EXTRACTION FOOD DESERT AREAS WITH DETAILED HOUSEHOLD DATA ESTIMATED BY MERGING THE DIGITAL MAPS AND THE POPULATION CENSUS

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KEY WORDS: Food Desert, Digital Maps, Census, Household Composition, Telepoint Data

ABSTRACT: Many kinds of data go digital to be available at all time (e.g. the national population census). Limitations of these existing statistical data are that aggregating units are spatially large and inconsistent between each statistical data. Many previous studies have difficulties in monitoring of the actual state of household behavior in detail because of these limitations. In the case of the national population census, the limitations can be solved if locations of each person can be monitored i.e. if we can disaggregate the census data. The disaggregation means to allocate the aggregated census data onto building polygons based on areas of each building and the housing statistics data etc. With this data, demographic changes can be grasped at scales of microscopic level like city blocks to the macroscopic like the whole area of a city or a prefecture. Furthermore, we can grasp population change of the city by considering moving rates, migration and age distribution of each household. It is expected that our new data will be used for various fields in the future. One of the examples of fields is the "food desert" problem. Using our data, food desert areas can be detected in detail. Using the disaggregate census data, as an example, "food desert" areas are detected in details. "Food desert" problem is one of the critical problem especially in Japan. Many previous studies have also tried to detect food desert areas. However almost all studies can monitor in limited areas. This study shows a method to develop detailed household composition data to extract food desert areas visually and quantitatively in detail to mitigate the food desert problem of Japan.

1. INTRODUCTION

In Japan, there are many kinds of digital census data of population, e.g. the national population census. Many previous studies also used such census data. Referred to theses, it is unclear to show areas with mesh data. A characteristic point of each data is to differ from cities in a list and a unit. Therefore the purpose of this study is to make new detailed data which are developed to allocate the aggregated census data onto building polygons based on building areas and the housing statistics data on household composition to make up with the point. The detailed household data in a minimum unit helps to grasp social problems. This study focuses on food desert problem with the data. In many countries including the United Kingdom and the United States (http://www.ers.usda.gov/Data/FoodDesert/fooddesert.html), this problem is discussed. Food desert areas are a part of inner city which people can't buy nutritious foods at low price. In particular, it is difficult for most of the aged over 65 years old to buy them in Japan. In this paper, they are called the "shopping weak". This problem is one of an aging society. People who lose stores near their houses are increasing more and more, and they need to go shopping farther than before.

1.1 Study area

In this study, we select Kashiwa City (Figure.1). Kashiwa City thrived as a commuter town in 1970s and increased population. However, almost all areas in Kashiwa city have aging problem because people who moved to this city in 1970s reach an advanced age. Kashiwa City as well as all over Japan tends to accelerate aging. This study is helpful to solve this problem in the future.

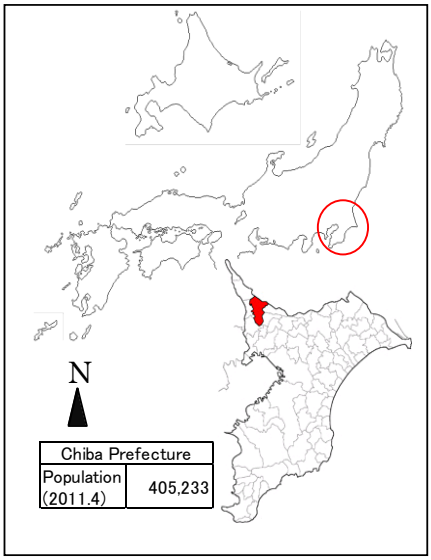

Figure 1: Study area

2 METHODS

This study uses two data. One is the population census data on a number of household in each city block or district (in this paper it is called the local unit) (Figure.2). The other is Digital residential maps (ZENRIN CO., LTD.) which have polygon data of almost all buildings in Japan.

2.1 Development of household composition data

At first, it is important to select a private housing from digital maps. Building polygons in digital residential maps are divided into the following classes in Table 1. These have characteristic data respectively. In these data, we consider (B), (D), (E), (F) as a private housing (Figure.3). Second, polygons of private housing are converted into point data. Finally, all points were given their longitudes and latitudes.

2.2 Sort of private housing data for aggregation

The data is sorted according to two rules. First rule is a kind of building. All buildings in each local unit were sorted by the following order. 1: a private housing 2: a private housing in the apartment 3: a room which doesn't have tenant information in the apartment 4: housing which doesn't have tenant information 5: other kinds of apartment and multi-tenant building. Second is a gross floor space of each house and room. It is seemed that the larger the space is the more people live. The gross floor space is defined by equation (1).

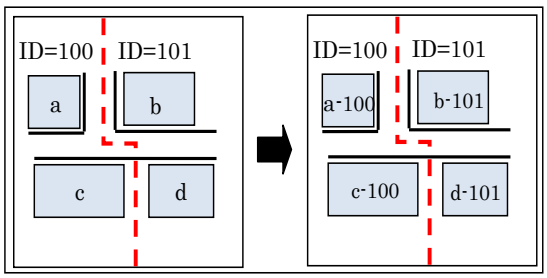

Figure 2: The local unit

Table 1: Building Type

Kind of building		Order	Class
Private house		1	(B)
Store and company		5	(G)
Apartment and multi-tenant building	Private house	2	(D)
	Office	5	(C)
	Others	3	(E)
Landmark		5	(A)
Others		4	(F)

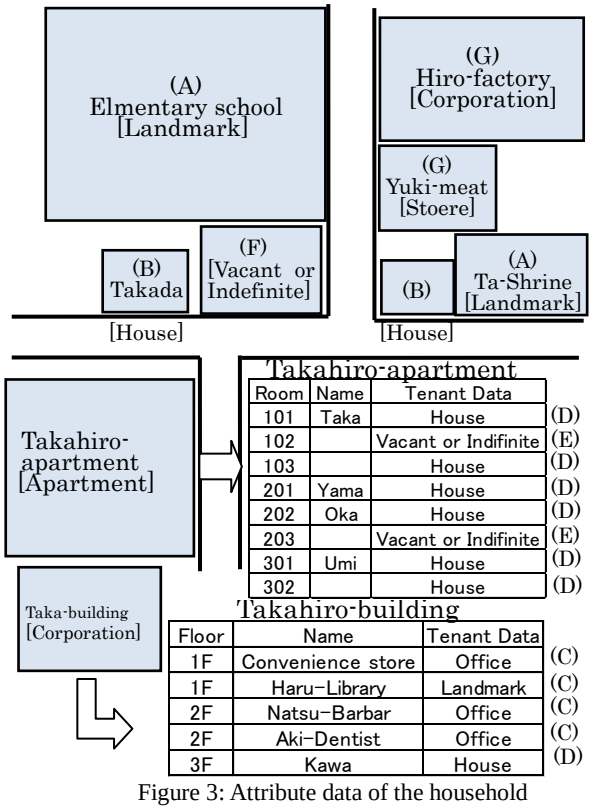

Figure 3: Attribute data of the household

$$A_n = \frac{F_n S_n}{N_n} \quad (1)$$

where A_n is the floor space of building n occupied by a household, F_n is the total stories of building n, S_n is floor space of building n, N_n is the number of rooms of building n.

2.3 Array of the number of people of household

We can get the number of people in each household by the population census. However the number of residents in households which have over 6 residents is not clear. Therefore a method is needed to allocate the number of residents to households which have over 6 residents. The number of residents is defined as follows (2).

$$N6_n = \frac{P_n - \sum_{k=1}^{5} Nk_n Rk_n}{R6_n} \quad (2)$$

where the number of residents in households which have over 6 residents in area n, $R6_n$ is the number of households is over 6 in "n" area, P_n is the total number of people in "n" area, Nk_n is the number of residents in households which have k residents in area n ($1 \leqq k \leqq 5$), Rk_n is that the number per a household is k in "n" area ($1 \leqq k \leqq 5$).

2.4 Aggregating two data

It is possible to estimate age and sex data of each resident in the local unit with census data. We have the household data which have the number of residents. Divided estimated data in residents of each household in the local unit at random, we can get the estimated data which has the detailed data of each resident (Figure.4). In this study, we used how to distribute at random. However the way to revise with the digital maps is available soon.

Figure 4: Attribution data of the household

2.5 Extraction food desert areas

Food desert areas are extracted by a distance from stores. Stores contain all kinds of grocery stores including super markets, department stores, convenience stores. Information of these stores is collected using the Telepoint data (ZENRIN CO., LTD.) which is the database of Japanese telephone directory. In addition, all stores are given their locations, i.e. longitude and latitude by address geocoding. The Ministry of Agriculture, Forestry and Fisheries defined areas more than 500m away from grocery shops are food desert areas for elderly people (Figure.5). Therefore areas more than 500m away from stores which are extracted from the Telepoint data were defined as food desert areas in this study. At first, distribution data of food desert areas were developed using the Telepoint data. There are 2 kinds of food desert areas developed in this study. First are areas where it is difficult for elderly people to access all kinds of grocery shops. Second are areas where it is difficult for them to access fresh stores. Secondly, distribution data of elderly people aged 65 were developed to extract elderly people from the estimated distribution data of residents. Finally, locations of elderly shopping weak were developed to integrate them spatially.

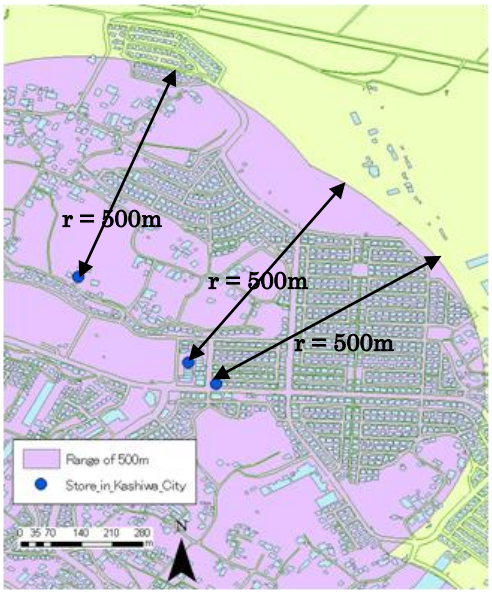

Figure 5: Range of 500m from a store

3. EXPERIMENT

3.1 Ratio of the shopping weak

Table 2 shows the result of the experiment. It shows that 5,044 elderly people are the shopping weak. In addition, 7,951 elderly peoples are difficult to access fresh stores. The ratio of shopping weak is calculated by dividing the number of the shopping weak by the number of elderly people (60,775 people). Compared with the data of the government, the ratio of Kashiwa City is less than that of Tokyo metropolitan area (The Ministry of Agriculture, Forestry and Fisheries. 2011). It is seemed that some factors (e.g. allocation at random without considering local characteristics) affect this study. If the method of allocation is improved, it is expected that detecting accuracy of the shopping weak distribution will be improved. In the view of "table 2", the ratio between two areas reverses compared with each data. This result shows the ratio of a fresh store in Kashiwa City is higher than Tokyo metropolitan area.

Table 2: Ratio of the shopping weak

Category	Area	Population	The number of the shoppig weak	Ratio of the shoppig weak (%)
Over 500m from residents to a **fresh food store**	Tokyo metroporitan area	6,500,000	1,100,000	19.1
	Kashiwa City	48,508	7,951	13.1
Over 500m from a residents to a **food store**	Tokyo metroporitan area	1,100,000	250,000	4.2
	Kashiwa City	30,208	5,044	8.3

3.2 Visualization food desert areas

Figure 6 shows a distribution of the shopping weak. Figure 7 shows that many food desert areas are (located) in suburbs (e.g. near the Tone River and Tega Marsh). The number of stores is clearly less than a city center of Kashiwa City. However it is likely that some areas near the center area are food desert areas. Figure 8 shows one of the examples of this area.

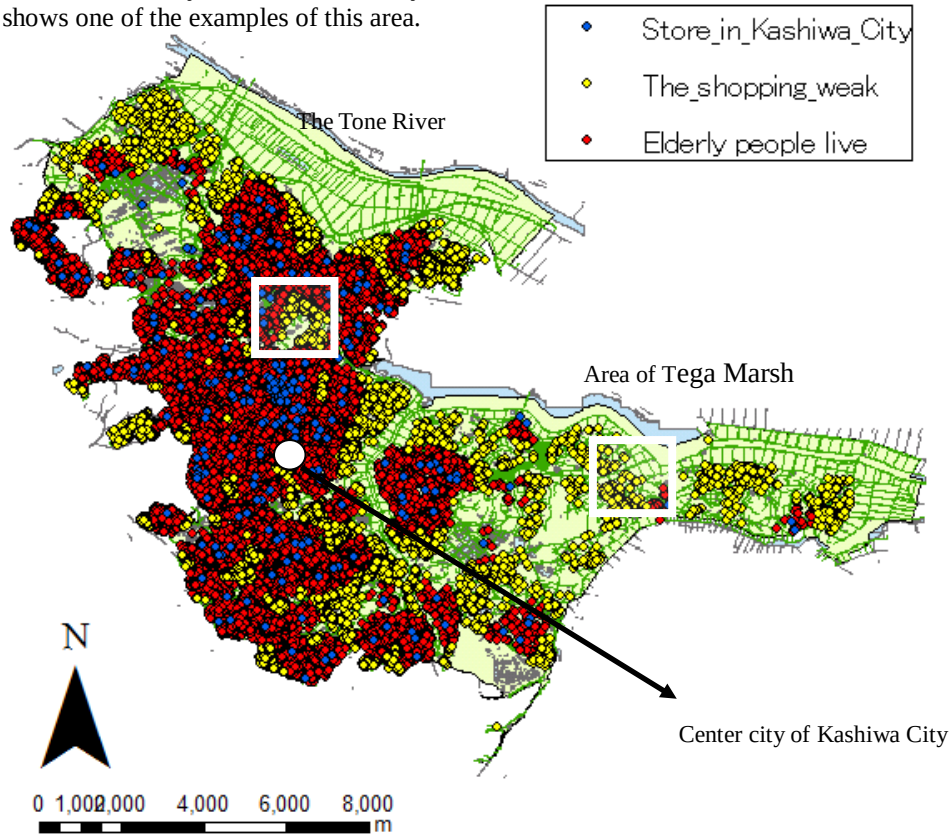

Figure 6: All areas of Kashiwa City

Figure 7: Area near Tega Marsh

Figure 8: Area near the center of Kashiwa City

4. CONCLUSION AND DISCUSSION

This study shows a development of household composition data and a sample to utilize the data. Developed one is given us new detailed information which have never been clear. In this study, we couldn't make sure validity of the data by inspection with real data. It is indispensable for us to inspect the detailed data. New detailed data shows it clear to decrease limits to use some kinds of the detailed household data. However there are some problems left in the way to develop the household composition data and to extract the "food desert". At first, it is necessary to improve and establish the way in Kashiwa City respectively. Secondly, we have a plan to widen areas to experiment, because there are many areas to face the "food desert" in Japan. The aim of this study is to experiment all over Japan. In addition, we hope that our data is used various field e.g. medical treatment, education, employment, welfare work and measures to deal with natural calamities in the future.

ACKNOWLEDGMENT

We are contributed the digital data by ZENRIN CO., LTD, so we would like to thank ZENRIN CO., LTD.

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