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Determining the Optimal Locations of Public Parking to Prevent Traffic Congestion with Boolean Logic and GIS Analysis: Case Study Taluqan City

SUHRAB AHADI[1], SAYED NAQIBULLAH HASHIMI[1*] & ZABIULLAH HAIDARI[2]

[1]Department of Engineering Geodesy, Faculty of Geomatics, Jawzjan University, Sheberghan, Afghanistan. Email: suhrabahadi2016@gmail.com, naqibhashimi2020@gmail.com.

[2]Department of Drawing and Descriptive Geometry, Construction Faculty, Kabul Polytechnic University, KPU campus, 5th District, Kabul, Afghanistan. Email: zabiullahhaidari11@gmail.com,

Abstract

Parking lots, as one of the most important urban infrastructures, play a major role in reducing curbside parking and traffic congestion. Also, the unbalanced growth and unprincipled urban development due to the incompatibility between different urban uses and the lack of urban unit management have caused problems in the urban system in the first and second districts of Taluqan city, Taluqan is one of the densely populated cities in the north-east of the country, whose transportation network is currently facing the fundamental problem of lack of parking for residential use and other uses, and the loading of activities without considering this use has caused this problem. Gradually manifests itself as an urban problem. On the other hand, the lack of sufficient parking lots at the same time as the development of roads and urban uses has caused problems in the transportation and urban traffic systems, so the traffic flow of the studied area has faced problems due to the occupation of the roads by roadside stops and peddlers' stalls. In this research, in order to determine the proper location of the parking lots in the city, first the aerial photo of Taluqan City was obtained from the website of the United States Geological Survey (USGS), and also the location of the existing parking lots was examined according to the detailed plan map of the municipality. The crowded locations of the city, such as commercial, educational, recreational, and health centers, were identified and determined by the precise calculation of traffic and geographic criteria using the hierarchical analysis method and with the help of the Geographical Information System (GIS). In this research, first, preliminary studies were carried out to identify the criteria influencing the selection of a suitable parking place, then, using the hierarchical analysis method, the weighting of the criteria was done, finally, by combining this model with the Geographical Information System of Tut Bagh locations, Taluqan Municipality, Provincial Authority and Commandery, Nilgari, Two hundred bed hospital, Department of Education and Abu Osman Taluqani High School, Shahr-Ravan Bridge, Golai Bagh Reserve and Takhar University, suitable areas were suggested for the construction of parking lots.

Keywords: Locating, Parking Lots, Traffic Congestion, AHP, Boolean Logic Method, GIS, Taluqan City.

* Corresponding Author

1. Introduction

With the increase in traffic in cities, the number of cars looking for a place to park on the roads inside the cities has increased. The urban transportation system comes with the expansion of alleys, highways underpasses, and overpasses to solve the current traffic problem to some extent. However, no basic work has been done regarding residential traffic. Heavy traffic has been one of the major problems in transportation, which is one of the main problems in some big cities [2]. Parking lots are one of the under constructions of the city that have not been given much attention. The lack of parking in cities causes cars to stop on the side of inner-city roads (marginal parking), in this way, the area that should be available to vehicular traffic is actually changed, and it causes an increase in road traffic [3]. A year is 8760 hours, if each car travels an average distance of 20,000 km during the year and travels at an average speed of 40 km/h, the time that the motor regiment is on the move in a year. It is equal to 500 hours. Therefore, each car is stopped for an average of 8260 hours a year and needs a place to stop. Therefore, it is possible to stop the vehicle, whether long-term or short-term, in a suitable way. While everything is possible to access and use it. One of the basic solutions to deal with the lack of parking spaces is the construction of public parking lots outside the roads. But one of the most important things to consider before building parking lots is their location. The inappropriate location of parking lots and their unprincipled scattering not only causes the inefficiency of parking lots but also increases urban traffic and as a result increases accidents, increases the time and distance of inner-city trips, fuel consumption and it will also increases fuel consumption and air and noise pollution. Therefore, it is necessary to use systems that analyze the number of parking lots at the same time. One of the systems is the geographic system, the possibility of using these systems in the fields of use [5]. Regarding locating and choosing the best places for different purposes, evaluating the existing location and the suitability of the location, as well as using location methods such as hierarchical methods, Boolean logic, and its interpretation with the information system. Geography is discussed [6].

Large and densely populated cities of the world need urban traffic management, and precisely this population growth and the increase in the ownership of personal vehicles lead to the expansion of cities. In all cities, the urban transportation system is important, so it should be designed to be as efficient as possible for serving. This matter has been considered in the big developed cities of the world and it has not been considered in the cities due to political-economic or political-social problems. On the other hand, perhaps the lack of attention to transportation engineers is the reason for not considering urban transportation systems in big cities. One of the most important services of the urban transportation system is choosing the right location of the parking lots [7]. If sufficient parking spaces with suitable locations are not considered in cities, cars will use the surface of the road network to stop, as a result, the useful surface of the network will decrease and cause slow movement, create traffic jams, increase accidents, and pollute the environment. Life, waste of time, decrease in the use of cars by passengers, reduction in the transfer fee of drivers. Therefore, one of the major problems in traffic management is the management of stationary traffic, precisely this has been one of the major problems in transportation, which is one of the main problems in some cities. In order to smooth

the movement of vehicles and solve traffic problems, it is necessary to seriously plan the construction of flyovers, underpasses, overpasses, public parking lots, etc. In this regard, the construction of numerous parking lots in the vicinity of city roads in order to prevent long and unnecessary parking lots on the side of the streets, one of the specifics is aimed at traffic. Parking lots have been one of the infrastructures that have not been paid attention to in several cities.

The current research is locating parking lots in order to prevent traffic congestion in Taluqan city using a Hierarchical Method With Geographic Information System and the reason for choosing this issue is the lack of parking in Taluqan city, which causes cars to stop on the side of the streets (marginal parks) and the useful positions that should be available for vehicular traffic have been turned into parking places for cars and peddlers' stalls, which actually increases road traffic. In this way, heavy traffic in provincial cities, including Takhar province, which has a large population and non-standard roads, and most of the commercial centers and government agencies are located in the center of the city, thus the problem of solving the traffic problem It will play an important role in the process of smoothing the transportation. Nowadays, the need to create different parking lots in the city is clearly visible, so to get the right locations for creating parking lots and managing urban traffic, the best option is to use the geographic information system. The geographic information system has many capabilities, including urban planning, planning for the extension of gas, water, and electricity pipelines, traffic management and control, urban changes and development, and ambulance system networking. , fire, police, etc can be mentioned. Due to the mass traffic of cars, the unplanned parts of the city, the possession of part of the road surfaces by vendors, etc., the traffic problems that can be seen in Takhar today, therefore, the creation of parking lots in the locations that are responsible for traffic management. It should be considered for the construction and also to reduce the traffic of road bridges. The use of geographic information system in urban planning, especially in the traffic sector, is a new system that has major benefits. In this research, it is tried to reduce urban traffic and increase the level of service, and also make the city of Taluqan more beautiful and orderly.

2. Statement of the problem

Afghanistan is a country that has been involved in political, social, and economic problems for many years and less attention has been paid to the infrastructure fields. The city of Taluqan-Takhar is exactly what led to the present research. In order to prevent urban traffic congestion in Taluqan City, this research was carried out to determine and select suitable places for parking lots, using the hierarchical analysis method with the help of geographic information system.

So far, road construction designers have only paid attention to the dimension of road adaptation and that's it; However, traffic engineering, which is an integral part of road engineering, has not been given the attention of designers in this province, and this has caused traffic problems, including traffic jams and the turning of roadsides into parking lots, according to engineers. The road is not very familiar with the management of resident traffic and this itself has caused acute traffic problems in the city of Taluqan, therefore, in order to solve this problem, the current research was conducted so that

engineers can consider this principle in the next plans and create to prevent traffic problems in the city, this research, which is under the title of locating parking lots to prevent traffic congestion in Taluqan city by hierarchical analysis method with the help of geographic information system, can be a good solution to solve this problem.
This research is not the first research, but it has been considered in the region and the world in order to prevent traffic congestion, accidents, depreciation of vehicles, and for the public welfare of the city.

3. Importance of research

One of the most important reasons for the disorder of the current parking situation in Taleghan City is the lack of location and the lack of matching of the appropriate parking places with travel attraction centers, the lack of appropriateness of the distribution of parking spaces with the requirements and urban context, and the insufficient number of parking lots. It is relative to the two criteria of population and area of the city. This has caused the slowness of traffic in the city crossings due to the marginal parks along the inner city roads and the simultaneous stops of motorcycles and stray cars that are looking for a place to park. Considering the constant traffic and the fact that every car needs a parking space at its origin and destination, it was necessary to pay attention to planning for it in Taluqan city, which this research has dealt with the appropriate solution.
Taluqan city connects the vast and densely populated province of Badakhshan to the north-eastern zone (Kunduz province). It also has 17 independent administrative units, which has always seen traffic and congestion inside the city, precisely one of the important reasons. Lack of parking space in the city. The city's lack of standards for traffic causes delays in travel time, accidents, noise, and environmental pollution, which we see in the city of Taluqan. In order to eliminate the bad state of the city, it was decided to use the system in this research. Identify and determine suitable parking positions with geographic information and hierarchical analysis method.

4. Literature Review

The construction of public parking lots is accompanied by an increase in efficiency and classification with the purpose of opinion when all parking lots are considered in the construction of parking lots. One of the most important plans for the construction of parking lots is their construction. Improper location of parking lots and their unprincipled dispersion not only cause the inefficiency of parking lots, but also increase urban traffic and as a result complications, increase the time and distance of intra-city trips, increase fuel and air consumption, and increase noise. Follow Hierarchical analysis design is a flexible, robust, and simple method that is used to make decisions in situations where decision-making is conflicting, making the choice between alternatives difficult [11].
Currently, the location of parking in our country is done in a traditional way, which causes the lack of proper efficiency of these parking lots. Therefore, new systems that use the analysis of a large number of compounds at the same time are necessary for the location of parking lots. One of these systems is the geographic information system that analyzes and analyzes all types of data simultaneously [9].

The factors and criteria that are effective in choosing the location of various urban activities such as service, industrial, commercial, and military activities and should be taken into consideration are numerous and diverse. Some of these factors are variable. In other words, there are changes in some factors such as: communication ways, block population, etc. Some other factors are constant. In this way, the length of time and with the change of conditions, there is no change in some factors such as earthquake susceptibility and weather conditions. Examining all the criteria together and considering all the factors with each other is a difficult task and can be the source of errors and mistakes in decision-making. Also, according to the number of criteria, using traditional methods of mapping maps is not a suitable method for locating. Today, in order to evaluate the effective criteria in a multi-criteria decision-making, the method of hierarchical analysis is used in this research. In fact, by using this method, the problem of the number of effective criteria in parking locations and how to value each of these factors can be solved so that acceptable results can be provided to decision-makers [14]. After determining the necessary criteria, each of these criteria should be valued so that the weight given to each of them is close to reality so that subsequent analyses can be performed with more confidence. For this purpose, the expert opinion of traffic and urban planning experts should be used regarding the importance of the criteria with each other, and finally, the value and importance of each of these factors will be obtained. Of course, this point should also be taken into account that the views and opinions of different experts in this field are not the same. For example: traffic and urban planning experts may have different views and opinions about different criteria. Meanwhile, one should try to weigh the criteria as closely as possible to the experts' opinions and establish a balance between these expert opinions. Finally, by using the analysis of the geographic information system, the results obtained from the previous stage are combined with each other to find suitable parking places. In the next chapter, the details of the research method will be discussed [16].

5. Research Methodology

In order to locate the parking lots in GIS, first the studied area and then the effective parameters of the parking lot location were fixed, then this parameter was valued and compared, the information layers were prepared according to the calculated values and analytical functions of GIS, then the prepared layers were integrated with each other and applied. And research steps and methods are clearly explained in the graph (diagram) below:

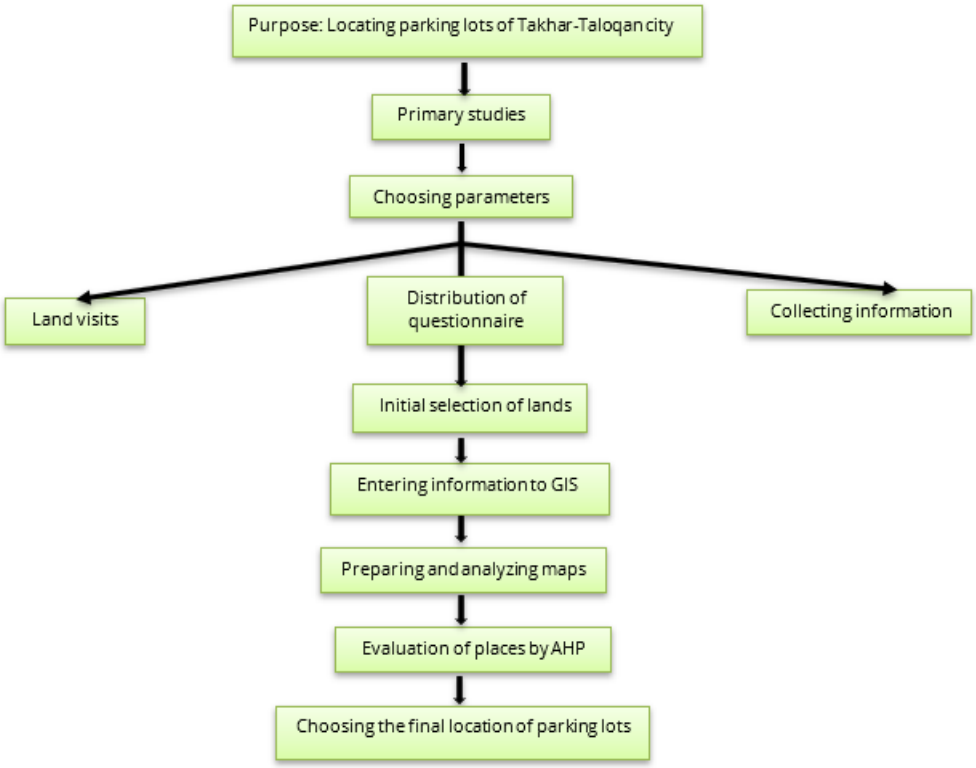


Fig. 1. The process of research steps

5-1. Scope of research

Takhar province is located in the north-east of Afghanistan and has an internal common border with Badakhshan, Panjshir, Baghlan, and Kunduz provinces and an external common border with Tajikistan, where the Amu Sea is the border between this country and Takhar province. Also, this province has an area of 12457 square kilometers and an elevation of 804 meters above sea level and has the following separate administrative units, which are clearly highlighted on the map:

Iskhamish, Chahab, Khajabahawuddin, Farkhar, Yangiqala, Baharak, Khajaghar, Kalafgan, Taloqan, Darqad, Namakab, Dashtiqala and Worsage Hazarsomoch, Chal, Rustaq, Bangi,

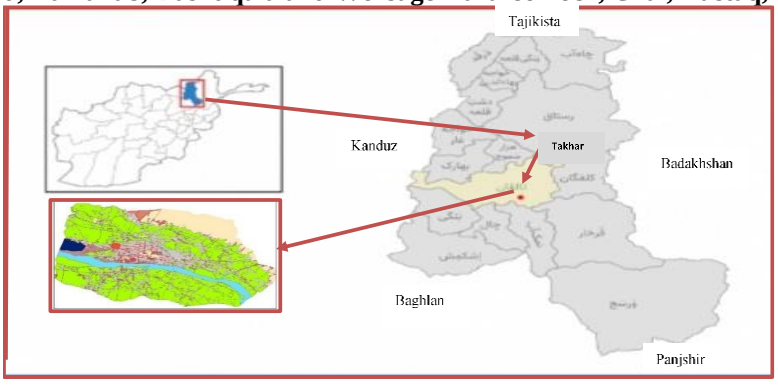


Fig. 2. Geographical location of the study area, Author source

5-2. Effective criteria in locating parking lots and preparing information layers

Different criteria are used to locate public parking lots. The capacity of the current parking lots, the purpose and duration of parking, and the walking distance from the parking lots to the destination play an important role in determining the locations of future parking lots[17]. The appropriate distance, criteria, and effective sub-criteria in the location of parking lots in this research are shown in the flowchart Below:

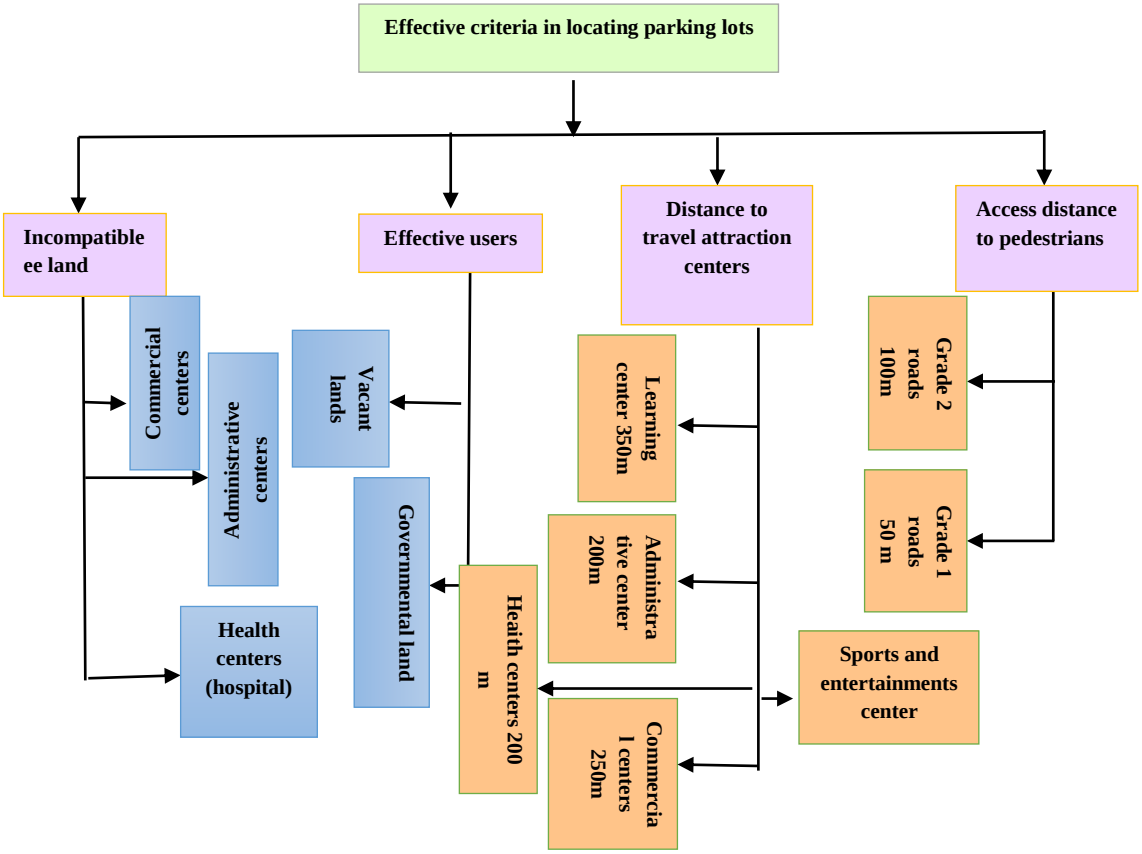


Fig. 3. Appropriate distance, effective criteria, and sub-criteria in locating parking lots

After entering the initial information into the GIS software, informative layers such as land use, commercial centers, administrative centers, educational areas, sports-recreational areas, medical centers, 1st and 2nd grade roads were created and then from the shape file, the land use layer was created. Lists 0 and 1 (Boolean) of hospitals, commercial centers, offices, parks, and green spaces in the region, because we are not allowed to build parking in them, were created as layers of restrictions. In the next step, according to the appropriate distance of each of the factors with the parking place which is given in flowchart 1, the Distance command was applied to each of the layers and the Distance layers were converted to Raster and in this step, the information is prepared. Entering the Expert Choice software to prepare the AHP method.

5-3. Layers of access distance to roads

Layers of access distance to roads include sub-criteria such as 1st grade roads and 2nd grade roads (which should have the shortest distance to the parking place, the appropriate distance in this sub-criterion is 50 meters) 1st grade roads and 100 meters from 2nd grade roads is considered.

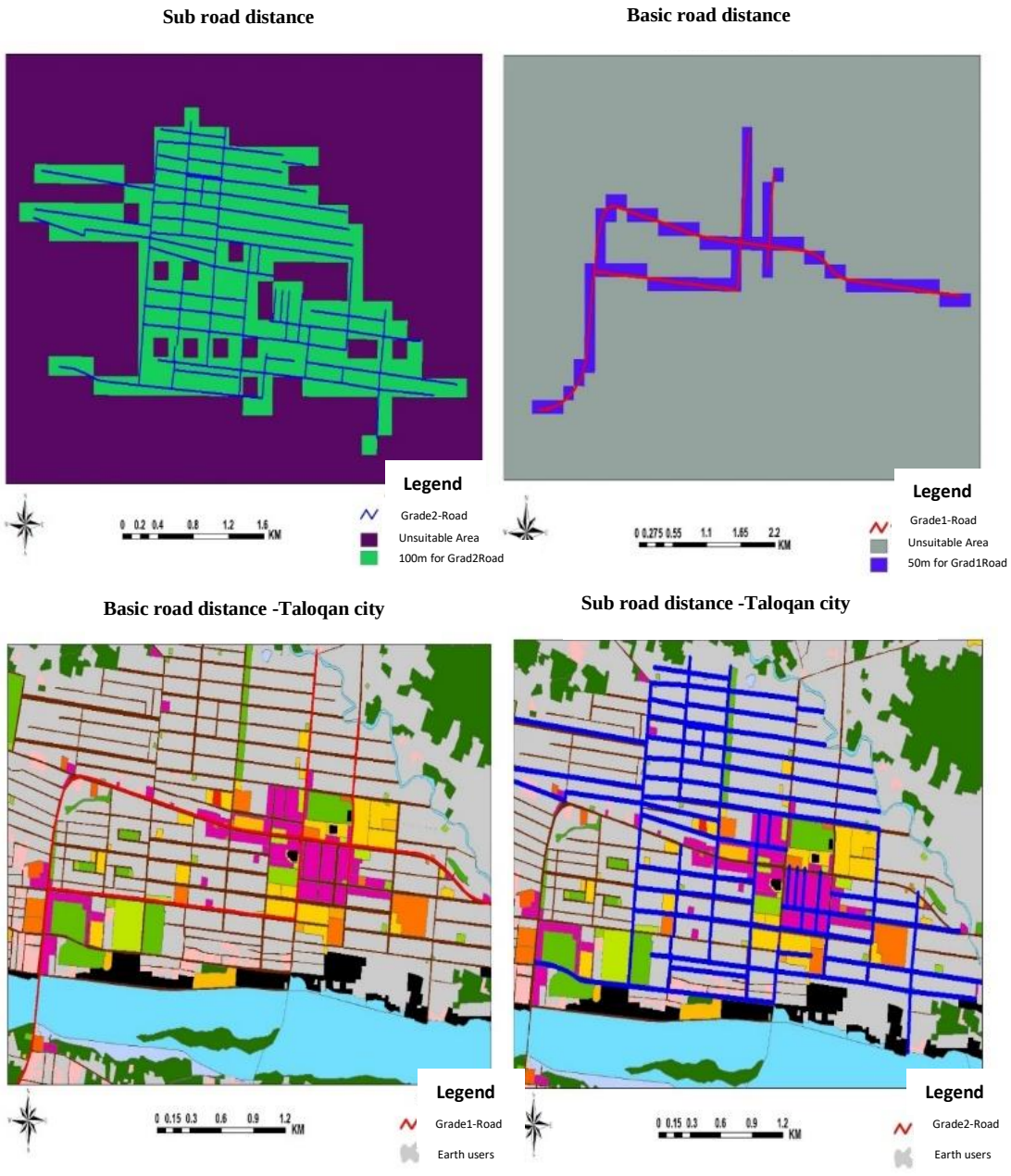


Fig. 4. Grade 1 and Grade 2 roads layer with their access distance, Author source

5-4. Distance layers of travel attraction centers

Layers of distance to travel attraction centers that include sub-criteria such as: commercial centers, medical centers, administrative centers, educational centers, and recreational-sports centers (and must have an acceptable walking distance to the parking place, respectively for each sub-criterion 350 meters for commercial centers, 200 meters for medical centers, 350 meters for educational centers, 300 meters for administrative centers, and 300 meters for recreational and sports centers were determined at specific distances.



Figure 5: layers of travel attraction centers and the layers related to the access distances from travel attraction centers, Author source

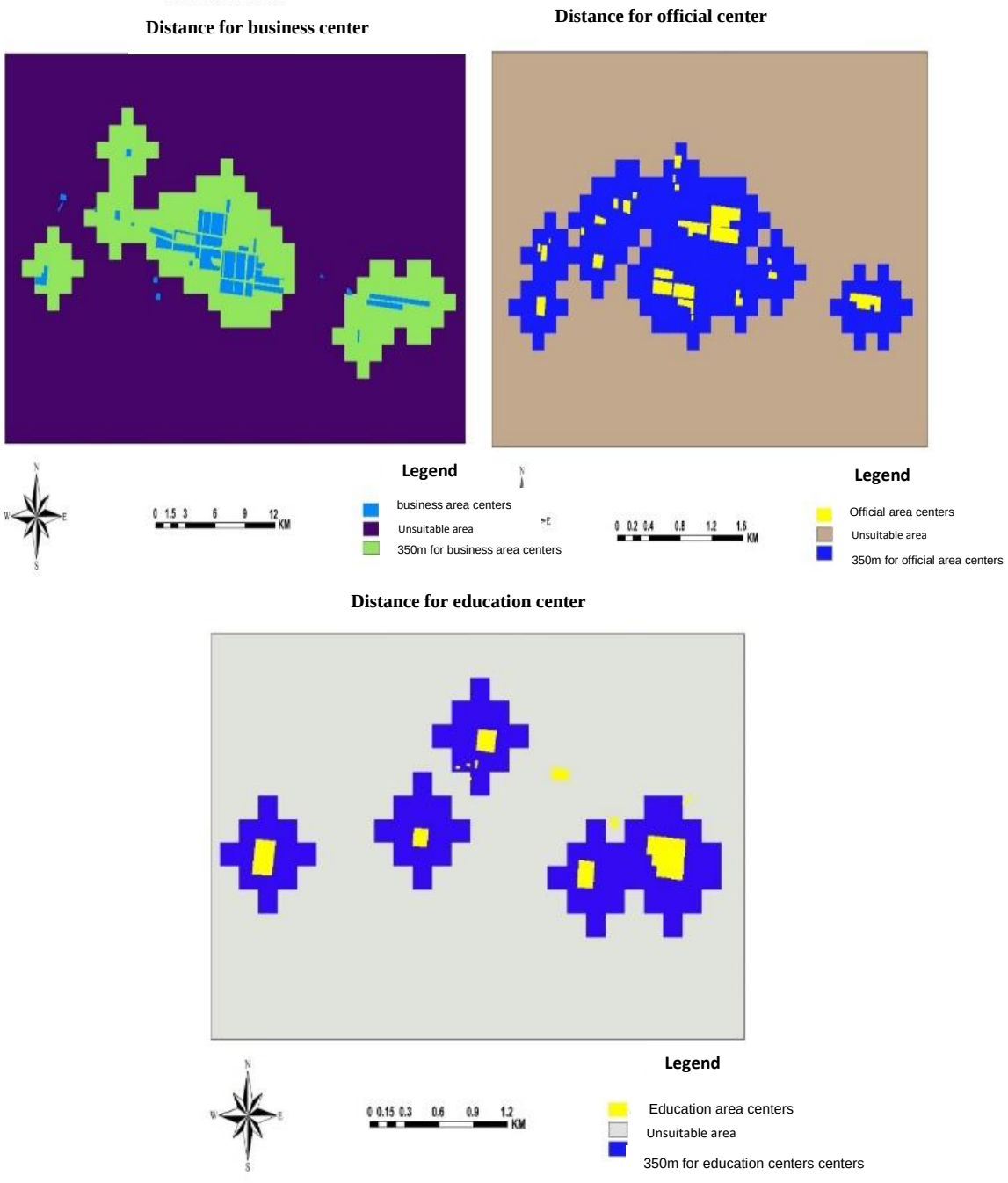


Fig. 6. Layers of travel attraction centers and the layers related to the access distances from travel attraction centers, Author source

5-5. Effective uses

Effective land uses that include sub-criteria such as government lands and vacant lands. In the researched area, government lands and vacant lands were prepared separately on maps, and the purpose of this work is to save the government's financial resources to purchase private properties and pay damages for the Demolition of residential areas instead of building parking lots.

It causes unpleasant effects on the clients of these centers. Also, parking lots should not be placed near commercial centers because traffic jams are created in the area due to the exchange of cars and it causes many problems for customers.

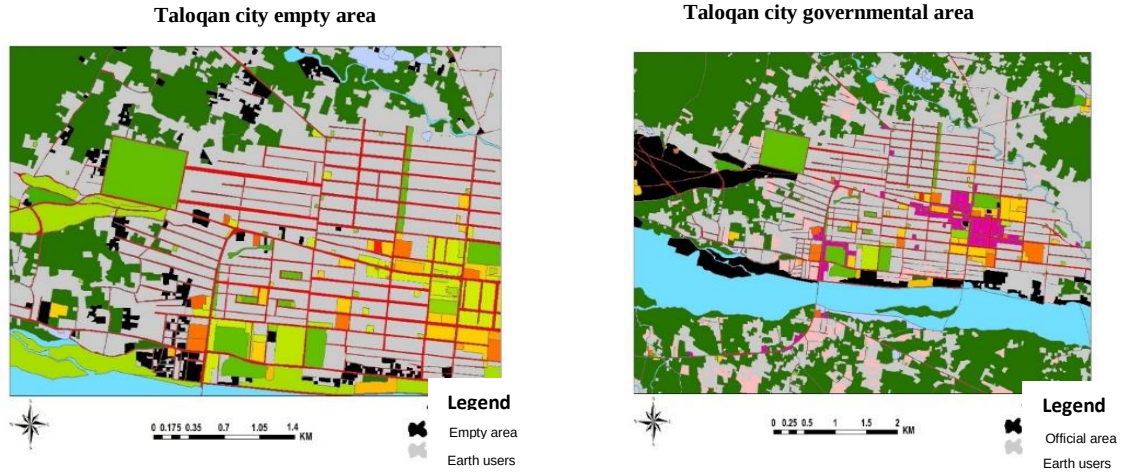


Fig. 7. Effective uses, Author source

5-6. Preparation of layers of susceptible areas for parking lot construction using the Boolean method

First, the access distances were defined for the layers related to each of the standards of the Minister of Standards Transportation. And later in the GIS environment, the areas that were within the access distance were identified using the Boolean 1 method, and the areas that were outside this range were identified as 0, which the Boolean method allows us to use this method to identify areas. Which does not include the research area and has only the locations on the map that are effective for locating these locations.

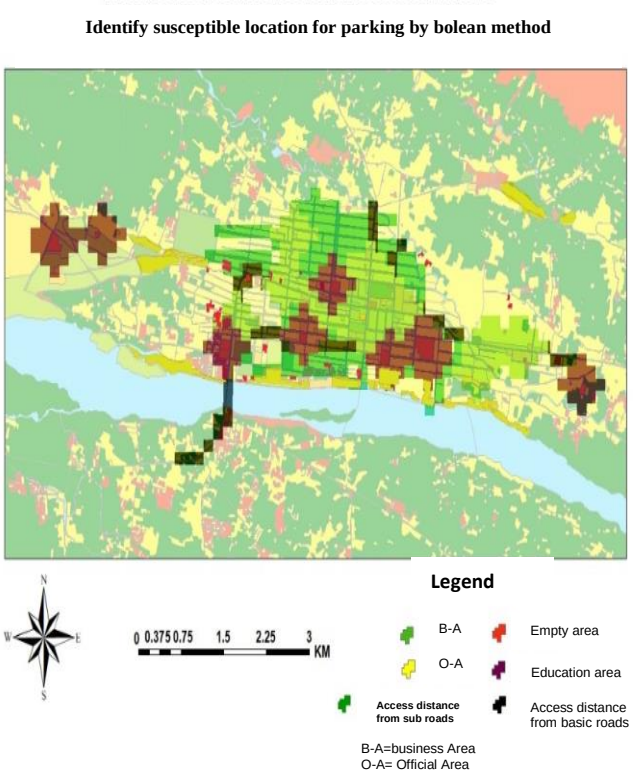


Fig. 8. Parts of the land use that are suitable places for the establish of a parking lot, Author source

6. AHP method

After choosing the effective parameter and sub-parameter in locating, in order to combine them with each other in the form of information layers, the weight of each of them should be determined according to their importance using one of the weighting methods. Because the criteria used in positioning are usually not of equal importance. Some criteria are more important than other criteria and play a decisive role in positioning.

6-1. Weighting through AHP

The pairwise comparison method (AHP) is one of the most reliable and widely used methods due to its strong theoretical

basis, high accuracy, ease of use, value and validity, and the correctness and accuracy of the result[17].

Table 1. Importance or preferences of the criteria with each other

Preferences	Quantity
Extremely Preferred	**9**
Very strongly Preferred	**7**
Strongly Preferred	**5**
Moderately Preferred	**3**
Equally Preferred	**1**
Medial Preferred	**2, 4, 6, 8**

Comparisons in this method are made based on theoretical judgments and the ratio is expressed qualitatively. The criteria according to Table 1, the quantitative values between 1 and 9 are expressed as a matrix of coefficients.

To locate using the AHP method, we first prepared the matrix of coefficients, which is given below this matrix. In the matrix of coefficients in AHP, the numbers are determined based on a pairwise comparison, so that each of the criteria written in the first column with the criteria written in the row First, they are compared two by two, and according to their importance, they are assigned a number, the numbers on the main diameter are always 1.

6-2. Weighting of the main criteria with the AHP method in the Expert Choice program

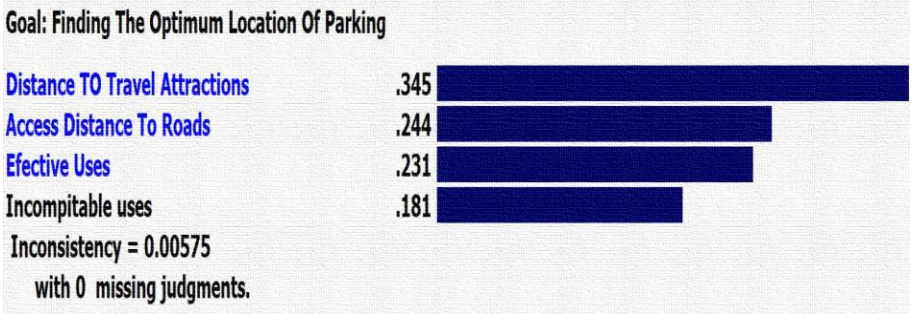


Fig. 9. Calculated weights of the main criteria in the Expert Choice program

6-3. The weighting of travel attraction centers sub-criteria by the AHP method in the Expert Choice program

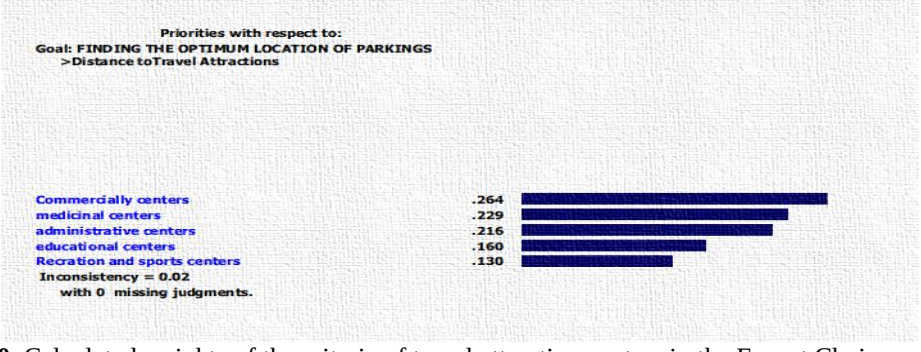


Fig. 10. Calculated weights of the criteria of travel attraction centers in the Expert Choice program

6-4. Weighing sub-criteria of access network (roads) by AHP method in Expert Choice program

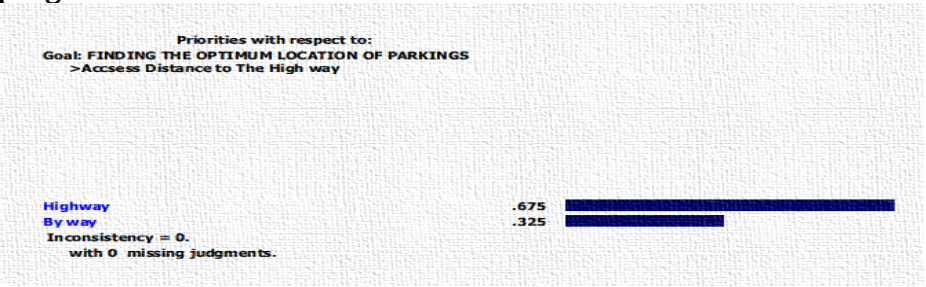


Fig. 11. Calculated weights below the criteria of the passages (roads) in the Expert Choice program

6-5. The weighting of the following criteria of effective users by the AHP method in the Expert Choice program

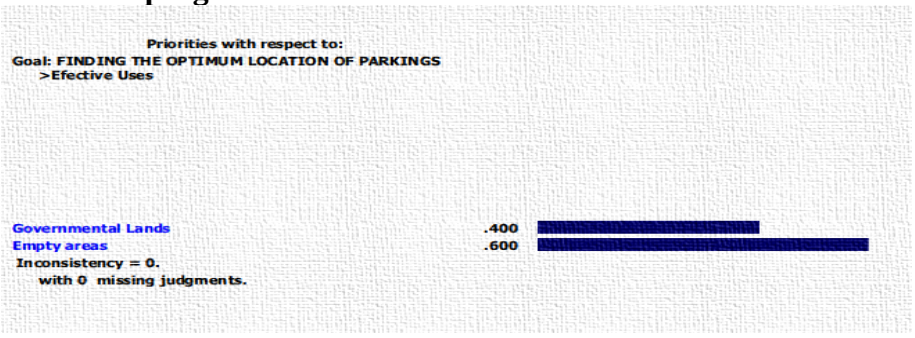


Figure 12: Calculated weights under the criteria of effective users in the Expert Choice program

6-6. Weighing sub-criteria of incompatible users by the AHP method in the Expert Choice program

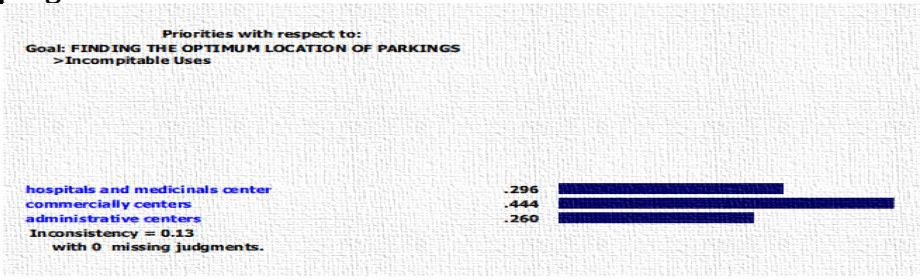


Fig. 13. Calculated weights of the following criteria of incompatible users in the Expert Choice program

6-7. Graph of sensitivity analysis of criteria based on efficiency in the Expert Choice program

At this stage, the sensitivity of the ranking of the options to the changes in the weights of the criteria is checked. In the case of a three-level hierarchy, the sensitivity analysis from the target node shows the sensitivity of the options to the criteria under the target.

For sensitivity analysis, there are five graphical modes available in Expert Choice software:

1- Based on performance 2- Being dynamic 3- Based on gradient 4- Two-Dimensional 5- Based on the difference

Here we have drawn the sensitivity graph based on efficiency.

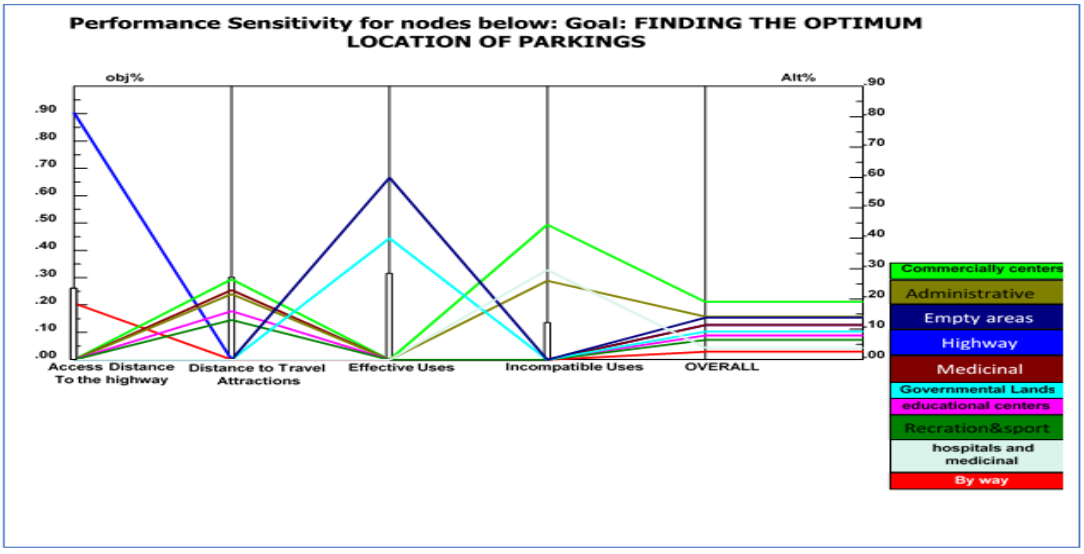


Fig. 13. Graph the sensitivity analysis of the standards of the Minister of Standards

In this graph, criteria are shown on the horizontal axis and options are shown on the vertical axis. The intersection of the lines of the options with the vertical lines of the criteria shows the weight of each option regarding that criterion. The priority of the criteria is indicated by vertical lines. The total weight of each option can be seen on the right vertical axis of the graph.

7. The final result of the pairwise comparison method in the Expert choice software

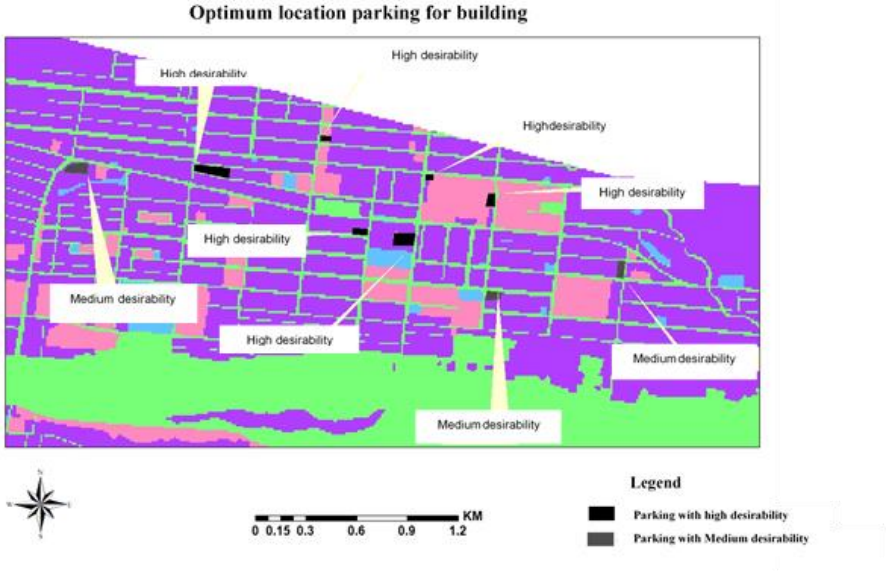


Fig. 15. Optimum location for building parking lots with two classes of high and medium desirability, Author source

8. Conclusion

In general, based on the studies, the establishment of each urban element in a specific structure -spatial position of the city depends on certain principles, rules, and mechanisms, which, if followed, will determine the success and functional efficiency of that element in the same place, and otherwise, This causes problems. The establishment of many urban elements is mostly dependent on economic mechanisms and depends on free competition, but for public services, in which parking is also a part of this type of urban service, the issue cannot be left to the market mechanisms and be satisfied with this, but to compensate for the inefficiencies of the market to Decisions and policies based on the interests of the public are also a must. One of the suitable location methods for transportation is Boolean logic, because this logic is based on the theory of certainties and uncertainties, based on this theory, places that do not meet the criteria's demands are included as uncertainties and are identified with the code number (0). and includes the areas that meet the demands of the criteria with certainty categories and specifies with the code number (1), the most important topics that we have achieve are listed below:

1- Using the geographic information system of the suitable parking location based on the weighing method between the criteria
2- By using the geographic information system, the locational data was analyzed quantitatively and qualitatively at the same time, and as a result, the most suitable parking place was determined.
3- In order to get better results, Boolean logic was used by specifying the access distances to the layers and identifying the eligible areas, and removing the extra areas, and the appropriate location of the Taloqan parking lot was determined.

9. Suggestions

Locating and determining the appropriate location of parking lots is traditionally done by distributing questionnaires, but it will have inadequate accuracy. Therefore, the best and most modern method of obtaining and determining the location of parking lots is to use the comprehensive and practical software of the geographic (spatial) information system with the help of peripheral software such as Export Choice and the hierarchical analysis method; Because by using these systems, all the desired criteria in locating the parking lot can be taken into account according to the value of each of them in the construction and construction of the parking lot, because these systems cause high efficiency, prevent wastage of time and save costs.

In addition to the above, another thing is that other organizations and institutions can also benefit from geographic information systems for their specific locations. It is obvious that the things mentioned with the advantages of using geographic information systems in parking lot locations also apply to the location needed in other organizations and offices. A very important point is that in the matter of locating the location of the parking lots, the hierarchical analysis method alone should not be used because it will not provide us with more accurate results. Therefore, it is suggested that in addition to this method, FUZZY AHP-OWA-BOOLEAN methods should also be used in order to achieve more accurate and favorable results.

The effectiveness of the current research brings advantages such as people's well-being, creating nationwide urban order, facilities for the public, preventing of traffic congestion, smoothing traffic, reducing pollution, reducing road accidents, and preventing early depreciation of cars. And the reduction of people's deaths has become and has a special place. Therefore, the competent authorities are respectfully requested to consider this research as a practical study and make it a criterion for implementation to bring prosperity to the provinces and the country.

If approximately by calculating the average cost of parking each car once a day for government employees and business owners, 30 Afghanis and for others 50 Afghanis, if 60% of the parking spaces are for city employees and shop owners and 40% % for others use, immediately the amount of profit and government revenue will increase dramatically, that is, 51,300 Afg daily, 1,539,000 Afg monthly and 1,8724,500 Afg are added to the government treasury.

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Authors Profile



Suhrab Ahadi received the BSc. Degree in Geodesy Engineering from Jawzjan University in 2013 and an M.Sc. degree in Road and Transportation from Sakarya University of Turkiye, in 2019. Currently, He is working as an Associate Professor in the Department of Geodesy Engineering Department, Geomatics Faculty, Jawzjan University, Jawzjan- Afghanistan. His areas of research include Surveying Engineering, GIS, and Road & transportation.



Sayed Naqibullah Hashimi received the BSc. Degree in Geodesy Engineering from Jawzjan University in 2013 and an M.Sc. degree in Road and Transportation from Tehran University of Iran, in 2020. Currently, He is working as an Associate Professor in the Department of Geodesy Engineering Department, Geomatics Faculty, Jawzjan University, Jawzjan-Afghanistan. His areas of research include Pavement, Surveying Engineering, GIS, Road & transportation, Physics and Mathematics.



Zabiullah Haidari received the BSc. Degree in Engineering Geodesy from Jawzjan University in 2014 and a M.Sc. degree in Mine Surveying from the National University of Tajikistan, in 2019. Currently, He is working as an assistant. Professor in the Department of Drawing and Descriptive Geometry, Construction Faculty, Kabul Polytechnic University, Kabul Afghanistan. His areas of research include Surveying Engineering, GIS-transportation, and Technical Drawing.