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Parking Site Selection In Downtown of Khabarovsk City Using GIS

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Abstract

Public parking as a part of a modern urban transportation system plays an important role in decreasing the load of heavy traffic. Optimum site selection for public parking spaces not only increases the parking efficiency, but also decreases marginal car parking and therefore, results in increase of streets' width and traffic fluency. In the most cities, public parking site selection is done by traditional methods or just by visiting of the site. In this traditional method, considering all of the effective parameters in site selection is difficult and site selection is done by just considering some limited factors like land price. In this study, we introduce an optimum method for parking site selection using GIS based on Khabarovsk City. The study process consists of two steps. Firstly, it is finding effective criteria for parking site selection. Secondly, we build the model of parking site selection process based on our criteria. As the output of research is the model of parking site selection process which lead us to define suitable place for parking.

Keywords*: Public parking site selection, GIS, model of parking site selection process*

1. Introduction

1.1 Background

Khabarovsk is a city in Russia, a center of Khabarovsk krai and Far Eastern Federal District. In 1858, it was founded as the military outpost of Khabarovka, named after a Russian explorer Yerofey Khabarov. The post later became an important industrial center for the region [1].

Nowadays Khabarovsk City is a rapidly growing and developing Russian City. Historically the city started to grow up with the central part which has been deemed as business and commercial city center. The commercial and trade leaders companies and big shopping centers are placed in this part and the number of working people is growing every year. Due to this the downtown of the City suffers from lack of parking spaces and a lot of people have to leave their cars on the roadway, blocking the traffic and causing traffic jams (Figure 1).

Thus, the goal of the project is to find the best location with desired conditions that satisfy predetermined selection criteria. Public and private parking space which is one of the important parts of a modern urban transport system plays an important role in decreasing the load of heavy traffic. Lack of enough accessible parking spaces can hurt local business and decrease the quality of life of residents. Suitable site selection for parking spaces increases parking efficiency and indirectly results in increase of traffic fluency.

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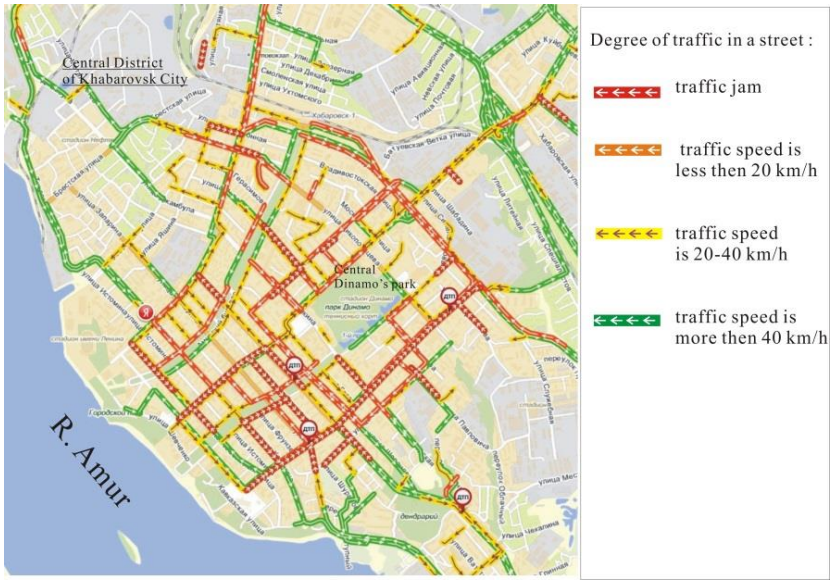

Figure 1. Traffic Jams in the Downtown of Khabarovsk City During the Rush Time

1.2. Study Area

As it was mentioned above, historically Khabarovsk City began to grow up with a central part where 156 years ago first buildings were raised. Therefore majority of historical and architectural heritage of the City is concentrated in central part and preserved by government. Due to this area is already organized and built up, siting of new parking place is undesirable(bordered with a black line Figure 2). The study area is focused on area out of black line boundary with a distance from it less than 15 min of walking which around 1000 meters.

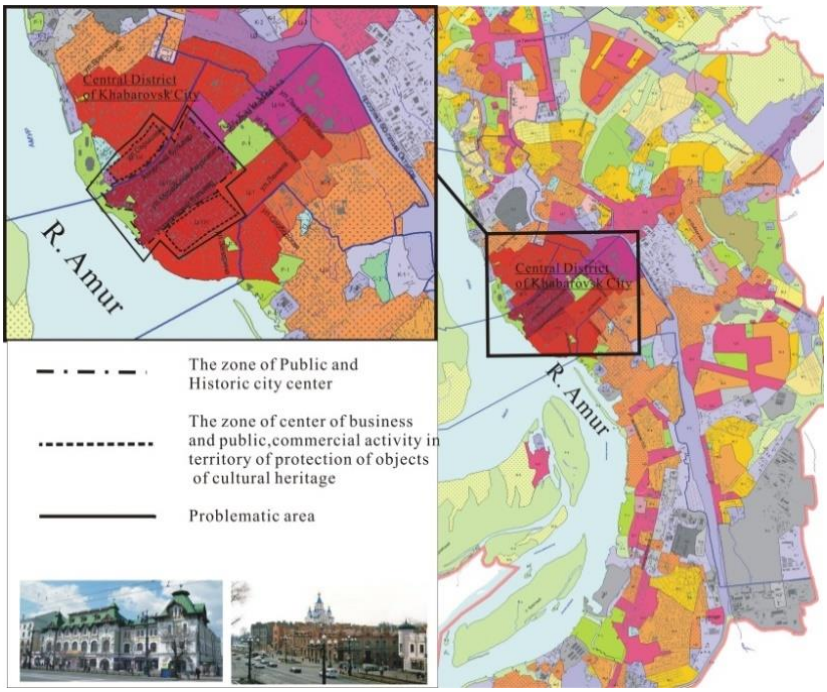

Figure 2. The Map of Land Using and Urban Zoning of Khabarovsk City

1.3. Objectives and Methodology

This research is focused on creation a model for determining optimal site selection for neighborhood parking facilities in our study area using GIS model builder application. As a result of model building process is the most effective zone for new parking sites.

The most important component of model building process is criteria which plays a role as a tool to reduce rang of researching area.

1.4. Determine Efficient Criteria in Parking Site Selection

There are many parameters to determine site selection of parking lots. Considering civic construction and traffic critics views, effective parameters in parking site selection are classified into five main classes, which every class includes several subclasses (Table 1) [2-3].

The study indicates that factors such as the capacity of the existing parking facilities, the aim of trip and the duration of park and the walk distance from parking facility to the destination, size of land have an important role in determining the places for future parking facilities.

Distance to major centers that generate trips such as service and commercial centers, administrative centers, health centers, cultural and recreational centers, religious centers, educational centers and taxis and bus stations.

Table 1. Efficient Criteria in Parking Site Selection

Criteria	Sub-criteria
Distance to major centers (not far than 1000 meter buffer)	From commercial centers, from the official-governmental centers, from the residential area;
Population	Population density, employment density
Efficient land use for parking places	Type of land using is not residential, location in study area, site not less than 500 SQM
Attainment of major streets	Pedestrian and streets crossing, streets width, distance to first grade street, second grade street, third grade street
Existing parking facilities	Existing parking facilities in study-area, in problematic area

The size of the land can have an effective role in optimal site selection for parking facilities considering the number of cars, the level of commute and parking of the cars along trip generation centers. If the size of the land is smaller than the limit for creating and constructing a parking facility or if the capacity of the parking is not as much as the determined capacity, the intended location is eliminated from the selected locations on the map.

Regions with highest population density and employment density should be involved in list of site selection criteria. Because naturally this areas need to be provided with more amount of parking sites.

Attainment of major Street is important criteria. Organization of major streets with friendly-pedestrian paths plays a significant role in choosing new parking site. Distance to first grade streets and connection networks (second grade main streets with the characteristic of entering and exiting district one), second grade streets (second grade main streets without the characteristic of entering and exiting district one) and third grade streets (neighborhood streets).

And the following parameters have been applied as limitation layers in site selection.

2. GIS Possibilities for Managing Parking Facilities

2.1. GIS Technology

Geographic Information Systems (GIS) based method has provided an excellent platform in planning, managing, quantifying, displaying and analyzing geographical transport related information. GIS is the most promising and universally accepted new technologies in the field of decision analysis and data management. It is an innovative means of organizing database by geographic area and presenting the information in spatial forms. The use of GIS makes site/area-specified data more accessible and information can be displayed in an easily understood format. In the last few years, there have been many applications of GIS in assisting traffic engineers and transport planners in dealing with complicated transport problems. It has played an important role in planning and decision making process. They can be used to display spatial information, query particular attributes or features and to create new data set based on existing resources of data. One of the applications is to use GIS in managing parking facilities [2].

2.2. Measured Benefit of using GIS in Managing Parking Facilities

Evaluation of future needs of parking is very difficult because of following different factors such as increasing of private cars, growth of population, development of commercial areas, and increasing the shopping areas. They will be reasons for increasing of displacement of population cases such as current parking capacity, purpose of the trip, park time, walking distance from parking to destination; they have an important role in determining the future parking [3]. However, with use of GIS technologies we can receive the most accurate and effective results of this complicated process, considering all factors.

Using a GIS makes it possible to store data about individual parking spaces in a logical and precise way. Through simple searches, it is possible to view the many different types of parking that exist in a city. The ability to sort the different characteristics of a parking space by location and to view these characteristics on a map make GIS an invaluable tool. Another benefit of GIS is the ability to easily update the map layers. Every time a new space is added, or characteristics of an old space are changed, it is far easier to update the information digitally than in a traditional system [4].

Further, GIS can help support parking (structured and unstructured, on-site, off-site) visualization and analyses, potentially in real time, to ease campus congestion and increase customer satisfaction [5].

3. Building GIS Model: Phases for Process of Parking Site Selection

In this study, modeling processes are divided into four major phases, which is interrelated to one phase to another. In order to clearly understand process of building model for parking site selection we will describe all phases one by one, according to Modeling for Mapping and Analysis Task Lists:

- Phase One: Build up desirable area for new parking sites map
- Phase Two: Build up desirable area for new parking sites by distance map and Build up Qualified land-use and area map
- Phase Three: Build up Population and Employment density with more than 2000 people on one SQKM map
- Phase Four: Build up general suitable parking sites map

However, before start modeling building process we need to explore our study area to determine the desired amount of parking sites.

3.1. Determination of Desired Amount of New Parking Sites

Within existing requirement we can calculate total amount of desired parking places in study and problematic area and then calculate amount of existing parking lots. Thus, we will find out the amount of new parking lots which have to create by using the simple mathematical calculation.

According to urban planning requirement for parking space, 5-7 lots per the 100 SQM of commercial space should be provided. Using the data for SQM of existing commercial space in downtown of Khabarovsk City we can calculate total SQM of commercial space which allows determining the amount of total desired parking places in study and problematic area:

$$\frac{Total\ commercial\ SQM}{100\ SQM} \times 5(7) = \quad Total\ amount\ of\ desired\ parking\ places \qquad (1)$$

In order to determine amount of existing parking lots in study and problematic area it will be used spatial and attribute data for existing parking lots.

After determination of desired amount of new parking lots we can start to build modeling processes.

3.2. Phase One: Build up Desirable Area for New Parking Sites Map

The purpose of the first phase is mainly defining the desirable area for new parking sites. It shows the areas which can be possible to use for creation new parking lots.

As the first phase of the modeling, the amount of existing parking sites should be input to the system and use like limiting criteria.

The amount of existing parking sites help to reduce study area for possible parking sites. The process of this phase consists of several steps. There are areas such as areas around existing parking sites (with a buffer distance 1500 meter) and problematic area, where creation new parking sites are not necessary or impossible, which have to combine in one territory. As a next step in order to make a range of research more limited we have to extract undesirable area for new parking sites.

The result of the first phase is desirable area for new parking sites map (Figure 3). This area will be used to prioritize further research of new parking sites within criteria.

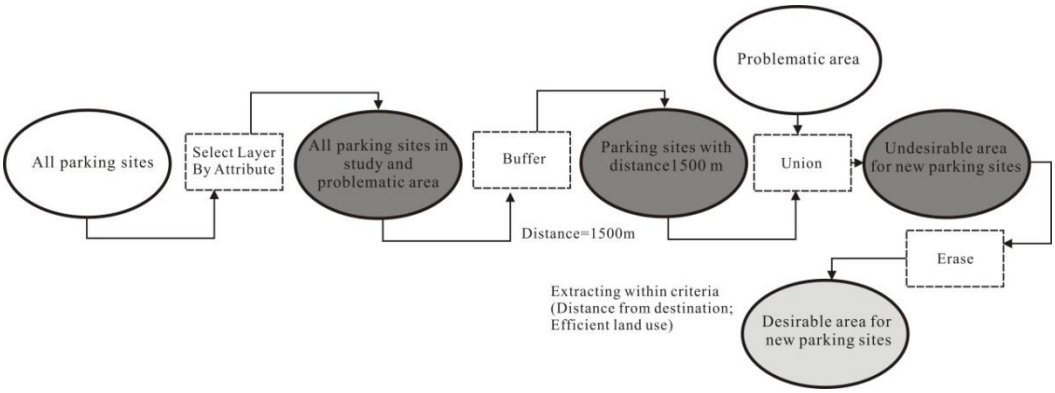

Figure 3. Phase One: Build up Desirable Area for New Parking Sites Map

3.3. Phase Two: Build up Desirable Area for New Parking Sites by Distance Map and Build up Qualified Land-Use and Area Map

The second step of model building process of site selection is minimizing the range of desirable are for new parking sites by using criteria and effective factors.

There are different criteria involved in parking site selection that are pointed out in this section. Assessing the future needs of parking facilities is difficult and this is due to different factors in this regard such as:

-Distance from trip generator**:**

Based on the viewpoints of the traffic and urban development experts, the criterion of distance from trip generator is the most important criterion in parking facility site selection. Trip generators includes centers that people come and go in there in high numbers due to various reasons, these centers include shopping and commercial centers, governmental offices and centers, parks, main health care centers such as clinics and hospitals, recreational places, historical and touristic places, schools, *etc.* The distance to these centers should be in a way that the individuals that park their cars in public parking facility could have the minimum walk to the destination. Based on studies, the mean distance for walk from public parking facilities to centers generating trip depends on the city's population and the aim of the trip.

Table 2. The Distance for Walk From Parking Facility to Trip Generating Centers [6]

Type of the area	Appropriate distance
Commercial and service	100 -350 meter
Administrative	150 -300 meter
Others such as recreational, health, educational, religious and terminals	200 - 350meter

Type of the land use and the size of the land**:**

Sometimes by having knowledge of different types of land use, the conditions of urban lands can be benefited for creating parking facilities in a more appropriate way. The size of the land can have an effective role in optimal site selection for parking facilities considering the number of cars, the level of commute and parking of the cars along trip generation centers. If the size of the land is smaller than the limit for creating and constructing a parking facility or if the capacity of the parking is not as much as the determined capacity, the intended location is eliminated from the selected locations on the map. In this study section the limit size for parking site is 500 SQM.

The results of these phase is desirable area for new parking sites by distance map and qualified land-use and area map.

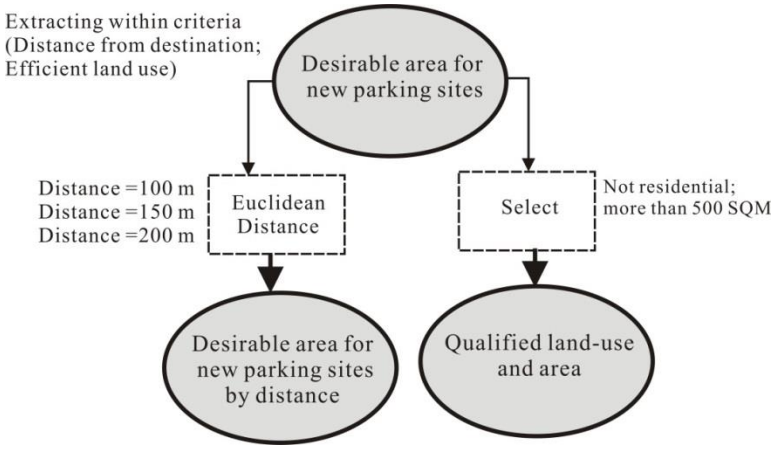

Figure 4. Phase Two: Build up Desirable Area for New Parking Sites by Distance Map and Build up Qualified Land-use and Area Map

3.4. Phase Three: Build up Population and Employment Density with More than 2000 People on One SQKM Map

The purpose is determining high level need parking sites area by Population and Employment density. For Khabarovsk city the most high density area is area with density more than 2000 people on one SQM. Population and Employment map should be input in system. During the process highly populated areas will be find out within criteria 2000 people on one SQKM.

The process in third phase is focused on identify the area with high density population where necessity of parking lots is high.

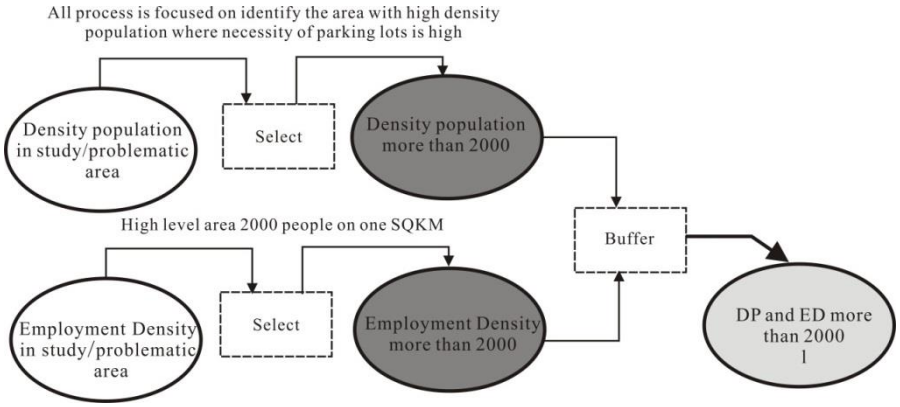

Figure 5. Phase Three: Build up Population and Employment Density with More than 2000 People on One SQKM Map

3.5. Phase Four: Build up General Suitable Parking Sites Map

At this final stage using three factors: desirable area for new parking sites by distance map and Qualified land-use and area map, Population and Employment density with more than 2000 people on one SQKM map we will determine the most suitable parking sites (Figure 6). Using the Weighted Overlay tool lets us implement several of the steps in the general overlay analysis process within a single tool. The input criteria layers which we build in previous three phase will help to finish all model process by using Weighted Overlay tool (Figure 7).

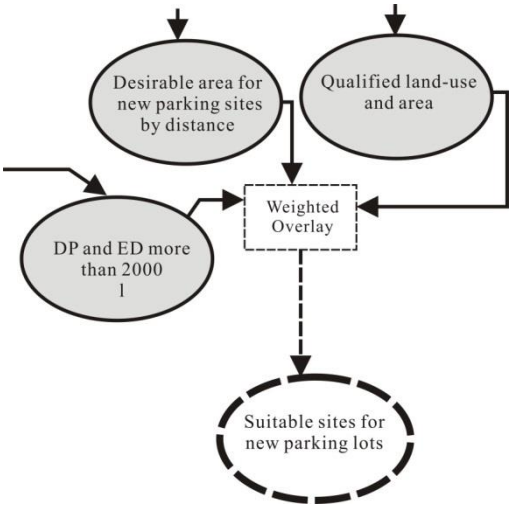

Figure 6. Phase Four: Build up General Suitable Parking Sites Map

3.6. The Weighted Overlay

The Weighted Overlay tool applies one of the most used approaches for overlay analysis to solve multicriteria problems such as site selection and suitability models. In a weighted overlay analysis, each of the general overlay analysis steps are followed [7]. In the Figure 6, the two input rasters have been reclassified to a common measurement scale of 1 to 3. Each raster is assigned a percentage influence. The cell values are multiplied by their percentage influence, and the results are added together to create the output raster. For example, consider the top left cell. The values for the two inputs become (2 * 0.75) = 1.5 and (3 * 0.25) = 0.75. The sum of 1.5 and 0.75 is 2.25. Because the output raster from Weighted Overlay is integer, the final value is rounded to 2.

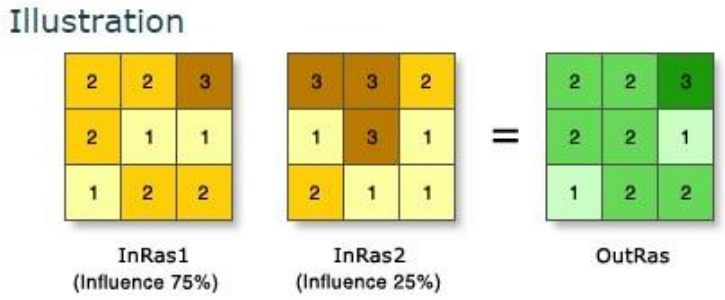

Figure 7. Process of Working of Weighted Overlay Tool (Spatial Analyst)

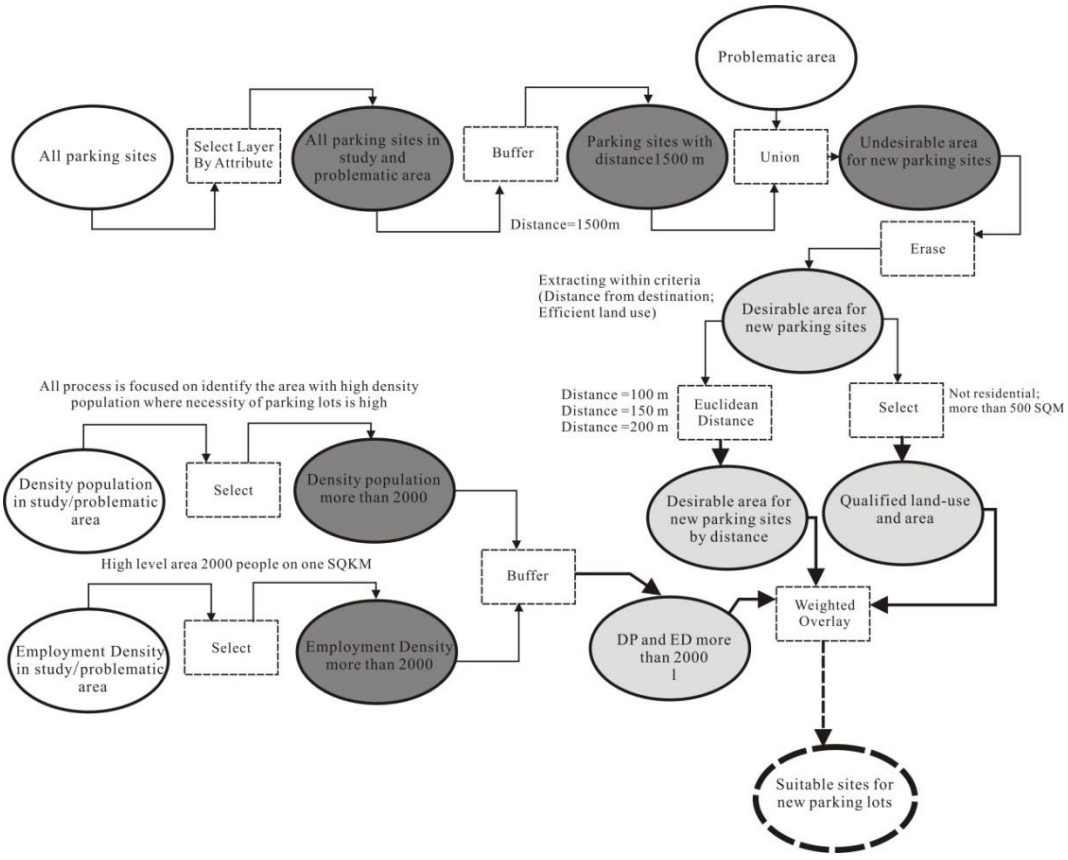

Figure 8. Combined Model for Parking Site Selection GIS Application

4. Conclusion

The project was designed to make the modeling processes of parking site selection in downtown of Khabarovsk city. During the study process criteria is the most important tool which can reduce a range of site selection for potential parking lots. By using GIS tool, like Weighted Overlaying, lead us to evaluate and analyze the results of three final phases and make suitable parking sites map for potential parking lots. The following final combined model shows the connection between the all four phases and their results.

Use of GIS in location of parking instead of the traditional methods increases the speed of location process as well as suitable efficiency of the built parking. The most important elements in selection are criteria which lead us make correct site selection. In parking site selection, criteria such as distance to major centers and major streets, population, land use and existing parking facilities play important role in correct and efficient site selection

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