論 文 の 内 容 の 要 旨

論文題目　Achieving resilience with urban agriculture in cities: Quantifying vegetable and nutritional self-sufficiency for food security during post-disaster situations in Tokyo, Japan

(都市農業によるレジリエンスの形成：　東京を事例とした災害時における食料安全供給のための蔬菜・栄養の自給率算定)

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Over half of the world population lives in urban areas and 60% of these areas are prone to natural disasters. When a disaster occurs, the distribution of food cannot be guaranteed. Conventionally, governments and households prepare rations and emergency food for short-term response (3 days). Such foods consist primarily of designed to provide energy. Most foods in the mid-term (several days to a few weeks) provided by international organizations consist of carbohydrates due to availability and ease of distribution. Previous studies show that the restoration of normal food distribution, in particular that of fresh food products, often takes time; and this has caused survivors to depend on emergency food much longer (several weeks, months, or years) than intended. Post-disaster dietary nutrition studies show that survivors lack several valuable nutrients in their diets causing non-specific health symptoms, gastrointestinal symptoms, and cardiovascular diseases. In search of other nutrient sources, FAO (2012) reported that urban agriculture (UA) is a potential source of dietary nutrition that can be utilized during emergencies. Namely, nutrients in fruits and vegetables help prevent the health issues described in post-disaster studies. The benefits of UA to social, environmental, psychological, and physical health on a day-to-day basis are widely expanded upon in literature. However, self-sufficiency studies are limited and mostly focus on annual food security in developing countries. Also, no study has assessed the contribution of mixed urban and agricultural land use patterns to resilience. Furthermore, no study estimates the availability of UA products throughout the year for their value during emergency events.

This study aims to quantify the potential of urban fruit and vegetable production and their dietary nutrition value for local use during emergencies. It is hypothesized that urban-rural mixed land-uses in cities increase disaster preparedness and resilience to large earthquakes by providing fresh fruits and vegetables as a source of dietary nutrition in addition to current carbohydrate-heavy emergency

foods.

The present research consists of five chapters with each is core focus linked to the research aim: 1) urban agriculture and its characteristics in Japan; 2) identifying farmlands by a spatial analysis, and the spatial distribution of self-sufficiency in the case study Tokyo; 3) estimating production and nutritional self-sufficiency across time in the case of a large earthquake in Nerima ward; 4) integrated discussion and policy implications on different scales of the case studies and their applicability to other cities around the world with similar land uses; 5) conclusions on resilient land use planning and seasonal emergency food as well as practical recommendations to increase resilience through mixed land use planning.

Regarding the methodology, firstly, two professional (vegetable field and orchard) and two hobby farmland types (allotment and experience) were identified through a literature review and field observations in Tokyo. The locations of professional UA were retrieved from the Land use Section of the Tokyo Metropolitan Government (TMG). The hobby UA locations and sizes were documented by type, using three methodological approaches: a) government database, b) aerial photos, and c) spatial data from the TMG (2015). Furthermore, the present case study was divided into a grid structure and a land use classification was conducted in a Geographic Information System to identify four different land use patterns with varied mixtures of land uses. Based on this data, for each grid cell, the total production of UA products was estimated. Due to lack of data availability, the methods to estimate the production for professional UA and hobby UA differed. In the case of professional UA, the data was derived from governmental data and linked with the spatial data. However, no data on hobby UA production was available. Therefore, the estimation was conducted with data derived from a previous study. Tahara et al. (2011) collected the vegetable production per square meter according to type of hobby UA. Accordingly applied to the present study, the total proportion of consumable professional and hobby UA was utilized to quantify the self-sufficiency of the population based on the recommended intake of fruits and vegetables per capita in Japan. This empirical analysis found 48,773 professional plots covering 54,409,728 m^2 and 490 hobby UA plots covering 664,172 m^2. The self-sufficiency results varied according to the land use categorization; therefore, typical examples from each category were described and analyzed further in detail with the nutrient self-sufficiency for the population. Everything considered, the median fruit and vegetable self-sufficiency of the grid cells was 4.13%. The median self-sufficiency in the core of urban area was found to be 0% because of the virtual absence of UA. The urban area with more open spaces and urban area with UA was found to be 3% and 18%, respectively. The nature or forestry area was found to be 110% due to low population densities.

Secondly, Nerima ward was selected as an empirical study area because of its relative high density of existing farmlands, because it is one of Tokyo's 23 special wards, and because of its potential based on the results in section one. The production from professional UA and that from hobby UA were estimated according to the method developed in section one. Furthermore, a harvesting table for the Kanto area was developed from literature. This table divided each month into three time periods. The yields of

each vegetable were then equally distributed within the harvest periods of each vegetable. Refuse rates of each vegetable were omitted from the production in order to obtain the consumable weight by vegetable. These results were converted into nutritional values obtained from the Tables of Food Composition, and the nutrient content of all vegetables was totaled for each time period. The self-sufficiency of selected nutrients from vegetables was calculated for each farmland type. Nutritional needs were estimated using population statistics and dietary reference intakes by age and gender. Vegetable production amounted 5,660 tons with a weight-based self-sufficiency of 6.18%, which is higher than that in other literature (for example, the 1.7% estimated for the Cleveland case study). The averages in nutritional self-sufficiencies throughout the year from professional and hobby farms varied by nutrient with the highest being vitamin K (6.15%), followed by vitamin C (5.50%), folic acid (5.15%), dietary fiber (1.96%), and potassium (1.82%), vitamin A (1.54%), vitamin B6 (1.54%), vitamin E (1.13%), and calcium (0.96%). The self-sufficiency rate fluctuated through the year according to the harvest seasons of the available crop species.

Thirdly, based on an integrated discussion of the different chapters, three main policy implications can be drawn from the two case studies and results. The first relates to The Productive Green Land Act enacted in 1974 and revised in 1992 that reduced land taxations if a 30-year commitment to agricultural land use were made. In 2022, farmlands under this Act will have fulfilled their commitment and can be transformed into other land uses. The present study highlights the importance of UA in cities and suggests that further commitment be made to its protection. The second relates to Disaster Prevention Cooperation Farmlands. Registered farmlands can be used for evacuation and building of temporary shelters during emergencies. However, currently no means exist for utilization of available crops. The present study found that these could be useful to meet the nutrient needs of survivors. Therefore, it is proposed to allow their harvest during emergencies. The third is about the transformation of other underutilized land uses for UA productive purposes. Tokyo contains a vast number of small-scale vacant lots. Most plots are too small (average size = 840 m2, median = 153 m2) for large-scaled UA, and some are underutilized over long periods of time, particularly in areas with high population densities and limited amount of additional open spaces. Hobby UA can increase resilience by providing populations residing in these areas with evacuation spaces and a fresh supply of nutrients when a natural disaster occurs.

Regarding the conclusion, this research addresses the aforementioned gap in existing literature and concluded that urban-rural mixed land uses in cities contribute to disaster preparedness and resilience of urban populations. Depending on the time of year, urban agriculture provides a considerable amount of vegetables containing valuable nutrients in post-disaster situations for the prevention of health issues reported in post-disaster studies.