Suggestion of u-disaster-prevention Service through the Analysis of present condition of Gangnam-gu Emergency Shelters

Meenchel Jung, Kabsung Kim, and Jihye Han

Abstract—Recently, ubiquitous cities have risen to be the post city paradigm in South Korea. Ubiquitous cities are the cities that aim the advancement in function by providing ubiquitous services in various fields. Among several services provided, the importance of disaster prevention services is being emphasized due to the current threatening situation evoked by North Korea and the occurrence of many natural disasters and man-made disasters. Especially, the disaster prevention service in Gangnam-gu where holds the highest resident and floating population in Seoul, the capital of South Korea, is considered to be essential. However, most of ubiquitous projects are focused on newtowns. Therefore Gangnam-gu, being former town, is relatively discluded from U-service benefits. This research proposes u-disaster-prevention service which uses former existing emergency shelter facilities. The research range is bounded to Gangnam-gu and emergency shelters located in the area. Arc GIS was used to analyze network service and Buffer analysis. The subject data were limited to shelters located in Gangnam-gu. As the result, capacity of the shelters in the case of disasters was arithmetically sufficient; however, spatial capacity was insufficient. In order to prevent the insufficiency, this research suggests u-disaster prevention service.

Keywords—U-city, U-disaster prevention, Emergency shelter, Integrated management center

I. INTRODUCTION

RECENTLY, ubiquitous cities (u-city) which fused various information communicating technology and city construction to improve city competitiveness and loving condition, are being actualized in major local governments in South Korea. Under the support of government, u-city projects are spread nationally wide and by 2013, the projects are under planning or implementation stages in 49 local governments. These ubiquitous cities pursuit advancement in city function by applying ubiquitous technologies in areas, categorized by law, such as administration, transportation, health, crime and disaster

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prevention, environment, and etc.

Due to previous outbreak of casualties caused by natural disasters, man-made disasters, and the threat of North Korea in the situation of division, disaster prevention issue has a high profile. In former cities, practical usage was rather low due to the lack of advertisement or management insufficiency. Therefore, in ubiquitous cities, u-disaster prevention systems, linking former emergency facilities and ubiquitous services, are in need in order to enhance accessibilities for general public. It is concluded that ubiquitous disaster prevention system is especially required in Gangnam-gu district in Seoul which included in Metropolitan area where it borders North Korea, and records high resident and floating population.

II. LITERATURE REVIEW

A. Evacuation Shelter

Former studies on evacuation shelters can be categorized into to two topics: analysis on service coverage of former existing shelters, and calculating proper area for new evacuation shelter in regions where the existing service does not cover. In researches about the service coverage of evacuating shelter, average walking speed and walking distance were used as factors in deducting the serving area. The subjects were categorized into different types and each type's average waling speed was used. According to studies such as [1]-[3] and [5]-[9], average speed for slow steps was 1.00m/s, average speed of moderate steps was 1.29m/s, and average speed for fast steps was 2.05m/s . In this study, the numbers are set to 1.00m/s, 1.3m/s, and 2.00m/s for each types, children and elderlies, moderate walking speed of adult male and female, and fast walking speed of adult male and female. In the case of travel time, even though precise criteria to define required time to reach evacuating shelter do not exist, according to [4], at least one evacuating shelter must exist within the range of five minutes. Based on this reference, safe travelling time to reach the evacuating shelter is set to five minutes. Using average walking speed and travel time of each type, following results regarding possible travel distance can be calculated.

TABLE I
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

B. U-disaster Prevention Service

U-disaster prevention system is consisted of advanced prevention of disasters and services for efficient post gumption to promote safety. Former u-disaster prevention related services focused mostly on the technologies that predict and prevents disaster beforehand. These technologies are more convenient to apply to newly developing cities; therefore services are concentrated on new towns. As the result, applying u-disaster prevention system is relatively difficult, resulting relative shortcomings of gumption against disasters. Therefore, focusing on using already existing evacuating shelters, a kind of disaster prevention facilities, as post gumption has to be considered in prior to developing technologies of advanced prevention in former part of the city.

III. RESEARCH METHODS

The subject district, Gangnam-gu, holds 4th largest resident population in Seoul, and massive commercial district and business district are distributed around the subway stations which attracts large number of floating population. In this research, 10 Dongs(administrative division section unit) among total of 14 Dongs in Gangnam-gu are chosen as the research range. These 10 Dongs, according to the statistic data of Gangnam-gu in 2013, account for 80.28% of the total area and hold 93.74% of the total resident population, which can be assumed that these 10 Dongs represent general Gangnam-gu. Moreover, exempted four Dongs, unlike other ten districts, are in mountainous area where floating population is fairly low, therefore excluding the districts would not affect the result.

TABLE II
AREA AND POPULATION STATUS OF EACH DONG IN GANGNAM-GU

	Area (km²)	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

Ten emergency evacuation shelter located in 10 dongs are chosen as the research subject. Location and area data of shelter are acquired from National Disaster Information Center webpage. Gained data of shelters are embodied in a map, using Arc GIS 9.3. Road based network data are used to verify service coverage of shelters according to the walking speed.

Additionally, Buffer analysis was conducted to reflect allies that are not included in the network data but accessible by people.
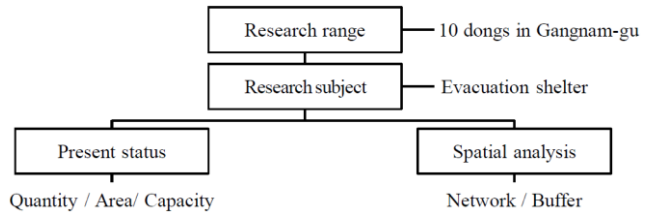

Fig. 1 Research process

IV. RESULTS

A. Status of Evacuation Shelter in Gangnam-gu

The number and the area of shelter in respective dongs are charted below. Total numbers of 211 shelters are located in the district, Dogok-dong possessing the largest number of 33, and Apgujeong-dong possessing the least number of eight. As the result of area calculation, Dogok-dong holds largest number of shelter accounts for the largest portion in the total area that is due to the evacuation shelters built in the basement of massive apartment complex. According to the civil defense law of South Korea, criteria of evacuation state the least floor space of evacuation shelter is 0.85m² per person. Using this standard criterion, acceptable populations of respective Dong are calculated, and comparing the result with the actual resident population, acceptance ratios are calculated. As the result, every Dong in Gangnam-gu except Irwon-dong showed over 100% of acceptance ratio, arithmetically indicating the existence of sufficient provision to disasters. However, it can be pointed out that this calculation is bounded to the mere resident population. Even though Gangnam-gu holds fairly high floating population in its massive commercial districts, precise statistics regarding the floating population does not exist. Still, among ten dongs, Sinsa-dong, Apgujeong-dong, Nonhyeon-dong, Cheongdam-dong, Yeoksam-dong, Samseong-dong, dongs where accepts large portion of floating population, show average of 261% of acceptance ratio which validates the conclusion of sufficiency of evacuation shelters.

TABLE III
CURRENT STATUS OF EVACUATION SHELTER IN GANGNAM-GU

	Number of shelters	Shelter area(m²)	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.
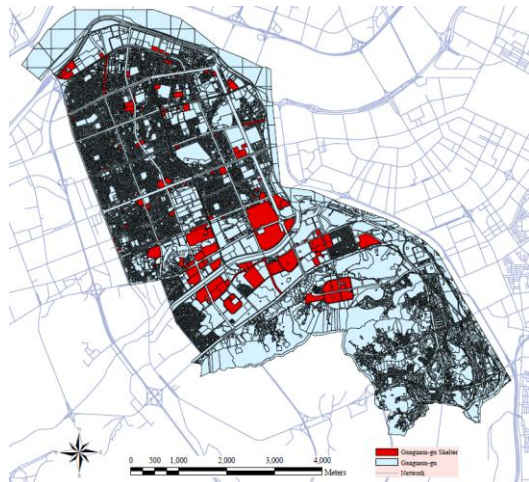
Fig. 2 Current status of evacuation shelter in Gangnam-gu

B. Network Analysis

Fig. 3 Network analysis service covered area

Service covered area of evacuation shelters is drawn from the conduction of service area of network analysis using the data of road based network. Various walking speeds of different types of evacuees are applied to analyze the service coverage of 211 evacuation shelters. Travel time is set to five minutes drawing travel distance of 300m, 390m, and 600m for the walking speed of 1m/s, 1.3m/s, and 2m/s respectively. Arithmetically, the result showed high acceptance ratio of over 100%, in accord with the previous result in this research. But, large portion of space is not included in the spatial service covered area. Especially, when calculated upon the speed of elderly and children, travel distance of 300m, the service covered area shrinks even more. There does exist limit of discarding pedestrian malls and narrow allies, where vehicles cannot access, from the analysis since the network analysis only covers vehicle accessible roads. As observed from the Fig. 3 above, areas where the buildings are densely concentrated are not included in the service covered area. In order to supplement the limitation, additional Buffer analysis was conducted.
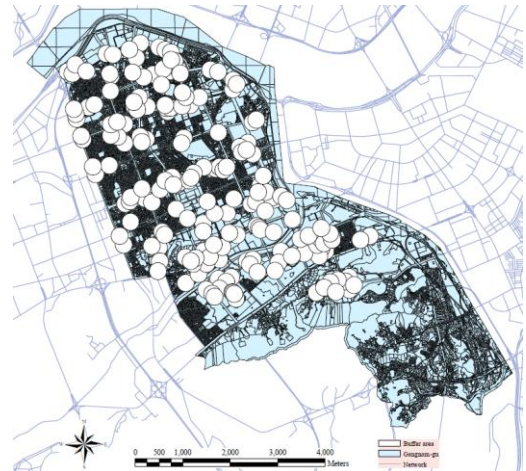
C. Buffer Analysis

Fig. 4 Buffer service covered area

In this analysis followings are hypothesized in cast of emergency: a narrow ally as the route, walking speed of 1m/s, and the travel time has been reduced from 5 minutes to 3 minute. As the result, narrow allies are shown to be included in the service covered area in the Buffer analysis. Meanwhile, to reflect peculiar condition of narrow allies, very strict standards were applied; therefore the result of service covered area is smaller in the Buffer service covered area compare to the network service covered area.
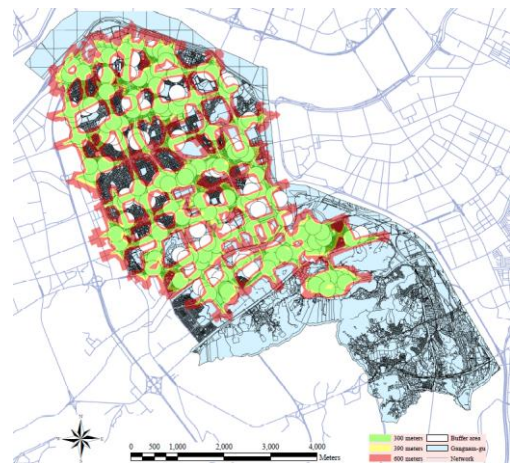
D. Overall Analysis

Fig. 5 Overall analysis

Total service covered area of 211 shelters, network service covered area and Buffer service area combined, are marked in the map above. There still are locations where they do not fall into either of service covered area in case of disasters. It can be deducted that regardless of high acceptance ratio of total resident population; areas where people can evacuate in valid time are limited, therefore being spatially vulnerable.

V. CONCLUSION

Recently the interests in ubiquitous cities have been

increased, and actual number of cities providing ubiquitous services is growing. However, ubiquitous related projects are conducted in new towns, isolating former old town that have been more than 30 years since the first development, such as Gangnam-gu, from the benefits of ubiquitous services. This initiated the idea of applying ubiquitous services to the districts around the Gangnam-gu which has largest commercial and business districts and resident and floating population among former old towns. Considering the growing interest in natural and man-made disasters, disaster prevention service is selected as priority service among various services that ubiquitous cities offer, choosing preexisting evacuation shelters as the subject of the research.

Total of 211 evacuation shelters are located in 10 Dongs of Gangnam-gu. The service covered areas of these shelters are confirmed through network analysis categorized by the walking speed of different types of evacuees, and the Buffer analysis to supplement. The result shows the arithmetical sufficiency of acceptance population of evacuation and the insufficiency of spatial acceptance population.

To resolve this matter, this research suggests u-disaster prevention service applicable to former towns. Firstly, services to raise awareness of former evacuation shelters should be provided. Even though there are total of 211 evacuation shelters, few citizens are aware of the existence and the location of the shelters. Developing map application that contains the information of shelters and shows distance to a neighboring shelter based on the GPS information of user's current location is required. Secondly, when designating new evacuating shelters areas where relative population of elderlies is high have to be considered in prior to other areas. In ubiquitous cities, a person who have physical limitations and people whose accessibility of information is relatively low have to be considered. Especially, in disaster prevention services, the walking speed and the travel distance are important factors, but the number of these factors of elderlies and children are relatively low, making the situation of evacuation for the subjects more difficult. Therefore, as the part of u-disaster prevention service for vulnerable subjects, the location of the shelter should be carefully decided when building new shelters. Thirdly, for persistent management of former shelters, integrated management center has to be installed and operated. Integrated management center, installed mostly in new town areas, is a facility that manages various parts of u-service. Installation of these facilities is unavoidable to control and manage the evacuation shelters persistently for several situations of disasters. Above suggestions are estimated to be amply applicable to former old towns and are expected to expend the range of new town oriented ubiquitous application technologies.

APPENDIX

TABLE IV
WALKING SPEED BASED ON THE ADVANCE RESEARCH

Index	Average speed(m/s)	Standard speed(m/s)	Advance research
Fast	2.05	1.87	[6]
		1.75-2.53	[5]
Normal	1.29	0.7-1.2	[2]
		1.25-1.8	[9]
		1.3	[1]
		1.4	[7]
		1.27-1.46	[5]
Slow	1.00	0.8-1.1	[2]
		0.93-1.28	[3]
		0.92	[8]

Note: Reprocessed from [4]

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