International Journal of Safety and Security Engineering
Vol. 13, No. 3, June, 2023, pp. 433-444
Journal homepage: http://iieta.org/journals/ijsse

Evaluating and Improving the Spatial Distribution Using GIS to Avoid Environmental Risks and Achieve Safety for Petrol Stations in the Nile District Center in Mahaweel / Iraq

Baydaa Abdul Hussein Bedewy[1*], Marwan H. Abdulameer[2]

[1] Environmental Planning Department, College of Physical Planning, University of Kufa, Al-Kufa 54001, Iraq
[2] Environmental Department, College of Environmental Science, Al-Qasim Green University, Al-Qasim - Babylon 51013, Iraq

Corresponding Author Email: Baidaaa.bedewy@uokufa.edu.iq

https://doi.org/10.18280/ijsse.130306

Received: 22 May 2023
Accepted: 24 June 2023

Keywords:
petrol stations, GIS, spatial distribution, urban planning, Nile City/Mahaweel, improvement, planning standards, Iraq

ABSTRACT

The main objectives of this research are to analyze the spatial distribution of petroleum stations in the Nile City/Al-Mahaweel District using multi-criteria analysis based on Geographic Information Systems (ArcGIS 10.8). The study aims to provide a clear picture of station distribution and spatial variations, explain the underlying reasons for this distribution for each station, and assess the spatial compatibility with planning standards and site requirements. The research also aims to enhance safety and security by optimizing station locations and mitigating potential risks. However, a research problem indicates that the distribution of stations in the Nile City/Al-Mahaweel District needs to adhere to planning standards. Stations are primarily located outside the city center, resulting in a need for more service provision for residents and visitors. This distribution poses environmental risks and compromises spatial safety. The research hypothesis suggests that adopting sustainable and analytical planning standards can enhance station efficiency, achieve optimal distribution, ensure spatial safety, and mitigate risks. The study was conducted in the Nile City/Al-Mahaweel District, where three fuel stations are located outside the municipal boundaries, with no stations within the district. Various assessments were made concerning fuel stations, including detailed maps of the actual conditions, hypothetical geographic maps, standard distance distribution maps, directional distribution maps, allocation area maps, and petroleum stations in the city. By comparing the current status of petroleum refueling stations with the standards and site requirements, a multi-criteria spatial analysis was conducted using seven essential criteria: minimum distance between the station and service facilities, residential areas, population density, community services, road networks, accessibility distance, and distance from power lines. Key findings of the research indicate that station distribution in the study area adheres to the established standards, criteria, and regulations set by relevant official bodies concerning safety and security. However, some fuel stations only partially comply with all criteria, while others exceed certain parameters. Proposed locations for fuel stations (Station A with an area of 5000 m² and Station B with an area of 4500 m²) were determined based on planning standards to enhance the spatial distribution efficiency of stations and improve service provision to meet demand. Particularly, the Nile City/Al-Mahaweel District, which lacks fuel stations, relies on stations outside the municipal boundaries due to administrative divisions from the main district, resulting in insufficient station distribution that caters to the population's needs. The multi-criteria approach proves highly effective in determining the optimal number and location of petroleum stations within the city and district.

1. INTRODUCTION

Petroleum filling station services are essential for sustaining vehicle movement, especially after 2003, when functional transportation activities increased and expanded. Additionally, the ease and flexibility of transportation from one place to another for various purposes, such as acquiring different services or entertainment, all require petroleum filling stations to supply vehicles with fuel in various forms.

Fuel filling stations are among the most important service facilities for the movement of transport, as they provide a source of operation and movement of vehicles of all different types. It is an important element that must be available in a geographical distribution that is compatible with the movement and density of vehicles on the roads, as it achieves an appropriate amount of smooth and easy movement between cities and governorates at the country level in particular and the world in general [1].

Fuel filling stations are a vital part of road services, as they are a source of refueling, which is the basis for vehicle movement on these roads. Therefore, its importance stems from spatial considerations regarding its geographical distribution and location [2].

Transportation is critical in ensuring development success, especially in promoting societal, economic activity in all fields. The current transportation system aims to enhance transportation services for the population and other resources that may promote regional economic and social development.

Transport development cannot exist independently and cannot be distinguished from the growth of other sectors, such as economic, demographic, social, etc. The improvement of the transportation system must be carried out comprehensively, coordinated, and consistently. Therefore, the determinants that directly or indirectly affect the operation of the transport system, especially the spatial distribution of petrol stations and their locational impact within the transport system, must be coordinated [3].

Moreover, the activities carried out by the filling stations have several impacts, such as traffic and the environment, meaning a potential danger exists [4].

Petrol stations are becoming more competitive with longer hours of operation, more products to offer, and faster shipping. For gas stations to succeed in retail, they depend on an effective strategy with an important role that depends on additional services to attract customers. This is done by determining the best location for the spatial distribution of the stations while defining the locational, qualitative, and service competitive strategy, as well as products and services adapted to what is presented by demand, market conditions, and society [5].

Using the case of Maiduguri, petrol stations in the city are privately signed as per the guidelines laid out in the Petroleum Resources Procedure Manuals section (2010) and include specifying where and how petrol stations will be located. However, the responses of many of these facilities to the city's site guidelines were determined according to the decisions of the project owner. And as such, decisions for location are affected by their preferred choice of locations, mainly affected by the importance and price of the site [6, 7].

It mentions that petrol stations are often located far from densely populated areas, which means that the consequences of an accident, especially a fire, can be severe. The text also provides some statistics on gas station accidents, including the fact that (NFPA) estimates an average of 4,150, fires at petrol stations in the United States each year [8-12].

The text concludes by discussing some of the ways that researchers are working to improve fire safety at petrol stations. One of the most promising methods is the use of water mist, which has been shown to be more effective than traditional water in extinguishing fires.

Petrol stations are a major source of flammable materials, so it is important to take steps to prevent accidents. This includes following safety procedures, such as not smoking near fuel pumps and keeping vehicles away from the pumps when they are refueling.

Petrol stations should be well-maintained and have up-to-date fire suppression systems. This will help to minimize the damage caused by a fire if one does occur.

Employees at petrol stations should be trained in fire safety procedures. This will help them to respond quickly and effectively in the event of an accident [13-15].

Fuel is nature's most important creation. Today, it is the most widely used commodity due to the increasing number of automobiles routinely used for transportation [16].

Petrol filling stations can have a significant impact on the environment, especially in urban areas. Some of the environmental problems associated with petrol filling stations include [17]:

- Air pollution: Petrol fumes can contain harmful pollutants such as carbon monoxide, volatile organic compounds, and particulate matter. These pollutants can contribute to respiratory problems, heart disease, and cancer.
- Water pollution: Petrol spills can contaminate soil and groundwater. This can make the water unsafe to drink and can also harm aquatic life.
- Soil contamination: Petrol leaks can contaminate soil, making it unusable for agriculture or other purposes.
- Noise pollution: Petrol filling stations can be noisy, especially when vehicles are refueling or being serviced. This noise can be disruptive to people who live or work nearby.
- Fire risk: Petrol is highly flammable, so there is always a risk of fire or explosion at a petrol filling station.

In order to reduce the environmental impact of petrol filling stations, it is important to ensure that they are properly sited and operated. They should be located away from residential areas and other sensitive sites. They should also have adequate spill containment and fire protection measures in place.

In addition, there are a number of new technologies that can be used to reduce the environmental impact of petrol filling stations. For example, vapor recovery systems can be used to capture and recycle petrol fumes. Electric vehicles do not produce emissions, so they can help to reduce air pollution in urban areas.

By taking these steps, we can help to make petrol filling stations more environmentally friendly.

Spatial distribution analysis can be a valuable tool for improving urban planning, especially when it comes to the location of oil stations. By analyzing the spatial distribution of existing oil stations, planners can identify areas that are underserved or that could benefit from additional stations. This information can then be used to plan new stations in a way that ensures that they are accessible to all residents and that they do not create traffic or safety hazards.

In addition to providing information about the location of oil stations, spatial distribution analysis can also be used to assess the impact of these stations on the surrounding environment. For example, planners can use spatial analysis to identify areas that are at risk of air pollution or water contamination from oil stations. This information can then be used to develop mitigation strategies to protect the environment [16].

Overall, spatial distribution analysis is a powerful tool that can be used to improve the planning of oil stations and to ensure that these stations are located in a way that benefits the community.

Spatial distribution analysis is a valuable tool that can be used to improve the planning of oil stations and to ensure that these stations are located in a way that benefits the community. By using spatial analysis, planners can make better decisions about the location of oil stations, which can lead to a more efficient and sustainable use of resources.

Research problem: It consists of the following points:

1. Has the distribution of petrol stations been carried out according to planning standards?
2. The spatial distribution efficiency of fuel stations in the center of the Nile district in Al-Mahaweel district is weak.
3. Environmental risks and the failure to achieve spatial safety for petrol stations in the city of Nile.

Research hypothesis: The distribution efficiency follows sustainable planning standards and analytical planning methods to achieve optimal spatial safety and risk avoidance distribution.

Research objectives:

1. The main objective is to analyze the spatial

distribution of petrol stations in the Nile in Al-Mahaweel district using a multi-criteria analysis based on Geographic Information Systems (GIS).

2. Provide a clear picture of the spatial distribution of stations and identify their spatial variation in the center of the Nile district in Al-Mahaweel.
3. Achieve safety and security by eliminating potential risks through optimal distribution of station locations.

2. RESEARCH METHODOLOGY

The research relied on a comparative analysis method based on planning standards and spatial indicators to derive procedural recommendations based on the necessary spatial indicators for fueling station locations. It also relied on the GIS 10.6 software technology for spatial analysis of the stations (Figure 1).

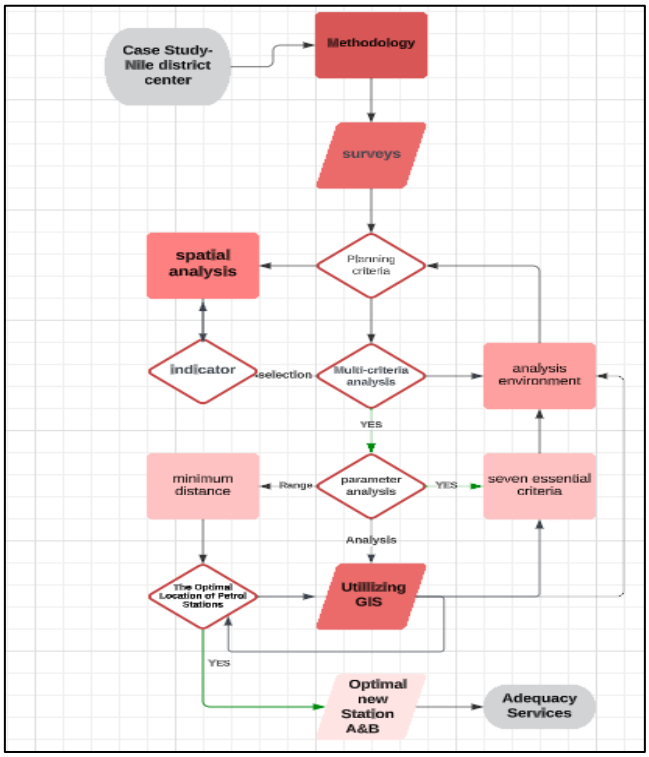

Figure 1. Methodology

3. IMPROVING THE LOCATION

Traditionally, petrol stations are located in largely uninhabited and distant areas. However, a different scenario is currently being applied, where petrol stations are now being built within residential areas, public building areas, and main streets, based on investments and the personal interests of decision-makers. This trend has been observed regardless of the risks associated with petrol stations. Petroleum products are the main drivers of industrial activities, and it is assumed that the industrial and transportation sectors are the main consumers of fuel [3].

The rapid growth of urban centers has led to an increase in the demand for petroleum products, which has in turn led to the proliferation of fuel stations. However, many of these fuel stations are not built or operated with environmental safety in mind. This can lead to a number of problems, it is important to ensure that fuel stations are built and operated in a way that minimizes the environmental risks. This includes [18]:

- Locating fuel stations away from populated areas. This will help to reduce the risk of fires and explosions that could impact people and property.
- Using containment systems to prevent leaks. Underground storage tanks should be lined with a leak-proof material, and aboveground tanks should be equipped with spill containment systems.
- Installing air pollution control devices. These devices can help to reduce emissions of VOCs, NOx, and PM.
- Educating employees about environmental safety. Employees should be trained on the proper procedures for handling and storing petroleum products.

By taking these steps, we can help to reduce the environmental risks associated with fuel stations and protect public health.

One of these requirements when selecting facility locations is proximity to population centers, distance from neighboring stations, ease of use of existing facilities, and the magnitude of environmental pollution standards.

According to the World Health Organization (WHO, 2004), over 2.3 million people and properties worth over $4.5 billion have been affected by fires associated with improper use of petroleum products. Most cities are exposed to traffic congestion, pollution, accidents, fire explosions, and environmental problems. These problems are more common in developing countries like Iraq, where there is a lack of coordinated development planning and adherence to planning laws. The recent urban growth witnessed in Al-Mahaweel district in general and specifically in the city of Nile has led to the need to improve and assess the spatial distribution of petrol stations. This research aims to study the spatial distribution of a petrol station [19].

This study interestingly notes a gap between the location of the stations and their efficiency within their multi-criteria spatial distribution. It aims to find optimal station locations while improving the number of required stations to meet demand. In the multi-criteria approach, a series of evaluation criteria are used to meet requirements and improve the locations of petrol stations [20].

4. IMPORTANCE OF FUEL STATIONS AND SPATIAL DIMENSION

Fuel stations are essential services in cities as they provide fuel for various types of vehicles. The transportation system has become the nerve center of modern cities, and the distribution of these stations is related to fairness in service provision and the impact on traffic flow, as land uses in the city are a function of traffic movement [21].

They are known as the final station for transportation means, and these stations have special characteristics suitable for the type of transportation means. They represent prepared and qualified spaces for the sale and distribution of fuel and petroleum products, and the private sector or government entities can own these places. These stations have spatial considerations regarding their geographic distribution and location, including the pathways or routes leading to and exiting from them, their impact on overall transportation, and the causes of traffic congestion or accidents [22].

4.1 Service efficiency

Fuel filling stations are spread inside villages and cities and on external roads to provide services and supply vehicles of all sizes with fuel of all kinds [18].

The services provided by gas stations are not limited to supplying vehicles with fuel only but rather go beyond this service, providing many services such as car batteries, changing oils, changing vehicle tires, car washing, and every other service provided to vehicles, and even some of them contain small workshops for vehicle repair. Some stations contain places to rest and sell fast food and drinks, increasing the attraction to this station and thus indicating the station's efficiency, work, and fuel supply [23].

And that the oil stations and the distribution of services in the city have a great interdependence, especially as it is a service provided to the community to achieve the greatest fair distribution [24].

The spatial dimension is an attempt to find the appropriate and possible method for the different activities, how to distribute and link them, the efficiency of service distribution, and the appropriate relationship for distances and the possibility of estimating them.

4.2 The commercial and economic impact of the stations

They are places designated for the sale of fuel of all kinds, and these places or stations may belong to the government or private sectors [21].

Gas stations are one of the services cities provide to their residents. These have witnessed significant changes in their number and functional and spatial characteristics. They have spread widely and increased within cities as an investment sector that achieves guaranteed profitable returns. It has become a commercial activity using a competitor's land for other commercial and service uses. And they converged with each other and appeared with new specifications and large areas. They began to crowd many streets until the large increase in their numbers became controversial and raised many questions until it often became the subject of interest and criticism by specialists, planners, and the public. The province of Babil is witnessing a large commercial expansion in the fuel stations due to the city’s urban area expansion. That it represents an important center in regional and urban transport because it connects the provinces and the city, as well as the presence of fuel stations as a result of the continuous movement and the influx of traffic makes the demand for fuel increase and thus increases the proportion of the economic and commercial impact For the province and its cities, and encourages the interdependence between land uses and traffic, and achieve commercial and economic aspects that have a return on the individual and society [25].

4.3 Planning for sustainable development with effective spatial distribution of fuel stations

Modern planning trends focus on the geographic distribution of public service facilities needed by individuals in their daily lives to provide them with the best assistance easily and conveniently. This is a fundamental factor in the region's distribution of public service centres. In this context, the spatial distribution of petrol stations is subject to the influence of a large number of interacting factors, which can be divided as follows [26]:

(1) Spatial distribution of petrol stations based on population and area: This distribution relies on two factors, population and area. The distribution occurs in municipalities, neighborhoods, and secondary regions.

(2) Spatial distribution of petrol stations based on population density: Population density is an important variable that affects the numerical and spatial distribution of petrol stations. The distribution should be proportional to population density, as the commercial goal is to link station locations with population density, considering that the population is the target of the services provided by the stations.

(3) Spatial distribution of fuel stations based on urban scope: This distribution includes two levels of the urban area: distance from the city center and proximity to neighborhoods.

(4) Spatial distribution of fuel stations based on the road network and street characteristics: This factor considers the road network, its characteristics, and the types of streets.

By relying on a balanced development strategy that includes successful management of refueling stations and optimal spatial distribution while preserving it, it helps overcome environmental and social challenges, protects the population, and achieves a connection between land uses, their integration, and their update within the flexibility of urban expansions, increasing population growth, rapid urbanization, and compliance with location-based standards and urban laws to maintain the city's image and planning character. This represents the greatest challenge in serving petrol stations and their distribution [27].

4.4 Characteristics of fuel stations

Fuel stations have characteristics that affect their spatial penetration and the size of vehicles. Some of the important characteristics are [28]:

A. Ownership pattern: Ownership patterns differ based on land ownership in Iraq. All stations fall under the following ownership categories: government-owned, leased, or private.

B. Number of employees at stations: Stations' workforce has distinct characteristics, such as regularity, suitability for workload, working hours, experience in the field, and age groups.

C. Operating hours at the station: Fuel stations vary in their operating hours based on their size, number of tanks, and locations. They are divided into two types: less than 12 hours and more than 12 hours.

D. Fuel marketing: Fuel is marketed daily due to its connection with transportation activities that occur throughout the day. It has distinct characteristics, including the spatial distribution of consumed fuel types, fuel prices, and fuel shortages.

5. RISKS OF FUEL STATIONS AND ENVIRONMENTAL IMPACTS

The environmental problems associated with the location of fuel stations and their importance in achieving environmental safety have been investigated in the case of Maiduguri, Nigeria [8].

5.1 Potential hazards

The various studies that have been conducted on gas station safety. The author does a good job of highlighting the different types of hazards that gas station workers and consumers face, as well as the contributing factors to gas station accidents.

The author also mentions some of the steps that have been taken to improve gas station safety, such as fire and explosion risk assessments and health risk assessments. However, the author also notes that accidents still happen and that human factors are often the leading cause [29, 30].

Overall, this is a valuable resource for anyone interested in learning more about gas station safety. It is well-written and informative, providing a comprehensive overview of the hazards and risks associated with gas stations.

It is important to remember that gas stations are inherently dangerous places. There is always the potential for a fire or explosion, and even minor accidents can have serious consequences [31-33].

It is therefore essential to take all necessary precautions to stay safe at gas stations. This includes following the safety rules, being aware of your surroundings, and being careful not to overload your vehicle with fuel [34, 35].

Gas station owners and operators also have a responsibility to take steps to improve safety. This includes providing adequate training for their employees, keeping their facilities well-maintained, and installing safety features such as fire suppression systems [36-38].

By taking all necessary precautions, we can help to reduce the risk of accidents at gas stations and keep ourselves and others safe [39].

5.2 Environmental and spatial safety

Ensuring safety across different sectors and industries, such as aviation, construction, refining, petrochemicals, container operations, etc., is essential for performance, production improvement, and service enhancement. Recent studies have revealed that continuous support from management teams, including participation in safety audits, site visits, safety communication with workers, etc., are key factors influencing employee safety behavior and determining the success of safety management systems [40].

The operation of fuel stations requires safe and reliable functioning to protect human life, health, the environment, and the economy. Any improper operation can significantly affect service quality, production costs, and life. Furthermore, the effects of accidents or disasters that threaten the station can be controlled, reduced, and eliminated by implementing appropriate risk assessment mechanisms [41].

The need for security and safety is one of the most important human needs. In the context of administrative buildings, this is especially important due to the large number of people who may be present, the abundance of flammable materials, and the potential for serious accidents.

There are a number of factors that can contribute to safety and security in administrative buildings, including:

- Proper design and construction: The building should be designed to minimize the risk of fire, flooding, and other hazards. It should also be constructed using materials that are fire-resistant and durable.
- Effective fire prevention and suppression systems: These systems should be designed to detect and extinguish fires quickly and efficiently.
- Well-trained staff: The staff of the building should be trained in fire safety and emergency procedures. They should also be familiar with the location of fire alarms, extinguishers, and other safety equipment.
- Adequate security measures: The building should have adequate security measures in place to deter and prevent crime. This may include security guards, video surveillance, and access control systems.

By taking these factors into account, it is possible to create a safe and secure environment for everyone who works or visits an administrative building.

In addition to the factors you mentioned, there are a few other things that can be done to improve safety and security in administrative buildings. These include:

- Regular fire drills: These drills help to ensure that everyone in the building knows what to do in the event of a fire.
- Emergency preparedness plans: These plans should outline the steps that will be taken in the event of a fire, flood, or other disaster.
- Proper maintenance: The building should be properly maintained to ensure that fire alarms, extinguishers, and other safety equipment are in good working order.

By taking these steps, it is possible to create a safe and secure environment for everyone who works or visits an administrative building [42].

5.3 Mitigating risks

Mitigating risks in fuel stations involves adhering to planning standards for their location. The main supervisory and regulatory authority responsible for granting official approvals for fuel station construction is the General Company for Oil Products in Iraq. This company has established several regulations, conditions, and standards to be met when selecting and designing the station's location. Furthermore, legal regulations and conditions need to be enforced to allow for the establishment of fuel stations [43]. These planning standards have been used to assess and improve the spatial distribution of petrol stations in the Nile City in the Al-Mahaweell District.

Some measures for mitigating risks and environmental impacts in fuel stations, after achieving optimal distribution based on planning standards, include implementing safety regulations, establishing monitoring teams, enforcing zoning laws and service location regulations, promoting the use of alternative energy sources to reduce environmental risks, and The above information highlights that the Nile District has a relatively low number of fuel stations compared to its administrative and geographic significance. Being close to the center of the governorate and located on major transportation routes connecting Babil Province with southern and Northern provinces increases the district's importance and the need for adequately equipped stations to provide comprehensive services.

Detailed data on stations, including ownership, location, and available products, will be presented in Table 3.

Following these measures ensures that the location of petrol stations is a crucial stage in urban and regional planning to achieve safety and security and mitigate environmental risks, thereby preserving lives.

6. PRACTICAL ASPECT

6.1 Study area

A. Location of the Nile District in Al-Mahaweell District (Nile City):

The Nile District is one of the districts within the Al-Mahaweell District in Babil Province, Iraq. It is located southeast of the district center and is known for its agricultural nature, particularly palm cultivation. It is also home to significant archaeological sites, including the ruins of Kish, Tel Al-Ahmar, and Tel Abu Srida. (Ministry of Municipalities, Babil Governorate) (Figure 2).

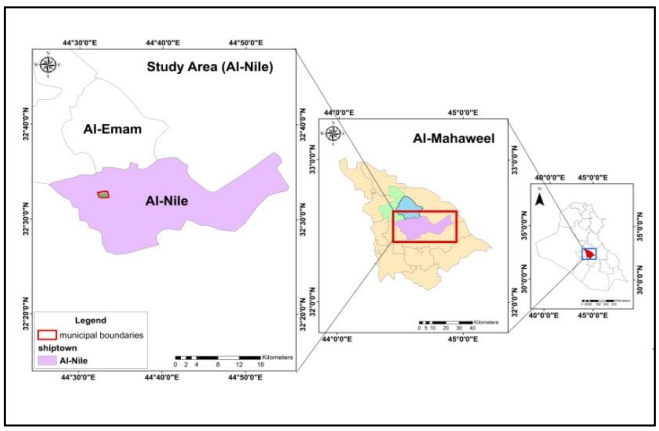

Figure 2. The location of the Nile sub-district center in the Mahaweel district

B. Statistical Study of the Population and its Characteristics in the Study Area:

In the Nile District, it is necessary to study the characteristics and population growth rates to assess their future impact on the provision of fuel stations. This will ensure improved services that align with the natural population growth. See Table 1.

Table 1. Population numbers in the Nile district for the years (1987, 2014, 2021)

Administrative unit	Year	Population
Al-Nile Township	1987	24151
	2014	58,763
	2021	66229

Source: Republic of Iraq, Ministry of Planning, Central Agency for Statistics and Information Technology, Babylon, population estimates for the year (1987, 2014, 2021).

6.2 Fuel stations in the Nile district

Fuel stations in the Nile District are distributed between the government and private sectors. There are three stations, with a higher proportion belonging to the private sector (67%) and the remaining to the government sector (33%). This imbalance between the government and private sectors poses challenges in providing efficient services, as there is a reliance on private stations and neglect of the public sector. This imbalance encourages price manipulation, material storage with lower stock levels, and a lack of commitment to safety standards. The public sector needs to be strengthened to ensure a more balanced distribution of fuel stations and efficient service provision. See Table 2 and Figure 3.

Table 2. Filling stations in Mahaweel district by administrative units for the year 2021

Administrative Unit	Number of Filling Stations
Al-Mahaweel D.C	3
Al-Nile ship town	3
Al-Imam ship town	1
Total	7

Source: Department of Petroleum Derivatives, Babylon Branch / Statistics of Petroleum Stations for the year 2021, unpublished data

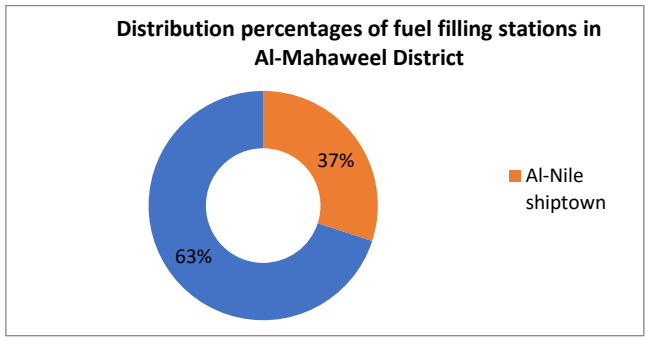

Figure 3. Percentage distribution of the fuel station in the Mahaweel area

The above information highlights that the Nile District has a relatively low number of fuel stations compared to its administrative and geographic significance. Being close to the center of the governorate and located on major transportation routes connecting Babil Province with southern and Northern provinces increases the district's importance and the need for adequately equipped stations to provide comprehensive services.

Detailed data on stations, including ownership, location, and available products, will be presented in Table 3.

Table 3. Classification of stations in the Nile sub-district by ownership

Administrative Unit	Station Name	Property	Municipal Boundaries
Al-Nile ship town	Al-waseem Staion	Private Sector	Out of bounds
	Al-Nile Aldewalia Station	Private Sector	Out of bounds
	Keesh Station	Government Sector	Out of bounds

Source: Department of Petroleum Derivatives, Babylon Branch / Statistics of Petroleum Stations for the year 2021, unpublished data

A. Ownership:

Table 3 and Figure 4 shows that most stations are privately owned, accounting for approximately 67%, followed by government-owned stations at 33%. This unbalanced ratio between the government and private sectors has created a clear disruption in service efficiency, relying heavily on private and non-governmental stations while neglecting the public sector. This situation encourages price and material manipulation and a lower stock of supplies, which results in lower public trust and efficiency in service provision. Therefore, there is a need to address this imbalance and strengthen the public sector, ensuring fair competition and improved service provision.

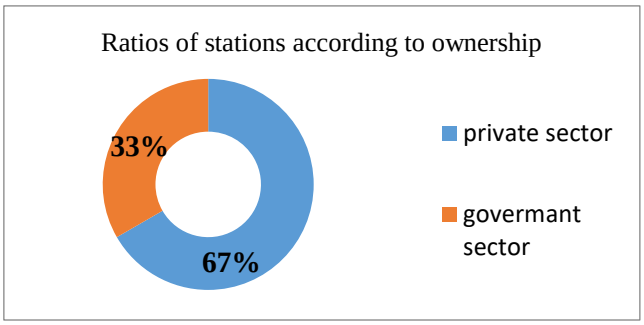

Figure 4. Ratios of station according to ownership

B. Available products: Table 4 and Figure 5.

Table 4. Stations and products provided in the Nile sub-district

Station	Station Property	Products				
		Gasoline	Gas	Kaz	Oil	High Octane
Al-Athar Station	Private Sector	O		O	O	
Al-Nile Aldewalia Station	Government Sector	O		O	O	
Keesh Station	Private Sector	O		O	O	

Source: Department of Petroleum Derivatives, Babylon Branch / Statistics of Petroleum Stations for the year 2021, unpublished data.

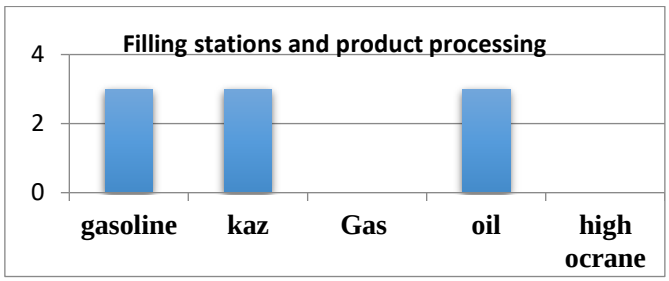

Figure 5. Products available at the petrol stations in the center of the Nile sub-district

6.3 Data analysis according to the method of comparative analysis

The previous data was analyzed according to the method of analysis according to the standards of the Ministry of Oil for the year 2015, to divide the standards into the standards of the stations established within the municipal borders, and into the standards of the stations established outside the borders of the municipality, both according to experts and decision-makers.

First: The standards of the Ministry of Oil for stations inside and outside the municipal borders (Table 5):

Second: Comparing the locations of the stations with the standards of the Ministry of Oil for the year 2015:

To obtain the best result and planning, the comparison must be made with the standards prepared by specialists and decision-makers. A comparative analysis is used between the reality of the situation and the model standards to obtain the most accurate assessment of the reality of the situation in order to develop appropriate solutions accurately (Figure 6).

Table 5. Ministry of Oil standards

Criterion	Cursor	The Index
Within the municipal boundaries		
Residential use	The distance between the apartment and the station	40 m
Population	Every 60000 people	Two stations
Community services	The station's distance from the services (schools, hospitals, mosques.)	100 m
Road network	The distance between the station location and traffic intersections.	1000m
Arrival distance	The beneficiary's distance from the station	1600 m
The distance of the stations from each other	Station distance from station on the same street	750 m
Outside municipal boundaries		
The distance of the stations from each other	The distance of a station to a station in the same administrative unit	10 km
The distance of the stations from the electrical pressure lines	Distance from high-pressure areas	10 m
	Distance from low-pressure areas	5m

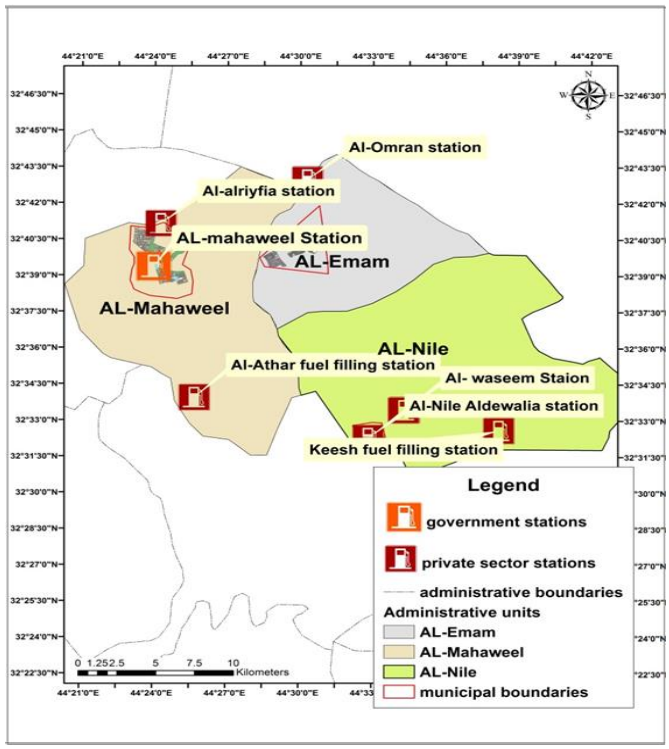

Figure 6. The spatial distribution of stations within the Mahaweel district

7. OPTIMAL LOCATION OF FUEL STATIONS

To reduce disparities in development levels through regulating multiple procedures, guiding event locations and development efforts, and achieving the goal according to mechanisms and laws governing the interaction between the

basic elements of the spatial dimension, including its economic, social, political, and urban aspects, comprehensive spatial development is achieved. Regional and urban planning corrects deviations in the spatial structure, starting from the urban settlement structure and organizing land uses to population movement, resulting in a spatial balance of services within the same area. The optimal signature of fuel stations will be a successful foundation for providing service for everyone.

7.1 Determining the ideal location for stations in the Nile District

First: The analysis environment is determined to identify areas of use for filtering, as shown in Figure 7.

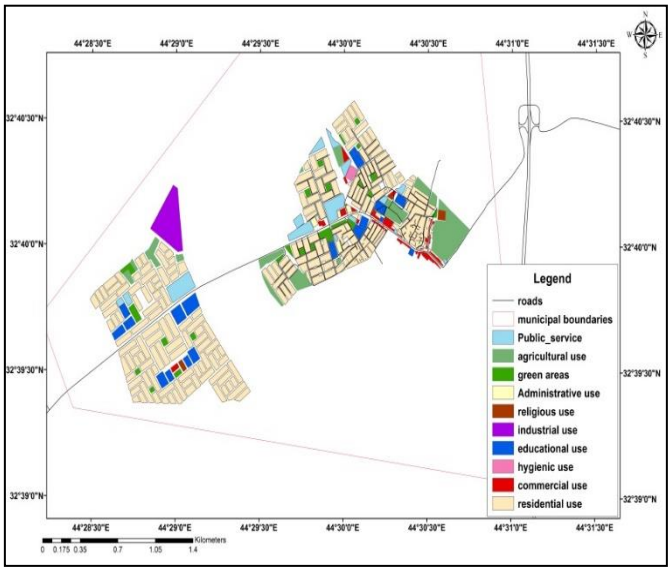

Figure 7. Selecting the analysis environment

Second step: The range of each use and the distance of the station from it are determined, as shown in Figure 8.

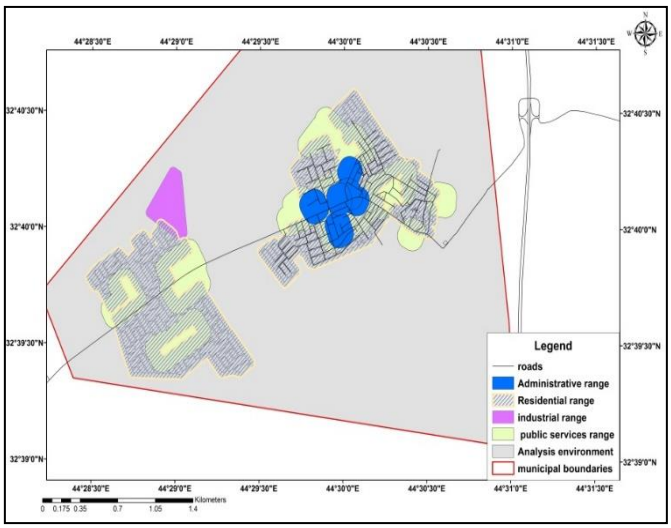

Figure 8. Determine the ranges for each use by distance

The analysis environment is determined within the municipal boundaries using a buffer tool to determine the range of each use and the distance of the station from it according to the municipal boundaries.

Third step: Areas are deleted from the analysis environment layer to determine the typical station locations based on the specified criteria, as illustrated in Figure 9.

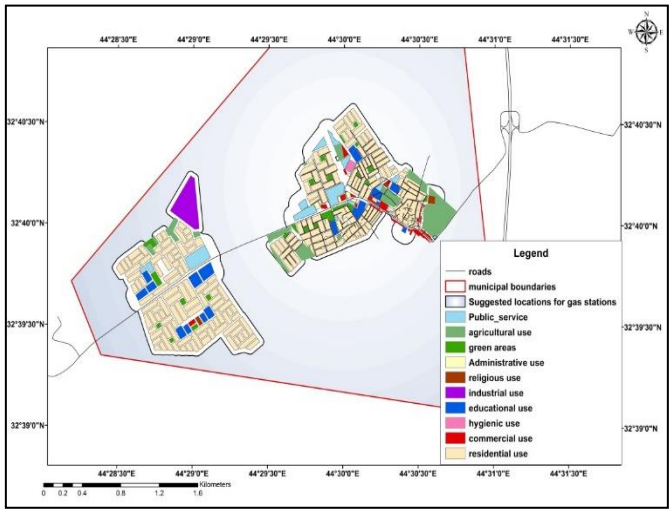

Figure 9. Deleting regions from the analysis environment

Fourth step: Finally, the typical site for the stations is selected: proposed stations for the center of the Nile District in Al-Mahaweel District (Figure 10, Table 6).

Table 6. The proposed stations based on the criteria of the Ministry of Oil station **A**

Station A	The Estemated Station Index	The Standard Index	Evaluation to Standard
The Space	5000	2000m^2 or more	matches the standard
The distance relative to the residential land use	40 m	40 m	matches the standard
Distance from these services (schools, hospitals and health centers)	100 m	100 m	matches the standard
Industrial use	40 m	40 m	matches the standard
The distance between the stations	834 m	750 or more	matches the standard
Arrival distance	1600 m	1600 m	matches the standard
The dimension of Administrative use	100 m	100 m	matches the standard

Appropriate criteria were applied after analyzing the spatial aspect and creating an analytical environment. The analysis revealed the availability of typical station locations at 40 meters from residential, 100 meters from public service, and 40 meters from industrial use. In conclusion, more typical sites were identified in the center of the Nile District in Al-Mahaweel District, meeting all the criteria without compromising any of them, thus achieving spatial safety and avoiding environmental risks (Table 7).

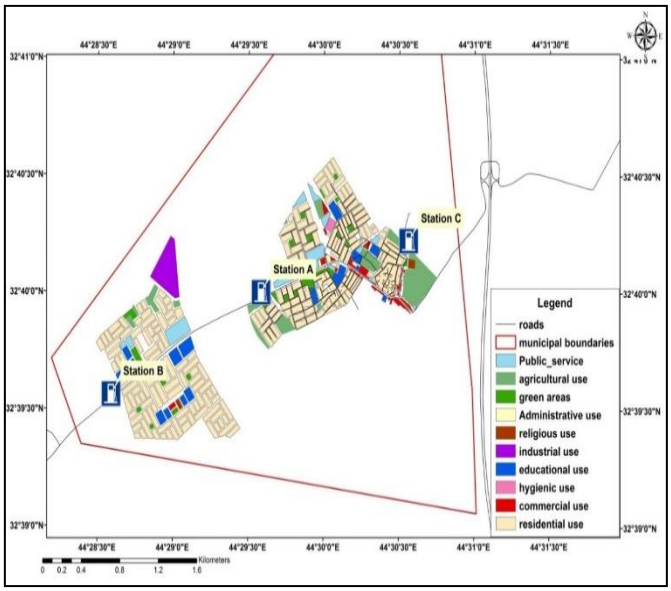

Figure 10. Typical locations for stations

Table 7. The proposed stations based on the criteria of the Ministry of Oil station **B**

Station B	The Estemated Station Index	The Standard Index	Evaluation to Standard
The Space	4000-4500	2000m^2 or more	matches the standard
The distance relative to the housing unit.	40 m	40 m	matches the standard
Industrial use	40 m	100 m	matches the standard
Distance from these services (schools, hospitals and health centers).	100 m	40 m	matches the standard
The distance between the stations	750 m	750 or more	matches the standard
Arrival distance	1600 m	1600 m	matches the standard
The dimension from Administrative use	100 m	100 m	matches the standard

8. CONCLUSIONS

Several conclusions can be drawn from the content of the research:

1. The process of distributing services is one of the important aspects in the process of planning services for the secondary region. This distribution of services is linked to urban agglomerations and population centers, generally distributed within a hierarchical system. They are signed according to the number of populations served on the one hand and according to the need of the population on the other.

2. The petrol stations' location and activities play an important role in adding pollutants to the environment, thus increasing the percentage of risks. The spread of these stations appeared without reference to laws and requirements, and most of them were profitable and did not consider the environmental aspects. As a result, environmental risks occur, and safety loses its role in this profitable situation.

3. This study was conducted in the Nile City in the Mahaweel District. This study aims to analyze the reality of fuel stations in the Nile City using the geographic information system, a multi-criteria analysis. 2 petrol stations distributed within the borders of the municipality (A, B) were proposed, and from the initial inspection of the petrol stations in the Nile City, which includes the map of the actual and hypothetical condition, the map of the geographical condition, the standard distance of the distribution map, the directional distribution map, and the allocation areas for petrol stations. The spatial analysis of the distribution of petrol stations operates according to 7 basic criteria.

4. The need for several fuel filling stations with the need of the province and the presence of great economic importance from their establishment. The reason for this is the recent unprecedented increase in the number of new cars, the survival of old cars, and the lack of fuel products.

5. The study revealed, through the spatial analysis of the spatial signature criteria of the fuel filling stations, that most of the fuel stations in the city of the Nile in the district of Al-Mahaweel were established without taking into account the standards and requirements of the site for construction, which were set by the competent authorities, and that there are neighbourhoods served by more than one gas station. At the same time, some neighbourhoods do not exist. It has this service and neighbourhoods that need to expand the service.

6. The city of the Nile in the Al-Mahaweel district witnessed inaccurate fuel station distributions due to administrative shifts from the sub-districts to districts divided from the main district.

7. The location of most of the stations outside the municipal borders explains the need for more services for the local population of the districts and the district center.

8. Quality of service is the most important element for customers to choose a gas station. Besides the quality of service, the quality of the petrol, the proximity to the station and the environmental situation are the factors customers look for when choosing a petrol station.

In conclusion, the optimal Location of fuel stations based on comprehensive spatial analysis and adherence to specified criteria is crucial for ensuring safe and environmentally-friendly service provision.

9. RECOMMENDATION

(1) The selected location should have the potential for future expansion to avoid any potential problems.

(2) It is necessary to understand all the determinants and criteria necessary for selecting the location of fuel stations based on the needs of the city and the district and the municipality's plan for distributing services within the basic plans of the Nile City in Al-Mahaweel District. This is due to the absence of stations in the center of the district and the urgent need for proximity, as the existing stations outside the center are far away, and most of the fuel is consumed in distant areas.

(3) Using geographic information systems (GIS) should be actively promoted as a technological tool in all planning and regulatory government administrations. GIS provides the possibility to contribute to finding solutions to most planning

issues by relying on spatial analysis and using its tools to build a spatial database that helps guide services according to site-specific and environmental requirements. This will assist in making better decisions without the interference of other factors that hinder the effectiveness of any decision aimed at improving the level of service as desired. Hence, adopting technology as part of the requirements for proper planning of transportation services in any city is crucial.

(4) Propose implementing a smart fuel station control system using RFID and GSM technology. In this system, RFID technology accurately dispenses the amount of fuel, reducing fuel misuse and labor costs. Additionally, if a customer tries to use an unauthorized card, the RFID system rejects the card, making the system highly secure. However, this system has some limitations, such as network issues related to the server system. In the future, a server system can be established for enhanced security and control, utilizing a regular Master Card or Visa Card. Furthermore, integrating the Internet of Things (IoT) with Raspberry Pi can increase the system's reliability.

(5) It is essential to strongly support land use policies and land management by strictly adhering to safety regulations to avoid major fire disasters within the city. This is important considering the high temperatures prevailing in Iraq, which have often resulted in fires during the summer season.

(6) Adherence to the proposed areas outlined in the research findings is recommended when establishing new fuel stations.

(7) Document GIS maps, plans, and research findings in a database specifically designed for the Ministry of Oil, Housing, and Construction to enable their retrieval in case of granting licenses for new petrol stations.

(8) Strengthen legal procedures and enforcement to ensure petrol station owners comply with planning standards.

(9) Maintain oversight by the licensing authority, the Ministry of Oil, and inform stations of any violations that need to be rectified.

(10) Create a green belt surrounding the stations and incorporate green spaces within petrol stations.

Safety training is crucial in implementing safety measures and should be a key factor in safety and security assessments.

REFERENCES

[1] Kadhim, A.A. (2022). Spatial analysis of the geographical distribution of petrol filling stations for part of the outer road (Baghdad – Hila). RESS Journal Route Educational & Social Science Journal, 9(4): 539 http://www.ressjournal.com/Makaleler/1712330359_32.pdf.

[2] Picone, M., Busanelli, S., Amoretti, M., Zanichelli, F., Ferrari, G. (2015). Advanced Technologies for Intelligent Transportation Systems. Springer International, Switzerland. https://doi.org/10.1007/978-3-319-10668-7

[3] Adisasmita, S.A., Pallu, M.S., Ramli, M.I. (2022). Assessment of road network connectivity in support of new capital development. Civil Engineering Journal, 8(10): 2190-2204. https://doi.org/10.28991/CEJ-2022-08-10-011

[4] Al-Attaby, E.A.H.A.S. (2013). Geographical distribution of the filling stations in the province of Najaf in 2013. Kufa Journal of Arts, 1(16): 357-383. https://www.iasj.net/iasj/article/79359.

[5] Šafranić, P., Petljak, K., Naletina, D. (2017). The growing importance of petrol stations as channels for expanding the retail services. Trade Perspectives.

[6] Ulasi, J.O., Uwadiegwu, B.O., Okoye, C.O. (2020). Assessment of the level of compliance of petroleum filling stations to development control standards on land space/size and setbacks in Anambra State. Civil and Environmental Research 12(2): 81. https://doi.org/10.7176/CER/12-2-10

[7] Taylor, T.K., Sichinsambwe, C., Chansa, B. (2016). Public perceptions on location of filling stations in the city of Kitwe in Zambia. Developing country studies, 6(6): 133-151.

[8] Mshelia, A.M., Salihu, A.C., Ubachukwu, N.N., Dibal, I.J. (2023). Environmental risk perceptions of residential and commercial neighborhoods of petrol stations in Maiduguri Metropolis, Nigeria. Geografia-Malaysian Journal of Society and Space, 19(1): 32-45. https://doi.org/10.17576/geo-2023-1901-03

[9] Page, C. Creeslough: Ten Dead after Donegal Petrol Station Explosion. https://www.bbc.com/news/world-europe-63183510.

[10] Bakidamteh, S.A., Teye-Kwadjo, E., Abdul-Nasiru, I. (2022). Understanding the role of proactive personality in occupational health and safety at oil and gas service stations in Accra. SAGE Open, 12(2): 21582440221089949. https://doi.org/10.1177/21582440221089949

[11] Zhou, S.Y., Huang, A.C., Wu, J., Wang, Y., Wang, L.S., Zhai, J., Xing, Z., Jiang, J., Huang, C.F. (2022). Establishment and assessment of urban meteorological disaster emergency response capability based on modeling methods. International Journal of Disaster Risk Reduction, 79: 103180. https://doi.org/10.1016/j.ijdrr.2022.103180

[12] Ahrens, M. (2020). Service or Gas Station Fires. National Fire Protection Association: Quincy, MA, USA. https://scholar.google.com/scholar_case?case=3952274124408674197&hl=ar&as_sdt=0.

[13] Lestari, F., Modjo, R., Wibowo, A., Sunindijo, R.Y. (2023). Influence of safety climate on safety performance in gas stations in Indonesia. Safety, 9(3): 44. https://doi.org/10.3390/safety9030044

[14] Yin, X.Y., Liu, T., Liu, Y.C., Tang, Y., Huang, A.C., Dong, X.L., Liu, Y.J. (2022). Feasibility study of fine water mist applied to cold storage fire protection. Processes, 10(8): 1533. https://doi.org/10.3390/pr10081533

[15] Liu, T., Yin, X.Y., Liu, Y.C., Tang, Y., Huang, A.C., Dong, X.L., Liu, Y.J. (2022). Influence of Water Mist Temperature Approach on Fire Extinguishing Effect of Different Pool Fires. Processes, 10(8): 1549. https://doi.org/10.3390/pr10081549

[16] Mayur, G., Gawde, S., Kanade, S. (2015). A review paper on automated fuel pump security system. International Journal on Recent and Innovation Trends in Computing and Communication, 3(11): 6156 - 6158, https://ijritcc.org/index.php/ijritcc/article/view/5009.

[17] Adedeji, O.H., Olayinka, O.O., Badejo, A.A., Osunde, E.O. (2022). Spatial distribution and environmental risk assessment of petrol stations in Abeokuta metropolis, Ogun state, Nigeria. Journal of Applied Sciences and Environmental Management, 26(11): 1843-1850.

https://doi.org/10.4314/jasem.v26i11.16
[18] Afolabi, O.T. (2011). Assessment of safety practices in filling stations in Ile-Ife, South Western Nigeria. Journal of Community Medicine and Primary Health Care, 23(1-2): 9-15.
[19] Ismaila, A., Sirajo, A.I., Muhammad, M.M. (2018). Spatial distribution of petrol filling stations in Sokoto Metropolis and its implication on environmental management. Environmental Issues, (8): 107-108. https://www.researchgate.net/publication/363280611_Environmental_Issues_volume_8_2018_Spatial_Distribution_of_Petrol_Filling_Stations_in_Sokoto_Metropolis_and_Its_Implication_on_Environmental_Management
[20] Juliawati, M., Darwita, R.R., Adiatman, M., Lestari, F. (2022). Patient safety culture in dentistry analysis using the safety attitude questionnaire in DKI Jakarta, Indonesia: A cross-cultural adaptation and validation study. Journal of Patient Safety, 18(5): 486-493. https://doi.org/10.1097/PTS.0000000000000980
[21] Jassim, I.A. (2014). The spatial distribution of gas stations and its relationship to the urban environment - the city of Kut as a model. Journal of Human Sciences - Issue (26): 438. https://www.iasj.net/iasj/article/93283.
[22] Al-Atabi, I.A.H.S. (2013). Geographical distribution of petrol filling stations in Al-Najaf Governorate. Journal of the University of Kufa. https://www.iasj.net/iasj/article/79359.
[23] Valenduc, G., Vendramin, P. (2017). Digitalisation, between disruption and evolution. Transfer: European Review of Labour and Research, 23(2): 121-134. https://doi.org/10.1177/1024258917701379
[24] Bredmar, K. (2017). Digitalisation of enterprises brings new opportunities to traditional management control. Business Systems Research: International journal of the Society for Advancing Innovation and Research in Economy, 8(2): 115-125. https://doi.org/10.1515/bsrj-2017-0020
[25] Aoun, A., Hussein, N. (2011). Efficiency of spatial signature of fuel filling stations in Iraqi cities, dissertation. Introduction to the Urban and Regional Planning Center for Graduate Studies, University of Baghdad. https://iqdr.iq/search?view=102ca1598639fb0103b084d90c13d485.
[26] Saad, A.H., Abbas, H.A.A. (2014). Spatial analysis of fuel filling stations in the holy city of Najaf using GIS. Journal of the University of Kufa, Iraq. https://www.iasj.net/iasj/article/93349.
[27] Saleh, M.B. (1996). Land Transport Sector and its Importance in Economic Development, with a study Applied study on Iraq, unpublished doctoral thesis, Faculty of Management and Economics, University of Baghdad. https://iqdr.iq/search?view=25d086b39c33ad.
[28] Nainaa, M.A.A.R. (2021). Fuel Supply Stations in Houm Hamada Countryside, Master Thesis. Faculty of Arts, Fayoum University.
[29] Mohsin, M., Yin, H., Huang, W., Zhang, S., Zhang, L., Mehak, A. (2022). Evaluation of occupational health risk management and performance in China: A case study of gas station workers. International Journal of Environmental Research and Public Health, 19(7): 3762. https://doi.org/10.3390/ijerph19073762
[30] Soltanpour, Z., Mohammadian, Y., Fakhri, Y. (2021). The concentration of benzene, toluene, ethylbenzene, and xylene in ambient air of the gas stations in Iran: A systematic review and probabilistic health risk assessment. Toxicology and Industrial Health, 37(3): 134-141. https://doi.org/10.1177/0748233720981218
[31] Shinohara, N., Okazaki, Y., Mizukoshi, A., Wakamatsu, S. (2019). Exposure to benzene, toluene, ethylbenzene, xylene, formaldehyde, and acetaldehyde in and around gas stations in Japan. Chemosphere, 222: 923-931. https://doi.org/10.1016/j.chemosphere.2019.01.166
[32] Sulistyanto, R.A., Kusumaningrum, D.A., Suaebo, N.M., Tualeka, A.R. (2020). Safe concentration of benzene exposure to worker's in gas station at the area of Diponegoro University, Semarang. Indian Journal of Forensic Medicine & Toxicology, 14(2): 2049-2054. https://doi.org/10.37506/ijfmt.v14i2.3254
[33] Almadiana, C.S., Tualeka, A.R. (2020). Determination of safe benzene concentration at Ciputat gas station. Indian Journal of Forensic Medicine and Toxicology, 14(1): 124-129. https://doi.org/10.37506/v14/i1/2020/ijfmt/192892
[34] Ma, G., Huang, Y. (2019). Safety assessment of explosions during gas stations refilling process. Journal of Loss Prevention in the Process Industries, 60: 133-144. https://doi.org/10.1016/j.jlp.2019.04.012 .
[35] Wang, W., Jiang, F., Jiang, Q., Shen, H., Zhang, R., Liang, D. (2019). Characteristic and Fire Experiment of Gasoline Spraying in Gas Station. In 2019 9th International Conference on Fire Science and Fire Protection Engineering (ICFSFPE), Chengdu, China, pp. 1-7 https://doi.org/10.1109/ICFSFPE48751.2019.9055871
[36] Setyawan, H. (2020). The determinant of fire disaster mitigation (fire practices study in gas station operator Surakarta, Indonesia). In IOP Conference Series: Earth and Environmental Science, 423(1): 012005. https://doi.org/10.1088/1755-1315/423/1/012005
[37] Ahmed, M.M., Kutty, S.R.M., Shariff, A.M., Khamidi, M.F. (2011). Petrol fuel station safety and risk assessment framework. In 2011 National Postgraduate Conference, Perak, Malaysia, pp. 1-8. https://doi.org/10.1109/NatPC.2011.6136346
[38] Nwankwo, C. D., Arewa, A. O., Theophilus, S. C., & Esenowo, V. N. (2022). Analysis of accidents caused by human factors in the oil and gas industry using the HFACS-OGI framework. International journal of occupational safety and ergonomics, 28(3), 1642-1654. https://doi.org/10.1080/10803548.2021.1916238
[39] Wibowo, A., Lestari, F., Modjo, R. (2022). Preventing fuel station accidents: The importance of community involvement. In IOP Conference Series: Earth and Environmental Science, 1111(1): 012077. https://doi.org/10.1088/1755-1315/1111/1/012077
[40] Hiep, H.Y., Hien, N.N. (2023). Safety leadership, Covid-19 risk perception, and safety behavior: The moderator role of work pressure. International Journal of Safety & Security Engineering, 13(2): 255-266. https://doi.org/10.18280/ijsse.130208
[41] Santospriadi, S., Tjahjono, T., Sunaryo, S. (2023). Safety improvement model in small multipurpose ports. International Journal of Safety and Security Engineering, 13(2): 289-299. https://doi.org/10.18280/ijsse.130211
[42] Taib, G.M., Al-Dabbagh, A.H. (2023). Design characteristics that achieve the factor of safety and security from fire accidents for users of administrative

buildings. International Journal of Safety and Security Engineering, 13(2): 227-236. https://doi.org/10.18280/ijsse.130205

[43] Bhandari, S., Hallowell, M.R. (2022). Influence of safety climate on risk tolerance and risk-taking behavior: A cross-cultural examination. Safety Science, 146, 105559. https://doi.org/10.1016/j.ssci.2021.105559