Site selection of emergency hospitals under public health events

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Part I

1 Introduction

In early 2020, novel coronavirus pneumonia epidemic broke out worldwide. The epidemic spread to more than 200 countries and regions in the world. It became the longest public health event with the longest spread and the largest number of infection since 21st Century. By October 2020, the novel coronavirus pneumonia in Europe and South America was again rebounded, which is characterized by increased infectivity and mortality.

In 2020, Wuhan built emergency hospitals such as Huoshen Mountain and Leishen Mountain. With the spread of the epidemic in the world, Russia, South Korea, Italy, Iran, Germany and other countries have also begun to build emergency medical facilities, which shows that rapid preparation for the construction of emergency medical facilities has become an important means to control the spread of the epidemic. The scientificity of site selection and timeliness of construction are important prerequisites for emergency medical facilities to play a role in treatment. Shanghai is an important city in China. A large number of people enter and leave Shanghai Pudong International Airport every day. Recently, Pudong Airport has many covid-19 virus carriers, so it is imperative to formulate corresponding emergency plans. Taking Zhuqiao town and Chuansha town near Shanghai Pudong Airport as examples, this paper discusses the best location of emergency hospital near Pudong airport.

2 Literature review

2.1 Site selection of emergency facilities

Many scholars have studied the location of emergency facilities. Scholars generally believe that the location problem of emergency facilities is to solve a complex multi-objective problem. The research focuses on which objectives are the main objectives or main problems, and the models and algorithms used to solve the problems.

Met (2010) designed a stochastic optimization method suitable for various possible large and small disasters for the storage and distribution of medical supplies for disaster management. Caunhye (2012) reviewed the optimization model of emergency logistics in detail from three aspects: the location of emergency equipment, the distribution of rescue materials and transportation business. Under the constraints of limited facility capacity, Shariff (2012) designed a maximum coverage facility location problem model to study the coverage of medical facilities in a region of Malaysia, and proposed a model solution method based on genetic algorithm. Murali (2012) took a catastrophic biochemical terrorist attack in a major big city as the background, and designed a maximum coverage location model to solve the location problem of drug storage facilities under the conditions of distance sensitivity, opportunity constraints and demand uncertainty, so as to distribute a large number of medicines to residents in time and effectively after the disaster. Rawls (2010) et al. established a two-stage random mixed integer scale model for the location of emergency rescue facilities, and took the hurricane in the Gulf of Mexico as an example to verify the model. Aksen (2012) et al. established a model for the location of refuge sites according to the emergency state and the randomness of the selection of refuge sites. Dantrakul (2014) constructed an emergency service facility location model aiming at minimizing transportation and installation costs, and three model solution algorithms based on greedy algorithm, p-median algorithm and p-center algorithm. Erdemir (2010) combined land and aviation to establish the location coverage model of emergency materials and facilities, and used greedy heuristic algorithm to solve it. Dessouky (2013) established an effective integrated optimization model of location and vehicle routing problem for the drug supply chain after the disaster, and analyzed the model and algorithm by taking the Beiling earthquake in Los Angeles as an example. Jia (2007) et al. established a mathematical model for facility location in large-scale emergency situations, and verified through an example that the model can be used to solve the location problem of emergency medical facilities in Los Angeles after the earthquake. Balcik (2008) established a humanitarian emergency supplies supply chain and a facility location decision model for rapidly occurring disasters.

2.2 Function of grassland in urban emergency

Urban disaster prevention green space can provide construction site for emergency medical facilities. When studying the park green space with emergency risk avoidance function in Beijing, Tong Yue(2010) pointed out that the country park located in the periphery of the city is a good construction site for central risk avoidance because of its advantages of large scale, flat terrain and sparse population. Based on the perspective of composite function, Gao Xiangduo(2015) proposed that country park is an important carrier to undertake urban ecological space and urban disaster prevention and reduction space, also took disaster prevention and refuge as the starting point to improve the design of Tianjin Dongli country park. In 2018, the Chinese government proposed that urban disaster prevention green space should include long-term risk avoidance green space. With the outbreak of novel coronavirus pneumonia, Anson(2020) concerned countries have played a positive role in the outbreak of the disease. Li Luo(2020) discussed the relationship between landscape architecture and public health in the post epidemic era. Ouyangdong(2020) proposed to incorporate the treatment facilities for public health emergencies into the land space planning system, and country parks can be used as temporary special treatment facilities. Wang Jun(2021) discussed the preparatory design of emergency medical facilities in country parks.

2.3 Research objectives of this paper

As the political, economic and cultural center of a country or region, the importance of cities to national and social development is self-evident. Every hour and moment, COVID-19's development threatens the public safety of the city. Pudong Airport, as a densely populated place, needs to be attached great importance to. Emergency service is the most important emergency activity when urban disasters occur, and the emergency service place is an important support for people's life. For passengers whose nucleic acid test results are positive, it is very necessary to take them to the emergency place for centralized isolation in time. This involves the location of emergency hospitals.

This paper intends to consider the four factors of water source, airport, road density and urban infrastructure density to comprehensively evaluate the construction suitability of emergency hospitals in each grassland of Zhuqiao Town and Chuansha Town in Pudong New Area, Shanghai.

3 Methodology

3.1 Brief description of analysis process

We can use the following steps to summarize the analysis process of this paper:

Determine the evaluation factor is the first step.

Each factor is analyzed separately. In addition, we will give different numerical intervals. The interval from the most inappropriate to the most appropriate will be displayed in 1-10 scores respectively. Linear density analysis, Euclidean distance, and nuclear density analysis are mainly used. This is the second step

Determine the weight of each index is the third step. In this paper, according to the importance of factors, the author gives them different weights.

Next, we will carry out weighted overlaying, you need to use the raster calculator here, in order to obtain the evaluation results of applicability, which is the fourth step.

In the last step, the author makes an online interactive map of the selected grassland in R language.

3. 2 Study area

Pudong New District is a municipal district of Shanghai. The research area in this paper is Zhuqiao town and Chuansha town in Pudong New District, Shanghai. These two towns are very close to Pudong International Airport, which can easily lead to the outbreak of COVID-19. Zhuqiao town covers an area of 160.19 square kilometers, governing five communities and 64 villages. The town has a population of 120000, including 241138 permanent residents. The town of Chuansha has an area of 59.48 square kilometers, with 33 administrative villages and 155 thousand permanent registered residence population. The location map of the study area is shown in Figure 1.

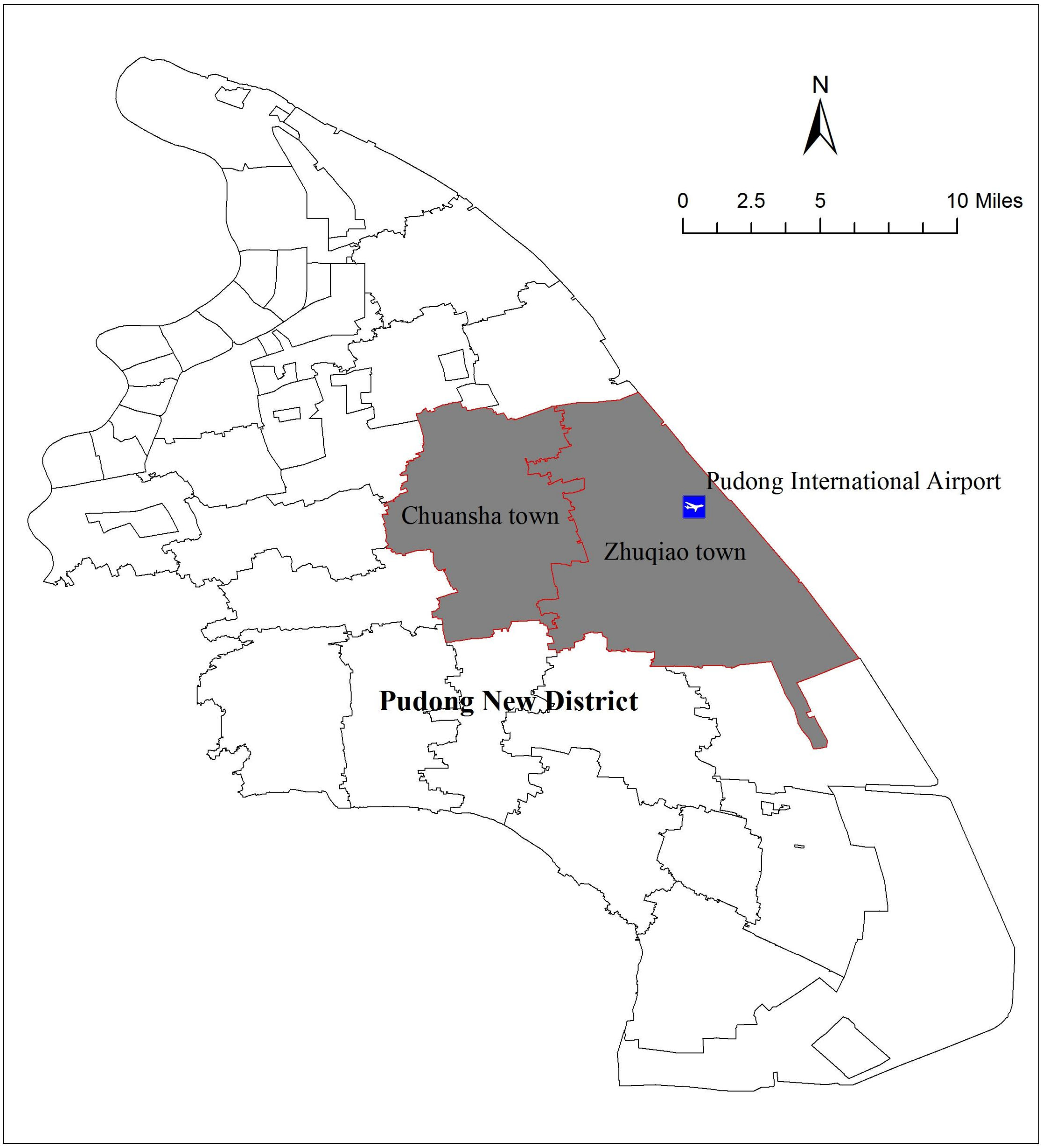

Figure 1 Location of study area[1]

[1] The outline of the administrative district is from Bigmap Software. http://www.bigemap.com/

The distribution of green space, water system and roads in the study area is shown in Figure 2. It can be seen that there are dense road networks in the study area, the green area of Chuansha is larger than that of Zhuqiao, and the distribution of water bodies in the study area is relatively small.

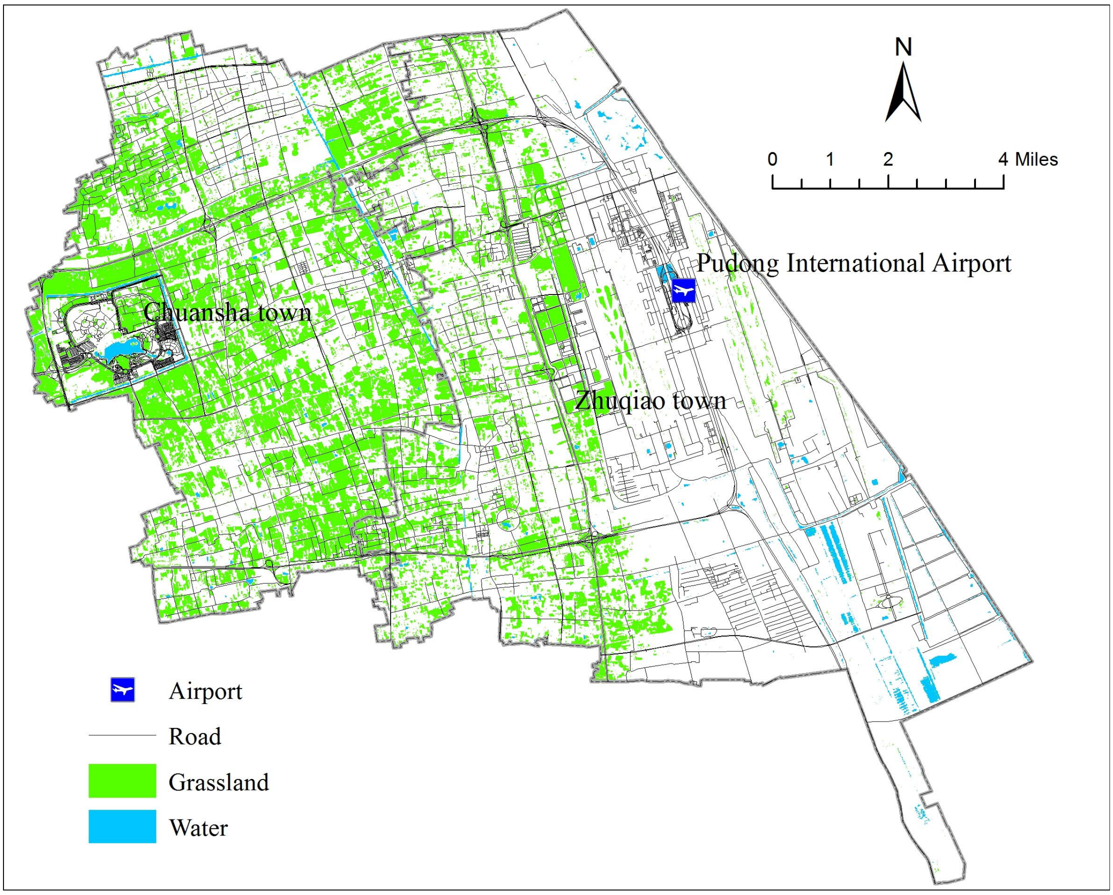

Figure 2 Distribution of grassland, water and roads in the study area[2]

3.3 Single factor analysis

3.3.1 Distance from water

Water ingestion or contact with pathogenic microorganisms is an important vector for the transmission of diseases, such as cholera, hepatitis A and typhoid fever. Therefore,

[2] Road data is from Open Street Map. Grassland and water data are from the website of http://data.ess.tsinghua.edu.cn/fromglc10_2017v01.html

it should be avoided to set the grassland close to the water as the site of emergency medical facilities.

Figure 3 shows the distance from each location in the study area to the nearest water body, which is divided into 10 intervals. The closer it is to the water, the less suitable it is to build an emergency hospital.

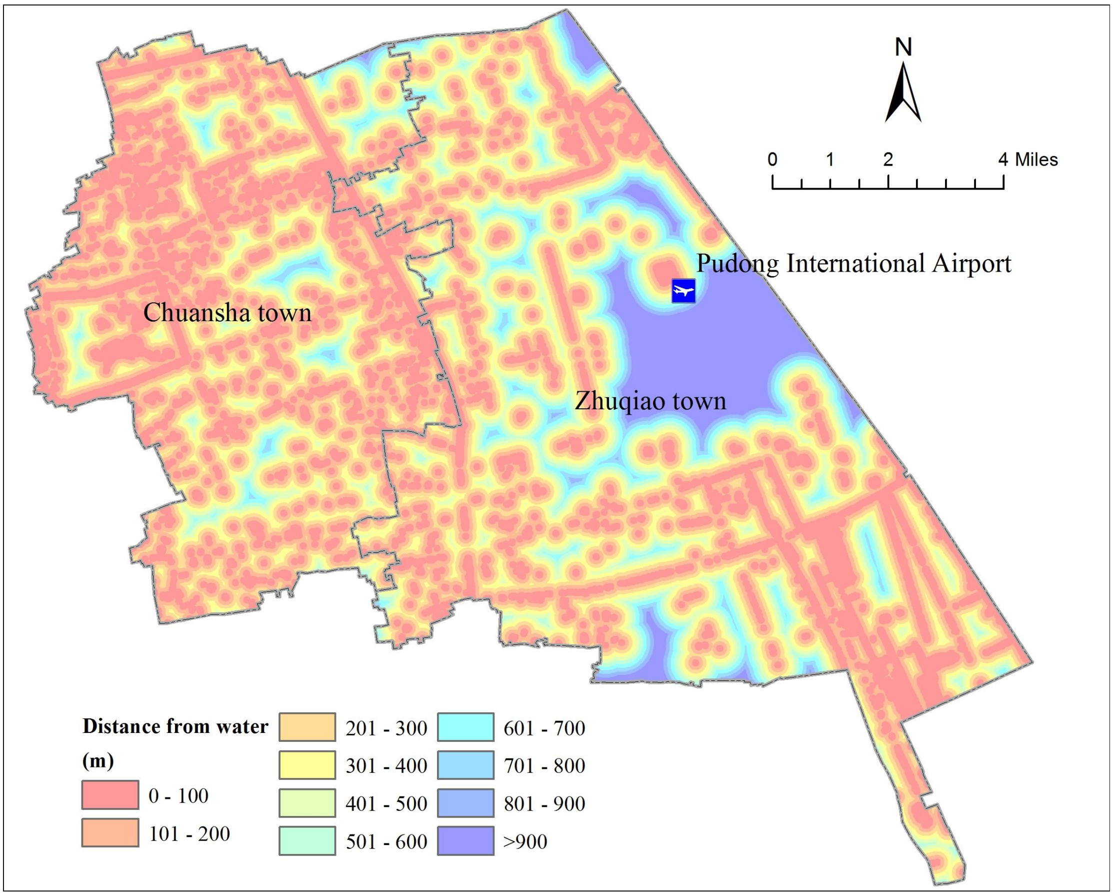

Figure 3 Distance from water in the study area

3.3.2 Distance from airport

Pudong airport is the high frequency of COVID-19 outbreak. If a passenger whose nucleic acid test result is positive is found, the passenger should be isolated as soon as possible and nearby. If the emergency hospital is too far from the airport, it may infect others during transportation. Therefore, the closer the emergency hospital is to the airport, the better. Figure 4 shows the distance from each position to Pudong International Airport. The author divides the distance into 10 intervals.

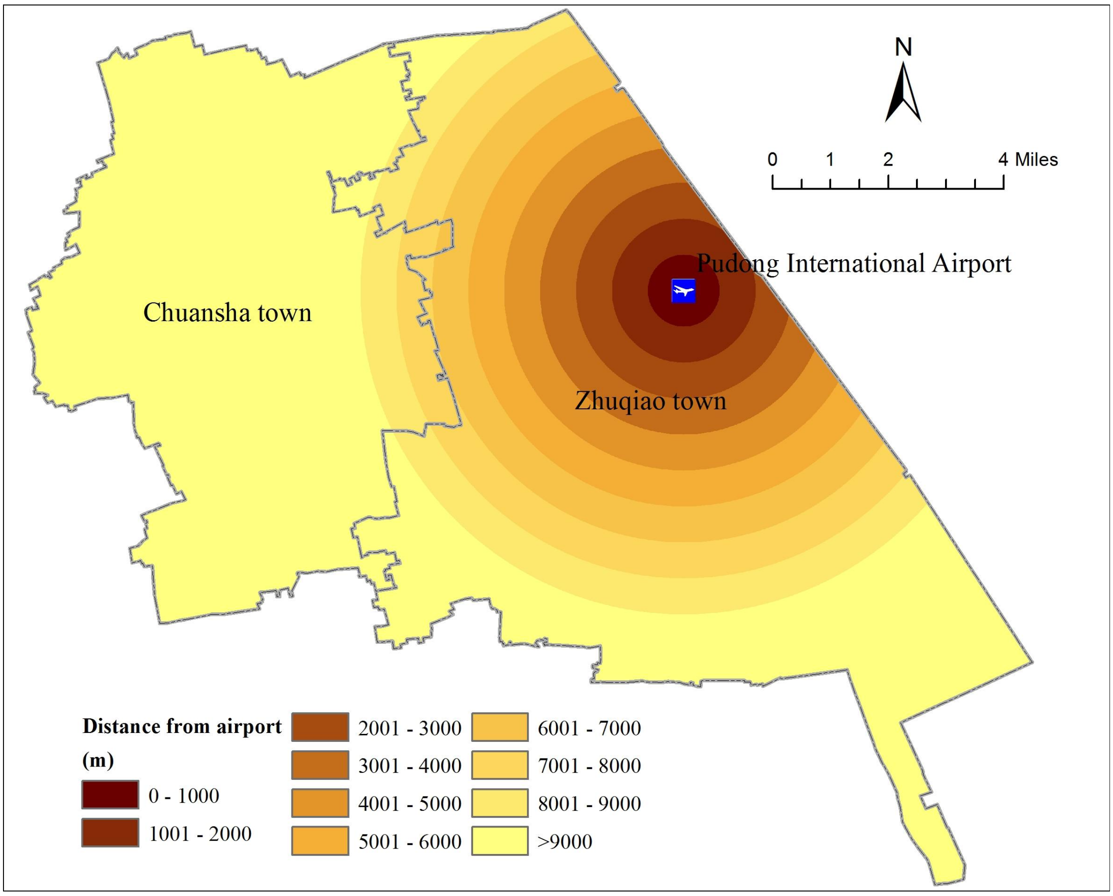

Figure 4 Distance from airport in the study area

3.3.3 Road density

Road network density can reflect the convenience and development of regional transportation. During the outbreak, apart from the passengers carrying the New Coronavirus at the airport, a large number of critically ill patients need to be transferred from the designated hospitals in the urban area to the location of the emergency medical facilities. Therefore, the convenience of transportation is very critical. The denser the road network, the more efficient it is to transport patients. Using the "linear density analysis" tool in GIS, the author takes 1000m as the search radius to obtain the road network density map of the study area. Like other factors, the road network density factor is also divided into 10 intervals, as shown in Figure 5.

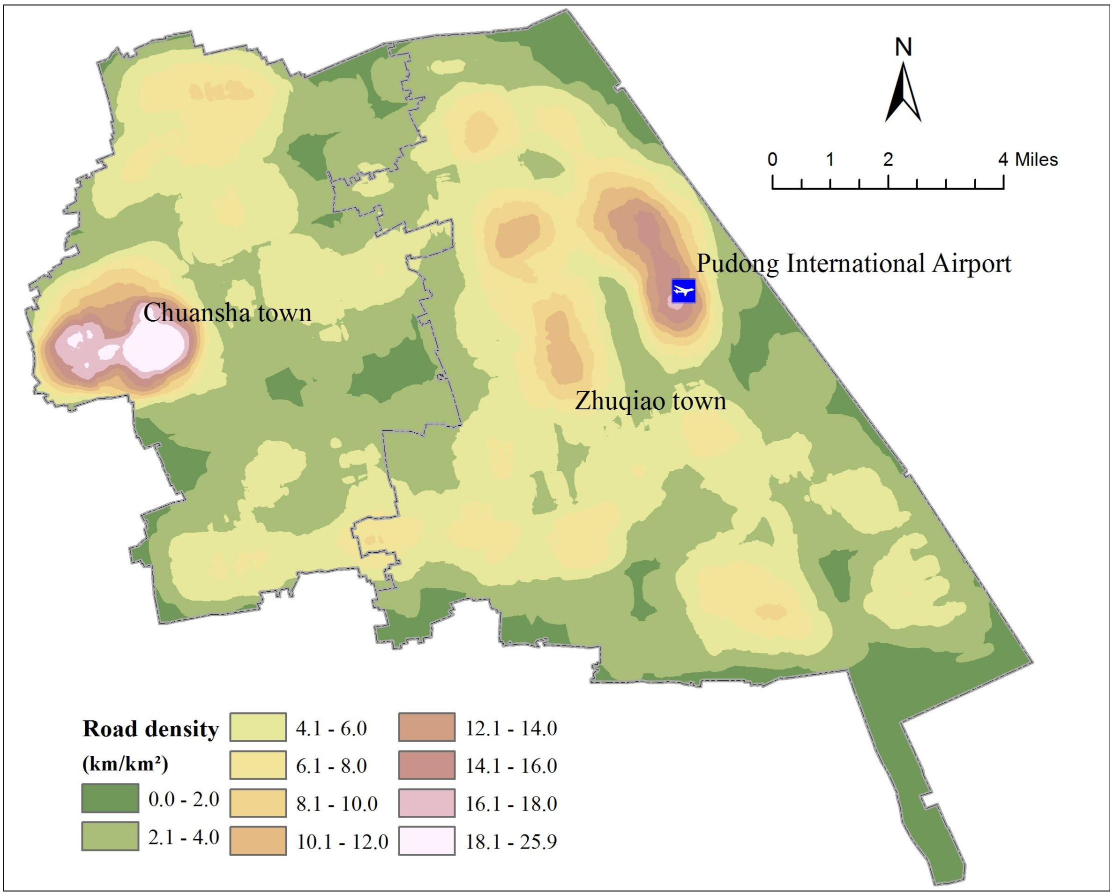

Figure 5　Road density in the study area

3.3.4 Urban infrastructure density

Material engineering facilities that provide public services for social production and people's life, this is infrastructure. Infrastructure is a public service system, which to ensure the normal social and economic activities of a country or region, such as houses, shops, schools, railway stations, etc. Infrastructure is the general material condition for the survival and development of society. Using the "kernal density analysis" tool in GIS and taking 1000m as the search radius, the kernal density map of infrastructure in the study area can be obtained. The denser the infrastructure, the greater the possibility of crowd concentration and the greater the possibility of virus infection. Therefore, emergency hospitals should be built in places where infrastructure is not densely distributed as far as possible.

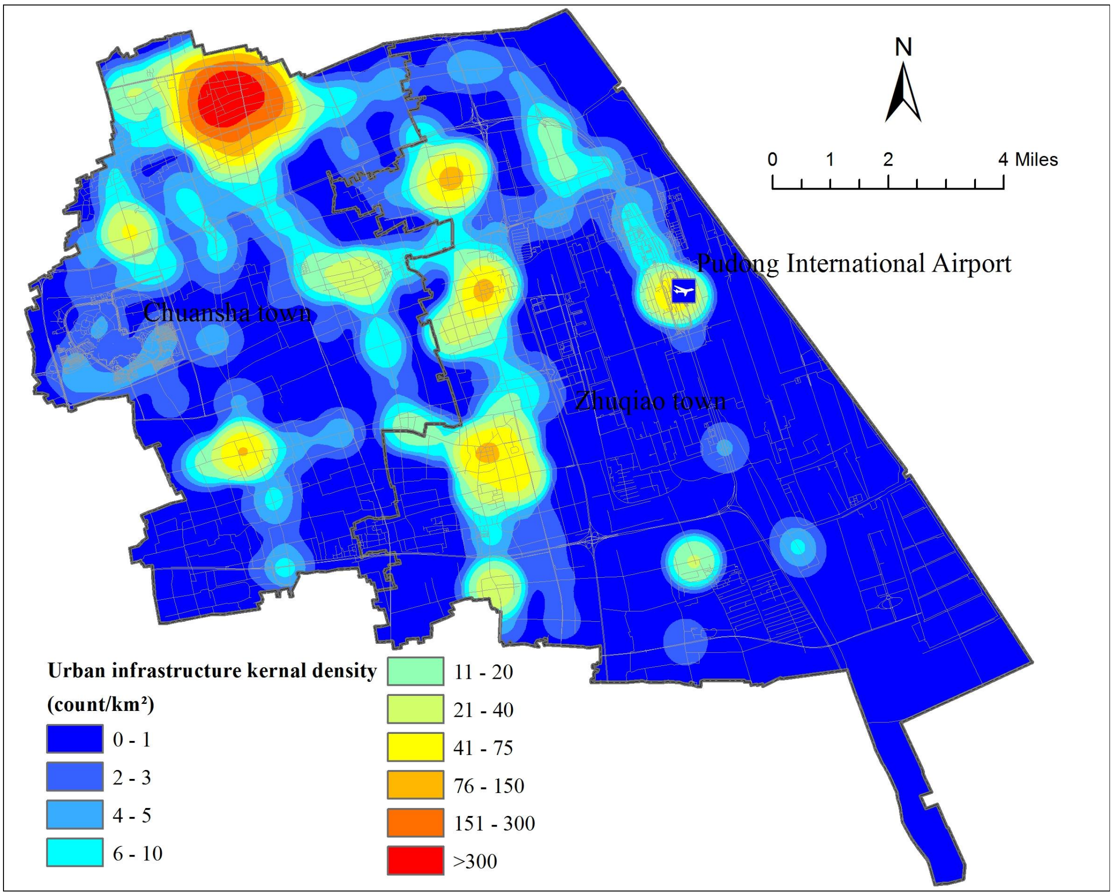

Figure 6 Urban infrastructure kernal density in the study area[3]

3.4 Multi factor comprehensive superposition

The score of each factor is shown in Table 1.

Table 1 Score of each factor

Score \ Factor	Distance from water (m)	Distance from airport (m)	Road density (km/km^2)	Infrastructure density ($count/km^2$)
1	0-100	>9000	0-2	>300
2	100-200	8000-9000	2-4	151-300
3	200-300	7000-8000	4-6	76-150
4	300-400	6000-7000	6-8	41-75
5	400-500	5000-6000	8-10	21-40
6	500-600	4000-5000	10-12	11-20
7	600-700	3000-4000	12-14	9-10
8	700-800	2000-3000	14-16	4-5
9	800-900	1000-2000	16-18	2-3
10	>900	0-1000	>18	0-1

[3] Urban infrastructure data is from Bigmap in csv format. The longitude and latitude of each point are visualized and transformed into SHP format, and then the kernel density analysis is carried out.

According to the importance of each factor, the author gives the weights of the four factors(from left to right in Table 1) 0.25, 0.15, 0.2 and 0.4 respectively. The evaluation results of the suitability of building an emergency hospital can be obtained by weighted superposition of the four factors with raster calculator in GIS.

Part II

4 Results

The suitability evaluation result of emergency hospitals in the study area is shown in Figure 7. As can be seen from Figure 7, the scores of areas around Pudong airport are relatively high, and some areas in Chuansha town also have high scores, but on the whole, it is not as suitable as Zhuqiao town to build an emergency hospital. The surrounding area of Pudong Airport is open, which meets the construction requirements.

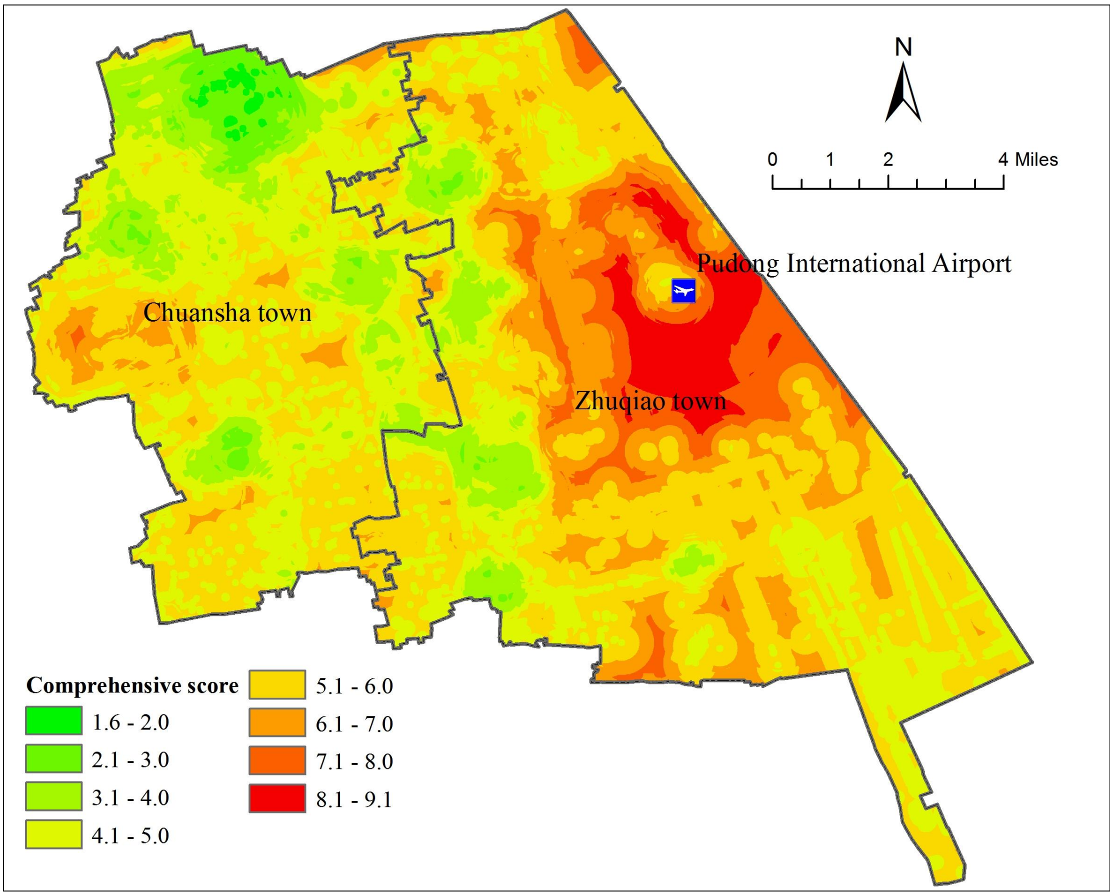

Figure 7 Suitability evaluation result of emergency hospitals

Next, according to the results in Figure 7, use the statistical tools in GIS to calculate the average score of each grassland in the study area, screen out the grassland with an area greater than 20 hectares, and visually display its score. The results are shown in Figure 8. The grassland with the highest score (6.7 points) is also marked in the figure. This grassland is located in Zhuqiao town, close to Pudong International Airport, covering an area of about 32 hectares.

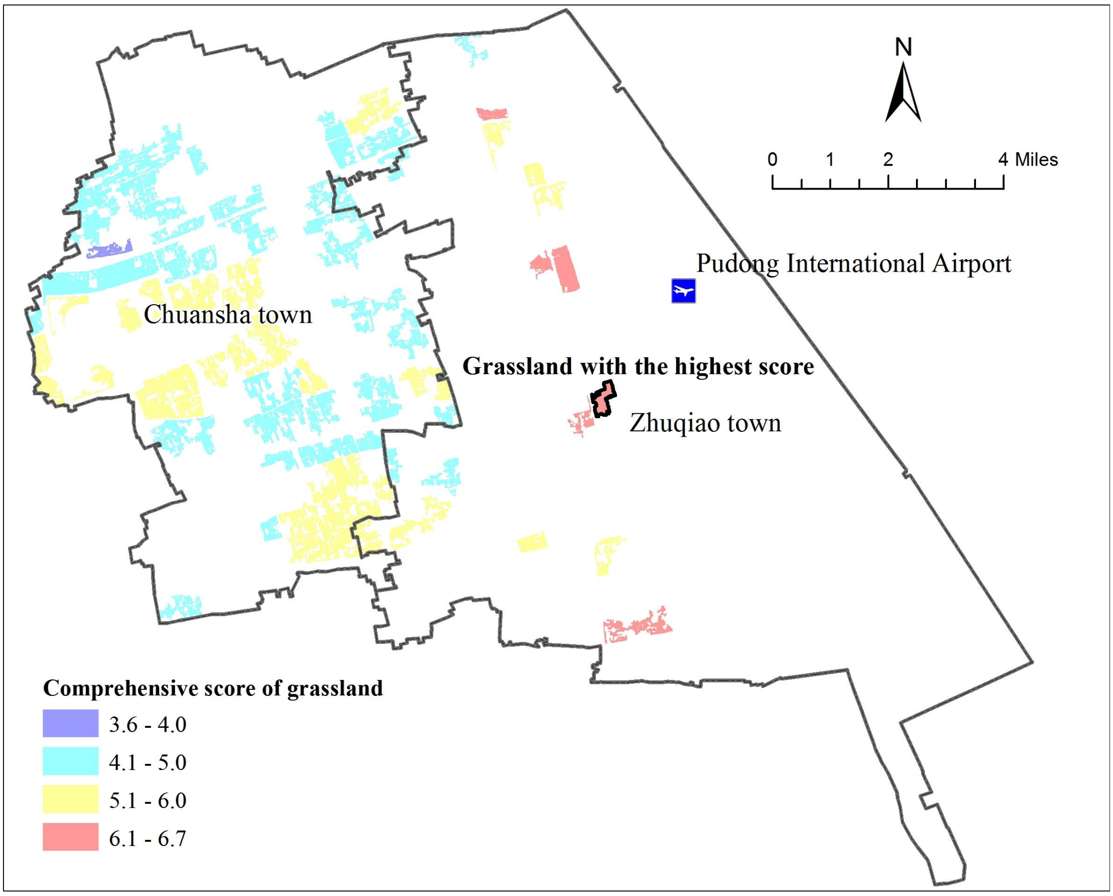

Figure 8 Comprehensive score of grassland

Based on the above analysis, the best emergency hospital is located in a grassland near Pudong International Airport in Zhuqiao town. The longitude of the center point is 121.783928 and the latitude is 31.130227. For Chuansha town, the yellow area in Figure 8 is more suitable for the construction of emergency hospital than the light blue area. Therefore, the government can consider investing more medical funds in Zhuqiao Town, so as to ensure the timeliness of emergency response in case of emergency and isolate virus infected persons quickly and orderly.

5 Discussion

Based on the four factors proposed in this paper, Zhuqiao town is more suitable for the construction of emergency hospital than Chuansha town. Although the green area of Chuansha town is large, Chuansha town is closer to the urban area, the urban infrastructure is more densely distributed, and there are more water bodies in

Chuansha town than Zhuqiao town. Therefore, the location advantage of Zhuqiao town is greater. In addition, medical staff must ensure that the patient's isolation days meet the requirements before allowing the patient to leave the hospital.

In order to better display the selected grassland, the author makes an online interactive map in R language, and the selected base maps are Open Street Map and satellite map respectively. The R code and interactive map are shown in Figure 9 and Figure 10 respectively.

```
library(leaflet)
leaflet()%>%
setView(lng=121.783928,lat = 31.130227,zoom=16)%>%
addProviderTiles("OpenStreetMap.Mapnik",group = "street")%>%
addProviderTiles("Esri.WorldImagery",group = "Imagery")%>%
addLayersControl(baseGroups = c("Gaode","Imagery"),options = layersControlOptions(collapsed = FALSE))
```

Figure 9 R code

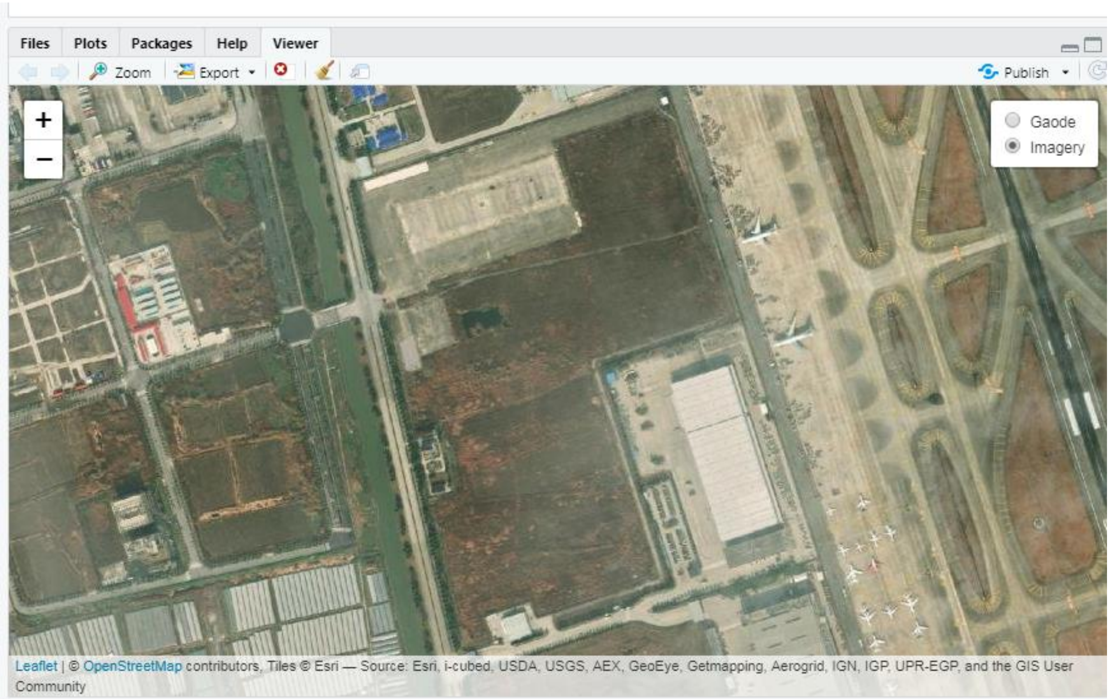

Figure 10 Online interactive map

However, this paper also has many deficiencies. For example, the factors considered are not comprehensive enough. Factors such as air flow direction and groundwater depth can also be added to the model. For another example, the weight of each factor in this paper is determined subjectively. In the next research, we can learn some numerical calculation methods (such as analytic hierarchy process).

6 Conclusion

In conclusion, the author draws the following conclusions:

First, Zhuqiao town and Chuansha town, as the areas closest to Pudong Airport, are suitable for building emergency hospitals to control the spread of the epidemic. However, Zhuqiao town has more obvious geographical advantages, especially in the areas close to Pudong airport.

Second, the final selected grassland is located in Zhuqiao town, southwest of Pudong airport. This grassland covers an area of about 32 hectares, and the surrounding area is also relatively open, which is suitable for the construction of emergency hospitals.

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