack of enough bus station along each current line and no timetable for bus or min-bus. All buses or mini-buses belong to the private; therefore, no uniform label (such as bus No.) for these buses even the distributed lines and routes of these buses are out of control.

According to the educational institutes and health centers in the city as determined by Figure 5 and 6 using the GIS program. This program has also been used to suggest the proposed transport lines as illustrated by Figure 7. Moreover, tram lines also have been proposed using GIS as indicated by Figure 8 in order to facilitate both accessibility and mobility.

Figure 9 demonstrates the proposed BRT lines. These lines have been distributed on the main lines used by mini-buses through the city. The proposed lines also have suggested on the busiest or the most congesting roads in the network.

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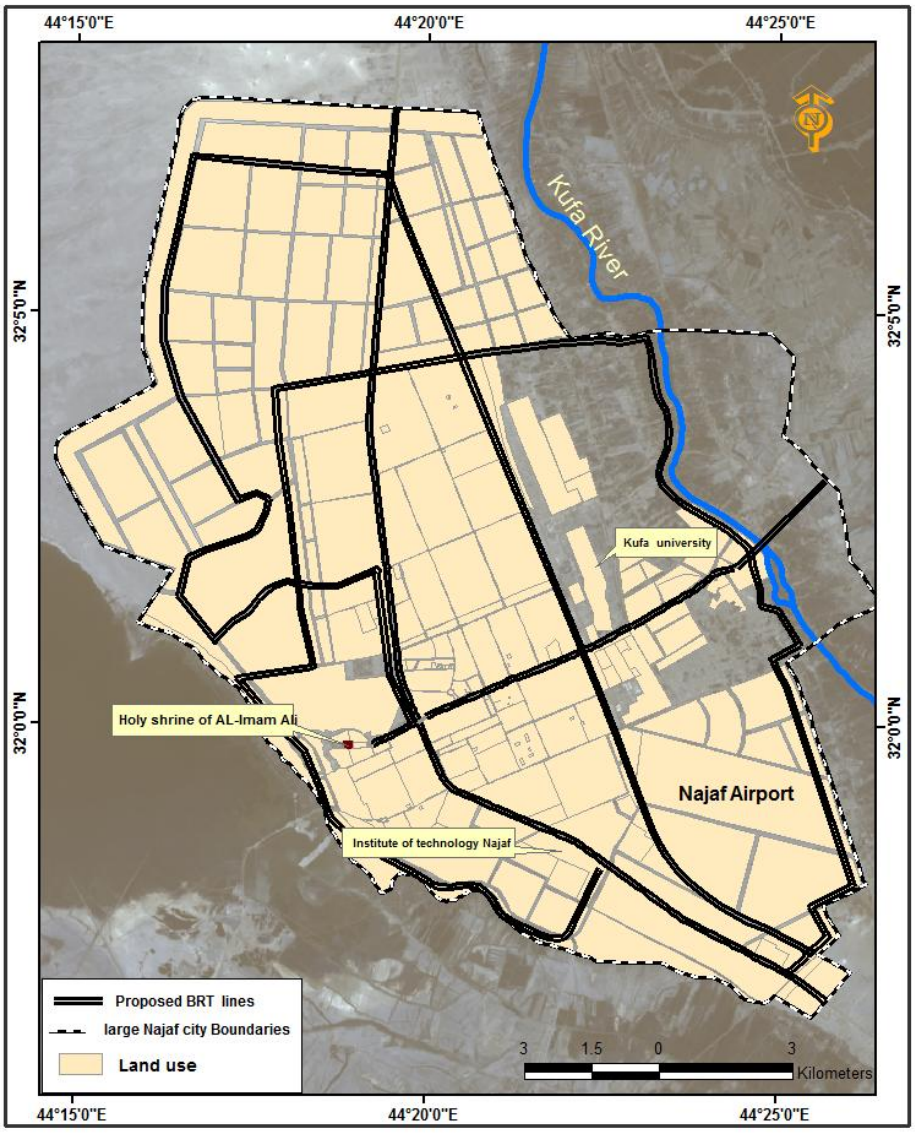


**Fig. 9 Proposed BRT lines in the large Najaf city.**

In addition to what has been mentioned above, the main characteristics which should be provided in the city are:

- Enough bus station with protection in order to provide protected place from weathering during summer and winter.
- Time table for each bus number to monitor the community to use it.
- The first step should be coming from governorate by using specific types of buses belong to the governorate with motivated fee.
- Putting the specific cameras and loop detectors in order to determine the suitable routes and guides and warnings for drivers.

## 7. CONCLUSIONS AND RECOMMENDATIONS

The current study has come up with the following main points:

**1.** The current public transport system suffers from a lot of lacks in terms of studied public transport facilities such as specific buses, trams and even timetables and routes.

**2.** Main trips generations and distributors have been determined using GIS program. The determination of such center activities

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is so important to suggest the suitable public transport lines in the optimum routes.

**3.** Suggested lines for public transport, Trams and BRT in this study may be the suitable solution to improve the public transportation in the city and could be used for strategic solutions.

**4.** This study recommends evaluating the proposed transport lines and trams using either VISSIM or Transcad models.

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