RESEARCH PAPER

ASSESSING SPATIAL DISTRIBUTION AND ACCESSIBILITY OF PUBLIC PRIMARY SCHOOLS IN MAFRAQ CITY, JORDAN: A GIS-BASED APPROACH

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ABSTRACT. The spatial accessibility of educational services is important in planning and managing educational services. This study seeks to evaluate the spatial distribution of basic schools, find the optimal location for the distribution of those schools, and develop solutions and proposals to improve accessibility by creating new schools. p-median models were applied to allocate sites. After analysing the locations of schools and demand points (residential buildings) in the city of Mafraq, where this model tries to provide recommendations regarding the area that service should cover, the standards of the Ministry of Education were adopted; they stipulate that the distance between the site of the basic school and the residential building should range 750 m. Accordingly, two models were applied: The first scenario was applied to evaluate the current school sites, whereas the second suggested the establishment of new schools in underserved areas and the evaluation of the effectiveness of accessibility after the construction of new schools. The results of the study showed that the number of unserviced demand points according to the optimal criterion for distance of access is approximately 58.9%, while it decreased to 38% after proposing the establishment of 10 schools in new locations. The study concluded that the analysis of site allocation using p-median models is an effective method in the spatial planning of schools. It can assist decision-makers and urban planners in improving accessibility to primary schools by establishing new schools and upgrading access to existing schools in underserviced areas..

KEYWORDS: accessibility, spatial analysis, p-median models, primary schools, Mafraq city

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INTRODUCTION

Public services are a human activity, and many sciences are involved in the study of this phenomenon; hence, the concept of public services differs according to the different sciences and encompass education, health, parks, and social and cultural centres. The importance of public services is highlighted when they are able to meet the needs of the population with the least effort, time and cost. This means that the service location should be close to the centre of the population density (Murray & Tong 2009). Educational service is one of the essential services to provide the city residents with. It is significant to take care of this service, plan for it, and follow up on it. Also, an attention must be paid to this service in terms of its distribution and its relationship to both population growth and distribution; this will considerably provide a geographical vision that contributes to urban planning and development programs. (Duwaikat, 2013).

In geography, there are two types of optimization techniques: (1) location–allocation models and (2) spatial suitability maps (Murray 2010). They both take a different path. The first method approaches it as a mathematical problem that must be solved in phases to identify acceptable methods. The second approach chooses a set of candidate places based on established spatial parameters. Location-allocation is a location theory development model that can be used to locate facilities spatially based on demand (Yasenovskiy & Hodgson 2007). The location–allocation model has mathematical characteristics and is a normative model to solve location problems (Utami et al. 2022) Location-allocation models in GIS are divided into seven main problems, which can be simplified into three subgroups: (1) p-median problems, (2) coverage problems and (3) competition problems.

Educational services in the Hashemite Kingdom of Jordan in general and the city of Mafraq in particular face difficulty in access. In recent years, Mafraq, similar to other Jordanian cities, has experienced an increase in population growth rates and urban expansion. This reflects negatively on the poor distribution of public services in it, especially educational services. What Mafraq city has witnessed as a result of the natural increase of the population and the influx of forced migration by Syrians to the city has put pressure on educational services, and there is an urgent need for educational services for all residents due to the increasing importance of education in our time.

The subject of this study is to improve the ease of access to the sites of primary public schools in Mafraq city using geographic information systems in accordance with the local standards of the Hashemite Kingdom of Jordan. The study relies on the standards of the Ministry of Education, requiring that the distance between the location of the basic school and the application points (residential building) range between 500-750 m. (Al-Dulaimi 2015). The current study utilizes the application of modern technologies such as GIS to build a spatial information base through which to produce applied maps to improve the ease of access to the locations of primary schools.

Thus, this study seeks to develop a geographic approach based on GIS to improve the accessibility and coverage of primary schools of Mafraq using the p-median model of site allocation. In addition, it endeavours to identify the number of candidate schools required to cover all or most of the demand points (for population) by identifying the proposed new optimal locations for basic schools. The study also aims to determine whether new schools should be established, leading to improving the ease of access to schools and helping to identify the future needs of the population of schools in light of the urban expansion witnessed in recent years by the city of Mafraq.

LITERATURE REVIEW

A literature review shows that researchers have much interest in educational services studies; some are interested in highlighting the spatial distribution pattern of schools. Abdul Jabbar & Laffta (2020) addressed the use of GIS in identifying differences in accessibility to private schools. Jiang et al. (2022) discussed the spatial pattern and factors influencing basic education resources in rural areas around major cities. Abraha (2019) also studied the evaluation of the spatial distribution pattern of schools by studying the characteristics of beneficiaries and analysing the obstacles that affect the efficiency of this service and the impact of location on different educational facilities. Another trend was concerned with the spatial distribution of schools in relation to population growth rates and evolution of the number of school centres Bulti et al. (2019), while others used some theories to evaluate school distribution, such as central place theory and efficiency distribution Yang et al. (2017). Some authors also suggested school mapping and geographic analysis of schools through spatial analysis and GIS (for example, the study of (Al-Enazi et al. 2016).

Site allocation models added another dimension in the development of studies related to the selection of school sites, as they benefited from the application of advanced algorithms. A series of recent studies indicated that some have shifted to the use of GIS-based site allocation models, which has been discussed by a large number of authors in previous studies. One study Menezes & Pizzolato (2014) examined locating public schools in fast expanding areas, applying the capacitated p-median and maximal covering location models. Mindahun & Asefa, (2019)applied a GIS-based location allocation model to improve geographic location and access to urban services. Utami et al. (2022) aimed to provide an alternative solution to the problem of empty space in the school division system and applied the p-median model (site allocation analysis) and service area analysis within the road network analysis within the GIS environment. In the same direction, some studies have focused on the use of geographic information systems as an educational decision support system and for the management of educational services. Iubadewo et al. (2013) examined the spatial distribution of primary schools to create a geographic database of schools and analyzed the pattern of distribution of schools. Al-Rasheed & El-Gamily, (2013) studied the use geographic information systems in the inventorying, mapping and analysis of educational facilities and unoccupied land reservations to improve planning and decision-making.

Some authors have also suggested providing a practical model for evaluating school sites in a way that helps planners improve access to school sites, the extent of their commitment to the conditions for choosing the optimal location and the effectiveness of providing these services in light of urban development to reach the optimal distribution of schools. Al-Sabbagh (2022) discussed site allocation as a model for establishing new schools and examined the appropriateness of location–allocation models for improving primary school access. Meena et al. (2022)applied site allocation models to primary school assessment and accessibility and applied the travelling salesman problem (TSP) to help choose the best path to school access. Fabiyi& Ogunyemi (2015) discussed post primary spatial re-engineering to enhance access to schools.

In previous studies, a large number of authors have presented a multi-objective model for site allocation that takes into account the reduced overall cost of travel, uneven access to schools, and incompatibility of uses. Mustapha et al. (2015) addressed assessing accessibility to private primary schools. Data analysis was performed using neighbour nearest analysis by performing a set of origin and destination (OD) matrices on the network dataset to assess the distance travelled to school by students. Rekha et al. (2020)studied site customization and accessibility models to improve spatial planning for educational services. Sumari et al. (2019)addressed the integration of accessibility models and location allocation in GIS as a proposed strategy for improving spatial planning for educational services. Batsaris et al. (2021) used the spatial decision support system (SDSS) to assist school location allocation decisions with the goal of reducing commuting distance to school from the perspective of capacity and proximity constraints.

Through the presentation of previous studies, we find that the present study constitutes a basis on which decision-makers can design a model to be used in planning and replanning the locations of primary schools in the future. It represents the first of its kind for Mafraq city, since the spatial distribution of school locations there has never been studied using GIS technology.

Study area

The city of Mafraq is located in the Hashemite Kingdom of Jordan 69 km to the northeast of the capital Amman, as shown in Fig.1. The total area of the city is 42 km^2, and the population of the city is 122785 (Department of General Statistics 2022), constituting 19.27% of the population of the Mafraq Governorate; the number of families in the city is 23590, and the population density of Mafraq City is 2923 inhabitants/km^2.The city of Mafraq is administratively divided into twenty-six residential neighbourhoods; the city centre is located within the old neighbourhoods, which contain most commercial and administrative activities. The city's name "Mafraq" stems from the fact that it is located at the crossroads of international roads heading to Syria in the north, Saudi Arabia in the south and Iraq in the east. Mafraq city played a historical role in the Islamic era since it has served on a major route for the Levantine pilgrimage. The city became one of the public transportation stations in the Ottoman Empire because of the presence of a Hejaz railway station there. From 1945 on, the city began to accelerate the local development process and witnessed a comprehensive service development renaissance that had the greatest impact on improving the features of life in the city and sparking urban advancement.

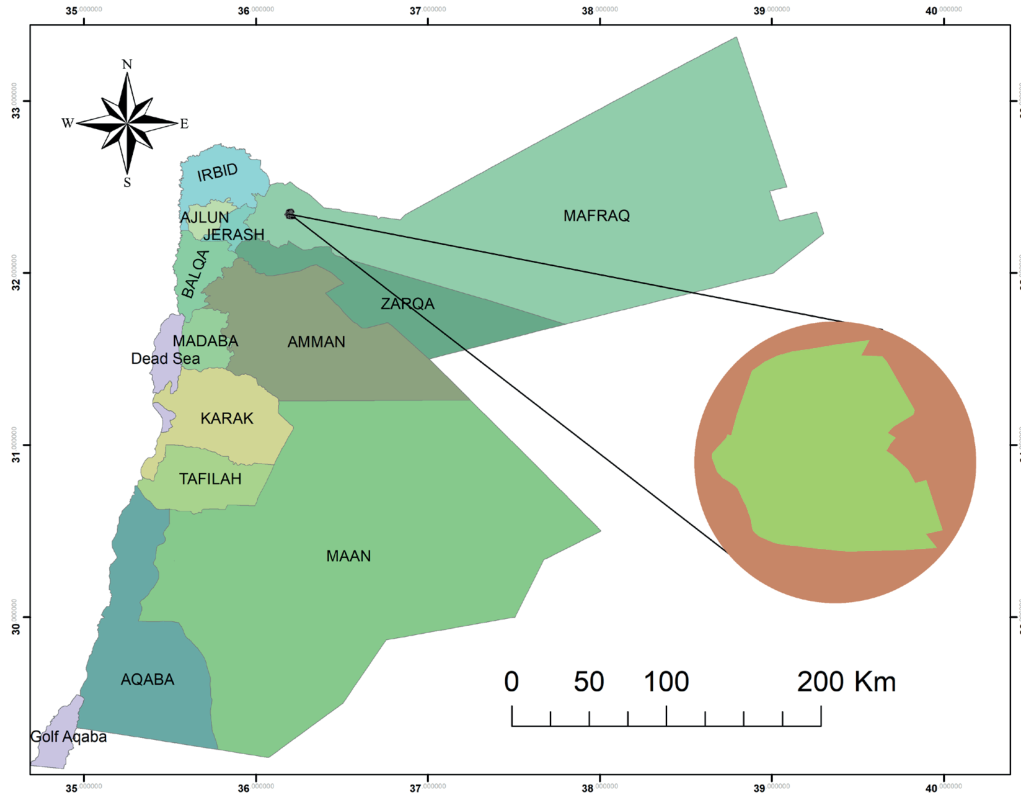

Fig. 1. Area targeted by the present study

MATERIALS AND METHODS

Spatial analysis of the accessibility of approach schools is attempted through geospatial techniques and includes data collection, spatial database creation, modelling and analysis of results to assess the location of schools in the city, as well as the development of candidate reality for improving the overall performance of the city's approach schools. The procedures used to carry out this study are summarized in Fig. 2. The methodology flow chart is shown. It involved collecting spatial and attribute data, including boundary data, road data, school location data, school raw data and census data.

Data sources

In any model for allocating sites, the location of the facilities, the sum of the demand points, and the supply network that meets the needs of the demand points are necessary to build the model. Accordingly, the present model applied here has used five basic maps with the coordinate reference system, Jordan Transverse Mercator (JTM) is a grid system created by the Royal Jordan Geographical Center (RJGC). The system is based on a 6° zone with the central meridian at 37° East. JTM is based on the 1924 International Hayford ellipsoid: School data were obtained from the school map of Mafraq City for 2021from the Ministry of Education, the road network for Mafraq City was obtained from the GIS Department at the Ministry of Public Works and Housing, and the location and administrative boundaries and population buildings of Mafraq City for 2021 were obtained from the GIS Section at the Department of Statistics. The data on population were obtained from the Department of Statistics, the General Population and Housing Census for 2015 and the population estimates for the city of Mafraq for 2021.Table 1. Data used in spatial analysis.

Preparing for analysis and processing study data

Conducting network analysis and location–allocation of primary schools in Mafraq city through tools a network analysis within the ArcGIS 10.4.1 software environment requires the preparation of the following maps

A- Preparing a base map of the city of Mafraq, (Fig. 3), with the coordinate reference system, (JTM) where the following layers appear:

1. The administrative boundary layer of the city of Mafraq in the form of an area (polygon)

2. The current school layer, in the form of points.

3. Road network layer: At this stage, the road map for Mafraq city has been prepared in the form of a polyline.

4. Preparing the map of residential buildings was prepared by relying on the ARC GIS program, where the built area was divided into a network of cells of equal dimensions (100 x100 m), These dimensions are suitable for the study area, numbering 4383 cells. A total of 2144

Table 1. Data used in spatial analysis

Data	Data Source	Type Data	Purpose of data
Map of the location	Department of statistics (2021)	shapefile (Polygon)	Showing the administrative divisions
Location of schools	Ministry of Education (2021)	shapefile (Points)	Identifying the available facilities
Residential buildings	Editing by Google Earth	shapefile (Polygon)	Identifying the residential areas to clarify the demand points
Road networks	Ministry of Public Works and Housing	shapefile (Polyline)	Clarifying the service coverage area

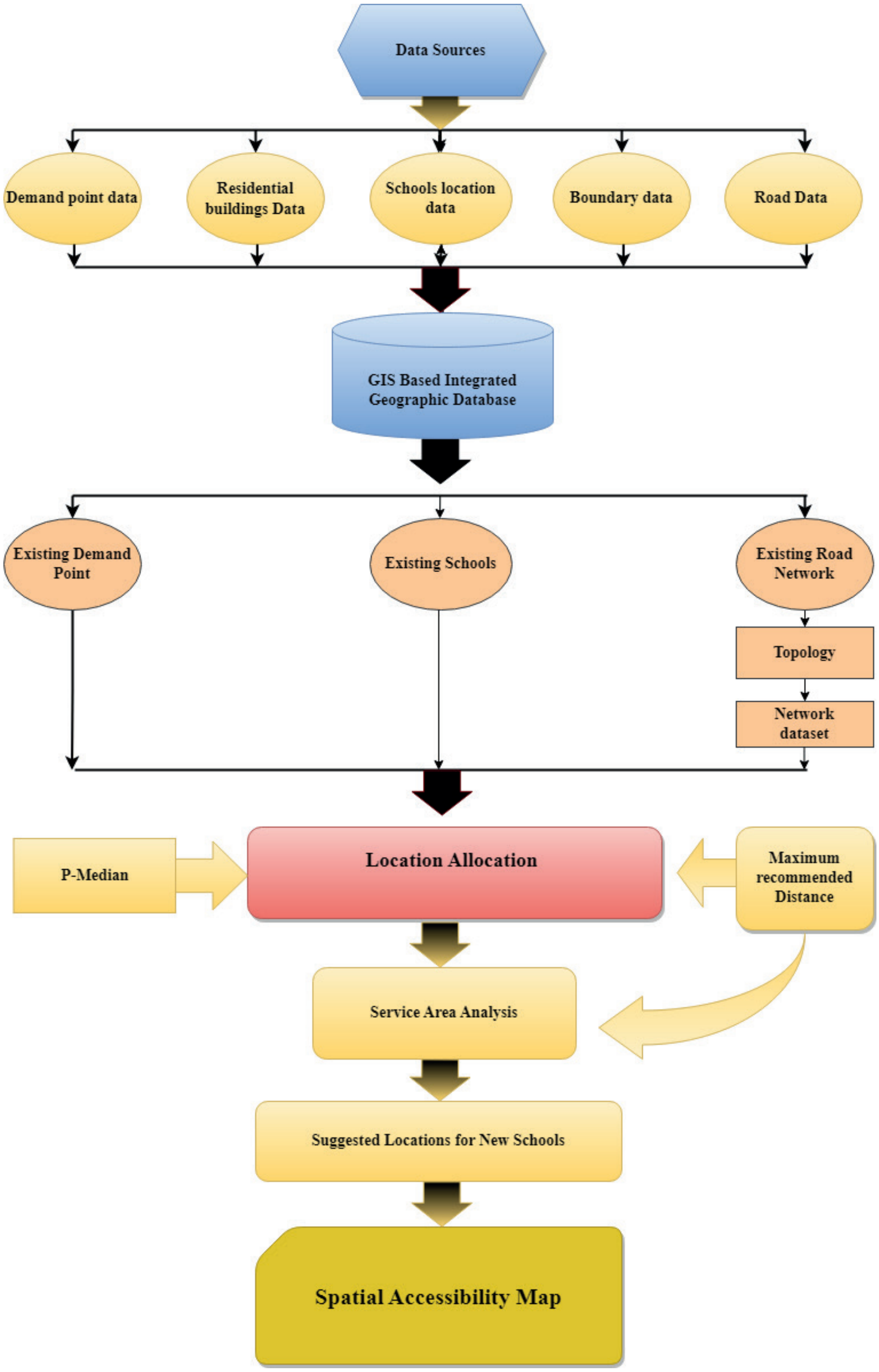

Fig. 2. Flowchart of the methodology used in the study

cells were excluded because they were not residential areas, while 2239 cells were retained for the purpose of determining demand points. The data (residential building network layer) have been converted from a cadastral layer (polygon) to a point layer (points)to be used as demand points to analyse the current locations of schools and study the proposed locations of schools and demand points at the same time.

B. It is necessary to build a dataset network that contains data tables, while working, the study classifies the roads into three types (i.e., main roads, side roads and secondary roads). The data related to the classified types of roads are grouped in columns in a table. These columns include: data about the names and the length of the roads in metres, data about the directions of the roads (i.e., one side or two-side roads), and the types of roads (main roads, side roads or highways) (AlFanatseh and Sababhi, 2023)

c. According to p-median problem, for specific demand points, the number (x) of facilities is calculated for the minimum total weights of the distances moving between facilities and demand. This assumes that the recipients of the service are using the nearest facility, and the equation of the p-median problem can be formulated as follows (Polo et al. 2015):

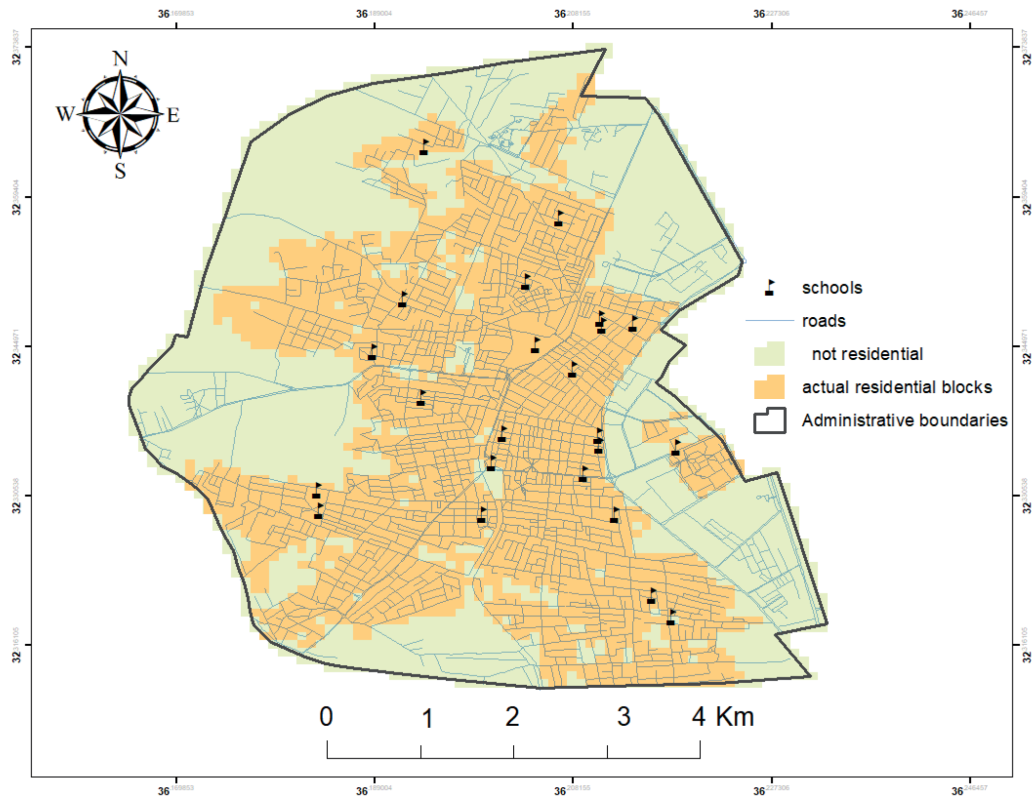

Fig. 3. Administrative divisions, road networks and the location of schools and the residential building areas in Mafraq

Maximize:

$$Z = \sum_i \sum_j a_i d_i j x_j$$

Subject to:

$$\sum_j xij = 1 \quad \forall i,$$

$$xij \le yj, \quad \forall i, \quad \forall j,$$

$$\sum_{jyj} = p,$$

$$xij, yi = \in \{0, 1\}.$$

Where:
i : Locations of demand.
j : Service sites.
dij: The shortest distance from the site (*i*) to the site(*j*).
x j: if the site is assigned (*i*) to site (*j*) 0 otherwise.
ai: Population on site (*i*)

RESULTS

Spatial Analysis Model for Choosing Appropriate Locations for New Schools

Building a spatial analysis model to choose the best place to establish a service is one of the proposed effective solutions for choosing the appropriate location for establishing a school at the city level. Spatial analysis methods are the most important planning tools for determining the proposed location's suitability. Designing a model to determine appropriate locations for new schools in Mafraq entailed completing the following steps:

Creating information layers for geographical variables related to the conditions for suitable locations for new schools. The most important criteria that were considered are summarized in Table 2.

This study used the Euclidean distance tool, which works at the expense of distances from the centre of the source cell (location) to the centres of all the surrounding cells. Each cell is appointed a value that represents the value of the source cell.

After defining the necessary parameters and determining spatial suitability, reclassifying all the informational layers was required. To achieve the goal for which the model was built, the distances were divided into ten periods using the equal interval method, and each period was given a specific value from one to ten. If the value was nine or ten, the distances would be of a large and close value. From the proposed location to be created, it will be highly convenient. If the value is one or two, the distance will be great, and it will be permanently inappropriate.

A weighted overlay was used on all the information layers, which were reclassified to produce a single information layer. The researcher accurately determines these using the weighted matching tool, and the program relies on them. The result of deriving a new information layer classified into new categories is that the categories of each layer overlap with others in all input layers. The criteria weighting and the relative importance of each were determined based on previous studies and research, in addition to the researcher's vision after reviewing the conditions of the study area and the lessons learned from the current school location. Next, Model Builder was utilized to determine appropriate locations for new schools. Model Builder is an application used to produce the final map, which includes areas that meet the selection conditions for the optimal location that were previously identified and excludes all areas that fail to meet these conditions (Fig. 4).

The final location suitability map divides the study area into two categories of suitable locations for establishing new schools in Mafraq. sites that were deemed suitable and sites that were deemed highly suitable. As shown in Fig. 5, which provides the results of the weighted map matching analysis, it determines the location's degree of suitability for establishing new schools

Table 2. Standards for new school locations in Mafraq

General Standards	Description
Land uses	It is not ideal to locate a construction site for educational institutions near commercial, industrial, religious or administrative districts. Therefore, such districts are accorded low weight values, while high weight values are given to residential, recreational and health districts, due to their high level of attractiveness for educational services.
Current school locations	The new location must be far from extant schools.
Slope	Choose flat areas to build new schools and avoid steep areas.
Population	Since the goal of building new schools is to serve the population, it is necessary to choose high-density areas and avoid new school construction in low-density areas.
Unused areas	Schools occupy urban land areas. When building the suitability model, construction priority is given to empty and unused areas.
Roads	It is necessary to determine the construction location for primary education schools. The proposed location must be easily accessible via the main roads.
Drainage networks	Avoid locating new school construction near watercourses and river valleys.
Dangerous locations	The construction site must be as far as possible from any source of potential risk or danger (e.g., fuel and gas stations).

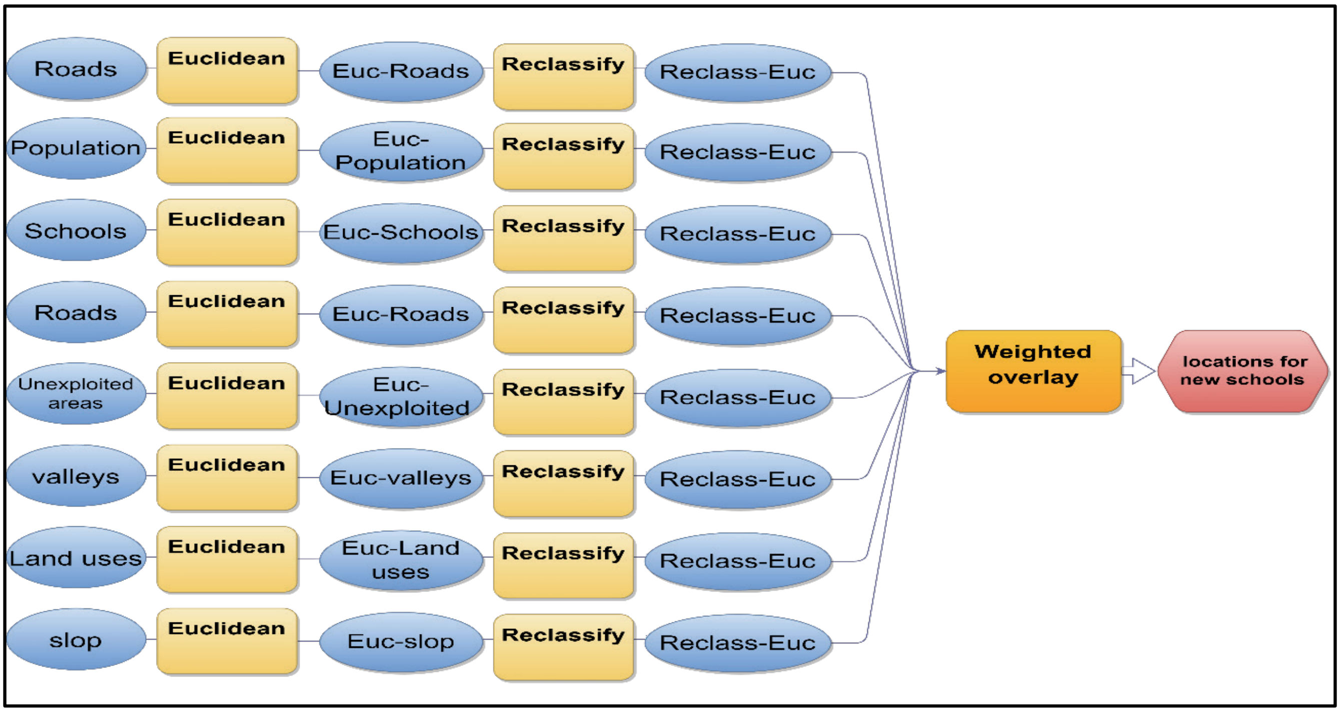

Fig. 4. Structural model for analysing the spatial suitability of new school locations in Mafraq

P-median modelling analysis

The site allocation model was created to improve accessibility to approach schools, such as by including the school layer and the request points layer in the created site specification form. It also helped to determine the type of problem to be solved through this analysis, where the issue of reducing weighted impedance p-median was used here to identify the assessment of the geographical distribution of the locations of basic schools within the neighbourhoods of the city; two scenarios were used to assess the accessibility of basic schools. This analysis has been used in a number of geographical studies that have dealt with the planning of educational services and other services to improve access to schools. For example, see the studies by Al-Sabbagh (2022), Utami et al. (2022) and Sánchez-Partida et al. (2020),in addition to the study by Mindahun & Asefa (2019). This method was used to assess school accessibility by proposing the redistribution of existing schools to increase the efficiency of accessibility.

The first scenario focused on the current geographical distribution of schools Fig.6.

The second scenario centred on the proposed distribution through the establishment of new schools in neighbourhoods not served by schools Fig. 6. The result of the analysis of the allocation models for primary schools in the city of Mafraq can be noted from the data contained in Table 3.

With reference to Table 3 and Fig.6, the results of the allocation of sites for accessibility assessment for the first scenario (current geographical distribution of schools) are given. The Minimize impedance model showed that the total network lengths were 403 km, and the average distance was 439 m. In the second scenario (proposed distribution of schools through the establishment of 10 new schools, the total network length was 602 km, with an average distance of 334 m.

The analysis of the data of Table (4) showed that there are five neighbourhoods where the points of demand constitute (57.76%), where the reach distance is 480 m, 519

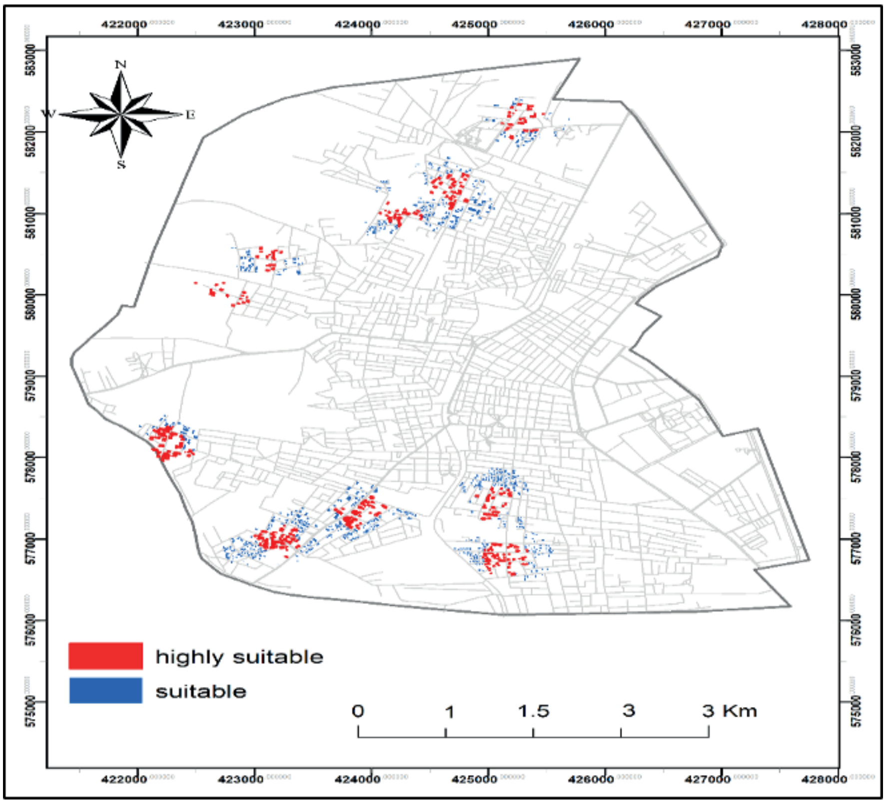

Fig. 5. Outputs of weighted map matching analysis to determine the degree of suitability of a location for new schools

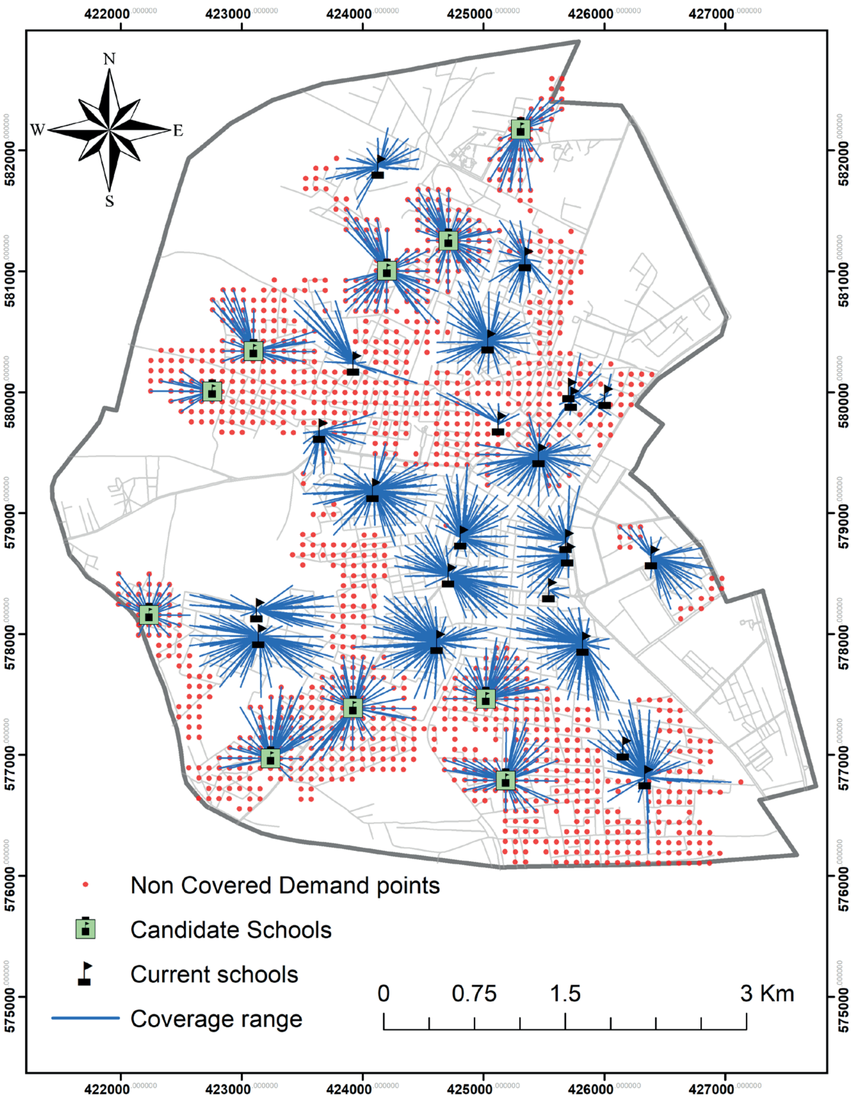

Fig. 6. The results of the proposed location–allocation models for primary schools in Mafraq

Model	Scenario No. 1			Scenario No. 2		
	No. Schools	Total network lengths/km	Average distance/m	No. Schools	Total network lengths/km	Average distance/m
Minimize Impedance	23	403	439	33	602	334

m, 442 m, 426 m, 471 m, and 574 m for the neighbourhoods Alhusban, Alsafwa, West Hashemi, Alnahda, King Abdullah, and Almizh, respectively. These neighbourhoods extend continuously in a westwards direction on the margins of the city, Despite the existence of numerous residential structures, the paucity of schools in these neighborhoods is attributable to the fact that these neighborhoods were developed recently as a result of Mafraq's fast urban development, and constituting 36% of the city's total area, while the rest of the city's neighbourhoods (twenty areas) comprise 42.24% of the demand points.

It was found from the analysis of Table 4. According to the proposed impedance reduction model for the geographical distribution of school locations where it was proposed to establish 10 new schools at the level of the city's neighbourhoods, there are four neighbourhoods that have witnessed an increase in the number of schools to their current status, namely, Aljundiu neighbourhood,

Table 4. The pointers of accessibility for reaching the main schools in the districts

No	District name	Minimize impedance model (current geographical distribution)			Minimize Impedance Model (Proposed geographical distribution)		
		Schools	Demand Points	Average distance/m	Schools	Demand Points	Average distance/m
1	Alzuhur	0	0	0	0	0	0
2	Craft area	0	0	0	0	0	0
3	Hamza	0	81	0	1	81	0
4	Industrial	0	0	0	0	0	0
5	Prince Hassan	3	67	284	3	67	221
6	Alfadayn	1	64	385	1	64	292
7	Alnasr	1	74	411	1	74	313
8	Princess Ealia	1	95	507	2	95	314
9	Aldubaat	0	9	397	0	9	325
10	Nwarat East	1	85	456	1	85	336
11	East Hashemi	1	93	479	1	93	343
12	Wasfi Altal	1	55	466	1	55	350
13	Aljaysh	0	30	459	0	30	351
14	Aljundiu	0	46	492	1	46	354
15	West Hashemi	2	146	442	3	146	360
16	Alnahda	6	196	426	6	196	372
17	Alqadisia	1	53	456	1	53	372
18	Alhusban	2	253	480	3	253	377
19	King Abdullah	2	469	471	4	469	389
20	Alhusayn	1	58	445	1	58	390
21	Ghazi	0	84	585	1	84	435
22	Alkarama	0	11	589	0	11	436
23	Alsafwa	0	111	519	0	111	450
24	Nwarat West	0	83	635	1	83	474
25	Almizh	0	120	574	1	120	464
26	Alnuzha	0	48	565	0	48	492

from 0 to 1 school, Princess Ealia from 1 to 2 schools, Ghazifrom0 to 1 school, Nwarat West from 0 to 1 school, Alhusban from 2to 3 schools, West Hashemi from 2to 3 schools, King Abdullah neighbourhood from 2to 3 schools, Hamza neighbourhood from 0 to 1 school, and Almizhneighbourhoodfrom0to 1 school.

Nine neighbourhoods witnessed stability in the number of schools, Alfadayn, Alhusayn, Wasfi Altal, Alnasr, Nwarat East, East Hashemi and Alqadisia, with one school for each neighbourhood, and Prince Hassan neighbourhood, with three schools. Alnahda neighbourhood has 6 schools, while eight neighbourhoods have remained without schools due to the lack of demand points in these areas because these areas are low in population density or are not qualified as rugged, industrial, military, and agricultural areas.

As a result of the establishment of new schools between the areas of the city, accessibility indicators have improved in areas that were far from the nearest school. As per the average distance (Table4) and (Fig. 7): Princess Ealia decreased from 507 m to 314 m, Ghazi from 585 m to 435 m, Nwarat West from 635 m to 474 m, Alsafwa from 519 m to 450 m, West Hashemi from 652 m to 360 m, and Almizh from 574 m to 464 m. In general, all indicators of access to basic schools have been improved in all neighbourhoods of the city compared to those of the current distribution. (Fig. 8)

DISCUSSION AND CONCLUSION

This study demonstrated the dynamic capabilities of geographic information system (GIS) applications in the spatial distribution and accessibility of primary schools in Mafraq. This study will help the Ministry of Education visualize the locations of primary schools on the map, guide them in establishing new schools to benefit unserved areas and consider the nature of primary school accessibility. We employed a GIS-based optimization model based on the P-median tool to allocate primary school services to ideal locations in Mafraq.

The results show the integration of site allocation and spatial suitability analysis. Therefore, a P-median site allocation model and spatial analysis based on a GIS are the best methods for determining the most suitable sites for new schools and other relevant public services. Site allocation technology and land suitability analysis enhance the efficiency of school sites more than traditional methods. However, reorganizing existing primary schools will not be possible because doing so consumes resources and the state may be unable to bear the additional costs.

Network analysis, both P-median, can run optimally if the road network data (network data set) is correct and detailed - in the sense that it includes information about the direction of the road (one or two directions, turning, etc.), However, a notable limitation of construction-level analysis was the lack of detailed data for the road network in the city; this limitation may seriously affect the results of the study.

The study presents two scenarios for the development of accessibility to schools. The first scenario was applied to evaluate the current school sites, whereas the second suggested the establishment of new schools in underserved areas and evaluation of the effectiveness of accessibility after the construction of new schools. The results of the study show that all indicators of access to primary schools in all neighbourhoods of the city have been improved when compared to the current distribution. This result is consistent with previous studies, whose findings showed that the integration of spatial accessibility and site allocation models represents an alternative solution to the problems associated with spatial planning and distribution. The study presented a model for spatial analysis of basic schools using spatial planning methods and standards for choosing new school sites. Planning standards related to the conditions for suitable sites for new schools were introduced, and among the most important standards that were considered were the following: current school sites, slope, population, road networks, drainage network, land uses, and hazardous sites. The results of the spatial analysis allowed for the derivation of a map of suitable sites for establishing new schools in the study area. Sites

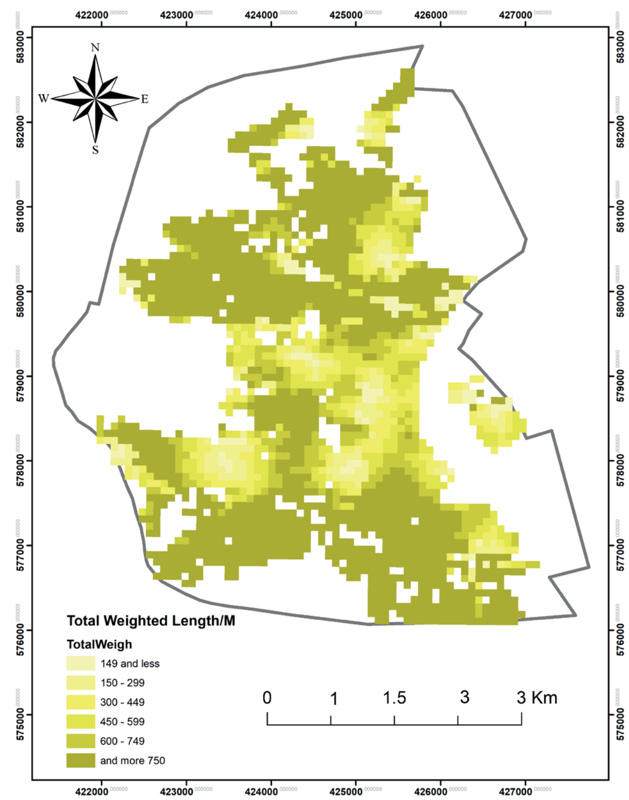

Fig. 7. Accessibility indicators of current location-allocation models for Mafraq city districts

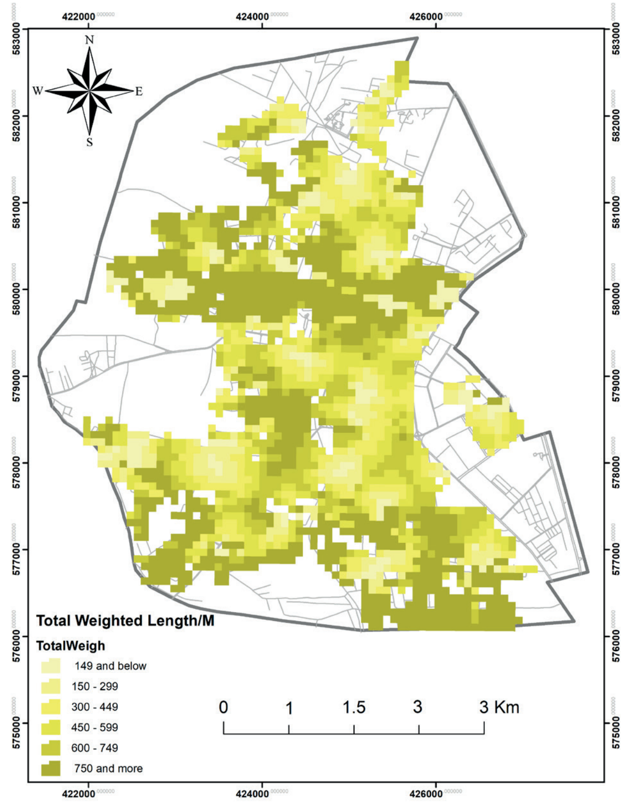

Fig. 8. Accessibility indicators of proposed location-allocation models for Mafraq city districts

in the study area were divided into two different suitability categories: sites that were deemed suitable and sites that were deemed highly suitable.

The study was able to demonstrate the dynamic capabilities of (GIS) for improving access to primary schools. The study results were analysed through the following site allocation models: the p-median impedance reduction model problem and a spatial suitability analysis. This approach helped the developer determine the type of problem to be solved, as the problem of reducing the p-median impedance was used to determine suitable places for establishing new schools in the Mafraq city. Residential buildings (demand points) that fell within the scope of primary school services were also identified.

By applying the proposed impedance reduction model, the number of schools needed to cover the needs of the population was determined, and it became clear that for improving access to primary schools, 10 new schools would need to be created to cover all or most of the residential buildings (demand points) in the city. According to the proposed impedance reduction model According to the proposed impedance reduction model and because of the establishment of new schools in model, accessibility indicators improved in areas where the distance to schools was high.

The results of the study showed the average access distance to primary schools decreased after the implementation of the proposal to establish new schools, which led to an improvement in all indicators regarding access to primary schools in all neighbourhoods of the city.

The high cost of establishing new schools in the city is one of the biggest problems facing the process of improving access to primary schools as a result of the meagre financial resources available in Jordan, which is a developing country. Another issue is infrastructure problems represented by the road network. The Ministry of Education can resort to temporary solutions, such as renting residential buildings for the purpose of providing schools in appropriate areas and identifying locations that need new roads to ensure better access to schools.

The location–allocation p-median models' approach can be applied in other countries and cities of the world while considering the planning standards specific to each country, and this method can be useful in distributing other related public facilities, such as hospitals, public health care centres, warehouses and markets. The adoption of spatial decision support models can also help countries improve the selection of locations for public facilities, especially with the proliferation of decision support models that have become more widely used as GIS programmes mature.

Based on the findings of the study, we recommend making use of GIS techniques in making planning decisions, especially spatial planning decisions. With the possibility of benefiting from this model, planners, especially in the field of services in general and primary services in particular, can formulate the appropriate plan for best and proper development in the region involving easy access to these services. Further research on several fronts and additional studies are recommended in other cities in Jordan. Comparative analysis would provide a growing empirically based understanding of effective social service planning.

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