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Recommending U-disaster-prevention Services Based on Present Conditions of Gangnam-gu Emergency Shelters*

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Abstract: Recently, ubiquitous cities, which are known as "U-cities" or "Smart Cities", have emerged as the post-city paradigm in South Korea. U-cities aim to provide multiple services in various areas. Among these services, the importance of disaster prevention is highlighted because of the current threat posed by North Korea as well as natural and man-made disasters. Research was conducted on the disaster prevention services in Gangnam-gu, which has the highest resident and floating population in Seoul, the capital of South Korea. Gangnam-gu would not normally be considered for U-service benefits because these features are focused primarily on newer municipalities. However, this service is considered essential to this locality. Research and subject data were confined to Gangnam-gu and emergency shelters located in this area. ArcGIS was used to analyze the network service and buffer data. Results indicated that in the event of a disaster, Gangnam-gu has sufficient shelters, although spatial accessibility was not. To correct this discrepancy, this research recommends the implementation of a U-disaster prevention service for Gangnam-gu.

Key words: U-city; U-disaster prevention; emergency shelter; integrated management center
JEL Code: R1

1. Introduction

The concept of ubiquitous cities or U-cities, which fuses communications technology with city construction, aims to improve city competitiveness and living conditions. Major local governments in South Korea have implemented the U-city concept. With government support, U-city projects have spread nationwide. As of 2013, projects in 49 local governments are already in the planning or implementation stages. The law allows ubiquitous technologies to be applied in administration, transportation, health, crime, disaster prevention, and environmental areas.

Given the previous outbreaks of casualties caused by natural and man-made disasters as well as threats posed

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by North Korea, disaster prevention is a high profile issue. Before the paradigm of U-cities, practical usage of available facilities was lower due to lack of promotion or management insufficiency. However, by implementing U-disaster prevention systems, which link former emergency facilities with ubiquitous services, accessibility to these facilities will be enhanced for the public. Research indicates that the implementation of a ubiquitous disaster prevention system is imperative for the Gangnam-gu district in Seoul because of high resident and floating population. Included in this district is the metropolitan area of Seoul that borders North Korea.

2. Literature Review

2.1 Evacuation Shelter

Earlier studies on evacuation shelter adequacy are categorized into two areas, namely, analysis of service coverage of existing shelters and calculation of proper areas for new evacuation shelters, where none previously existed. Walking speed and walking distance were used to calculate the placement of new shelters. Subjects were categorized according to age and sex, as well as the average walking speed of each type. According to many studies, the average speed for slow steps was 1.00 m/s, 1.29 m/s for moderate steps and 2.05 m/s for fast steps (Bohannon, 1997; Hong et al., 2011; Jeon, 2011; Kim, 2005; Lee, 2001; Older, 1964; Pouls et al., 1983; Studenski et al., 2011). In this study, the numbers were set to 1.00 m/s, 1.3 m/s, and 2.00 m/s for slow, moderate, and fast steps, respectively. In the case of travel time, at least one evacuation shelter must exist within five minutes of its population center, even though precise criteria to define the required time to reach each evacuation shelter did not exist, according by Park and Kim (2012). Based on this reference, the safe travel time to reach each evacuation shelter was set to five minutes. Probable travel distance was calculated by averaging walking speed and travel time of each type.

Table 1 Travel Distance According to the Walking Speed of Types of Evacuees

Average walking speeds (m/s)	Types of evacuees	Travel time (min)	Walking distance (meters)
1.0	Children and elderly		300
1.3	Moderate steps of adult male and female	5	390
2.0	Fast steps of adult male and female		600

2.2 U-disaster Prevention Service

Disaster relief was previously focused on prediction and prevention. Present U-disaster prevention consists of both disaster prevention and post-disaster relief services. These technologies are easier to apply to developing areas, and are more effective when focused on the use of existing evacuation shelters. These technologies also provide post-disaster services for the safety and preservation of the population.

3. Research Methods

The subject district, Gangnam-gu, has the fourth largest residential population density in Seoul. With a massive commercial and business district distributed around the subway system, the district attracts a large floating population. For this study, 10 dongs (administrative division section unit) were chosen as the research range among the 14 dongs in Gangnam-gu. These 10 dongs represented the general concentration of population in Gangnam-gu. According to statistical data for Gangnam-gu in 2013, these 10 units accounted for 80.28% of the total area and held 93.74% of its total residential population. The remaining four dongs were exempted because

they are in a mountainous area where floating population is relatively low.

Table 2 Area and Population Status of Each Dong in Gangnam-gu

	Area(km^2)	Percentage (%)	Number of population	Percentage (%)
Gangnam-gu	39.51	100	569,150	100
Apgujeong	2.53	6.40	29,175	5.10
Cheongdam	2.33	5.90	31,198	5.50
Daechi	3.52	8.90	85,440	15.00
Dogok	2.04	5.20	58,619	10.30
Gaepo	5.27	13.30	80,738	14.20
Irwon	4.74	12.00	60,321	10.60
Nonhyeon	2.72	6.90	48,747	8.60
Samseong	3.18	8.00	48,303	8.50
Sinsa	1.89	4.80	19,753	3.50
Yeoksam	3.5	8.90	71,233	12.50

Emergency evacuation shelters located in the 10 selected dongs were chosen as the research subject. Location and area data were acquired from the National Disaster Information Center webpage. By using ArcGIS 9.3, shelters in the target areas were indicated on a map. Road-based network data were used to verify service coverage of shelters according to walking speed. Additionally, buffer analysis was conducted to reflect other accessible data not included in the network data.

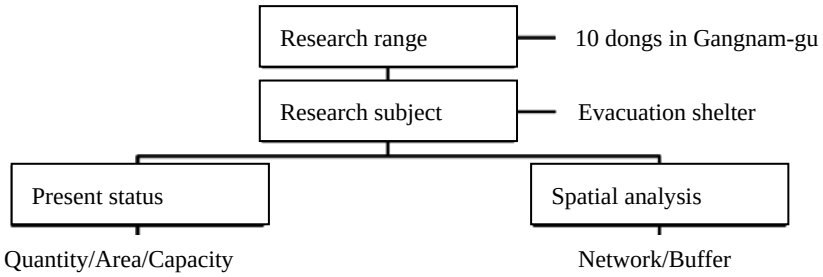

Figure 1 Research Process

4. Results

4.1 Status of Evacuation Shelters in Gangnam-gu

Table III presents the number and the areas of shelters in each dong. Two hundred eleven (211) shelters are located in the district. Dogok-dong has the largest number of 33 and Apgujeong-dong possesses the least number at 8. Dogok-dong holds the largest number of shelters, which is primarily attributed to the evacuation shelters built in the basement of a massive apartment complex.

According to the civil defense law of South Korea, the criteria of evacuation state that the minimal floor space of each evacuation shelter is 0.85 m^2 per person. Using this standard, acceptable populations of the dongs were calculated. Acceptance ratios were calculated by comparing this result with the actual resident population. According to this calculation, dongs in Gangnam-gu, with the exception of Irwon-dong, revealed over 100% acceptance ratio, which indicated the existence of sufficient shelters for its population. However, this calculation is restricted to the resident population. Precise statistical data regarding the floating population of the dong do not exist. Still, among the 10 dongs, Sinsa-dong, Apgujeong-dong, Nonhyeon-dong, Cheongdam-dong,

Yeoksam-dong, and Samseong-dong are dongs with a large portion of floating population. This result indicates an average of 261% acceptance ratio, which validates the conclusion of sufficiency of evacuation shelters for all populations.

Table 3 Current Status of Evacuation Shelter in Gangnam-gu

	Number of shelters	Shelter area (m^2)	Acceptable population	Resident population	Acceptance ratio (%)
Apgujeong	8	29,476	35,728	29,175	122
Cheongdam	16	61,536	74,589	31,198	239
Daechi	29	157,502	190,911	85,440	223
Dogok	33	625,878	758,640	58,619	1294
Gaepo	32	73,882	89,554	80,738	111
Irwon	23	45,263	54,864	60,321	91
Nonhyeon	22	68,154	82,611	48,747	169
Samseong	15	160,411	194,438	48,303	403
Sinsa	11	39,736	48,165	19,753	244
Yeoksam	22	175,974	213,302	71,233	299

The locations of shelters are marked in the map below.

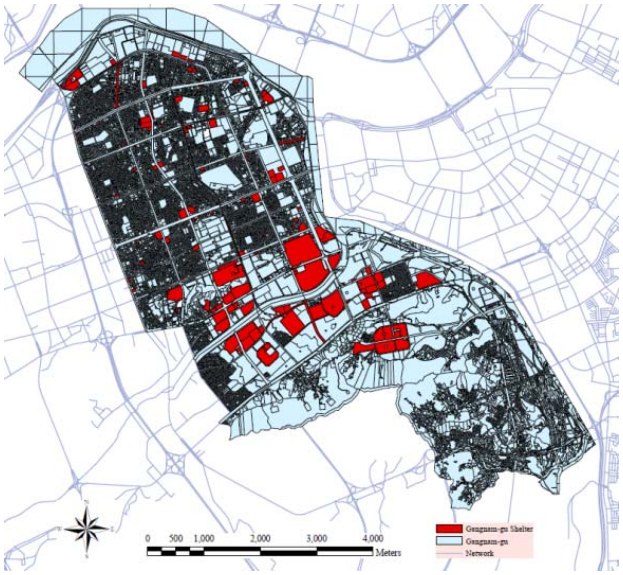

Figure 2 Current Status of Evacuation Shelter in Gangnam-gu

4.2 Network Analysis

Selection of evacuation shelters was drawn from network analysis of the targeted service area by using the data of the road-based network accessible to vehicular traffic. Various walking speeds of different types of evacuees were applied to analyze the service coverage area of 211 evacuation shelters. Travel time was set to 5 minutes, with travel distances of 300, 390, and 600 m for walking speeds of 1, 1.3, and 2 m/s respectively. Results indicated a high acceptance ratio of over 100%, which was in accordance with previous results in this research. However, the service area covered shrank when calculating the walking speed of the elderly and children with a travel distance of 300 m. Another limiting factor was the inaccessibility of pedestrian malls and narrow alleyways to vehicular traffic. Figure 3 shows that areas with densely concentrated building were not included in the covered service area. To supplement the limitations, additional buffer analysis was conducted.

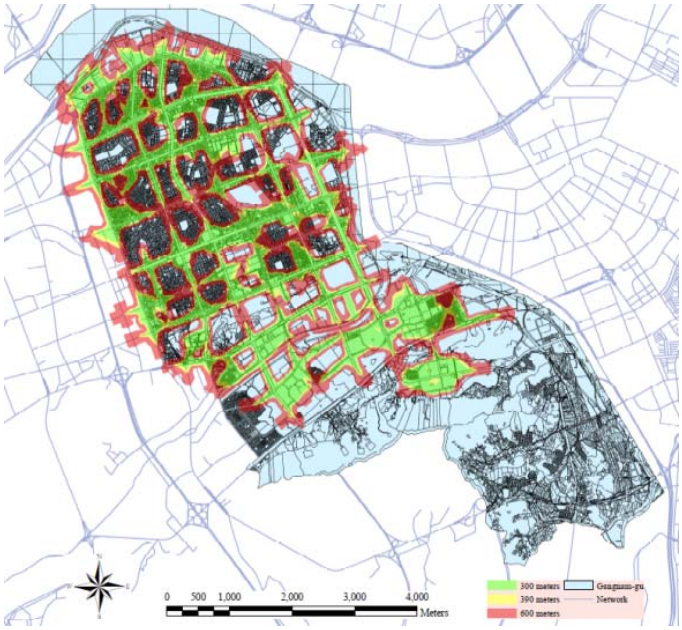

Figure 3 Network Analysis Service Covered Area

4.3 Buffer Analysis

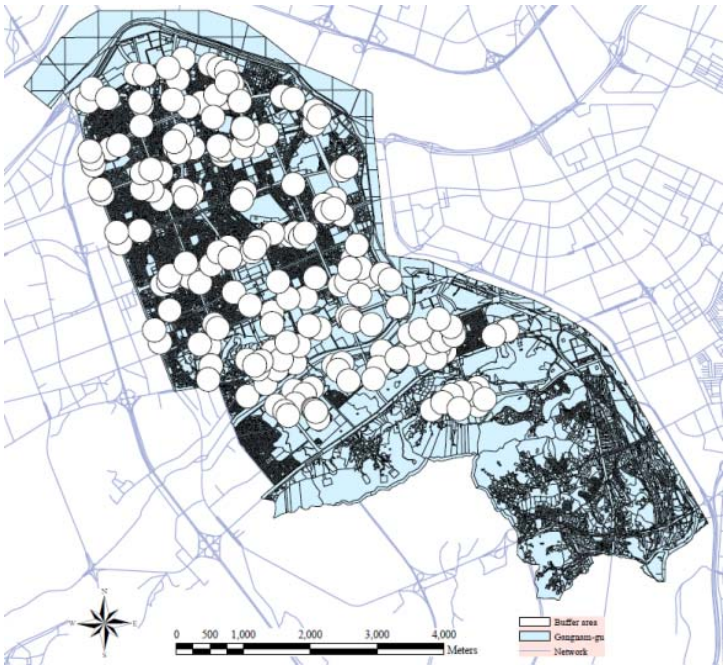

Figure 4 Buffer service covered area

The following hypotheses are derived from this analysis. In case of emergency, with a narrow alley as the established route, with a walking speed of 1 m/s, travel time to the designated shelter was reduced from 5 to 3 minutes. In this way, narrow alleys may be included in the service-covered area in the buffer analysis. To reflect the peculiar conditions presented by narrow alleys, very strict standards were applied. This situation resulted in a smaller service-covered area in the buffer zone compared to the network-service covered area.

4.4 Overall Analysis

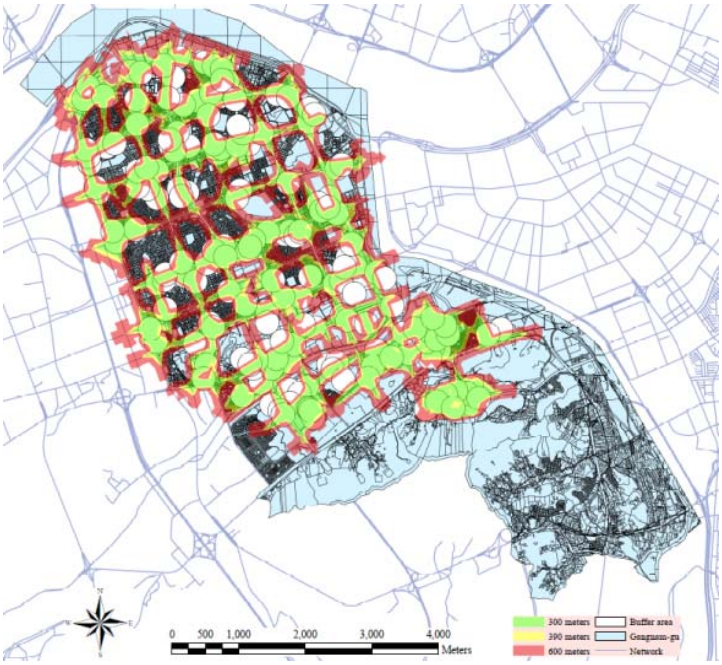

Figure 5 Overall Analysis

The total service covered area of 211 shelters, including network service-covered area and buffer service area, is marked on the map in Figure 5. Some locations do not fall into service-covered areas in the event of a disaster. Therefore, regardless of the high acceptance ratio of the total resident population, shelters that can be reached within acceptable time limits are few. This situation leaves a large portion of the target population spatially vulnerable.

5. Conclusion

Interest in u-cities and the actual number of cities providing ubiquitous services has increased. However, ubiquitous related projects are presently restricted to newly developed areas and has neglected districts, such as Gangnam-gu, that were developed over 30 years ago. The largest concentrations of commercial and business districts and resident and floating population are found in older areas. Hence, applying ubiquitous services to the districts in Gangnam-gu is necessary. Considering the growing concern over natural and man-made disasters, disaster prevention service was selected as the priority over other services offered by the Ubiquitous Cities project. Preexisting evacuation shelters were targeted as the subject of the research.

A total of 211 evacuation shelters are located in the 10 dongs of Gangnam-gu. Service-covered areas of these shelters were confirmed through network analysis and categorized based on the walking speed of different types of evacuees. Buffer analysis was compiled to supplement the overall study. Results showed arithmetical concentration of the acceptance population for evacuation purposes and the insufficiency of optimally located shelters for the acceptance population.

To resolve this matter, this research recommends the availability of U-disaster prevention services to older districts. An initiative to raise awareness of the location of evacuation shelters should be provided. Only a few

citizens are aware of the existence or location of the 211 evacuation shelters in the Gangnam-gu area. Therefore, the development of a map application is critical. The map should show the location of shelters and the distances to a neighboring shelter based on GPS information.

When designating new evacuation shelter areas in U-cities, certain conditions must be considered for the dense population of elderly residents and citizens with physical limitations and limited access to information. Walking speed and the travel distance are important factors, which make the situation of evacuation for children, elderly, and infirm persons more difficult. Therefore, an important part of the U-disaster prevention service for vulnerable subjects should be the careful consideration of the location of the construction of new shelters.

For consistent management of existing shelters, an integrated management center should be established. Integrated management centers, which are installed mostly in new development areas, are facilities that administer various parts of U-services. These services should be directly related to evacuation shelters and disaster management, especially for the purposes of this study. The above observations indicate that the ranges of new district-oriented ubiquitous application technologies are similarly applicable to areas with a longer history of development.

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Appendix

Table 1 Walking Speed Based on the Advance Research

Index	Average speed (m/s)	Standard speed (m/s)	Advance research
Fast	2.05	1.87	Lee (2001)
		1.75-2.53	Bohannon (1997)
Normal	1.29	0.7-1.2	Jeon (2011)
		1.25-1.8	Kim (2005)
		1.3	Pouls et al. (1983)
		1.4	Older (1964)
		1.27-1.46	Bohannon (1997)
Slow	1.00	0.8-1.1	Jeon (2011)
		0.93-1.28	Hong et al. (2011)
		0.92	Studenski et al. (2011)

Note: Reprocessed from Park and Kim (2012)