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An Empirical Study on Inundation Vulnerability in Urban Declining Areas through Analysis of Sales Change in Living Businesses
: Focused on Ulsan Metropolitan City[*]

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Abstract

According to the IPCC 5th Assessment Report on climate change, climate change is expected to have a more serious impact on the vulnerable class, who are socially and economically unequal. Particularly, declining areas, which are considered to be the residential areas of the vulnerable class, are more easily influenced by typhoons and heavy rains owing to the old physical and economical environment. Nevertheless, existing urban regeneration areas are insufficient for a plan or policy that considers disaster responses. The purpose of this study is to reveal the vulnerability of declining areas damaged by Typhoon Chaba using sales change data in the region and to suggest the necessity of urban regeneration in response to the inundation vulnerability of the declining areas. The study area was Ulsan, South Korea, which was seriously damaged by Typhoon Chaba on October 5, 2016, and the spatial analysis unit was the census output area. We selected 51 declining areas designated as the districts of the urban regeneration plan and urban regeneration new deal areas in the urbanization area. We used a multiple regression model to analyze whether declining areas were more influenced by inundation damages than a general area using sales change data. The results indicated that the declining areas had more sensitive variables than the general areas and suffered more damages from inundation. In addition, this study revealed that the inundated depth was a major factor that influenced sales change in the region. In conclusion, this study indicated the requirement for an empirical study on inundation vulnerability and for suggesting the necessity of a disaster response in the existing urban regeneration plan.

Keywords   Urban Declining Area, Inundated Area, Sales change, Typhoon Chaba, Multiple Regression Model
주제어   도시쇠퇴지역, 침수지역, 매출액 변화, 태풍 차바, 다중회귀분석

Ⅰ. Introduction

1. Background and Purpose of the Study

Climate change, when combined with modern cities, increases occurrences of natural disasters such as extreme heat, drought, and floods. The irregular nature and scale of disasters that vary depending on physical and social characteristics of an urban space inflict serious losses of life and socioeconomic damage in different areas. The IPCC 5th Assessment Report on Climate Change projected that climate change, which has become increasingly severe recently, will have serious impacts on human beings and, in particular, those who are vulnerable to climate will suffer

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even bigger damage. As such, people who are marginalized due to social, economic and institutional inequalities are considered especially vulnerable to the effects of climate change, and the report emphasized the need for policy-oriented responses for vulnerable social groups.

Such damage is more likely to occur in urban communities experiencing decline due to deterioration of buildings, dwindling sales in commercial districts, and depopulation. Declining areas with deteriorated dwelling conditions and reduced economic activities are often considered for residence by vulnerable social groups. Due to this reason, local governments are endeavoring to re-vitalize their respective regions by carrying out public projects to create jobs and to improve residential environment under the Special Act on Promotion of and Support for Urban Regeneration (2013). As part of this effort, urban regeneration new deal projects are being implemented to revive depressed city centers across the nation. However, urban regeneration projects, launched as a way to improve declining areas economically, socially and culturally, seriously lack systems and policies that take disaster response into consideration1) (Yu, S.C. and Yeo, K.H., 2015).

Meanwhile, storms and floods account for over 90% of disasters that occur in Korea (Lee, M.W. et al., 2013). It is also emphasized that declining economic and physical characteristics raise inundation vulnerability (Lee, M.J. and Kang, J.E., 2012). As such, urban declining areas have distinctively different characteristics in terms of the status of infrastructure including population, building characteristics, land use, etc., which require responses in consideration of the spatial scale of a declining area (Park, J.K., 2016). In addition, while it has been reported that declining areas are vulnerable to inundation, most studies lack empirical analysis of actual occurrences of inundation and the level of damage. Moreover, studies on inundation damage focused on estimating direct damage on buildings and infrastructure (Lee, G.S. and Park, J.H., 2011). Estimating damage this way has limitations as it deals with data that can be collected only after a significant period of time has passed from the disaster, and thus it is difficult to promptly identify damage at the regional level.

Therefore, this study aims to demonstrate that declining areas are more vulnerable to inundation by using sales data from Ulsan Metropolitan City which suffered severe damage from typhoon Chaba on October 5, 2016. Unlike existing data on damage to buildings, sales data allow immediate

identification of time series changes caused by inundation. To that end, this study will identify a correlation between declining areas and factors of inundation vulnerability, and demonstrate inundation vulnerability of declining areas from changes in sales in the aftermath of a typhoon and the resulting inundation.

Ⅱ. Literature Review

1. Areas vulnerable to Inundations and Declining Areas

An area vulnerable to inundation is defined as an area of high flood vulnerability[2] (Kim, C. et al., 2003). In Korea, research on evaluating flood vulnerability caused by climate change has mainly dealt with spatial analysis units of *shi* (cities), *gun* (counties), *gu* (districts), or river basins (Kim, H.S. et al, 2012; Lee, B.J., et al, 2018; Lee, J.S. and Choi, H.I., 2018). However, information offered by such analysis is limited because the spatial range is wide. Moreover, inundation damage in urban areas due to localized heavy rains is increasing sharply, which shows a different tendency from damage caused by river inundation (Shin, S.Y. and Park, C.Y., 2014; Kang, H.W., 2015). To respond to and manage such phenomena, more detailed analysis was required for areas vulnerable to inundation.

Some studies have evaluated flood vulnerability for *eup*, *myeon*, and *dong* units of a particular city to determine relatively wide-range vulnerable areas and limited vulnerable areas (Son, M.S. et al., 2013; Kim, M.J. and Kim, G.S., 2018). Furthermore, the existing spatial analysis unit has a shortcoming of over-estimating vulnerable areas, and thus application of specific urban planning measures is limited. As such, Lee, S.H. and Kang, J.E. (2018) analyzed inundation vulnerability with the unit of census output area and suggested the necessity of a spatial analysis unit for specific application of urban planning. To that end, for areas vulnerable to inundation in communities, physical vulnerability factors such as detached housing, underground levels, and houses older than 20 years, and inundation trace maps[3] of areas where actual damage occurred were considered in addition to flood vulnerability indicators. Consequently, it was found that frequent inundation damage is closely related to the level of growth and decline of a city, and geo-

graphical locations such as an old downtown or a deteriorating, physically declining area are important determinants (Hallstrom and Smith, 2005; Myers et al. 2008; Saldana-Zorrilla and Sandberg, 2009). In other words, the phenomenon of urban decline in the form of deteriorated housing, vacant houses, reduced sales, and paralysis of commercial functions seems to have affected disaster management (Rheem, S.K. and Lee, C.G, 2013).

Because a declining area is often a very vulnerable space within a city, in which deteriorated housing and commercial/business facilities are densely situated, it suffers relatively greater damage from disasters and its energy inefficiency is severe (Wang, G.I. et al., 2014). As such, inundation damage may frequently occur in areas where vulnerable social groups are living closely together. Social vulnerability factors have been considered in conjunction with physical characteristics to deduce vulnerability to disasters (Cutter, 1996). Social vulnerability factors include social, economic, and demographic characteristics that affect sensitivity and adaptive capacity, and thus, they have been considered as major factors for formulating disaster prevention measures (Park, H.N. and Song, J.M, 2014; Lee, K.M. et al., 2016).

As such, a few studies of late have carried out empirical research through correlations between actual flooded areas and vulnerable social groups. Park, J.K. (2016) demonstrated that, among urban communities that suffered inundation damage, areas of high disaster vulnerability had a relatively higher ratio of low-income residents. Seo, J.S. and Han, W.S. (2019) examined the spatial correlation between areas vulnerable to inundation and vulnerability factors, and discovered that, in urban areas, a population group of over 65 years of age was sensitive to inundation damage, and as for physical characteristics, inundation damage was related to the ratios of deteriorated detached housing and of semi underground housing units. Based on these findings, the study emphasized the need for investigating the distribution of such areas and for devising response measures in terms of urban planning for areas where vulnerable social groups are concentrated.

2. Inundation Vulnerability and Impact on Local Economy

Conceptually, vulnerability works as a factor that raises the scale of damage and the likelihood of its occurrence under the same conditions, but disaster damage data are used as indicators to validate vulnerability assessment results. Studies that aimed to predict damage from storms and floods involved analysis using casualties or frequency of occurrence, or used the actual amount of damage on buildings and infrastructure, etc. In its process of urbanization, Korea has seen an upward trend in the amount of flood damage (Jung, J.C. et al., 2007). Furthermore, other studies used the amount of damage from urban flooding for correlation and factor analysis, and suggested urban flooding risk factors - rain being the inducing factor, demographic and social factors, as well as economic factors as weighting factors, and the inundation area as the damaging factor (Kim, B.K. et al., 2011; Park, D.H. et al., 2011; Park, C.Y. et al., 2013; Lee, M.W. et al., 2013).

Causes of inundation damage make the severity of damage by each region vary depending on the regional conditions and factors of damage causes. Jang, O.J. and Kim, Y.O. (2009) performed non-linear regression analysis between flood damage amount and precipitation amount, and discovered that areas within *shi*, *gun*, and *gu* that have a lower ratio of vulnerable social groups and high financial capabilities had a low level of damage. Sim, J.S. et al. (2014) used a geographically weighted regression model on the amount of inundation damage to reveal that natural and artificial risk factors aggravated damage depending on the areas of inundation damage. Outside Korea, houses that belong to areas vulnerable to inundation are priced lower than those that do not, and when actual inundation occurs, their prices tend to plummet temporarily (Samarasinghe and Sharp, 2010; Atreya et al., 2013).

Inundation inflicts not only direct but also indirect damage on the local economy. Considering the importance of the commercial sector in terms of providing products, services and employment in a city, damage to commercial buildings due to inundation and resulting business interruption indirectly causes decreases in sales amount. The smaller a business is, the more likely it is to suffer economic damage due to inundation. Businesses that attract consumers remotely or do not interact with consumers directly are less vulnerable to a shock caused by extreme inundation. Some studies revealed that businesses whose scale was relatively bigger before a disaster tend to cope better with post-disaster situations (Wasileski et al. 2011; Basker, E. and Miranda, J.

2018). In contrast, the retail business sector was expected to be vulnerable to inundation. Since retail businesses are more likely to depend on local customers, they will face inventory loss and sales interruption if extreme disaster damage occurs (Meltzer·Capperis 2017). Pearson, M.M. et al. (2011) used retail transaction demographic survey data to verify that sales of large distributors increased in New Orleans in the aftermath of Hurricane Katrina, while the average per store sales of individual retailers that sold automobiles, furniture, and electronics decreased. In other words, retail businesses do not have sufficient capital to pay for fixed expenditures such as monthly rent and repairs when they suffer damage. Washileski et al. (2011) revealed that wholesale and retail businesses are more likely to go out of business after a disaster as they are affected greatly by the local economy and consumer trust.

Existing data on damage have limitations in terms of identifying immediate changes depending on the characteristics of each region, as data that could be collected after a considerable time were used for research purposes. Due to this reason, a few studies attempted to discover damage characteristics within a region by using sales data. Meltzer, R., et al. (2020) noticed that sales decreases occurred mainly among retail businesses in the regions affected by Hurricane Sandy. While this may be attributable to direct impact from physical destruction, it was seen as a result of indirect impact from decreases in the resident population and income over time, as well as from weakened coherency among retail trades. Yang, L., et al. (2016) divided industries into six types (wholesale and retail, manufacturing, non-manufacturing, etc.) to analyze their economic losses due to heavy rains in the Tokai region of Japan. The study found that the decrease rate of sales can be an explanatory variable for the recession period of the business sector due to inundation. And also, such changes in sales were found to have a weak correlation with inundation depth and direct commercial damage. When the inundation depth exceeded 0.75 m, among the industrial sectors, manufacturing interruption increased exponentially, whereas non-manufacturing, and wholesale and retail sectors react relatively sensitively even at a low inundation depth of 0.25 m. In Korea, research using sales data to estimate inundation damage has been very insufficient so far. In particular, it is even impossible to total the sales damage due to business interruption suffered by small business owners[4]

who are mostly tenants paying rent. As such, Seon, C.N. et al. (2017) proposed a model to predict operational damage from inundation by using data on sales during general times based on credit card sales, and an inundation vulnerability function model.

3. Sub-conclusion

This study aims to demonstrate that typhoons and inundations have greater impact on declining areas with greater physical and social vulnerability factors than on general areas by using daily sales data.

The severity of damage from inundation varies depending on the characteristics of individual regions and causes of inundation. Despite this nature, prior studies that considered sales mainly dealt with business types and scales in terms of the level of damage and recovery. In addition, as declining areas are currently defined with eup, myeon, and dong units, research on inundation vulnerability considering the current scale of urban regeneration new deal projects is insufficient. Moreover, existing studies on inundation vulnerability had difficulties in validating a correlation with immediate damage. Due to declining population, relatively higher rates of vulnerable groups, deteriorated physical environments and weakened economic foundations, declining areas may suffer greater damage when inundation occurs. In other words, declining areas, due to their local economies lacking response capacity, may react more sensitively towards inundation damage, and thus, it is necessary to investigate up to which degree of actual damage that inundation vulnerability may inflict on a given area through sales data.

Existing urban regeneration projects have been implemented with the goal of reviving local economies in decline through various forms including community companies. However, the pursuit of urban regeneration projects without the consideration of inundation vulnerability of declining areas at an era when unpredictable disasters occur due to climate change may lead to another form of regional decline. Despite this, the current urban regeneration and revitalization areas and urban regeneration new deal projects have no consideration for disaster vulnerability factors. As such, basic research is required to illuminate the need for considering disaster vulnerability in selection of declining areas, as specified in the existing Special Act on Promotion of

and Support for Urban Regeneration. Thus, this study was performed with the following assumptions: first, urban declining areas are related to factors of inundation vulnerability; second, factors of inundation vulnerability affect decreases in sales; third, urban declining areas are more sensitive to sales changes due to inundation than general areas.

Ⅲ. Method of Analysis

1. Study Area

This study focused on Ulsan Metropolitan City (hereinafter, "Ulsan"), which suffered damage due to typhoon Chaba on October 5, 2016. Ulsan's urban district is formed around Taehwa River, with Dongcheon River joining Taehwa River from north to south. The city's annual precipitation is 1,252.41 mm and its average yearly temperature is 14.1℃. According to the 2018 annual disaster bulletin, Ulsan recorded KRW 68.89 billion in property damage and 4 casualties due to typhoons and heavy rains over a five-year period from 2014 to 2018. In particular, typhoon Chaba that slammed the city on October 5, 2016 caused massive property damage amounting to KRW 61.2 billion won, 3 deaths, and 2,756 sufferers (National Disaster and Safety Portal, 2019). According to the Ulsan Meteorological Observatory, typhoon Chaba recorded a maximum precipitation of 100 mm per hour and cumulative precipitation of 266.0 mm,

and areas in close proximity to the downtown and Taehwa River were inundated.

The spatial scope of this study covers Ulsan's urbanization areas excluding non-urban areas, and census output area was used as the analysis unit. Figure. 1 shows the spatial range of urbanization areas in Ulsan. This study limited the scope to urbanization areas due to the following reasons: first, inundation damage in urbanization areas has strong man-made characteristics due to increases in impervious area resulting from high-density development and the existence of artificially formed underground space, and as such they tend to suffer huge damage during localized heavy rains (Shin, S. Y. et al., 2011); second, most declining areas are designated within urbanization areas[5]; third, it is difficult to examine sales changes in non-urbanization areas as their daily sales occurrence frequency is low.

1) Urban declining areas and general areas

In this study, census output areas are divided into urban declining areas and general areas. Among 61 areas that were designated for urban regeneration and revitalization in the Report on Changes for Strategic Plans for 2025 Urban Regeneration for Ulsan Metropolitan City, this study considered 51 declining areas located with urbanization areas. Urban regeneration revitalization areas refer to more than two areas that satisfy the indicators of decline diagnosis (demographic change, changes in the number of businesses,
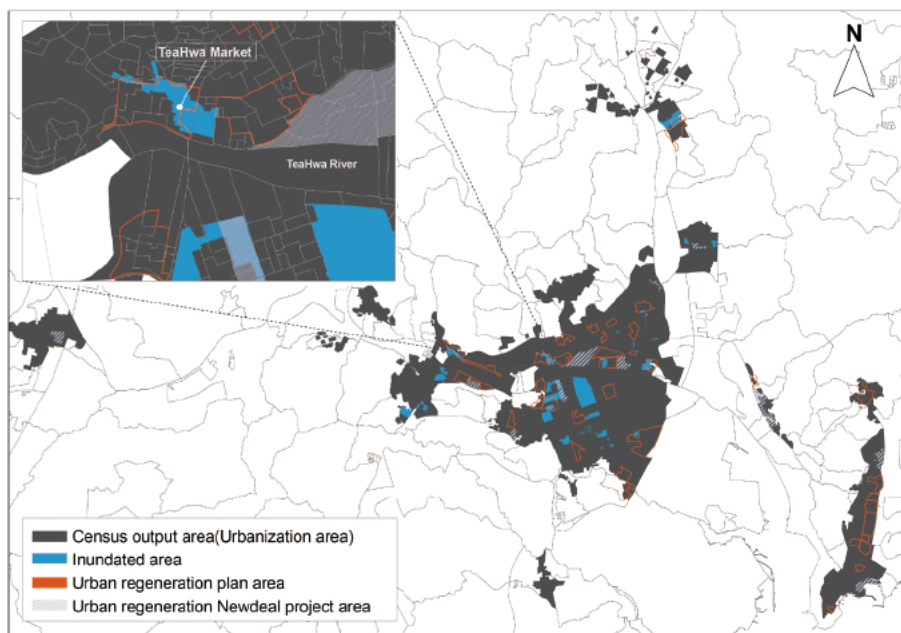

Figure 1. Study area (Ulsan Metropolitan City)

rates of deteriorated buildings) under Articles 13 and 17 of the Enforcement Degree of the Special Act on Promotion of and Support for Urban Regeneration, exclusive of development restricted areas, and that are divided into five business types.

Urban regeneration revitalization areas and urban regeneration new deal project areas, which are urban declining areas, do not match census output areas perfectly. This is because zones for urban regeneration projects are limited to within recommended areas for different business types. Due to this reason, this study considered a census output area that lies on the boundary of a project zone as an urban declining area. Therefore, this study had urban regeneration revitalization areas and census output areas overlap using Arc GIS10, and considered the overlapped census output areas as census output areas $(N = 244)$, and other areas as general areas $(N = 1,475)$ for analysis.

2. Data for Analysis

Table 1 shows the variables that are considered in this

Table 1. List of 15 indicator variables

|		Variables [Code]	Justification	Data source
Dependent variable		Rate of sales change in living business [RSalesChange]	Log(((sales on 5 October, 2016/ daily average sales on weekday-1)*100)+101)	Hyundai card sales data (2015.09-11, 2016.09-11)
Sensitivity	Social characteristics	Percent of declining area [DeclineA_rate]	Declining area/ Census output area*100	Urban regeneration strategic plan to change plan in Ulsan metropolitan in 2025 (2019)
		Percent population over 65 [PopOv65]	Number of population over 65/ total population*100	SGIS (2016)
		Percent population under 5 [PopUn5]	Number of population over 65/ total population*100	
		Percent of houses over 30 year [HouOv30]	Number of houses 65/ total houses*100	
	Physical characteristics	Average of land elevation [AveElv]	Average (DEM)	National Spatial Data Infrastructure Portal (2015)
		Distance to Nearest riverside from census output area center [DistRiver]	–	EGIS (2019)
Exposure variables	Inundated vulnerable area	Percent of inundated area covered by typhoon Cha-ba [Chaba_ID]	Inundated area/ Census output area*100	DATA.GO.KR (2019, 2020)
		Inundated depth of output census area covered by typhoon Cha-ba [Chaba_IA]	Average (Flooded depth)	
Capacity variables	Physical strength	Number of Evacuation facility in 400m radius from census output area center [FEvac]		
		Percent of green and open space [Green]	Green&Open space area/ Census output area*100	EGIS (2019)
Control variables		Number of living businesses [Lbusi]	living businesses: food, retail, Wholesale/ distribution, living service,	LOCALDATA (2016)
		Percent of census output area land use categorized as detached housing area [Resi1]	Detached housing area/ Census output area*100	EGIS (2019)
		Percent of census output area land use categorized as APT and multiple housing area [Resi2]	APT&Multiple housing area/ Census output area*100	
		Percent of census output area land use categorized as commercial area [Com]	Commercial area/ Census output area*100	

study and how they were calculated. For the dependent variables, sales data were used, while sensitivity, exposure, and adaptive capacity were established for the independent variables. The data obtained this way were re-processed based on the census output area unit to be used for this study's analysis.

1) Sales data and selection of living businesses

Sales data[6] used in this study were estimated using sales data from Hyundai Card, which were divided into small-scale spatial units. Sales data are provided in the small-scale unit because if sales data of different business sectors are provided, it may be possible to identify the sales amount of a particular store. Because small-scale spatial units are formed based on the 2016 census output area codes, the sum of the census output areas was calculated.

In order to compare the difference in the severity of damage from typhoons and inundation inflicted on different areas and to analyze factors of inundation vulnerability that affect the severity of damage, this study calculated the rate of sales change and considered it as a dependent variable in multiple regression analysis. To that end, daily sales data from September to November 2015, and from September to November 2016 were used. To see the trends in sales before and after typhoon and inundation damage, October 2016 - the month when inundation damage occurred due to Typhoon Chaba on October 5, 2016 - was set as the basis, and the preceding and suceeding months were considered. In addition, to discover sales at general times based on actual sales amount, daily sales data for 2015 were also considered. A time series comparison was performed on these trends found that changes in sales due to the typhoon and inundation damage in Ulsan showed a tendency to recover to the previous level within 1 to 2 days (Figure. 2).

Daily average sales were calculated to examine an area's general sales. In particular, sales on weekends and holidays when sharp changes in sales are more likely to occur compared to weekdays were excluded. This is because irregular activities such as recreation activities and shopping mainly happen on weekends and holidays rather than on weekdays, which affect sales of a particular area. As such, the daily sales from September to November of 2015 and of 2016 were averaged, and the average daily sales was subtracted from the sales on the day of Typhoon Chaba to calculate the rate of
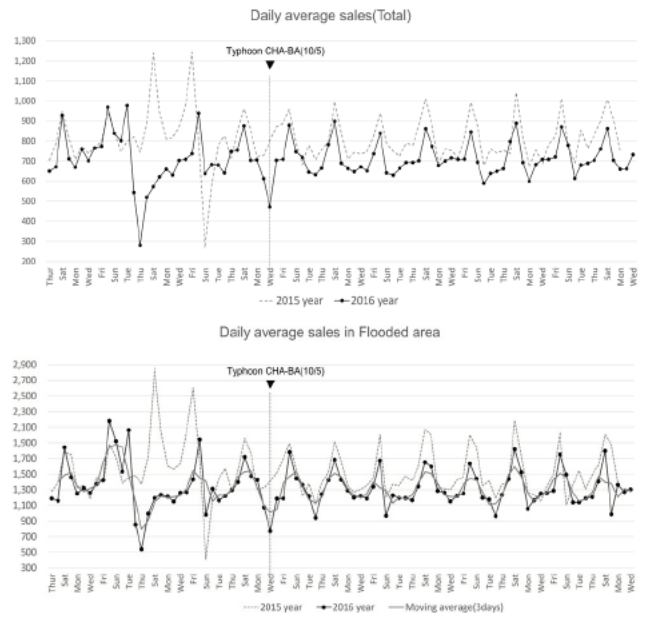
Figure 2. Time series of daily average sales in total census output area (up) and flooded area (down)

sales change.

Sales data include 17 business categories - tourism/leisure, transportation, finance, wholesale/distribution, real estate, retail, accommodation, sports, food, medicine, manufacturing, living services, etc. This study considered sales of 1) wholesale/distribution, 2) retail, 3) food, and 4) living services which are closely related to everyday living, to better understand declining characteristics, location variability, as well as formation of business districts. Furthermore, as the national business survey provided by the National Statistic Office offers information on living businesses in our communities, only the aforementioned four types of businesses were considered to calculate daily sales per each census output area. However, it is difficult to regard this as accurate sales data because the data do not reflect cash sales or sales though specific apps.

2) Factors of inundation vulnerability

This study considered variables that explain factors of inundation vulnerability in order to examine if urban declining areas are more vulnerable to inundation and if sales in these areas are affected more when a typhoon/heavy rain occurs. The data compiled were divided into (1) physical/social vulnerability characteristics (sensitivity), (2) areas vulnerable to inundation (exposure), and (3) physical strength (adaptive capacity), while land use and land cover (hereinafter, "LULC") characteristics and the number of

living businesses were considered as control variables.

For physical and social characteristics, the area of urban decline areas, the population aged 65 or over (hereinafter, "the 65-and-older population"), population aged 5 or younger (hereinafter, "the 5-and-younger population"), and the number of houses older than 30 years were obtained from the census output area data provided by the statistical geographical information service (SGIS), while the average land elevation of each census output area and the distance from the riverside to the center of each census output area were calculated by using ArcGIS 10.0 based on DEM data and LULC data provided by the National Spatial Infrastructure Portal. The area ratio of urban declining areas was calculated against the area of census output areas overlapping with the 51 areas designated for urban regeneration revitalization. In the multiple regression analysis, dummy variables (urban declining area＝1, general area＝0) were considered to analyze impact on sales depending on the existence of urban declining areas. For areas vulnerable to inundation, inundation trace map GIS data available on the Public Data Portal (2018) were used as a basis to calculate the inundation area ratio and average inundation depth as a result of Typhoon Chaba in 2016. For physical capacity, the area ratio of green and open space against census output areas was calculated using LULC GIS data provided by the National Spatial Infrastructure Portal. Moreover, by using evacuation facility location data (2019), the number of evacuation facilities located within a 400 m radius from the center of a census output area was calculated.

Since sales are influenced by location factors, LULC characteristics and the number of living businesses were used to control such factors. For LULC characteristics, the ratios of detached housing areas, multiple housing areas and commercial areas against the area of census output areas were calculated for use. Location data of business opening and closing provided by LOCAL DATA (2016) were used for the number of living businesses, and any business that had closed were excluded.

3. Analysis Method

This study was performed in three stages - comparison of daily time series changes, analysis of correlation, and multiple regression analysis. The comparison of daily time series changes involved sales patterns in Ulsan's urban areas and changes in sales of each area inundated due to Typhoon Chaba. To compare increases and decreases in sales between flooded areas, they were standardized as Min-Max, as different areas generated different sales amounts. Then, the correlation between flooded areas and factors of inundation vulnerability was analyzed by separating urban declining areas from general areas. Multiple regression analysis was performed to analyze how factors of inundation vulnerability affected changes in sales. R-studio was used to draw results from the correlation analysis and multiple regression analysis.

1) Correlation analysis

The correlation analysis mainly dealt with the correlation between factors of inundation vulnerability and flooded areas, and compared urban declining areas with general areas. Prior to this, basic statistical analysis was performed to obtain statistical data from flooded areas and non-flooded areas, as well as urban declining areas and general areas within flooded areas to compare factors of vulnerability. For quantification, this study used the Pearson correlation coefficient, which explains the degree of linear correlation between two variables. If the Pearson correlation coefficient is a positive (+) value, it means that there is a correlation between the two variables where an increase in the value of one variable leads to an increase in the value of the other variable.

2) Multiple regression analysis

The multiple regression analysis was performed with two models. Model 1 explains the impact urban declining areas and factors of inundation vulnerability have on changes in sales on the day of typhoon and inundation occurrence. In Model 2, a multiple regression analysis was performed only on flooded areas to demonstrate that urban declining areas are more vulnerable to inundation than general areas. Equation (1) is the multiple regression analysis model used in this study:

$$G_i = \beta_0 + \beta_1 DeclineA_i + \beta_2 PopOv65_i + \beta_3 HouOv30_i \quad (1)$$
$$+ \beta_4 AveElv_i + \beta_5 DistRiver + \beta_6 ChabaFD_i$$
$$+ \beta_7 Green_i + \beta_8 FEvac_i + f(control\ factors) + \epsilon_i$$

C_i: Rate of sales change

$DeclineA_i$: Percentage of urban declining areas

$PopOv65_i$: The 65-and-older population

$HouOv30_i$: The number of houses older than 30 years

$AveEle_i$: Elevation, $DistRiver_i$: Distance from the river

$ChabaFD_i$: Average flooded depth

$Green_i$: The ratio of green area,

$FEvac_i$: The number of evacuation facilities within a 400 m radius

$f(control factors)$: Lbusi (the number of living businesses), Resi1, Resi2, Com (detached housing, multiple housing, commercial), Sales-Vari (sales increase or decrease)

ϵ_i: Error term

This model excluded the 5-and-younger population and inundation areas that showed a high correlation among certain variables in Table 3. The rate of sales change, considered as a dependent variable, used variables of a total of 1,170 census output areas by using box-plot, exclusive of outliers and cases where sales remained 0 for over 30 days out of 122 days. The rate of sales change is represented as a positive or a negative value, and is obtained by adding 101 to the minimum value and taking the log. As all values of the dependent variable turn positive, the model is completed by adding sales increase areas ($=0$) and sales decrease areas ($=1$) as

Table 2. Descriptive statistics

Variables (n=1,719)		Non-flooded area (n=1,525)								Flooded area (n=194)							
		Urban declining area (n=192)				General area (n=1,333)				Urban declining area (n=52)				General area (n=142)			
		Mean	Min.	Max.	S.D.	Mean	Min.	Max.	S.D.	Mean	Min.	Max.	S.D.	Mean	Min.	Max.	S.D.
	RSales Change (%)	-25.3	-100.0	760.1	72.9	-17.8	-100.0	782.4	53.9	-53.7	-94.7	6.4	21.7	-36.6	-100.0	69.2	35.0
Social characteristics	DeclineA_ rate (%)	68.8	15.1	100.0	27.2	0.0	0.0	0.0	0.0	66.8	18.0	100.0	26.3	0.0	0.0	0.0	0.0
	PopOv65 (%)	13.2	1.9	35.4	5.3	6.5	0.0	31.1	5.6	16.0	6.4	27.0	4.5	11.1	0.0	25.7	5.7
	PopUn5 (%)	3.3	0.0	9.5	1.6	5.7	0.0	18.6	3.2	2.7	0.0	6.0	1.2	3.6	0.0	17.9	2.8
Physical characteristics	HouOv30 (%)	12.3	0.0	76.6	17.8	2.4	0.0	100.0	9.5	13.9	0.0	59.7	15.0	6.8	0.0	61.3	12.8
	AveElv (m)	25.4	1.5	161.4	22.6	30.4	0.8	290.4	32.1	17.8	1.3	155.8	24.1	16.9	1.4	148.9	20.7
	DistRiver (m)	1353.3	36.4	3260.7	983.7	972.1	0.0	6262.4	897.0	405.1	0.0	896.0	244.5	532.3	0.0	6346.1	776.8
Inundated vulnerable area	Chaba_ID (m)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.6	0.3	1.9	0.3	0.5	0.3	2.0	0.2
	Chaba_IA (%)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	29.7	0.0	100.0	32.9	19.8	0.0	100.0	24.7
Physical strength	Green (%)	8.8	0.0	56.1	10.2	17.7	0.0	89.5	14.9	8.1	0.0	48.2	9.9	11.9	0.0	75.2	14.4
	FEvac (Num.)	5.5	0.0	39.0	6.2	5.4	0.0	42.0	6.8	11.9	0.0	39.0	9.9	7.5	0.0	39.0	6.9
Control variables	Lbusi (Num.)	15.1	0.0	137.0	17.8	4.6	0.0	153.0	11.2	14.8	0.0	78.0	13.9	13.2	0.0	100.0	17.4
	Resi1 (%)	22.0	0.0	71.7	16.1	4.9	0.0	63.0	11.0	25.1	0.0	56.3	14.3	13.6	0.0	62.6	14.1
	Resi2 (%)	6.9	0.0	43.0	7.2	14.6	0.0	74.7	8.8	4.2	0.0	30.9	4.6	7.2	0.0	48.2	6.5
	Com (%)	16.6	0.0	60.2	11.6	5.6	0.0	55.1	8.7	19.9	2.2	55.0	11.9	15.0	0.0	68.4	11.8

Table 3. Result of correlation analysis

	①	②	③	④	⑤	⑥	⑦	⑧	⑨	⑩	⑪	⑫	⑬	⑭
RSales Change	1													
Chaba_IA	-0.38**	1												
Chaba_ID	-0.44***	0.83***	1											
DeclineA_rate	-0.36*	0.32***	0.37***	1										
PopOv65	-0.45***	0.42***	0.52***	0.74***	1									
PopUn5	0.37***	-0.47***	-0.56***	-0.69***	-0.92***	1								
HouOv30	-0.41***	0.29***	0.38***	0.64***	0.87***	-0.76***	1							
DRiver	0.20***	-0.45***	-0.53***	-0.18***	-0.39**	0.49***	-0.35	1						
AveElv	0.06	-0.33**	-0.37***	-0.30**	-0.30**	0.22*	-0.28*	0.04	1					
Green	0.25*	-0.43***	-0.40***	-0.59***	-0.60*	0.56***	-0.46***	0.12	0.23**	1				
FEvac	0.08**	-0.20	-0.17	-0.16	-0.16*	0.20**	-0.20	0.55***	-0.21**	-0.10***	1			
resi1	-0.39***	0.46***	0.49***	0.80***	0.89**	-0.82***	0.79***	-0.30	-0.29*	-0.65***	-0.25**	1		
resi2	0.36***	-0.44***	-0.55***	-0.66***	-0.77***	0.69***	-0.71***	0.35***	0.23**	0.27**	0.33***	-0.80***	1	
com	-0.43***	0.53***	0.59***	0.73***	0.82***	-0.81***	0.66***	-0.34*	-0.33***	-0.71***	-0.16	0.80***	-0.77***	1

***<0.001, **<0.01, *<0.05

dummy variables to reflect damage characteristics. For Model 2, as the scope was already limited to flooded areas, the multiple regression analysis was performed by excluding control variables.

Ⅳ. Analysis Results

1. Descriptive Statistical Analysis Results

Descriptive statistical analysis was performed between urban declining areas and general areas depending on occurrence of inundation to see if the former has additional factors that make them more vulnerable to inundation compared to the latter (Table 2).

As for the average value of the rate of sales change, which is a dependent variable, among non-flooded areas, the rate was -25.3% for urban declining areas and -17.8% for general areas, while among flooded areas, the rate was -53.7% for urban declining areas and -36.6% for general areas. Regardless of whether or not inundation occurred on the day of the typhoon, the overall daily average sales decreased, and the rates of decrease were 28.4% and 18.8% more in urban declining areas and general areas within flooded areas, respectively, than those within non-flooded areas. This dif-

ference seems to have been caused by the inundation depth and the inundation area. While the inundation depth and the inundation area for urban declining areas were 0.6 m and 29.7% on average, respectively, they were 0.5 m and 19.8% on average, respectively, for general areas.

As for physical characteristics, in urban declining areas within non-flooded areas, the number of houses older than 30 years accounted for 12.3%, its average land elevation was 25.4 m, and the distance from the riverside was 1353.3 m, while in general areas, they were 6.8%, 30.4 m, and 972.1 m, respectively. On the contrary, in urban declining areas within flooded areas, the number of houses older than 30 years accounted for 13.9%, its average land elevation was 17.8 m, and the distance from the riverside was 405.1 m, while in general areas, they were 6.8%, 16.9 m, and 523.3 m, respectively. In other words, these figures show that the physical environment of urban declining areas is under conditions that are relatively more prone to inundation damage. However, it seems that geographical factors such as the distance from the riverside or the average land elevation greatly influence the occurrence of inundation.

For demographic and social characteristics, the average area ratio of urban declining areas was 68.8% in non-flooded areas, while it was 66.8% in flooded areas. Irrespective of

inundation occurrence, the average values for the 65-and-older population in urban declining areas were 13.2% and 16.0%, respectively, while they were 6.5% in non-flooded areas in general areas and 11.1% in flooded areas, approaching the level of urban declining areas. In urban declining areas and general areas in non-flooded areas, the average values for the 5-and-younger population were 3.3% and 6.5%, respectively, while they were 2.7% and 3.6%, respectively, in flooded areas.

Irrespective of inundation occurrence, as for physical capacity characteristics, urban declining areas showed a lower ratio of green space than general areas, but surprisingly, urban declining areas had a larger number of evacuation facilities. The average ratio of green space for urban declining areas was 8.8% and 8.1%, respectively, and the average number of evacuation facilities within a 400 m radius was 5.5 and 11.9, respectively. Meanwhile, the average ratio of green space for general areas was 17.7% and 11.9%, respectively, and the average number of evacuation facilities within a 400 m radius was 5.4 and 7.5, respectively. urban declining areas had the largest number of evacuation facilities within a 400 m radius, and this is presumably because there are apartment complexes in the vicinity and each apartment building is designated as an evacuation facility.

As for the average number of living businesses, urban declining areas and general areas among non-flooded areas had 15.1 and 4.6 businesses, respectively, while urban declining areas and general areas among flooded areas had 14.8 and 13.2 businesses, respectively. This indicates that there are more living businesses in flooded areas and that urban declining areas had relatively more living businesses. Lastly, as for LULC characteristics, urban declining areas of non-flooded areas had 22.0% of detached housing, 6.9% of multiple housing, and 16.6% of commercial area on average, while general areas had 4.9% of detached housing, 14.6% of multiple housing, and 5.6% of commercial area on average. urban declining areas of flooded areas had 25.1% of detached housing, 4.2% of multiple housing, and 19.9% of commercial areas, while general areas had 13.6% of detached housing, 7.2% of multiple housing, and 15.0% of commercial areas on average.

2. Analysis Results of Correlation between Sales Changes, Urban Declining Areas and Factors of Inundation Vulnerability

Table 3 shows results of the analysis that examined to which degree the rate of sales change as the dependent variable is related to factors of inundation vulnerability, and the correlation between urban declining areas and factors of inundation vulnerability.

The analysis of the correlation between changes in sales and factors of inundation vulnerability found that the rate of sales change had negative (–) correlations with the area ratio of inundation, inundation depth, the area ratio of declining areas, and the rates of the 65-and-older population, houses older than 30 years, detached housing areas, and of commercial areas. These can be considered factors of inundation vulnerability that affect sales decreases. On the contrary, the rate of sales change had positive (+) correlations with the 5-and-younger population, distance from the nearest riverside, average land elevation, ratio of green areas, the number of evacuation facilities, and the ratio of multiple housing areas. Among these, the average land elevation and the number of evacuation facilities were found to have very weak correlation. However, as for the relationship between the inundation area and influence variables, the average land elevation and the number of evacuation facilities were found to decrease inundation damage by -0.33 and -0.20, respectively.

The analysis of the correlation between urban declining areas and factors of inundation vulnerability found that the area ratio of declining areas had positive (+) correlations with the inundation area and inundated depth, and positive (+) correlations with the rates of the 65-and-older population, houses older than years, detached housing areas, and of commercial areas. On the contrary, it had negative (–) correlations with the 5-and-younger population, distance from the nearest riverside, average land elevation, ratio of green areas, the number of evacuation facilities, and the ratio of multiple housing areas. This suggests that influence variables related to urban declining areas are related to variables that are major causes of inundation damage.

3. Results of Multiple Regression Analysis

Table 4 shows results of the multiple regression analysis

Table 4. Result of Multiple regression model

Variables		Model 1					Model 2				
		Coef.	Std.	t	Pr > |t|	VIF	Coef.	Std.	t	Pr > |t|	VIF
Intercept		10.92	0.196	55.60	***		8.672	0.453	19.13	***	
Social characteristics	DeclineA (dummy)	-0.308	0.137	-2.24	*	1.28	-0.684	0.264	-2.59	*	1.22
	PopOv65 (%)	-0.016	0.011	-1.46	0.14	2.10	-0.001	0.028	-0.04	0.97	1.64
Physical characteristics	HouOv30 (%)	-0.007	0.005	-1.54	0.12	1.54	-0.013	0.010	-1.32	0.19	1.54
	AveElv (m)	0.000	0.002	0.04	0.97	1.07	0.005	0.006	0.89	0.38	1.16
	DRiver (m)	0.000	0.000	3.78	***	1.32	0.000	0.000	2.06	*	1.03
Inundated vulnerable area	Chaba_ID (m)	-0.665	0.262	-2.54	**	1.20	-2.779	0.523	-5.32	***	1.05
Physical strength	Green (%)	0.005	0.004	1.45	0.15	1.10	0.000	0.022	0.00	0.99	1.04
	FEvac (number)	-0.002	0.008	-0.23	0.82	1.25	-0.087	0.168	-0.52	0.60	1.05
Control variables	LBusi (Number)	-0.002	0.003	-0.63	0.53	1.04					
	Resi1 (%)	-0.009	0.004	-2.23	*	1.64			–		
	Resi2 (%)	-0.004	0.007	-0.60	0.55	1.42					
	Com (%)	0.012	0.005	2.35	*	1.41					
	SalesVari	-3.451	0.123	-28.08	***	1.06					
R-squrared				0.4628					0.1695		

*** < 0.001, ** < 0.01, * < 0.05

that used Model 1 to explain the impact urban declining areas and factors of inundation vulnerability have on changes in sales, and Model 2 to evaluate how vulnerable urban declining areas are to inundation compared to general areas. Their model explanatory power was 46.3% and 17.0%, respectively, and the VIF outcomes were all under 10, showing no multicollinearity.

When the LULC characteristics and the number of living businesses are controlled, urban declining areas in Model 1 were found to influence decreases in sales following inundation more than general areas. However, the 65-and-older population and houses older than 30 years, which are sensitive factors that have high relevance to urban declining areas, were found to be statistically insignificant. **Distance from the nearest riverside**, however, showed a positive (+) relationship to sales changes, and the farther the area was from the nearest riverside, the smaller the decrease in sales became. **Inundation depth** was found to be the factor that affects sales decreases following inundation the most. Inundation depth showed a negative (–) relationship to sales, and the greater inundation depth was, the bigger the decreases in sales became. The ratio of green area showed a

positive (+) relationship to sales change, while the number of evacuation facilities within a 400 m radius showed a negative (–) relationship to sales change. It was believed that an area with a bigger ratio of green space and a bigger number of evacuation facilities, both representing physical strength, would have smaller deceases in sales, but they did not have statistical influence.

The ratios of detached housing and commercial areas, considered as control variables, were found to have statistical significance. Among the LULC characteristics, the ratios of detached housing and multiple housing showed a negative (–) relationship, and the higher the ratio of detached housing areas was, the bigger the decreases in sales became. The ratio of commercial areas, on the contrary, showed a positive (+) relationship to the sales change. While the number of living businesses showed a negative (–) relationship, it was not statistically significant.

Compared to the outcomes of Model 1, Model 2 had an explanatory power of 17.0%, and urban declining areas were found to be more sensitive to inundation damage than general areas. Although the statistical explanatory power is low, it can be interpreted that urban declining areas showed

greater decreases in sales due to inundation than general areas, and thus are more vulnerable to inundation. In Model 2, the distance from the nearest riverside and inundation depth were found to be the factors of inundation vulnerability that affected sales change.

V. Discussions

This study performed an empirical analysis to see if urban declining areas with greater physical and social vulnerability factors are more vulnerable to typhoons and inundation damage by using daily sales data. Although urban declining areas are related to factors of disaster vulnerability, urban regeneration revitalization plans have been implemented without consideration of such vulnerability. Moreover, urban declining areas, due to their weakened economic foundation, are likely to react relatively sensitively to inundation damage. As such, this study analyzed the impact the factors of inundation vulnerability have on sales changes and inundation vulnerability of urban declining areas using multiple regression analysis models, involving urbanization areas in Ulsan Metropolitan City that suffered severe damage from Typhoon Chaba on October 5, 2016. From this, the study aimed to shed light on the need for disaster response at the level of urban regeneration projects in order to reduce damage on urban declining areas that are vulnerable to inundation.

Urban declining areas in this study were found to have more sensitive factors to inundation. Declining areas that were examined in this study are urban regeneration revitalization areas and urban regeneration new deal project areas that were designated by local governments based on such indicators as population, businesses, and building characteristics as specified in the Special Act on Promotion of and Support for Urban Regeneration. Such declining areas are often characterized by deteriorated physical environment and a relatively higher proportion of vulnerable groups. This means that the correlation between factors related to inundation damage and sensitivity was found to be not greatly different from the findings of previous studies (Yeo, C.G. et al., 2011; Park, C.Y. et al., 2013; Seo, J.S. and Han, W.S., 2019). However, not all urban declining areas experienced inundation. As shown in Table 2, there are urban declining areas and general areas even among flooded areas, and they often

have lower average land elevation and are closer to the riverside compared to non-flooded areas. The distance from the nearest riverside, in particular, was found to be a major variable that affects sales change. While it is unclear if the ratio of green space as a factor of physical strength affects sales change directly, it is a major factor that reduces inundation vulnerability by raising water permeability, and thus, the different ratios of green space between urban declining areas and general areas are believed to be associated with the severity of inundation damage. Therefore, urban declining areas will need a plan to prepare for inundation in consideration of river overflows due to heavy rains and geographical location.

urban declining areas showed bigger decreases in sales due to inundation compared to general areas. Regardless of inundation, urban declining areas showed bigger decreases in sales on average compared to general areas (see Table 2). Furthermore, it was found that in urban declining areas, the distance from the nearest riverside and inundation depth influenced deceases in sales due to inundation damage. This is attributable to the fact that urban declining areas react more dramatically to external impact such as a disaster, in addition to deteriorated residential environments and declining local economy (Ko, D., 2015; Park, K.A. et al., 2018). However, while it is unclear in this study if higher rates of the 65-and-older population and detached houses older than 30 years affect decreases in sales more, they were found to be related to sales decreases. The fact that greater sales decreases are found in urban declining areas may be attributable to their environmental characteristics - that is, these areas have relatively higher ratios of detached housing but this is seemingly because living businesses are mixed in residential areas. Commercial and business areas, on the contrary, were found to influence increases in sales as large-scale distributors and companies are located in those areas.

Inundation depth was found to be a major factor that affect sales change. In general, inundation area was often considered when assessing inundation vulnerability. However, recession time is important when considering impact on local economy. The greater inundation depth is, the longer recession time gets, and as such, this has critical impact on sales decreases due to such damage as inventory loss and business interruption. It seems that greater inundation depth is associated with its proximity to a river, lower land

elevation, higher rates of detached housing and commercial areas, and lack of green space. In this study, the inundation depth of flooded areas was 0.5-0.6 m on average, and the daily sales tended to recover the pre-disaster level after 1 to 2 days. This is attributable to quick drainage after inundation or support provided from local governments in the form of emergency recovery efforts.

However, inundation damage can last long-term, and the area surrounding Taehwa Market that suffered the most damage recorded inundation depth of 1.2 m on average and maximum 1.9 m. Unlike other areas, Taehwa Market and its vicinity exhibited long-term inundation damage (Figure. 3). This particular area is planned as an urban regeneration revitalization area (general neighborhood type) and is in the vicinity of the river, but it has a less elevated topography than surrounding areas, which makes it easy for water to stay in. It is a severely deprived area with a higher rate of living businesses, where detached housing and deteriorated buildings account for 62.3% and 91.9%, respectively. In the wake of Typhoon Chaba on October 5, 2016, the community surrounding Taehwa Market recorded a decline in sales and and it took around 15 to 20 days for the sales to rebound to the pre-Chaba level. The temporary surge in sales after inundation damage is believed to be a result of emergency recovery efforts to which a large scale of personnel and equipment were committed.

This study has the following limitations. Firstly, the data for sales have great variability as they are based on Hyundai Card's sales data, which were totaled by including estimated sales in cash. Moreover, it is possible that the damage in residential areas is underestimated. Secondly, the study focused only on short-term damage for its analysis, despite the possibility that inundation damage may last over the long run. Lastly, despite the fact that sales loss can be caused not just by physical characteristics but also by various factors including company size and business type, the study only considered a limited number of variables. Not withstanding these limitations, this study is significant in that it focused on the scale of urban regeneration projects to illuminate the correlation with factors of inundation vulnerability in urban declining areas, while using daily average sales data to empirically demonstrate that inundation inflicts greater damage to urban declining areas. Although this study could not analyze long-term damage of inundation and level of recovery from it due to limitations in data, future studies will need to assess urban resilience from a disaster by considering differences in physical and social capacity.

VI. Conclusion

This study is meaningful in the sense that it performed an empirical analysis to verify if urban declining areas are vulnerable to actual inundation by using daily average sales data, and that it identified the need for disaster response in the existing urban regeneration projects. Major findings of this study can be summarized as follows. First of all, urban
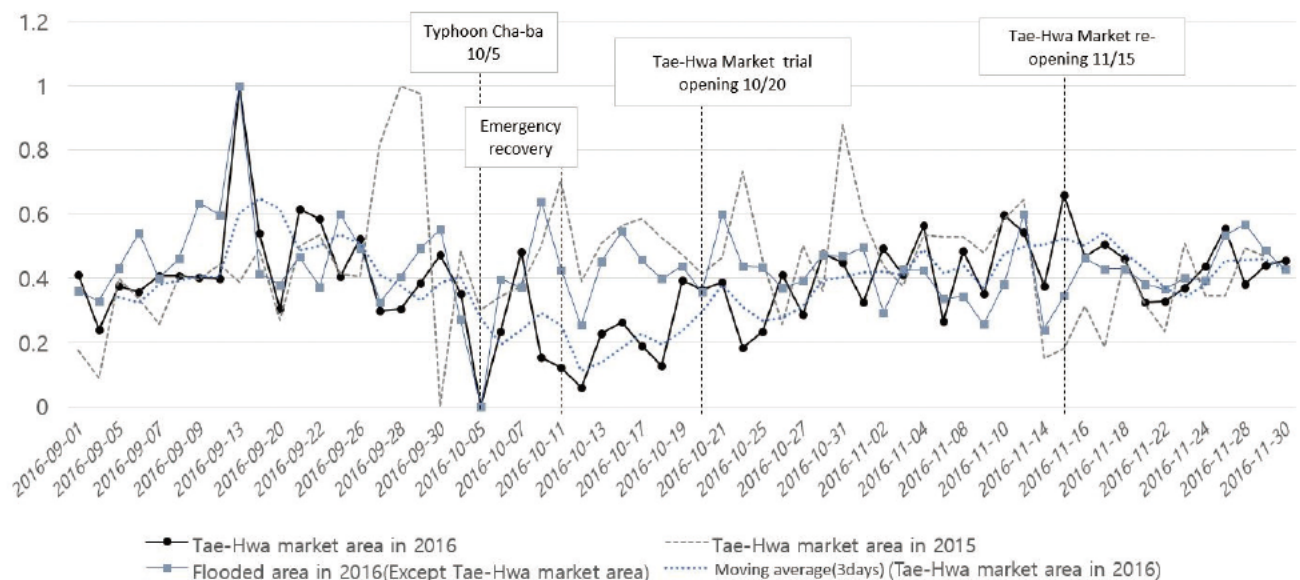

Figure 3. Daily change of normalized sales in Tae-Hwa Market area (Sep. to Nov. in 2015 and 2016)

declining areas have more factors that are sensitive to inundation. Secondly, among flooded areas, urban declining areas saw greater decreases in sales than general areas. However, additional research is needed for the sales data to serve as an absolute indicator that can be used to validate inundation vulnerability. Lastly, inundation depth was a major factor that influenced changes in sales.

To respond to inundation, this study proposes urban regeneration measures that take the characteristics of declining areas into consideration as follows. First, an institutional framework must be put in place in order to reflect disaster vulnerability analysis when establishing strategic plans for urban regeneration to respond better to inundation. Because Korea's declining areas react more severely to inundation damage, the National Land Planning and Utilization Act (2012) was amended to include a Comprehensive Plan for Storm and Flood Damage Reduction in basic urban planning for urban regeneration by local governments. As a result, disaster vulnerability analysis in consideration of climate change became mandatory in all basic urban planning established and modified from July 2012. However, at the current stage of strategic planning of urban regeneration, little consideration is given to an institutional basis for disaster vulnerability analysis that takes spatial characteristics of urban declining areas into account, and the criteria for applying it to the scale of urban regeneration projects are insufficient. Second, urban regeneration revitalization plans must include a survey on geographical locations and risk factors of urban declining areas, as well as urban planning measures suitable for urban declining areas to reduce inundation depth. Last, an institutional support system is needed to strengthen coherency among retail businesses in urban declining areas against disaster damage. While urban regeneration projects are being implemented in various forms including community companies to revitalize the regional economy on decline, damage from an unforeseen disaster may lead to another recession in the region. Therefore, it is necessary to consider developing support measures in the form of storm and flood insurance, or funding such measures partially.

Note 1. Pursuant to Article 35 of the Special Act on Promotion of and Support for Urban Regeneration, an institutional system related to disaster in urban regeneration projects currently is very limited, and it involves special regeneration areas which are designated based on their need for support after suffering large scale damage from a disaster. The Minister of Land, Infrastructure and Transport may designate an area in which large scale damage caused by a disaster, the amount of which is more than that prescribed and publicly notified by the Minister of Land, Infrastructure and Transport has occurred from among the areas proclaimed to be special disaster areas under the Framework Act on the Management of Disasters and Safety, as a special regeneration area at the request of a developer of a strategic plan.

Note 2. Vulnerability is a term that is used to explain a person or an asset that is relatively more prone to suffer damage from danger (Anderson, 1995). The generally defined concept of vulnerability is an outcome of the relationship between potential impact (sensitivity, exposure to climate) suggested by IPCC and adaptive capacity (McCarthy et al., 2001). In other words, assessment of vulnerability in consideration of adaptive capacity enables a comprehensive assessment of vulnerability to climate change by reflecting a region's response level, which can encourage establishment of measures at the national and local government levels to reduce vulnerability.

Note 3. Pursuant to Article 21 of the Countermeasures against Natural Disasters Act, traces of flooding, inundation, and other damage shall be investigated to prepare and manage inundation trace maps (flood maps). The Land and Geospatial Infomatrix Corporation of Korea compiled inundation trace maps, surveyed and prepared by local governments, to establish an inundation trace management system and offers inundation trace map information by year and region.

Note 4. Small business owners are categorized by business size, and in general they maintain a small business to make a living. Restaurant and retail businesses account for over 50% of the entire small businesses (Weon, J.H. and Jung, D.H., 2017).

Note 5. As of the end of December 2019, the number of areas designated for urban regeneration projects is 311, and of these, the number of project areas that include urban areas and declining areas stand at 307 (Kim, J.Y. et al., 2020).

Note 6. For sales data, the sales data from SKT-affiliated credit card companies are collected through VAN and POS companies to generate raw data for the entire consumption sales with cash payment compensated. Sales data of each affiliated store from the raw data generated this way involve private information, but when de-identification is performed through encrypted ID, it is difficult to extract characteristics information. As such, de-identification through spatial clustering allows external supply and even after spatial clustering, clustering of less than 3 stores is removed as it is classified as personally-identifying information.

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