Spatial Analysis of Flood Risk: A Case Study of Katsushika Ward, Tokyo

May 2019

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A Dissertation Submitted to

the Graduate School of Life and Environmental Sciences,

the University of Tsukuba

in Partial Fulfillment of the Requirements

for the Degree of Doctor of Philosophy in Science

(Doctoral Program in Geoenvironmental Sciences)

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Abstract

The proportion of human death caused by flood in Japan increased and the number per unit area has been rising every year. The reduction of local communities has been increasing due to the progression of an aging society and demographic change. At the same time, against the background of the rarefaction of disaster prevention awareness and the routinization of urban inhabitancy isolated from nature, there is a serious decline of local disaster prevention ability and social capital. Moreover, it is indicated that the human damage caused by extensive floods will tend to increase in the future due to the rise in heavy rainfalls as the result of climate change. The disaster risk map is an important basis for implementing flood risk management and reducing losses. However, disaster map is not perfect because of lacks any consideration of the weakness of local communities and their disaster prevention ability. Considering the above, in order to adapt to large-scale flood disasters, the author has assumed the worst-case situation and consider hazards, exposure, and vulnerability. In addition to deal with flood disasters by such means as cooperation and public assistance in the region, it is necessary to evaluate the flood risk on the human side at the small-area unit level and consider the problem-solving potential of using animal hospitals as medical institutions.

Accordingly, in this study, the author visualizes the flooding risk distribution and investigates its characteristic for each distribution level in Katsushika Ward, Tokyo, Japan using an indicator system for assessing risk from four perspectives, the information entropy method and AHP with GIS. The index system was constructed with 14 indicators: immersion depth, submersion duration, inundation population, number of inundated buildings, population aged 0–9 years, population over age 65, female population, number of one-story buildings, number of two-story buildings, population per household, ratio of males aged 15–59, kernel density of evacuation facilities, kernel density of a medical institution’s fields of practice, and kernel density of animal hospitals. The results of this study will help in understanding flood risk and taking countermeasures to reduce the flood damage.

This thesis consists of five chapters. Chapter 1 describes the background and motivation of this study, referring to the policy of disaster prevention, the importance of risk management in floods, and the necessity of synthesized risk analysis of floods from the angle of human susceptibility. The study's orientation, meaning, and constitution are expounded as well. Chapter 2 describes the theoretical study on the flood risk assessment model, research method, study area, system of indices, and data. In Chapter 3, the author

discusses each index of flood risk assessment, the distribution of flood risk, and the distribution factors. According to the flood risk distribution, the immersion area is 28.12 km^2, accounting for 80.7 percent of Katsushika Ward. Risk in this study shows the magnitude of risk in 5 levels from level 1 to level 5. The area ratios at level 1, level 2, level 3, level 4, and level 5 are 45.14 percent, 19.41 percent, 14.67 percent, 13.06 percent, and 7.72 percent respectively. The largest area is at level 1, then level 2, and level 3 is in third place. Looking at mesh distribution in the region, levels 1 and 2 are distributed more in the east. On the other hand, the western area has five levels in equilibrium; especially, levels 3, 4, and 5 are mainly distributed in north of the Nakagawa River. The inundated population is 40.03 million, accounting for 89.0 percent of the total population. Regarding the population by risk level, there are 149,100 people at level 1, 83,100 at level 2, 69,000 at level 3, 62, 200 at level 4, and 37,000 at level 5, with the respective population ratios of 37.24 percent, 20.76 percent, 17.23 percent, 15.53 percent, and 9.24 percent. The highest population is at level 1, then level 2, and level 3 is in third place. Of the total, 99,100 people are distributed at levels 4 and 5 with high flood risk level, accounting for 24.77 percent of the total inundated population. In Chapter 4, the author reviews the level of flood risk and the detailed flood risk situation of the area in reality, and the development situation for disaster prevention measures, followed by clarification of the characteristics of each level of flood risk. As well as verification of its prevention measures the shortcomings on it. Take the fifth level as an example. Level 5 is distributed mainly in Horikiri 1-3 chome; Yotsugi 1 chome and 3-4 chome; Yotsugi 1 chome; Higashiyotsugi 1 chome and 3-4 chome; Takaracho 1 chome; Tateishi 1 chome, 3-4 chome, 7 chome. What can be seen from the standardized value of each index at level 5 is as follows. According to the standardized values for each indicator by flood risk level, the indices that are higher than at other levels are immersion depth, submersion duration, inundation population, number of inundated buildings, number of two-story buildings, and ratio of males aged 15 to 59. The indices that are low than at other levels are kernel density of evacuation facilities and kernel density of a medical institution's fields of practice. According to the development of disaster prevention measures, it is necessary to strengthen the reduction of human vulnerability and the capacity for disaster-prevention of medical institutions. In Chapter 5, the author summarizes the results obtained and presents the conclusions from this study. Regarding the concept of flood risk, considering the hazard, exposure, and vulnerability, and taking into consideration of factors such as cooperation and public assistance in the region and the ability to respond using animal hospitals as potential medical institutions, the author clarified the spatial distribution of flood risk. Analysis of exposure and vulnerability was also considered from the aspects of both buildings and

population. To increase problem-solving ability, the author added new indices aimed at regional communities and medical collaboration, indicating that regional collaborative ability is progressing. The author's combined weight determination method, based on the index system, using both a typical subjective method (analytic hierarchy process) and a typical objective method (information entropy) to decide the weight of each index, is an improvement on previous weighting methods. The author was able to obtain information on the spatial distribution of flood risk. This will help policymakers to reduce flood disasters appropriately, especially with regard to evacuation plans and the number of deaths.

Keyword: flood risk, indicator system, geographic information systems, analytic hierarchy process, information entropy method, Katsushika Ward