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A Study on Distribution and Accessibility of Disaster Response Facilities

- Focusing on Cheongju City

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A B S T R A C T

This study tried to examine the distribution of disaster response facilities in Cheongju, and to examine the accessibility to these facilities. In addition, we tried to check the distance traveled by population characteristics according to age and to examine factors affecting the distance to disaster response facilities. As a result, disaster response facilities are located in proportion to the population, so the distance is short in areas with large populations. Areas far from disaster response facilities were generally scattered. Since this area is scattered over a wide area, it is unlikely that designation of disaster response facilities will be easy. Next, coverage from disaster response facilities was examined based on grid and population. Based on the grid, 86.1% were included within 1km from the disaster response facility. And 95.1% within 2km and 98.4% within 3km. Based on the population, 34.6% of the total grid is included within 1km from the disaster response facility. And 59.9% within 2km and 81.7% within 3km. As a result of regression analysis to examine regional characteristics according to the distance from disaster response facilities, the more children and buildings out of the total population, the closer to disaster response facilities. On the other hand, the greater the number of elderly people among the total population and the more old buildings, the greater the distance from disaster response facilities.

Key words: disaster response facilities; accessibility; distance by road

1. Introduction

The Climate crisis has far-reaching impacts on people's lives. The climate crisis appears as a change in the climate caused by the emission of greenhouse gases such as carbon dioxide due to human activities and development. Although many efforts are being made globally to respond to this, it is necessary to respond to various problems that may be caused by the climate crisis. The problem that can arise from the climate crisis is disaster. Many natural disasters can occur due to the increase in global temperature. Characteristics of disasters caused by the climate crisis are that the target of the disaster is unspecified, the pattern is diversified, and the scale is enlarged(Jang and Kang, 2012).

As the Global average temperature rises and heat waves and floods occur frequently, natural disasters are also on the rise. Due to this climate crisis, damage caused by torrential rain may increase near rivers or downtown areas, and further damage due to drought and sea level rise may increase. It is necessary to examine whether it is possible to cope with such a disaster situation in spite of the current situation or anticipated problems in the future. Through this, it will be possible to identify current problems and suggest alternatives.

This study examines the distribution of disaster response facilities in Cheongju, and calculates the distance from each area to these facilities. As a result, it will be possible to confirm the spatial distribution of the distance by region. such as areas that can quickly move to disaster response facilities and those that do not, and examine the benefit ratio according to the distance traveled by population characteristics(children and the elderly). Finally, we examine the factors that affect the movement distance to disaster response facilities through spatial characteristics (population, buildings, etc.) according to the movement distance.

2. Precedent Research

Disaster response facilities are facilities that enable people to respond quickly in the event of a disaster. Evacuation to disaster response facilities in a

disaster situation is important for survival. In other words, if people can evacuate as soon as possible after a disaster, chances of survival can be increased. Conversely, in the event of a disaster, people living in areas with low access to evacuation facilities are inevitably less likely to survive.

To examine accessibility between specific regions, some studies used network analysis among GIS spatial analysis(Ma and Kim 2011; Oh et al., 2012). Network analysis is performed through a network model composed of nodes and links. A node is a place where a change in speed occurs while moving. It is an intersection, the start or end point of a road, etc., and a link is a road that can be moved by a line connecting a node and a node. This method can be applied to the service area to which the vehicles of the 119 center could reach at a specific time(Oh et al., 2012), the areas vulnerable to emergency medical services (Yang, 2004), or the accessibility of urban public facilities through walking(Jeon, 2011).

As a study related to disaster response facilities, Kim(2005) used the distance to the shelter through walking in case of a disaster to select an appropriate location for the shelter. Also, Park and Kim(2012) identified at shelters that could be reached within 5 minutes by walking in Seoul, and also looked into walking speed considering individual differences such as age, health status, and physical condition.

3. Data and Method

3.1. Data

In Cheongju, the subject of this study, urban and non-urban areas coexist. As of 2020, the population of urban areas in Cheongju is 775.873(91.8%), and the population in non-urban areas is 69.120(8.2%). Most of Cheongju citizens live in urban areas. By area, the urban area is 339.4 km^2(36.1%) and the non-urban area is 601.0 km^2(63.9%), which is a very large non-urban area. By land use, residential areas accounted for 42.7 km^2(4.5%), commercial areas 5.2 km^2(0.6%), industrial areas 20.7 km^2(2.2%), green areas 270.8 km^2(28.9%), and agricultural and forestry areas 271.1 km^2(28.8%). The population of Cheongju is concentrated in limited residential areas. There is a difference in population density between urban and non-urban areas in Cheongju. Such demographic and geographical diversity according to the place of Cheongju may have different effects depending on the region in case of natural or social disasters. Therefore, it is necessary to examine the distribution and accessibility of disaster response facilities in Cheongju.

In this study, in order to understand the spatial characteristics in Cheongju, the 250m horizontal and vertical grid map(15,526 grids) of Cheongju provided by the geospatial information platform(https://map.ngii.go.kr/) and the population by grid(total population, children, and elderly population) and building characteristics(total number of buildings, number of buildings over 35 years old) were collected. In order to identify disaster response facilities in Cheongju, the public data portal(https://www.data.go.kr) collected 'disaster response data by region in Chungcheongbuk-do'. This data contains information such as types and addresses of disaster response facilities in Chungcheongbuk-do. Using the address of this data, disaster response facilities located in Cheongju were selected and converted into coordinates using geocoding. In this data, 456 civil defense evacuation facilities, outdoor evacuation for earthquake, and temporary housing facilities are provided separately. Among these data, civil defense evacuation facilities are generally designated as underground parking lot or underground roads, so they are judged to be inappropriate as facilities to respond to natural disasters such as earthquakes and floods. Therefore, in this study, only 186 outdoor evacuation and temporary housing for earthquake were analyzed. In addition, to calculate the distance between each of grid in Cheongju and disaster response facilities, information of road from the National Transport Information Center(https://www.its.go.kr) were collected.

3.2. Method

In order to examine the accessibility from each grid in Cheongju to disaster response facilities, the distance by road is calculated. It is easy to find the distance between two points using a lineal distance. However, a lineal distance does not reflect reality because it is impossible to move due to various obstacles such as buildings and rivers. On the other hand, the distance by road is the distance from the starting point to the destination using a road that can be moved by people. If the distance to the disaster response facility is used through the distance by road, it will be close to the actual distance by people in a disaster.

To calculate the distance by road, the starting point was based on the centroid of the grid. And the destination is a disaster response facility. The distance using the road from the starting point to the destination cannot be calculated simply by the length of road. This is because the distance from the starting point to the road must also be considered. And the same goes for destinations. Therefore, in this study, distance by road was defined as the sum of the shortest distance from the starting point to the nearest road, the shortest distance from the departure road to the road near the disaster response facility, and the shortest distance from the destination road to the disaster response facility.

The accessibility of each region in Cheongju can be examined through the distance by road to the disaster response facilities. In addition, we will examine the factors that affect the distance by road in each region. Through this, it will be possible to examine the characteristics of regions far from disaster response facilities.

In this study, analysis was performed using R. In order to calculate the distance by road, the 'geosphere' package of R was used to find the closest distance from the starting point or the destination. And to find the shortest distance from the departure road to the destination road, the 'stplanr' package was used. In addition, packages for analyzing spatial data such as 'rgdal' and 'sp' were used.

4. Result

The spatial characteristics of Cheongju were investigated through the collected data. Figure 1. Id the population by grid in Cheongju. As for the population of Cheongju, it can be seen that the population density is high in the central part and some parts of the outsides. In particular, the central area showed a high population density over a relatively large area.

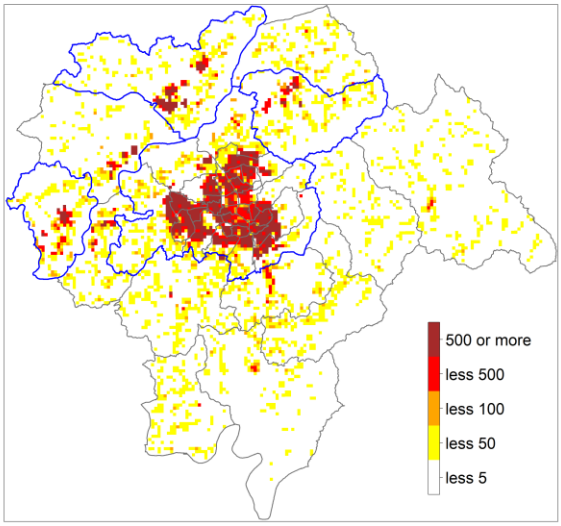
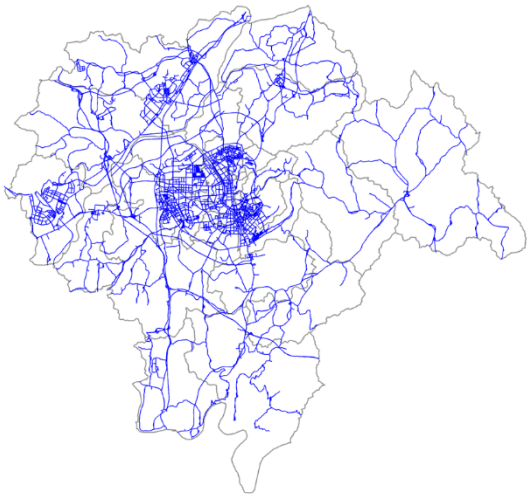


Figure 1. Cheongju population distribution

Figure 2. is the location of the road network and disaster response facilities in Cheongju. Through this result, it can be confirmed that the Cheongju road network and the location of disaster response facilities are concentrated in the central parts. Compared to the previous Figure 1., it appears that the road network is concentrated in areas with high population density, and disaster response facilities are also concentrated. In contrast, it was found that, with the exception of some areas, disaster response facilities were rare in the outsides of Cheongju, and movement was relatively difficult because the roads were far.



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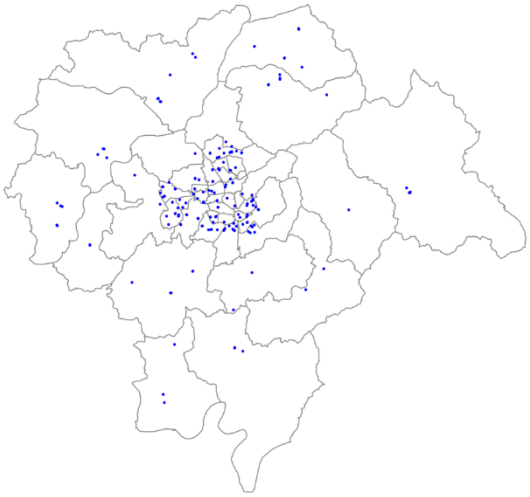

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Figure 2. Cheongju road network and disaster response facilities

<Table 1> shows the composition of disaster response facilities such as earthquake out door evacuation and earthquake temporary housing in Cheongju. Of the total 186, school such as elementary, middle, and high schools accounted for 168(90.3%) of them. In addition, parks is 9(4.8%), sports facility is 4(2.2%).

<Table 1> The state of disaster response facilities in Cheongju

Item	n	%
School	168	90.3
Park	9	4.8
Sports facility	4	2.2
Community service center	2	1.1
Etc	3	1.6
Total	186	100.0

The result of examining the distance to the disaster response facilities is shown in Figure 3. In many areas, the distance to the disaster response facilities could be reached within 2km in central parts. However, if the distance to the disaster response facility is 2km in a situation where evacuation is necessary due to disasters such as earthquakes or floods, it will take a considerable amount of time to move. Assuming that the walking speed of an adult is 1.5m/s, it can move 90m per minute, and it takes more than 22 minutes to move 2km. In this sense, in a situation in which an evacuation is urgently required, if the distance to the disaster response facility is more than 1km, it takes more than 10 minutes, so it may be difficult to effectively evacuate. In the case of children and the elderly, walking speed is lower than that of adults. For this reason, evacuation takes more time and may put in a more dangerous situation.

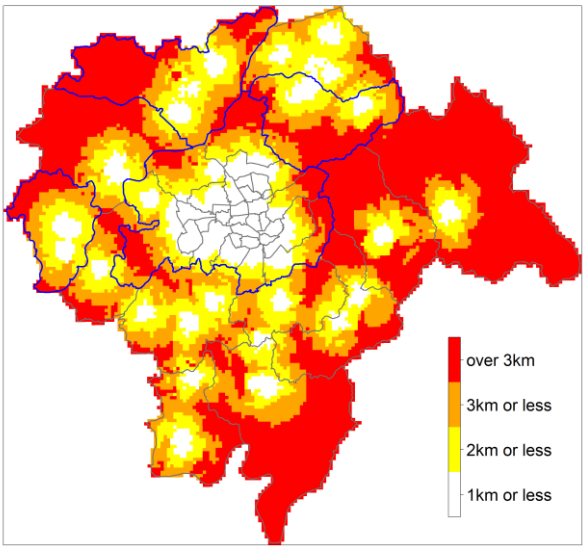


Figure 3. Distance from disaster response facilities(all areas of Cheongju)

In the outsides, there are many areas where the distance to disaster response facilities is more than 3km. In particular, in the northwestern, eastern, and southern region, it will be difficult to move to disaster response facilities in many regions. As shown in Figure 1, in the case of densely populated areas, the distance to the disaster response facilities was found to be closer than that of non-populated areas. In other words, disaster response facilities are mainly located in areas with large populations. This can be seen as considering the efficiency in the designation of disaster response facilities, but is does not seem to take into account equity.

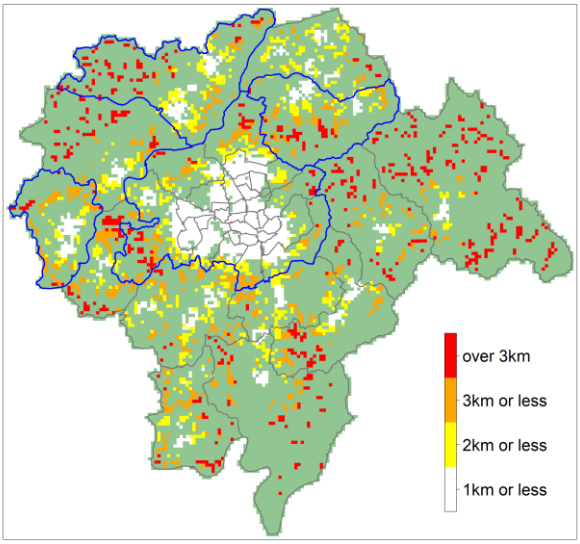


Figure 4. Distance from disaster response facilities(Areas where 5 or more people live in grid)

Even if it is necessary to designate disaster response facilities in consideration of regional equity, the need for disaster response facilities even in areas with very sparsely resident populations may again reduce efficiency. Therefore, it is necessary to examine the distances to disaster response facilities by grid except for areas with very sparsely resident population. Figure 4 shows the results of distances to disaster response facilities only for areas with 5 or more residents in the grid. In this result, areas with less than 5 residents are shown in green(11,990 of 15,526 grids).

Areas with a distance of more than 3km from disaster response facilities were generally scattered in areas with a sparsely populated population. In particular, this trend is shown in the northwestern, eastern, and southern region. In this area, it is very difficult to move to a disaster response facility, and it seems that designation is necessary for the equality of benefits for disaster response facilities. However, it is not likely to be easy to designate disaster response facilities as they are scattered over a wide area.

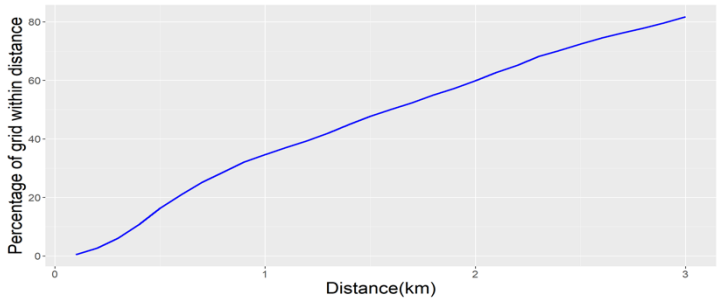
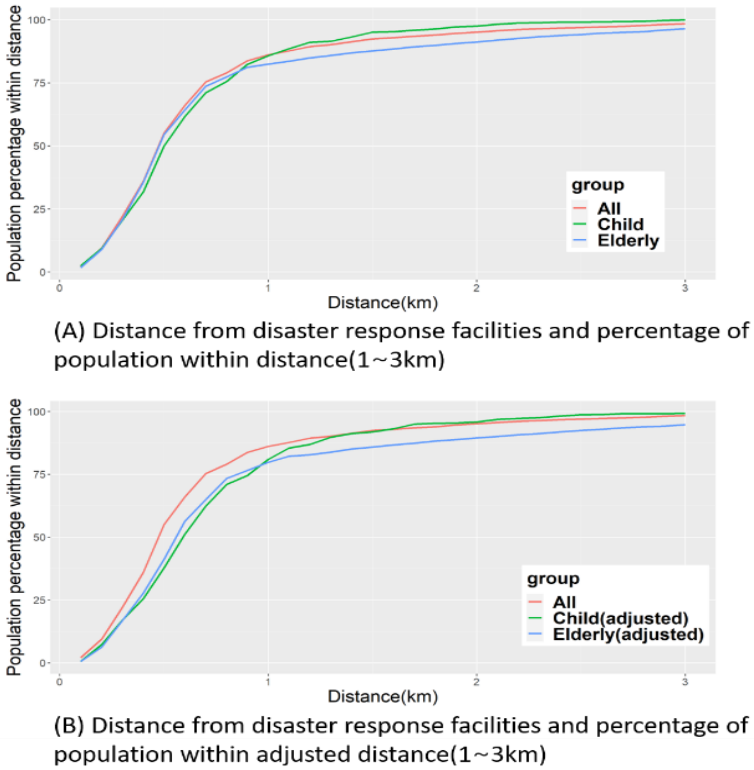


Figure 5. Distance from disaster response facilities and percentage of grid within disatance(1~3km)

Figure 5 shows the proportion of grids included according to the distance from the disaster response facility. This result excludes the grid with less than 5 residents. 34.6% of the total grid is included within 1km from the disaster response facility. And 59.9% within 2km and 81.7% within 3km. As previously assumed, in order for an adult to walk to the disaster response facility within 10 minutes, the facility must be located within 900m. However, only 32.1% of the grids can reach disaster response facilities within 10 minutes. The proportion of grids that could arrive within 15 minutes was 43.5%, and within 20 minutes was 55.0%.

Figure 6. shows the percentage of the population residing within the grid included according to the distance from the disaster response facilities among the total population. In addition, children and the elderly were examined separately. Also, in this figure, (B) is the distance considering that the walking



(A) Distance from disaster response facilities and percentage of population within distance(1~3km)

(B) Distance from disaster response facilities and percentage of population within adjusted distance(1~3km)

Figure 6. Distance from disaster response facilities and percentage of population within distance(1~3km)

speed of children and the elderly is slower than the of adults by 15%. First, looking at (A), it was found that 86.1% of the total population was included within 1km of the disaster response facilities. And within 2km, 95.1% of the total population was included.

In the case of children, 85.7% of all children were included within 1km from the disaster response facilities. And in the case of the elderly, it was 82.4%. In the case of children, there was no significant difference with the percentage of the total population, but in the case of the elderly, it was 3.7% lower than the percentage of the total population. In the case of children within 2km of the disaster response facilities, 97.5% were included, which was higher than the total population(95.1%). On the other hand, in the case of the elderly, it was 91.2%, which was still lower than the percentage of the total population.

Next, Looking at (B), assuming that the walking speed is slow for children and the elderly, 80.9% of children were included within 1km of the disaster response facilities. It was 5.2% lower than the total population(86.1%). In the case of the elderly, it was 79.8%, which was 6.3% lower than the total population. In the case of children, 95.8% of children were included within 2km of the disaster response facilities. It did not show a significant difference from the percentage of the total population. On the other hand, in the case of the elderly, it was 89.5%, which was 5.6% lower than the total population.

A regression analysis was performed to examine regional characteristics according to the distance from disaster response facilities. The unit of analysis in regression analysis is the grid. Regional characteristics include the proportion of children and the elderly among the total resident population for each grid, the number of buildings, and the ratio of buildings older than 35 years.

<Table 2> Regional characteristics according to the distance from disaster response facilities

Independent variables	coefficient	T value	
Child ratio	-.13	-12.35	***
Elderly ratio	.01	4.13	***
Number of buildings	-.01	-21.29	***
Ratio of buildings over 35 year	.01	9.01	***
F value		228.82	***
R^2		.21	

*: p < .05, **: p < .01, ***: p < .001

The results of the regression analysis are shown in <Table 2>. All four factors assumed as independent variables have a statistically significant effect on the dependent variable. Among these independent variables, the ratio of the elderly and the proportion of buildings older than 35 years had a positive effect on the dependent variable. On the other hand, the ratio of children and the number of buildings had a negative effect.

These results show that as the population of children, number of buildings, it is closer to disaster response facilities. On the other hand, the greater the number of elderly people among the total population and the more buildings over 35 years, the greater the distance from disaster response facilities.

5. Conclusions

This study tried to examine the distribution of disaster response facilities in Cheongju, and to examine the accessibility to these facilities. Also, in this study, the distance by age and population characteristics was identified and factors affecting the distance to disaster response facilities were examined. To this end, the accessibility of disaster response facilities was examined through the distance by road. To calculate the distance by road, the 250m horizontal and vertical grid was used, and the distance to the nearest disaster response facilities was calculated based on the centroid of each grid.

As a result, disaster response facilities are located in proportion to the population, so the distance is short in areas with large populations. This means that the distance to these facilities is longer in less densely populated areas. Areas far from disaster response facilities were generally scattered. In particular, this is mainly shown in the northwestern, eastern, and southern regions of Cheongju. In the area, it is very difficult to move to a disaster response facilities, and it seems that designation is necessary for the equality of benefits for disaster response facilities. However, it is not likely to be easy to designate disaster response facilities as they are scattered over a wide area.

Next, coverage from disaster response facilities was examined based on grid and population. First of all, 34.6% of the total grid is included within 1km from the disaster response facilities based on the grid. And 59.9% within 2km and 81.7% within 3km. In terms of population, 86.1% of the total population is included within 1km from the disaster response facilities. And 95.1% within 2km and 98.4% within 3km. And, in the case of children and the elderly, assuming that the walking speed would be relatively low, the distance from the disaster response facilities was corrected and examined. In this result, in the case of children, the proportion of children included compared to the total population within 1km from the disaster response facilities was low, but the difference decreased as the distance increased. On the other hand, in the case of the elderly, the inclusion percentage according to distance was generally low.

As a result of regression analysis to examine regional characteristics according to the distance from disaster response facilities showed that the more children and the number of buildings, the closer to disaster response facilities. On the other hand, the greater the number of elderly people among the total population and the more old buildings, the greater the distance from disaster response facilities.

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Profile

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