Identification of and Food Consumption in Food Deserts: A Case Study of South Korea

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Introduction

Household food security is closely associated with food supply and demand. For households to be food-secured, a variety of foods including healthy, functional foods and foods for elderly should be sufficiently supplied to the market at reasonable prices, and the households must have full access to the supplied foods both economically and geographically.

Though household income level has been identified as the most critical factor in determining household food security, access to foods has recently attracted attention of policy makers and researchers as a significant determinant of food security of households. Geographical constraints that consumers face on food purchasing squeeze their feasible set and thus could lower their utility. Furthermore, the existence of food deserts can result in significant regional inequalities in healthy food choice (Morland et al., 2002; Rose and Richards, 2004; Zenk et al., 2005), and thus cause serious health problems especially for the low-income households (Cotterill and Franklin, 1995; Weinberg, 1995). Studies of food deserts have been conducted in many countries, including the U.S., United Kingdom, Canada, New Zealand, Australia, and Japan.

While the income level is the most important factor limiting purchasing adequate foods for consumers, the influence of demographic changes such as aging and the rapid increase in the proportion of single-person households is expanding. The number of elderly people with mobility problems is increasing, and grocery shopping is becoming non-easy task for the elderly people due to the lack of grocery stores near the residence. Therefore, it is necessary to identify the problem of access to foods in order to guarantee the healthy eating habits at the national level,

and to refer to the related infrastructure and dietary support policy promotion. As can be checked in Table 2, results of simplified estimation of structural equation model, the inconvenience in food consumption is statistically significantly affected by residential area (rural vs. urban), health status, distance to supermarket, and whether or not is food desert resident in the first stage, and then the food security is affected by inconvenience in food consumption and income level in the second stage. This result implies that residing in food deserts can cause inconvenience in food consumption, and consequently food security of households.

The Korea National Health and Nutrition Examination Survey annually asks household main meal planners if they have been able to eat 'sufficient amount of foods and various kinds of food as much as the whole family wants' or 'all of our families were able to eat sufficient amounts of foods but did not eat various kinds of foods.' The proportion of household meal planners who positively responded have been slightly increasing from 87.9% in 2005 to 93.8% in 2014 (see Figure 1). More specifically, during 2013-14 years, the proportion of populations who are in serious food-insecure stages was 0.1 percent but it is 0.4% for both single-person households and lowest-income households (See Table 1).

The study adds to the food desert literature by being the first to examine food deserts in South Korea at the national level. A particular focus is on the disparities in food consumption and dietary life that the existence of food deserts can cause and on the role of food deserts for the elderly, a topic that has only been examined for Japan.

Literature

For example, based on the "*Food, Conservation, and Energy Act of 2008*", the U.S. Department of Agriculture (USDA) has been conducting a variety of research, mainly focusing

on accessibility to supermarkets, inequalities in food desert areas, and nutritional problems. USDA (2009) concluded that food deserts significantly impacted obesity and dietary habits. Similar conclusions have been reached by Lewis et al. (2005), Lopez (2007), Schaffer et al. (2009), Thomsen et al. (2016) and Hendrickson et al. (2006). In particular, USDA (2009), based on "*the Food, Conservation, and Energy Act of 2008*", utilized national surveys as well as geographic approach to identify food deserts. USDA's geographic approach divides the entire US territory by GIS into one square kilometer grids, uses the national supermarket list data to measure the distance from the center of the grid to the nearest supermarket for each grid. Each area was classified as highly accessible (within 0.5 mile of the nearest supermarket), medium accessibility (0.5 to 1 mile), and low accessibility (1 mile or more).

A different perspective on the impact of food deserts have been examined in Japan where low fertility and rapid aging has progressed significantly, specifically their increasing impact on the elderly. The Japanese Ministry of Agriculture, Forestry and Fisheries (2012, MAFF) found that the rate of population with a linear distance to the nearest grocery store of more than 500 meters was significantly higher for the elderly. MAFF (2012) evaluated access to foods at the national level and conducted regional studies by selecting three regions. Using mesh data of intervals of 500 meters, they estimated the proportion of the population for whom the straight-line distance to the nearest grocery store was higher than 500 m (the distance that can be walked in daily life) and display the density on the map. In order to consider the quality of the foods sold, the similar estimation was carried out separately by considering only the grocery stores selling fresh foods. Adding these constraints, the population with a linear distance to the nearest grocery store of more than 500m increased sharply from 14 million people (11% of the population) to 44 million people.

The problem of food access to the elderly in rural areas may be more serious in South Korea, the country with the fastest aging in the world. However, food deserts have not been studied in South Korea at the national level. Only a few studies on 'food-deserts-related topics' were conducted by the Rural Development Administration (RDA; 2015), Kim et al. (2014), and Chang et al. (2014). RDA (2015) conducted a pilot survey on the subjective dietary environment of individuals and households by extracting 503 individuals from 151 households in Hwaseong City, Gyeonggi Province. The main results include the comparisons of preferential transportation methods, average travel time and travel distance to supermarket, the number of supermarkets that are visited, easiness of food purchase, purchase of cereals/vegetables, securing foods through self-cultivation. It is suggested that this survey should be extended to the national level survey covering 692 villages and 6,920 households. Kim et al. (2014) focused on 'eating-out environment'. Using the GIS for 275 individuals living in two urban areas and one rural area, the distribution, density, and accessibility of restaurants were analyzed. The density of restaurants was relatively higher in urban areas, and the accessibility to non-Korean restaurants in urban areas and the accessibility to Korean restaurants in rural areas were relatively acceptable. Chang et al. (2014) developed a survey tool to measure the 'food access' and verified its availability and reliability. The survey items suggested to be necessary are the general characteristics of food stores (whether they are selling alcohol/tobacco, payment means, customer information), the geographical proximity of food stores (availability, address, accessibility, ease of parking), availability of food (eco-friendly products, sales by item, sales of healthy and functional foods, sales of fresh vegetables/fruits, whether canned or frozen fruits sold).

Data and Method

There are two main purposes of this study: to identify national-level food deserts and to examine disparities in food consumption and dietary behavior between the residents in the identified food desert areas and non-food-desert areas.

To identify food deserts, the national-level data for population distribution and supermarket information including business category and location are needed, as food deserts are identified based on the 500 meter criterion of distance from residence to the nearest supermarket.

The population information by age and gender is provided by the National Geographic Information Platform operated by the National Geographic Information Institute. The country is divided into 41 million $100m^2$ grids, with population residing only in approximately 986,000 grids (see Figure 2).

The supermarket information is obtained from the business database operated by the Small Enterprise and Market Service. The database specifies the business category to which each entry belongs and contains latitude and longitude information. As of the end of 2015, the business database includes approximately 3 million businesses that are classified into 20 major categories and 3,286 sub-categories. Of the three million businesses, 442,861 are restaurants and 76,207 are grocery stores. Among the 76,207 grocery stores, 35,885 are supermarkets which sell a variety of food including healthy, fresh, functional and premium foods, and 27,712 are convenience stores. Three cases (or scenarios) of supermarket inclusion are considered in identifying food deserts.

Given the food deserts identified, we examined if there are any disparities in food consumption and dietary behavior between the residents in food desert areas and non-food-deserts. Data from a consumer survey (n = 1,100) that is designed and conducted for this study in 2016 for 100 individuals sampled from the food desert areas and 1,000 individuals sampled from

non-food-desert areas are used for the disparity examination. For comparison purpose, the non-food-desert residents are classified into three sub-groups: non-food desert rural area residents (*n* = 100), mid-sized urban area residents (*n* = 440) and metropolitan area residents (*n* = 460). Attributes of food consumption and dietary behavior examined include the purchase frequency of entire foods, fruits, vegetables and meats, the rates of skipping breakfast, having meals regularly, having meals alone, transportation mainly used for food shopping, distance and moving time to supermarket, availability of a variety of foods, and the subjective evaluation on shopping inconvenience and current dietary life and food consumption and the reasons for that. Table 3 represents the demographics of survey respondents.

As introduced, South Korea is geographically divided into 41 million 100m x 100m grids among which only 986,000 grids contain residents. A grid of the 986,000 grids with residents[1] for which the straight-line distance from the grid's center to the nearest supermarket in the grid is more than 500 meters is identified as a food desert area in this study, and the entire population residing in the grids identified as food desert areas is specified as vulnerable population in terms of access to food (*i.e.*, the food access vulnerable population). Policy-wide useful information is the proportion of the food access vulnerable population for administrative districts, not for tiny 986,000 grids. South Korea can be divided into 252 administrative districts, known as Si, Gun and Gu. Each administrative district is, on average, consist of 3,913 grids, and each grid can be assigned into an administrative district. Two particular rules are applied in the assignment. First, a grid is assigned into the administrative district to which the center of the grid belongs. Second,

[1] As of the end of December in 2015, the total number of Korean populations was 51,529,338 (Statistics Korea, 2016), thus approximately 56 individuals were residing in each grid of the 986,000 grids with residents.

if the center of the grid deviates from the Korean territory, the grid is assigned to the administrative district that the grid is touching (See Figure 3).

The business database contains information on 76,207 grocery stores. Among them, we primarily focus on 35,885 supermarkets because it is almost certain that they sell a variety of food including healthy, fresh, functional and premium foods at reasonable prices. We consider focusing on this set of supermarkets as the most pessimistic scenario (Case 1), while including all the 76,207 grocery stores in the set of supermarket creates the most optimistic scenario (Case 3) in this food desert identification (See Table 4 for more details). We set 'Case 2' as relatively neutral case (not very optimistic and not very pessimistic).

Using a set of functions of ArcGIS including 'intersect' and 'near', the proportion of the population with a straight-line distance of 500 meters or more from the residence to the nearest grocery store is calculated (see Figure 4). The distance of '500 meters', which is the criterion for food desert identification, was selected based on the concept of neighborhood unit in Korean urban planning (Lee and Park, 2015), as the concept has been generally used in urban planning since C.A. Perry introduced it in 1920s.[2]

Results and Implications

Distance to the nearest supermarkets by administrative district

[2] Lee and Park (2015) suggested the radius of the neighborhood unit for South Korea to be 338.6~506.4 meters. Food desert literature in Japan also used 500 meter criterion, while the USDA literature applied 0.5 and 1 mile criterion.

Table 5 represents summary statistics for the distance from the center of each grid of the 986,000 grids to the nearest supermarket. For Case 1, the average distance to the nearest supermarket is approximately 1.8 kilometers with maximum of 90 kilometers. For the most optimistic scenario (Case 3), the average distance was approximately 1.5 kilometers with a similar maximum distance to it for Case 1.

Table 6 and Figure 5 show the average distance to the nearest supermarket by administrative district. For Seoul, capital of Korea, it is 199 meters, the shortest among the upper-level administrative districts (Si- and Do-level), while it is longest for Gyeongsangbuk-Do (2,555 meters). Upper-level administrative districts with average distance longer than 2 kilometers are Gyeongsangnam-Do (2,055 meters), Jeollanam-Do (2,084 meters), and Gangwon-Do (2,251 meters).

Proportion of food desert residents by administrative district

Table 7 shows the number of population residing in food deserts in South Korea. For Case 1, about 6.3 million people (12.3%) were vulnerable in access to foods. In the most optimistic scenario, 9.2% of total population was vulnerable in access to foods in South Korea as of the end of 2015. More serious problem is found for the population aged 65 or more (Table 7). About 20% of this age group was vulnerable in access to foods even when the most optimistic scenario was applied.

Table 8 and Figure 7 suggest the proportion of populations residing in food deserts by upper-level administrative district. In Seoul for Case 1, only about 2.4% of populations were vulnerable in access to foods, while Jeollanam-do suffers from the most serious food access issue as 34% of its residents was vulnerable in access to foods.

Table 9 represents the top (highest) 20 lower-level administrative districts (Gun- or Gu-level) in terms of proportion of populations residing in food desert areas. Looking at Case 1, approximately 85% of Ongjin-Gun residents are vulnerable in access to foods, while it is 12.3% in total. These 20 lower-level administrative districts need attention of policy makers as they are seriously suffering from food access issue as of the end of 2015. These 20 administrative districts include Ongjin, Sinan, Gunwi, Seongju, Hampyeong, Sancheong, Goesan, Jinan, Uiryeong, Ganghwa, Jindo, Hadong, Imsil, Cheongdo, Haman, Bonghwa, Jangsu, Uiseong, Hapcheon and Yeongyang-Gun.

Figure 6 depicts the proportion of populations residing in food deserts by age group. The proportion is quite stable below 10 percent (even at the most pessimistic scenario) until 40s, but starts to skyrocket in the middle of 40s and keep increasing until the middle of 80s. It implies that the food access issue could be more serious for the elderly (60s, 70s, and 80s).

Figures 8 (Case 1) and 9 (Cases 2 and 3) are the maps for food consumption environment that are the first national-level maps drawn for South Korea. These maps are drawn for the upper-level administrative districts based on the proportion of populations residing in food desert area (grid). One implication is that southeastern area of Korean territory experiences more serious food desert problem.

Disparities in food consumption and dietary behavior between residents in food deserts and non-food-deserts

Table 10 shows the frequency of purchasing foods for food desert residents and non-food-desert residents. Food desert residents tend to shop less frequently. The proportion of residents purchasing foods more than once a week was 24% for food desert areas while it was 40% and

42.1% respectively for non-food-desert rural area and metropolitan area. The proportion of residents purchasing foods once or less than once a month was 11% for both food desert areas and non-food-desert rural areas, while it was only 2.9% and 1.4% respectively for mid-sized urban areas and metropolitan areas. This disparity in frequency of food purchase is statistically significant at the one percent level.

Table 11 indicates the transportation mode that is mainly used for food shopping for food desert residents and non-food-desert residents. Food desert residents (53.0%) and non-food-desert rural area residents (47.0%) tend to more use their own vehicle than any other areas (43.9%, 36.1%). Metropolitan residents tend to move on foot for food shopping (57.6%). This disparity is also statistically significant at the one percent level.

Table 12 represents the frequency of purchasing foods using online websites for food desert residents and non-food-desert residents. Food desert residents (73%) and non-food-desert rural area residents (78%) tend to not purchase foods using online websites (internet). If they are more vulnerable in access to foods than any other areas, online shopping must be an alternative way for food shopping, but it seems that it is not currently an effective way to purchase foods for these vulnerable areas. This disparity in online food shopping frequency is also statistically significant at the one percent level.

Table 13 shows the average distance and moving time to the supermarket that is mainly used for food shopping for food desert residents and non-food-desert residents. The average distance was 7.2 kilometers for food desert areas, while it was only 2.0 kilometers for metropolitan areas and less than 4.0 kilometers for the other two areas. The average moving time to the mainly shopping supermarket was 14.8 minutes (one-way) for food desert residents, while it was about 10-11 minutes (4-5 minutes shorter) for non-food-desert residents. This disparity in distance and

moving time to the supermarket that is mainly used for food shopping is also statistically significant at the one percent level.

Table 14 indicates the subjective evaluation on the availability of a variety of foods needed for nutritionally balanced dietary life at the mainly shopping supermarket. About 88% of food desert residents responded that a variety of needed foods are fully available, while about 97% of residents of non-food-desert and metropolitan area confirmed the full availability. Table 15 represents the subjective evaluation on inconvenience in shopping foods. About 48% of food desert residents evaluated that food shopping is not inconvenient while approximately 63%, 79% and 85% of residents responded that it is not inconvenient respectively for non-food-desert, mid-sized urban area, and metropolitan area. These disparities in the availability of a variety of needed foods and subjective evaluation on inconvenience in shopping foods are also statistically significant at the one percent level.

Tables 16 and 18 represent the subjective evaluation on food security and the level of satisfaction with current dietary life for food desert residents and non-food-desert residents. About 76% of food desert residents responded that they are in high food-secure level, while only 65.4% of metropolitan residents responded that they are in high food-secure stage. It implies that food-insecure group may not know that they are in food-insecure stage. The level of subjective satisfaction with dietary life was also higher for food desert residents (3.72/4.00) than any other areas (3.42, 3.58, 3.61/4.00).

Table 17 represents the reasons for the negative evaluation on food security (shown in Table 16). For food desert residents, the most critical reasons for food insecurity were mobility (20.8%) and financial issue (20.8%). For non-food-desert rural area residents, the most critical reason was

unavailability of foods in the nearest store (38.2%), implying that non-food-desert rural area needs policy makers' attention in terms of the availability of needed various foods.

Figure 10 depicts the proportion of consumers purchasing fresh fruits, vegetables and meats more than once a week. This analysis of consumer survey data also suggests that food desert residents purchase fruits, vegetables and meats less frequently than non-food-desert residents.

There are two limitations for this study. First, this study measures the "straight-line" distance from the center of grid to the nearest supermarket. In order to appropriately figure out the actual accessibility between the residence and grocery store, the road network map and signaling system and the average speed of each road should be considered, but the straight-line distance is simply used due to the unavailability (and/or high cost) of related data. Second, a strong assumption is applied: entire population residing in a grid resides at the center of the grid. Since the individual-level population address data were not available, we simply adopted this assumption. However, it is very strong assumption, thus needs to be relaxed in future research by obtaining individual-level address data.

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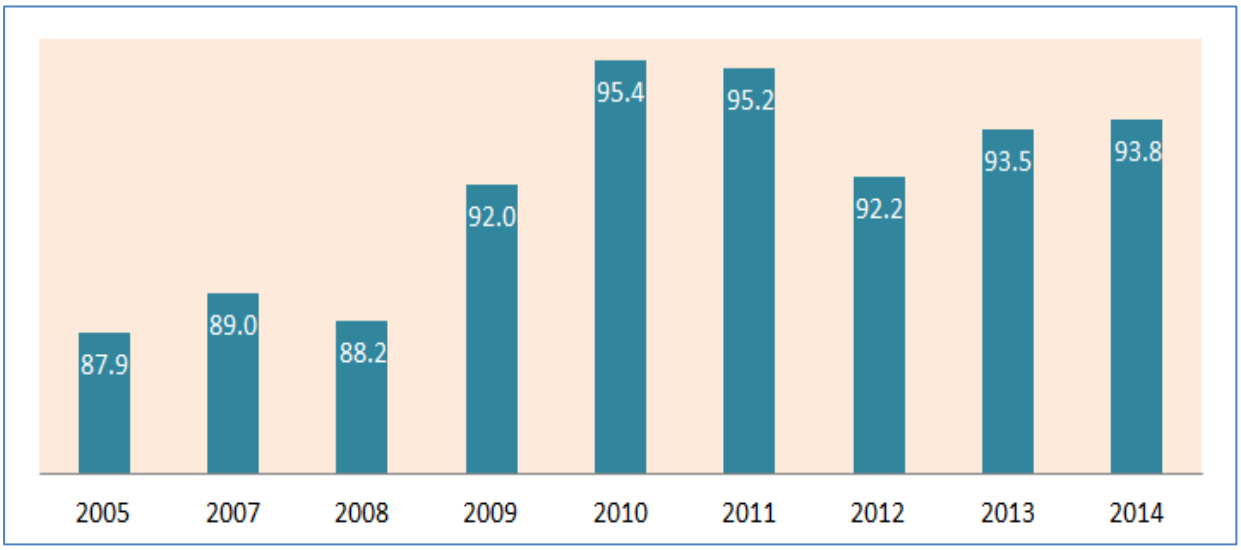
Figure 1. Food Security, South Korea, 2005-2014

(unit: %)



Source: Korea Centers for Disease Control and Prevention (KCDC)

Table 1. Proportions of Population Who are Food-Secure or Food-Insecure by Demographics, South Korea, 2013-14

		Total		Food-Secure Stage		Food-Insecure Stages					
						Early Stage		Middle Stage		Serious Stage	
		n	ratio	n	ratio	n	ratio	n	ratio	n	ratio
Total		19,402	100.0	17,604	90.4	1,525	8.2	255	1.3	18	0.1
Gender	Male	9,230	50.2	7,685	91.3	606	7.5	102	1.2	8	0.1
	Female	11,630	49.8	9,919	89.6	919	8.9	153	1.4	10	0.1
Age	6~11	1,707	6.2	1,531	89.1	130	9.1	24	1.7	1	0.1
	12~18	1,783	9.2	1,476	84.2	218	14.3	23	1.5	1	0.0
	19~39	4,948	32.2	4,163	92.3	279	6.5	45	1.1	2	0.1
	40～50	6,450	34.3	5,331	91.4	400	7.3	69	1.1	9	0.1
	above 60	5,972	18.3	5,103	88.9	498	9.3	94	1.7	5	0.1
Household size	1 Person	1,628	6.5	1,219	84.2	174	10.9	64	4.6	5	0.4
	More than 2	19,199	93.5	16,352	90.8	1,348	8.0	191	1.1	13	0.1
Income Level	Lower	5,137	26.3	3,729	78.2	806	17.7	178	3.7	15	0.4
	Lower-Mid	5,177	25.4	4,390	90.9	396	8.1	56	0.9	3	0.1
	Mid-Upper	5,192	24.6	4,595	95.2	219	4.6	12	0.2	0	0.0
	Upper	5,153	23.8	4,737	98.4	85	1.6	4	0.0	0	0.0
Residential Area	Urban	16,773	81.7	14,069	90.2	1,228	8.4	210	1.3	17	0.1
	Rural	4,087	18.3	3,535	91.5	297	7.4	45	1.0	1	0.1

Source: Korea National Health and Nutrition Examination Survey (NHANES) 2013-2014.

Table 2. Estimation Results of Structural Equation Model

	Estimate	Standard Error	Z-Statistics	*p*-value	Odd Ratio
Equation 1: Inconvenience in Food Consumption					
Age	-0.008	0.007	-1.27	0.203	0.992
Mid-Income	0.223	0.197	1.13	0.257	1.250
High-Income	-0.182	0.279	-0.65	0.513	0.833
Gender (Male)	-0.098	0.158	-0.62	0.537	0.907
Urban Residents	-0.561	0.210	-2.67	0.008	0.571
Housing: Apartment	-0.129	0.183	-0.70	0.482	0.879
Health Status (subjective evaluation)	-0.723	0.178	-4.07	0.000	0.485
Own a Vehicle	-0.405	0.220	-1.84	0.066	0.667
One-way Distance to Supermarket	0.105	0.016	6.51	0.000	1.110
Food Desert Residents	0.707	0.274	2.58	0.010	2.028
Constant	-0.109	0.456	-0.24	0.810	0.896
Equation 2: Food Security					
Inconvenience in Food Consumption	-0.393	0.150	-2.61	0.009	0.675
Age	-0.003	0.005	-0.65	0.518	0.997
Mid-Income	0.830	0.145	5.74	0.000	2.294
High-Income	1.153	0.199	5.80	0.000	3.168
Gender (Male)	0.118	0.129	0.92	0.359	1.126
Participation in Food Assistance	-0.445	0.692	-0.64	0.520	0.641
Constant	0.150	0.281	0.54	0.593	1.162
Number of Observations	1100				
Log Likelihood	-1199.517				

Table 3. Demographics of Survey Respondents, 2016

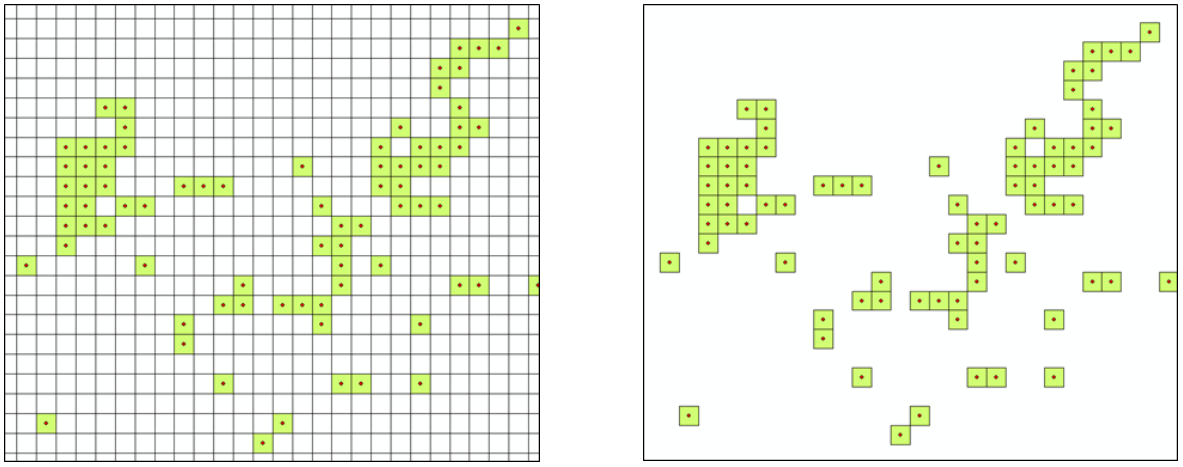
		Number of observations	Ratio (%)
Total		1,100	100.0
Gender	Male	555	50.5
	Female	545	49.5
Age	20～29	178	16.2
	30～39	211	19.2
	40～49	250	22.7
	50～59	247	22.5
	60～74	214	19.4
Education Level	Less than High School	151	13.7
	High School Graduates	424	38.5
	College Graduates	516	46.9
	Graduate School Graduates	9	0.8
Household Monthly Income	below 1 million Won*	44	4.0
	1～2 million Won	115	10.5
	2～3 million Won	211	19.2
	3～4 million Won	269	24.5
	4～5 million Won	260	23.6
	5～6 million Won	131	11.9
	over 6 million Won	70	6.3
Housing Type	Apartment	514	46.7
	Townhouse	210	19.1
	Single House	370	33.6
	etc	6	0.6
Administrative District	Capital Area	520	47.3
	Dongnam District	160	14.6
	Chungcheong District	100	9.1
	Honam District	160	14.6
	Daegyeong District	120	10.9
	Gangwon District	20	1.8
	Jeju District	20	1.8
Residential Area	Dong	800	72.7
	Eup-Myeon	300	27.3
Food Consumption Environment	Non-Food-Deserts	1000	90.9
	Food Deserts	100	9.1

Note: 1 million Won = US$893, as of May 2017

Table 4. Cases by Supermarket Inclusion Criterion

Case	Number of Supermarkets	Category Included
Case 1 (most pessimistic)	35,885	Farmers' Markets, Department Store, Large Supermarkets, Marketplace/Shopping Mall, Special Market for Organic Foods, Discount Chain for Foods
Case 2	48,495	Case 1 + Small Supermarkets and Arcade/Shopping Centers and Local Grocery Stores
Case 3 (most optimistic)	76,207	Case 2 + Convenience Stores

Figure 2. 100m x 100m Grid, Entire Grids (left) versus Grids with Residents (right)



< Entire Grids >

< Grids with Residents >

Figure 3. Allocation of 980,000 Grids into Administrative District (Si, Gun or Gu)

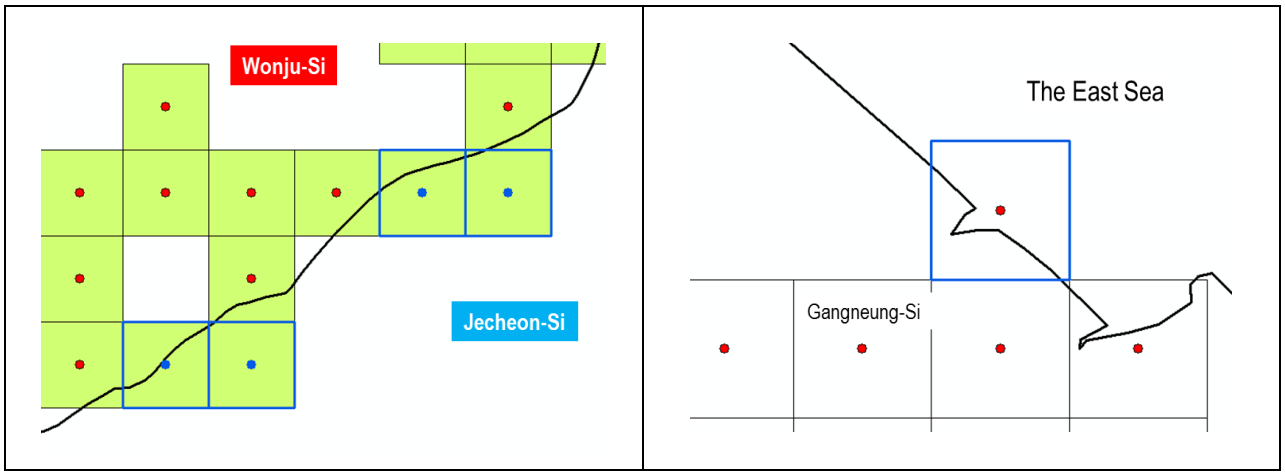


Figure 4. Measurement of Distance from Center of Grid to the Nearest Supermarket

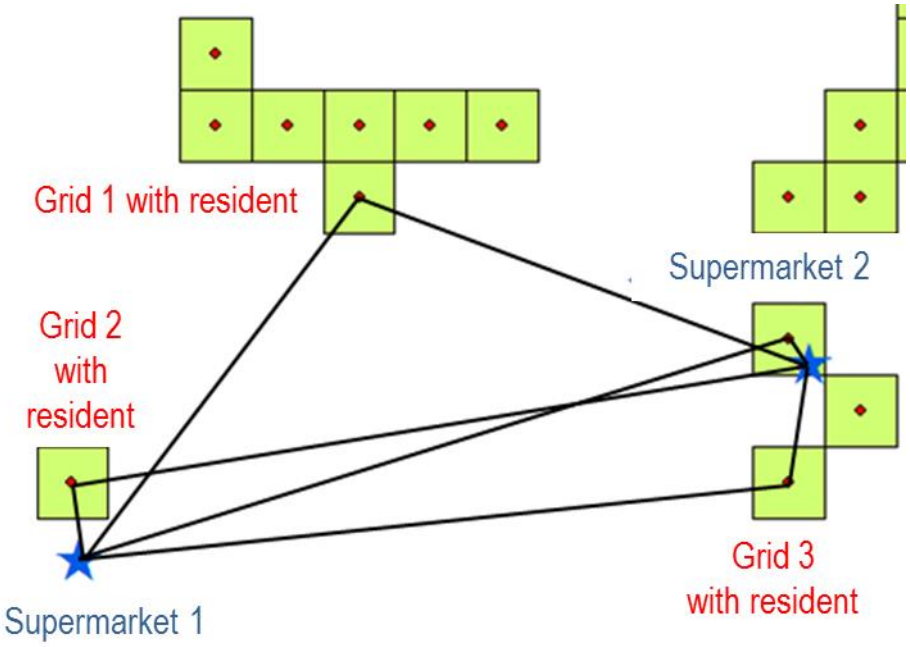


Table 5. Distance to the Nearest Supermarket by Case

(unit: meter)

Case	Number of Grids	Mean	Median	Standard Deviation	Minimum	Maximum
1	986,000	1,804	1,335	1,761	0	89,884
2	986,000	1,575	1,148	1,568	0	89,811
3	986,000	1,460	1,019	1,517	0	89,667

Table 6. Distance to the Nearest Supermarket by Case and Administrative District

(unit: meter)

	Case 1	Case 2	Case 3
Seoul-Si	199	166	123
Busan-Si	529	389	353
Daegu-Si	758	653	560
Incheon-Si	1,909	1,562	1,348
Gwangju-Si	752	722	618
Daejeon-Si	595	554	523
Ulsan-Si	1,489	1,229	1,053
Sejong-Si	1,551	1,411	1,371
Gyeonggi-Do	1,285	1,197	980
Gangwon-Do	2,251	2,154	1,968
Chungcheongbuk-Do	1,959	1,867	1,784
Chungcheongnam-Do	1,905	1,593	1,516
Jeollabuk-Do	1,800	1,533	1,480
Jeollanam-Do	2,084	1,927	1,872
Gyeongsangbuk-Do	2,555	2,037	1,958
Gyeongsangnam-Do	2,055	1,680	1,594
Jeju-Do	1,249	1,200	849
Total	1,804	1,575	1,460

Figure 5. Distance to the Nearest Supermarket by Case and Upper-Level Administrative District

(unit: meter)

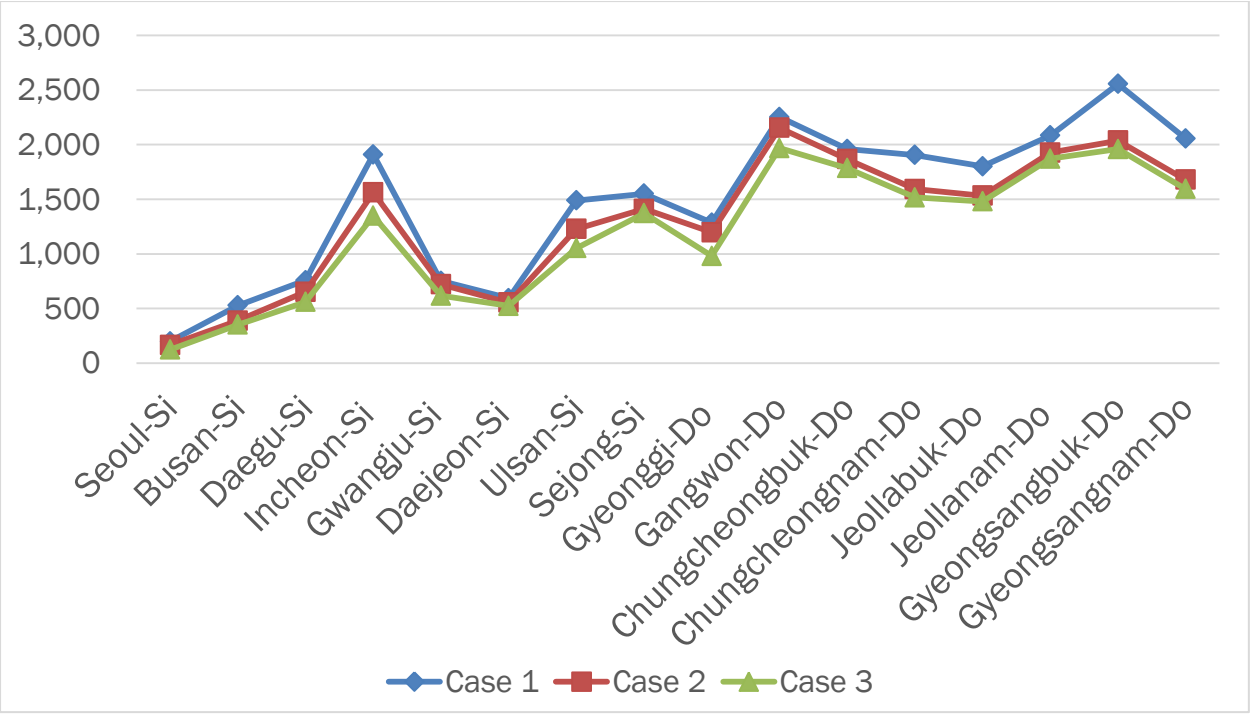


Table 7. Proportion of Populations Residing in Food Deserts by Case, Entire Population and Population Aged 65+

	Entire Population		Population Aged 65+	
	Number of Population Residing in Food Deserts	Ratio (%)	Number of Population Residing in Food Deserts	Ratio (%)
Case 1	6,297,371	12.3	1,561,376	23.2
Case 2	5,706,460	11.2	1,468,106	21.8
Case 3	4,695,377	9.2	1,356,986	20.1

Table 8. Proportion of Populations Residing in Food Deserts by Case and Upper-Level Administrative District

(unit: %)

	Case 1	Case 2	Case 3
Seoul-Si	2.36	1.57	0.50
Busan-Si	3.22	2.05	1.56
Daegu-Si	3.43	2.89	1.82
Incheon-Si	6.86	5.87	3.86
Gwangju-Si	3.67	3.61	2.74
Daejeon-Si	2.70	2.62	2.39
Ulsan-Si	9.65	8.26	5.53
Sejong-Si	17.25	16.55	13.70
Gyeonggi-Do	11.41	10.20	7.12
Gangwon-Do	22.08	21.41	18.92
Chungcheongbuk-Do	21.37	20.45	18.59
Chungcheongnam-Do	31.24	29.06	26.19
Jeollabuk-Do	23.44	22.10	20.50
Jeollanam-Do	34.03	33.06	31.63
Gyeongsangbuk-Do	29.30	27.07	24.97
Gyeongsangnam-Do	20.45	18.21	15.71
Jeju-Do	24.55	22.65	15.57
Total	12.31	11.16	9.18

Table 9. Top 20 Administrative Districts in Proportion of Populations Residing in Food Deserts by Case

Ranking	Case 1		Case 2		Case 3	
	Name of Si, Gun or Gu	Ratio (%)	Name of Si, Gun or Gu	Ratio (%)	Name of Si, Gun or Gu	Ratio (%)
1	Ongjin-Gun	83.88	Sinan-Gun	80.27	Sinan-Gun	80.10
2	Sinan-Gun	81.31	Ongjin-Gun	77.32	Gunwi-Gun	73.61
3	Gunwi-Gun	79.36	Gunwi-Gun	73.87	Hampyeong-Gun	71.35
4	Seongju-Gun	74.73	Hampyeong-Gun	71.78	Goesan-Gun	68.66
5	Hampyeong-Gun	73.35	Goesan-Gun	70.04	Ongjin-Gun	68.49
6	Sancheong-Gun	71.16	Seongju-Gun	68.84	Jinan-Gun	68.02
7	Goesan-Gun	70.92	Jinan-Gun	68.67	Seongju-Gun	67.39
8	Jinan-Gun	70.27	Sancheong-Gun	67.96	Imsil-Gun	65.27
9	Uiryeong-Gun	69.89	Imsil-Gun	66.30	Sancheong-Gun	65.16
10	Ganghwa-Gun	68.68	Hadong-Gun	66.19	Hadong-Gun	64.60
11	Jindo-Gun	68.29	Uiryeong-Gun	66.18	Jangsu-Gun	64.35
12	Hadong-Gun	67.82	Jindo-Gun	65.90	Jindo-Gun	63.69
13	Imsil-Gun	67.80	Ganghwa-Gun	65.41	Ganghwa-Gun	63.48
14	Cheongdo-Gun	67.02	Haman-Gun	65.00	Cheongdo-Gun	63.43
15	Haman-Gun	66.95	Cheongdo-Gun	64.53	Uiryeong-Gun	63.19
16	Bonghwa-Gun	66.59	Jangsu-Gun	64.35	Haman-Gun	63.04
17	Jangsu-Gun	66.09	Yeongyang-Gun	63.47	Uiseong-Gun	62.35
18	Uiseong-Gun	65.67	Bonghwa-Gun	63.07	Damyang-Gun	61.78
19	Hapcheon-Gun	64.84	Cheongyang-Gun	62.91	Hapcheon-Gun	61.66
20	Yeongyang-Gun	64.80	Uiseong-Gun	62.42	Cheongyang-Gun	61.40
Total		12.31		11.16		9.18

Figure 6. Proportion of Populations Residing in Food Deserts by Case and Age Group

(unit: %)

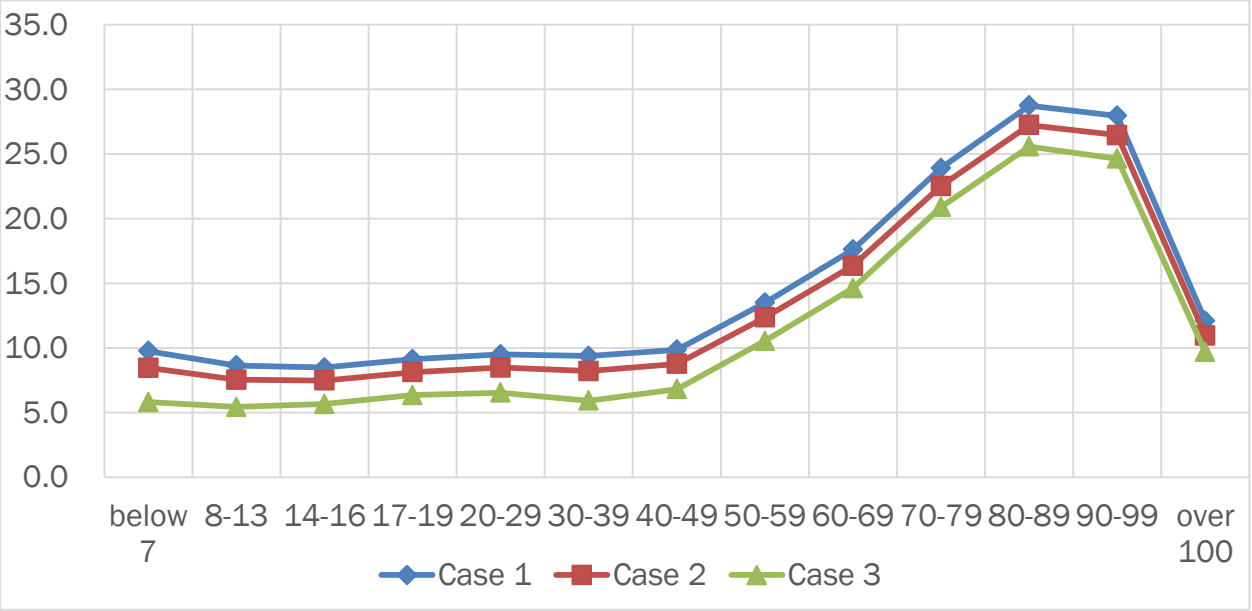


Figure 7. Proportion of Populations Residing in Food Deserts by Case and Upper-Level Administrative District

(unit: %)

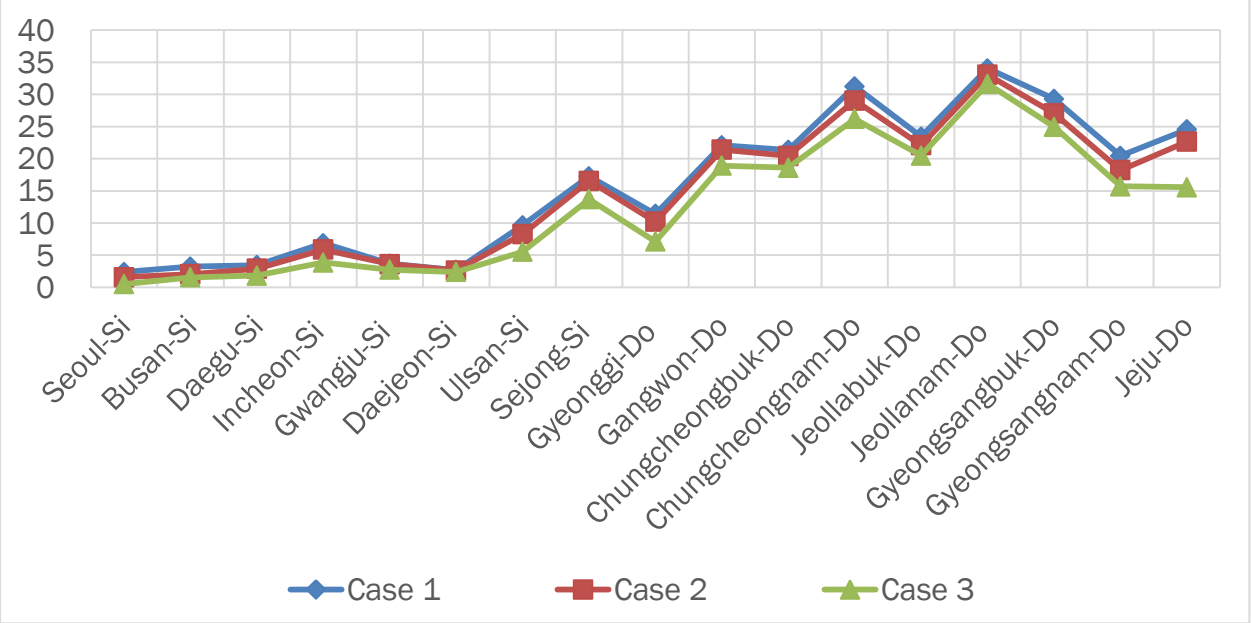


Figure 8. Food Desert Map (Case 1), South Korea, 2016

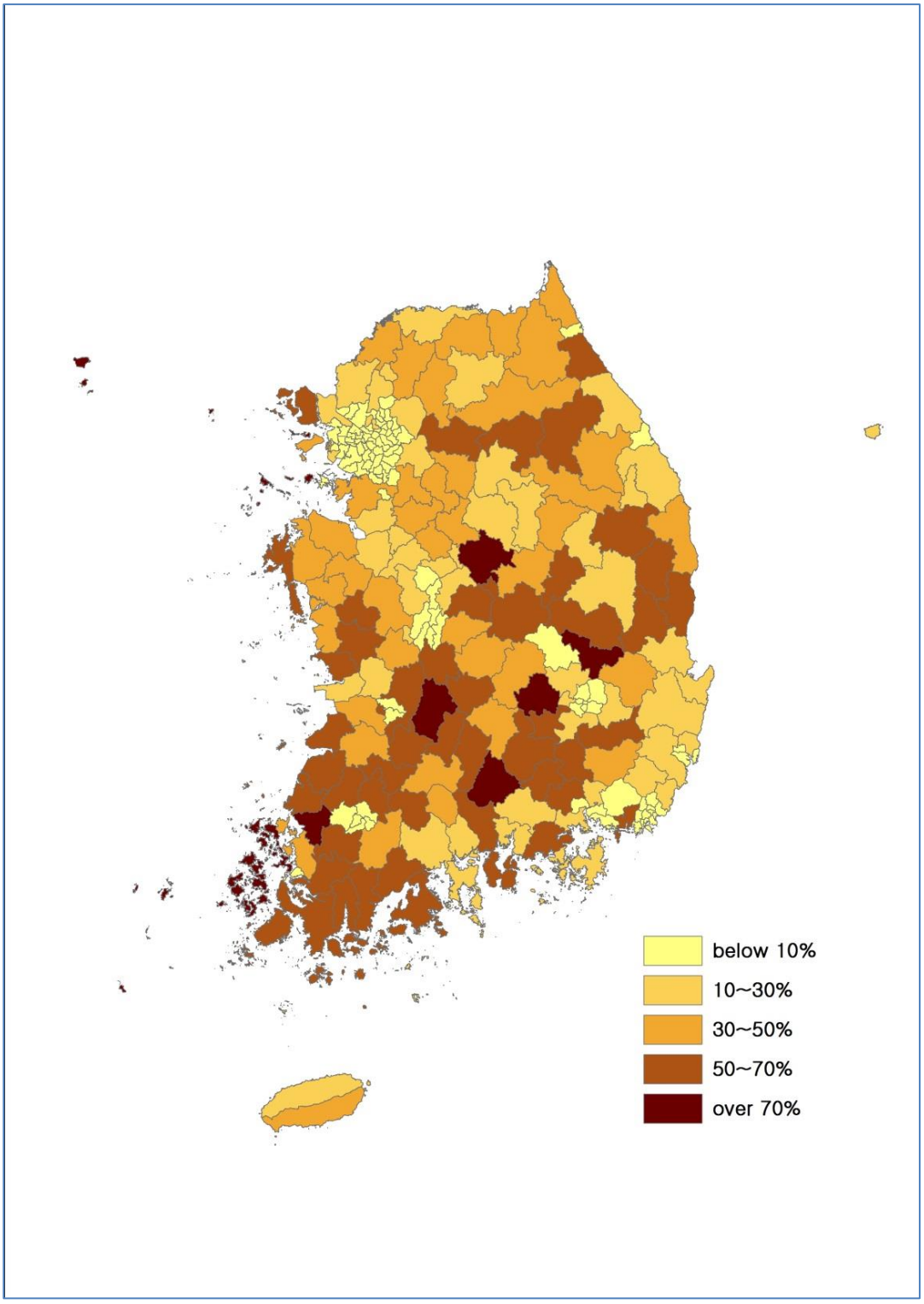


Figure 9. Food Desert Map (Case 2 and 3), South Korea, 2016

< Case 2 >

< Case 3 >

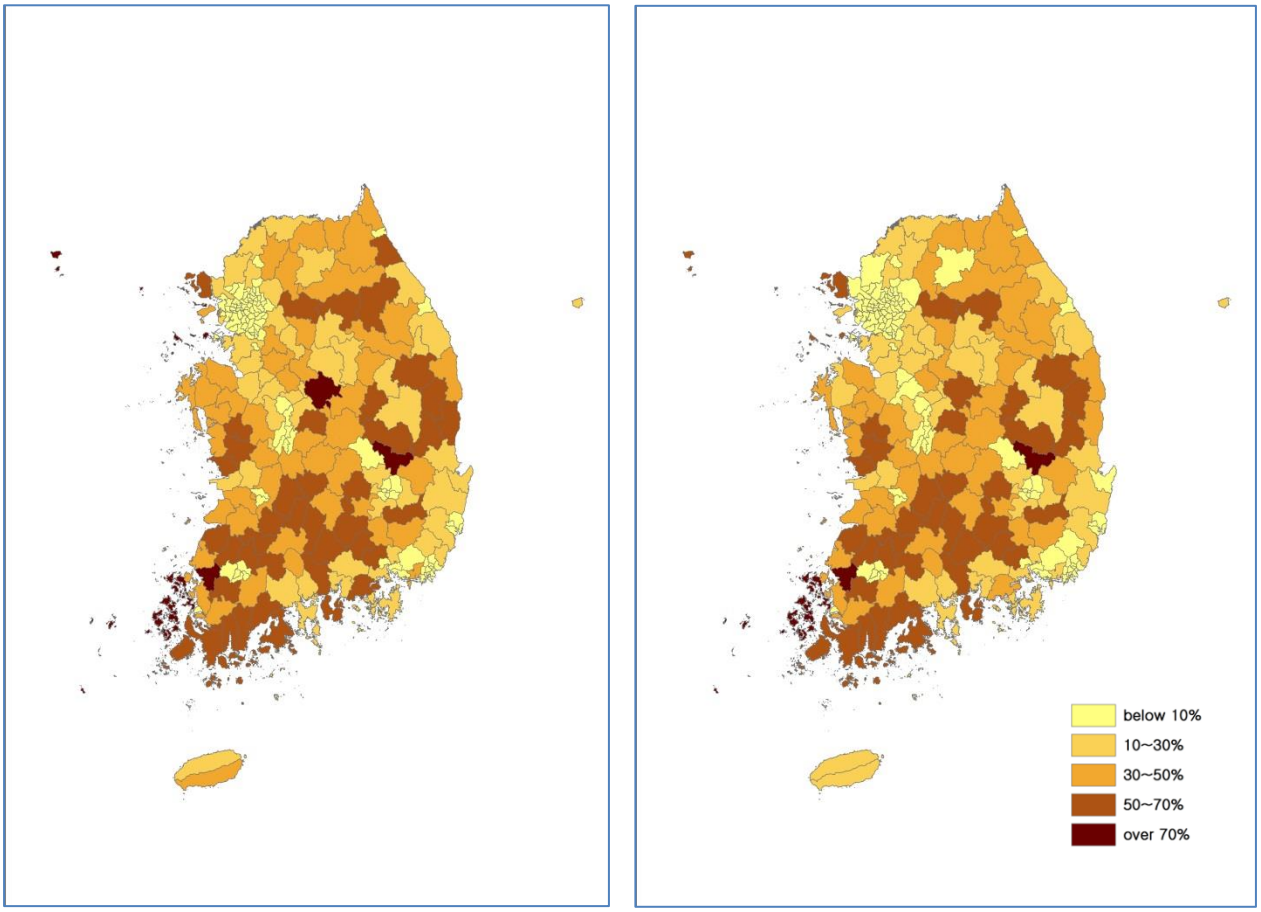


Table 10. Frequency of Purchasing Foods: Food Deserts vs. Non-Food-Deserts

		Number of Respondents	Frequency of Purchasing Foods (%)						Total
			Once a day	2-3 times a week	Once a week	Once per two weeks	Once a month	Less than once a month	
Top 5 Food Desert Areas		100	1.0	23.0	46.0	19.0	7.0	4.0	100.0
Non-Food-Deserts	Non-Food-Desert Rural Area	100	5.0	35.0	40.0	9.0	2.0	9.0	100.0
	Mid-sized Urban Areas	440	1.1	26.1	53.0	16.8	2.7	0.2	100.0
	Metropolitan Areas	460	3.0	39.1	49.6	7.0	0.7	0.7	100.0
Total		1,100	2.3	32.1	49.7	12.2	2.2	1.5	100.0

Note: p-value=0.000
Source: Survey for this study (*n*=1,100)

Table 11. Transportation Mainly Used for Food Shopping: Food Deserts vs. Non-Food-Deserts

		Number of Respondents	Mainly Used Transportation for Food Shopping (%)						
			Subway	Bus	Taxi	Own Vehicle	Bicycle	On Foot	Auto-bicycle
Top 5 Food Desert Areas		100	0.0	7.0	0.0	53.0	7.0	33.0	0.0
Non-Food-Deserts	Non-Food-Desert Rural Area	100	0.0	9.0	1.0	47.0	1.0	42.0	0.0
	Mid-sized Urban Areas	440	0.5	4.8	0.7	43.9	2.7	46.8	0.7
	Metropolitan Areas	460	0.7	3.9	1.1	36.1	0.4	57.6	0.2
Total		1,100	0.5	5.0	0.8	41.7	2.0	49.6	0.4

Note: p-value=0.000
Source: Survey for this study (*n*=1,100)

Table 12. Frequency of Purchasing Foods Using Internet: Food Deserts vs. Non-Food-Deserts

		Number of Respondents	Frequency of Purchasing Foods using internet (%)						
			Once a day	2-3 times a day	Once a week	Once per two weeks	Once a month	Less than once a month	Never
Top 5 Food Desert Areas		100	0.0	1.0	6.0	3.0	8.0	9.0	73.0
Non-Food-Deserts	Non-Food-Desert Rural Area	100	1.0	4.0	2.0	1.0	2.0	12.0	78.0
	Mid-sized Urban Areas	440	0.0	1.6	6.1	6.8	12.5	12.5	60.5
	Metropolitan Areas	460	0.2	3.3	6.1	4.6	8.0	17.2	60.7
Total		1,100	0.2	2.5	5.7	5.0	9.3	14.1	63.3

Note: p-value=0.001
Source: Survey for this study (*n*=1,100)

Table 13. Average Distance and Moving Time to Mainly Shopping Supermarket: Food Deserts vs. Non-Food-Deserts

		Number of Respondents	Distance and Moving Time to Mainly Shopping Supermarket (one-way)			
			Distance (kilometer)		Moving Time (minute)	
			Mean	Standard Deviation	Mean	Standard Deviation
Top 5 Food Desert Areas		100	7.2	9.6	14.8	13.0
Non-Food-Deserts	Non-Food-Desert Rural Area	100	3.5	3.9	11.4	8.2
	Mid-sized Urban Areas	440	3.6	7.1	11.2	13.4
	Metropolitan Areas	460	2.0	3.7	10.4	6.2
Total		1,100	3.3	6.1	11.2	10.5

Note: p-value=0.000
Source: Survey for this study (*n*=1,100)

Table 14. Availability of a Variety of Foods Needed for Nutritionally Balanced Dietary Life at Mainly Shopping Supermarket: Food Deserts vs. Non-Food-Deserts

		Number of Respondents	Fully Available (%)	Not Fully Available (%)
Top 5 Food Desert Areas		100	88.0	12.0
Non-Food-Deserts	Non-Food-Desert Rural Area	100	97.0	3.0
	Mid-sized Urban Areas	440	90.0	10.0
	Metropolitan Areas	460	96.5	3.5
Total		1,100	93.2	6.8

Note: p-value=0.000
Source: Survey for this study (*n*=1,100)

Table 15. Inconvenience in Shopping Foods: Food Deserts vs. Non-Food-Deserts

(unit: %)

		Number of Respondents	very inconvenient	somewhat inconvenience	neut-ral	not inconvenient	never inconvenient
Top 5 Food Desert Areas		100	0.0	16.0	36.0	37.0	11.0
Non-Food-Deserts	Non-Food-Desert Rural Area	100	0.0	6.0	31.0	33.0	30.0
	Mid-sized Urban Areas	440	0.5	5.9	14.8	57.5	21.4
	Metropolitan Areas	460	0.2	3.9	11.1	52.2	32.6
Total		1,100	0.3	6	16.6	51.2	25.9

Note: p-value=0.000

Source: Survey for this study (*n*=1,100)

Table 16. Subjective Evaluation on Current Dietary Life and Food Consumption: Food Deserts vs. Non-Food-Deserts

(unit: %)

		Number of Respondents	Highly Food-Secure	Food-Secure	Neutral	Food-Insecure	Highly Food-Insecure
Top 5 Food Desert Areas		100	76.0	13.0	6.0	4.0	1.0
Non-Food-Deserts	Non-Food-Desert Rural Area	100	66.0	20.0	12.0	2.0	0.0
	Mid-sized Urban Areas	440	57.7	26.8	9.8	5.5	0.2
	Metropolitan Areas	460	65.4	22.4	8.5	3.3	0.4
Total		1,100	63.4	23.1	9.1	4.1	0.4

Note: p-value=0.055

Source: Survey for this study (*n*=1,100)

Table 17. Reason for Negative Evaluation on Current Dietary Life and Food Consumption: Food Deserts vs. Non-Food-Deserts

(unit: %)

		economically vulnerable	unavailability of foods in nearest store	don't have time for shopping foods and cooking meals	hard to move to supermarket	poor cooking environment	can't cook or eat due to health status	don't want to eat foods or meals
Top 5 Food Desert Areas		20.8	8.3	16.7	20.8	4.2	0.0	29.2
Non-Food-Deserts	Non-Food-Desert Rural Area	11.8	38.2	11.8	2.9	5.9	0.0	29.4
	Mid-sized Urban Areas	8.6	18.3	29.0	7.0	5.9	2.2	28.0
	Metropolitan Areas	11.9	10.7	22.0	8.8	1.9	0.6	43.4
Total		10.9	16.4	24.1	8.2	4.2	1.2	34.2

Note: p-value=0.006
Source: Survey for this study (*n*=1,100)

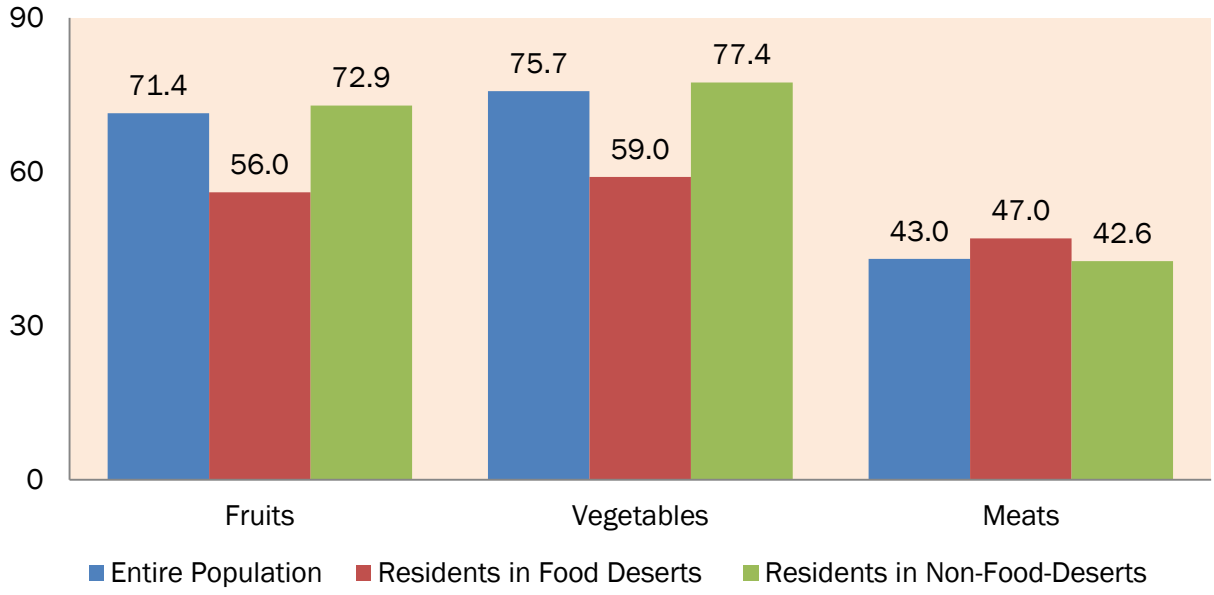
Table 18. Subjective Satisfaction on Dietary Life: Food Deserts vs. Non-Food-Deserts

(unit: %)

		Number of Respondents	very unsatisfied	unsatisfied	satisfied	very satisfied	Mean	Standard Deviation
Top 5 Food Desert Areas		100	5.0	23.0	67.0	5.0	3.72	0.64
Non-Food-Deserts	Non-Food-Desert Rural Area	100	4.0	50.0	46.0	0.0	3.42	0.57
	Mid-sized Urban Areas	440	4.1	34.5	60.5	0.9	3.58	0.59
	Metropolitan Areas	460	3.7	29.3	65.9	1.1	3.64	0.57
Total		1,100	4.0	32.7	62.0	1.3	3.61	0.59

Note: p-value=0.000
Source: Survey for this study (*n*=1,100)

Figure 10. Proportion of Consumers Purchasing Fresh Foods More than Once a Week (%)



Note: p-value=0.000 (Fruits), 0.000 (Vegetables), 0.035 (Meats)
Source: Survey for this study (*n*=1,100)