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Measuring Elderly People's Food Access in Urban Food Environments: The Potential Benefits of Urban Agriculture

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Abstract. This study aims to examine food access among urban residents in Japan – especially elderly residents – and to explore the potential benefits of urban agriculture in alleviating problems that relate to shopping for fresh food. In Japan, which has a high population density, urban agriculture has a locational advantage: many produce stands owned by individual farmers and farmers' markets are located close to urban residents, and it is convenient to visit these outlets to purchase fresh and healthy food at affordable prices. This study assesses how many people face insufficient access to fresh, healthful food, and how many people could benefit from local agricultural outlets. To that end, this study employs geographic information system tools to calculate, in detail, the number of people in food desert areas or in areas where people could otherwise benefit from local agricultural outlets. According to this study's results, in two study areas, approximately 60% of those aged 65 years or more reside far from food stores for daily shopping. This analysis sheds light on the difficulties that many face in shopping. Improving access to fresh food through the use of local agricultural outlets is one of the advantages of urban agriculture. In identifying the impact of improving food access via urban agriculture, this study quantitatively verified, using a real-world case, that it is possible to pinpoint the beneficial effects of urban agriculture against social disparities. This study's findings vis-à-vis the effects of agri-oases on food security among urban elderly people point to urban agriculture's contribution to environments with insufficient food supplies.

Introduction

Since 'the right to food' is a basic human right, people everywhere should have 'physical and economic access at all times to adequate food or means for its procurement' (United Nations, 1999, par. 6). The United Nations' recommendation is that its member nations create equitable health-promoting environments that empower individuals, families, and communities to make sound health-oriented choices and

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lead healthy lives (United Nations, 2012). Food insecurity arises when people lack this access or these means. Generally, having a low income restricts one's access to food, in developing and developed countries alike. As is well known, food insecurity is often synonymous with either hunger or obesity (Tanaka et al., 2014): low-income people have no choice but to purchase less food (and thus starve) or cheap fast food (and thus become obese). Even in developed countries, it is becoming difficult today for everyone to obtain adequate amounts of nutritious food. While low income is a leading cause of hunger in the world, another kind of determinant has also caused food insecurity, especially in developed countries: the lack of access to food, or the lack of availability of food, or the lack of an adequate amount of affordable food. When this problem is discussed, the term 'food deserts' frequently arises.

Food deserts were originally characterized by the collapse of food supply systems, facilitated not only by the growth of large stores (which forced small and mid-sized grocery stores out of business), but also by the declining number of grocery stores due to reduced purchasing power caused by ageing populations or depopulation (Iwama, 2013). As food deserts can be largely ascribed to corporate strategies that relate to market competition, solutions based on market mechanisms would not be practical. For example, attracting new retailers to food deserts without offering them government benefit packages would not be a sustainable practice, as private companies would eschew less-profitable areas. In this sense, food deserts signal a market failure. Therefore, there have been various policy responses, such as offering subsidies and tax breaks, categorizing commercial land, improving shopping environments by opening new stores, creating new mobile vending outlets, enhancing transportation routes, and redeveloping shopping centres. In addition, governments have provided customers with educational programs, many of which focus on the importance of healthful dietary patterns (Wrigley et al., 2003; Broad Leib, 2013). These efforts have been motivated in part by 'food justice' concerns (Cannuscio et al., 2014).

Food justice is one aspect of the social justice movement that aims to correct racial, economic, political, environmental, and other disparities, many of which are generated by the dominant contemporary food system. Food justice demands a more democratic process that can eliminate existing disparities in power and resource control, from production and processing to distribution and consumption (Alkon and Agyeman, 2011; Meenar and Hoover, 2012; Horst et al., 2017). In a food justice framework, equal access and opportunities for participation are fundamental to increasing food security at individual, household, and community levels. One of the alternative food movements that has emerged is urban agriculture, which offers several benefits to communities experiencing disparities. Through urban agriculture, these communities can enjoy improved access to fresh, affordable, and appropriate food, maintain their green spaces, receive youth and adult-oriented job training, and experience general community development (Draper and Freedman, 2010; Reynolds, 2011, 2015). As Horst et al. (2017) describe, urban agriculture is a diverse discipline and its impact on food justice varies both from situation to situation and from country to country. However, many researchers have found that urban agriculture can enhance both food access and food security (Macias, 2008; Meenar and Hoover, 2012; Algert et al., 2014; McClintock and Simpson, 2018). Identifying the impact of food access as wrought by urban agriculture in food deserts may quantitatively broaden the possibility of urban agriculture in addressing social disparities. Even so, there has been a dearth of quantitative research that measures the effects or func-

tions of urban agriculture.

This study aims to examine food access among urban residents in Japan – especially elderly residents – and to explore the potential benefits of urban agriculture in alleviating problems that relate to shopping for fresh food. In Japan, which has a high population density, urban agriculture has a locational advantage: many produce stands owned by individual farmers as well as farmers' markets are located close to urban residents, and it is convenient to visit these outlets to purchase fresh and healthy food at affordable prices. The current study assesses just how many people face insufficient access to fresh, healthful food, and how many people could benefit from local agricultural outlets. To that end, this study employs geographic information system (GIS) tools to calculate, in detail, the number of people in food desert areas or in areas where people could otherwise benefit from local agricultural outlets; it does so by comparing two different local areas in the same municipality in Japan. Yokohama municipality has a large elderly population, and these individuals are now at risk of being unable to access fresh, healthful food. On the other hand, urban agriculture in Yokohama could improve elderly people's access to fresh, healthful food, because the municipality has more than 250 agricultural outlets near agricultural land or farmers' homes. For these reasons, Yokohama is a suitable area for examining the potential benefits of urban agriculture in food deserts.

Food Access and Food Deserts in Japan

In recent decades, a considerable volume of research has been conducted on food deserts, and much of it has focused on the relationship between the food environment and dietary inequalities. Many studies provide evidence that the local food environment affects residents' dietary patterns and leads to disparities in diet-related conditions such as obesity and diabetes (Larson and Gilliland, 2009; McKinnon et al., 2009; Charreire et al., 2010; Walker et al., 2010; Gustafon et al., 2012). Several review articles examine evidence vis-à-vis the relationship between the food environment and health-related outcomes (Beaulac et al., 2009; Charreire et al., 2010; Caspi et al., 2012; Black et al., 2014a; Lytle and Sokol, 2017). These reviews offer mixed or limited evidence for associations that appear to be obvious. While much of the US literature shows a firm association between food environment and health-related outcomes, many other studies find no association between such outcomes and either proximity to food outlets or eating habits. Moreover, findings for other developed countries (e.g. Canada, United Kingdom, France, Netherlands, Australia, New Zealand, and Japan) have been relatively mixed, and display weak evidence for this association (Clarke et al., 2002; Wrigley, 2002; Wrigley et al., 2003; Cummins and Macintyre, 2006; Pearce et al., 2006; Winkler et al., 2006; Apparicio et al., 2007; Larsen and Gilliland, 2009; Bader et al., 2010; Gould et al., 2012; Shaw, 2012; Choi and Suzuki, 2013; Iwama, 2013; Helbich et al., 2017). Based on the results of these reviews, food deserts or inadequate access to food are not likely to damage community health overall. Nonetheless, empirical evidence relating to food deserts differs by country or region; in fact, findings for different study areas within the same country have derived inconsistent findings. These results suggest that the food environment varies with physical and socio-economic conditions (Bader et al., 2010; Su et al., 2017). Therefore, although many reviews suggest there is no association between food environment

and health-related outcomes, it is not necessary to conclude that there is no area in which people face insufficient access to healthful food.

Reviews also suggest that inadequate access to healthful food is frequently seen in low-income and ethnic-minority neighbourhoods (Beaulac et al., 2009; Hilmers et al., 2012; Helbich et al., 2017). To elucidate the underlying causes of dietary inequalities, much of the research on the food environment has focused on the *community nutrition environment*, which relates to food outlet accessibility in a neighbourhood area. Outlet proximity, population and outlet density, and variety of food outlets have been used as criteria to assess a community's nutrition environment. The *consumer nutrition environment*, on the other hand, is defined as the consumer environment within a food outlet, and it includes the types of food available, their prices, promotions, the range of choice, product freshness, and the nutritional quality of the food sold (Glanz et al., 2005; Glanz, 2009; Charreire et al., 2010; Black et al., 2014b). Geospatial access to food outlets is a major driver of consumer decisions regarding where to purchase food (Cannuscio et al., 2014). However, a number of recent studies have found that most urban residents go beyond the closest markets for their primary grocery shopping (Drewnowski et al., 2012; Cannuscio et al., 2013, 2014; LeDoux and Vonjnovic, 2013). These studies suggest that people in the study areas chose distant food outlets to purchase healthful fresh food, and that these shopping behaviours supported their health outcomes. Although these studies often conclude that proximity to food outlets is not associated with dietary patterns, this does not mean that people need not exert extra labour to shop. Indeed, those shopping behaviours that rely on access to distant food outlets for healthful food frequently incur additional burdens, and demand from shoppers more time, cost, and physical exertion.

Therefore, the trends in research on food access – which focuses strongly on the association between food environment and unhealthful diet – may overlook other kinds of problems in daily shopping. A different perspective could reveal new groups who face restricted access to food. For example, elderly people's access to food may differ from that of other groups, such as ethnic minorities or those with low income, because these groups have different social attributes. In 2015, the percentage of the elderly population (65 years and over) in Japan reached 26.7%, making Japan the country with the highest such percentage in the world (Cabinet Office, Government of Japan, 2016). For elderly people, a decline in physical performance due to ageing might disrupt their daily lives and activities, including food shopping. Ageing is an unavoidable process, and so too are the physical limitations associated with it; thus, for elderly people, spatial proximity to food outlets might be a major determinant of shopping, and accessibility might become a more universal concern in terms of the food environment.

As previously mentioned, structural inequalities in the food retail environment might affect diet inequality and diet-related outcomes. A significant body of research on food deserts hitherto attempted to identify their locations and verify the relationship between the proximity to food retailers and a healthy dietary intake, with some studies confirming the association between access to supermarkets and dietary patterns (Glanz et al., 2005; Hendrickson et al., 2006; Moore et al., 2008; Black et al., 2014a; Caspi et al., 2012; Lee, 2012).

A similar trend of deteriorating food environments has been observed in Japan. Problems related to food deserts first emerged in depopulated rural areas, where elderly individuals without access to transportation had difficulties purchasing food

because neighbourhood grocery stores had closed down (Sugita, 2008). However, recently, similar situations have occurred even in urban areas (City Planning Institute of Japan, 2011; Iwama, 2013). For instance, in several cities, local grocery stores have closed since the 1990s. Moreover, even the large supermarkets, which play a central role in food provision in both downtown and suburban areas, have begun to shut down throughout the country due to the depopulation of retail trading areas. Residents in urban areas, including the elderly, disabled, expectant mothers, and working couples, have thus gradually been faced with a deteriorating shopping environment. An advisory council of the Ministry of Economy, Trade and Industry (2010) estimated that around 6 million people had poor access to daily food.

Yakushiji (2015) differentiated between the situational characteristics of food deserts in Japan and those in western countries such as the USA and the UK. First, those who face shopping inconvenience in Japan are mainly elderly, while those in the USA or UK are low-income individuals and people without cars in suburban areas. Second, health problems, especially obesity, are not as serious in Japanese food deserts as in the USA or the UK despite the changing dietary patterns in Japan. Third, the main concern of the elderly in Japan pertaining to shopping is low access to food stores (accessibility), while problems associated with other food access dimensions, such as availability, affordability, acceptability, and accommodation, have not been as severe as in other countries.[1] Of course, income and poverty are important barriers to obtaining fresh food even in Japan. However, accessibility is a more important factor for the aged population in Japan compared to the USA and the UK (Yakushiji, 2015). Therefore, geographic distance, as well as time and cost, are key measures of accessibility. From the viewpoint of accessibility, the Ministry of Agriculture, Forestry and Fisheries's Policy Research Institute (2012) and Yakushiji and Takahashi (2012) estimated the food desert population in Japan. According to their results, the Japanese population without automobiles and living more than 500 metres from food stores was estimated at 9.1 million, out of which around 3.5 million were aged 65 years or above. These researchers used 500-metre mesh data on food stores and population from the establishment and enterprise census of Japan and the population census, respectively. This method has the advantage of objectively measuring the food desert situation at pan-country level. Several municipalities have taken measures to alleviate shopping difficulties for the residents in areas considered food deserts. For example, the municipalities provide subsidies to some local or social welfare corporations for home-delivery or shopping services, mobile sales wagons, and on-demand transport systems (Iwama, 2013). These services facilitate shopping for the elderly. Nevertheless, these measures are not available in all areas of the municipalities. Due to budget constraints, only the residents in some areas can benefit from such support. Further, these municipalities have not used statistical data to estimate or investigate in detail the areas that are likely to be food deserts in the way Ministry of Agriculture, Forestry and Fisheries's Policy Research Institute (2012) and Yakushiji and Takahashi (2012) have. Therefore, more detailed data are needed to investigate this problem for small areas (Hirai and Minami, 2012).

Characteristics of the Study Areas

Yokohama has a population of 3.7 million and is the second-largest municipality in

Japan. Yokohama has Japan's largest international trading port, and many leading Japanese corporations in the heavy chemical and light manufacturing industries are located in the Keihin Industrial Zone, which is along Yokohama's coastline. Additionally, Yokohama has vast and populous suburban areas away from the coastline. In general, Yokohama's residents consider its urban and suburban areas convenient; however, its suburban areas do comprise mostly uneven and hilly terrain, making it difficult for residents to carry home their shopping bags. For this study, using aggregated data for the entire city area would mean ignoring differences in each local area, as Yokohama is a large urban municipality. On the other hand, consumers' actual shopping behaviour and perceptions can be observed directly in a smaller area. Thus, this study focuses on various areas within the ward, thus enabling a more realistic analysis than that afforded by a study examining a large geographic area (Thomas, 2010).

For this study, data were extracted on two districts to compare their food environment features. One district is Hodogaya, located in central Yokohama, which contains both urban and suburban areas. The other district is Izumi, which is located on the western side of the city and has the municipality's largest farmland area. Both areas have large ageing populations. (In 2015, Hodogaya had approximately 50 000 people aged 65 years or more (25%), while Izumi had roughly 40 000 people (26%) in that age bracket.) However, they differ in terms of shopping environment and the state of urban agriculture.[2] Thus, Hodogaya is an urban residential area with modest urban agriculture, while Izumi is a suburban residential area with large tracts of farmland.

Although Yokohama's population has increased—unlike most areas in Japan, which are generally experiencing depopulation—Yokohama also has a significant ageing population, in consonance with Japan's nationwide trend. The municipality's ageing population, which was 348 000 in 1995, rose rapidly to 850 000 in 2015, at a growth rate outpacing that of the national population. Therefore, Yokohama should address the many problems associated with its rapidly ageing population. One such problem is the decline of food retailers in each area – or, in other words, the problem of food deserts. While the populations of both study areas have increased, the number of food retailers therein has decreased: indeed, the growth of the ageing population in these areas would have inevitably and adversely affected food retailers' profits. Some food store owners explained that sales figures fall as the population of an area grows older, and so they need to consider shutting down operations in such areas. Along this line of thinking, they suggest that elderly households consume less, compared to younger households with children.[3] Nationally, 60% of elderly households in Japan comprise only a couple, while 34% of them are single-person households. Younger households have more family members, consume more food, and hence contribute higher profits to food retailers (Ministry of Agriculture, Forestry and Fisheries of Japan, 2017).

Thus, the statistical data suggest that with population ageing, the food-shopping environment would gradually deteriorate in the study areas (Figure 1). In both districts, the number of food retailers declined gradually over a 20-year period, while the population of elderly people increased markedly. Although opening new stores in a food desert might seem the common-sense way of alleviating poor food access, corporate strategies generally preclude the establishment of new stores in less-profitable areas. In the absence of adequate public budgets, public support through local civic groups or social-welfare corporations is likely to lead only to temporary

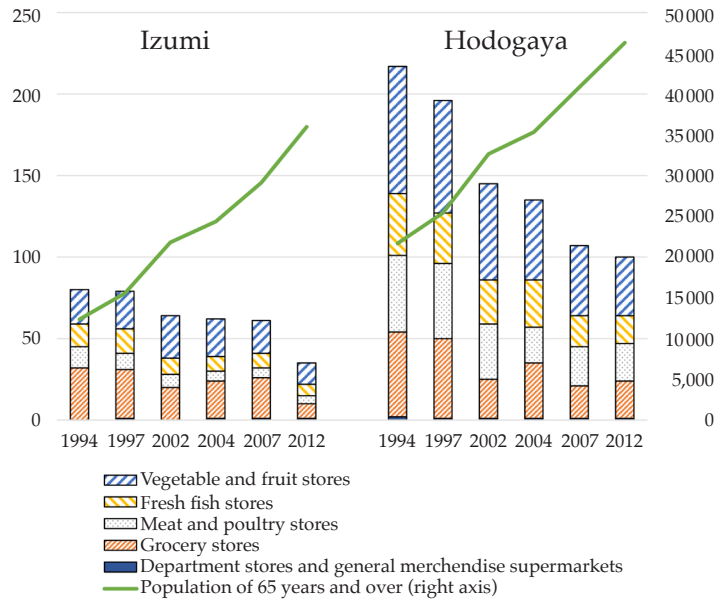

Figure 1. Trend of population and food stores in Hodogaya and Izumi.
Sources: Population Census and Census of Commerce.

solutions. A better alternative would be to leverage existing local resources.

According to a survey of consumer shopping behaviour in Yokohama City (2016), about 47% of 1,665 respondents used walking as their travel mode for daily shopping, while 33%, 17%, 10%, and 6% used automobiles, motorbikes, buses, and trains, respectively. Approximately 80% of respondents purchased fresh food, including vegetables, fish, and meat, at supermarkets, and only 4% used small grocery stores. Mail-order shopping – including home delivery and internet shopping – was used by 4% of respondents aged 60 years or older. While internet shopping is generally becoming more popular, it has yet to become a primary food-shopping mode. When asked the reasons for selecting these shops to obtain fresh food, the respondents stated that they 'were close to home', 'offered a wide variety of goods', 'offered good freshness/quality' and 'had available parking' (in descending order of prevalence). These survey results clearly show that most people choose supermarkets close to their homes to obtain fresh food. In addition, people prefer to walk to food retailers if they can obtain fresh food nearby, but use automobiles if fresh food retailers are far away.

The results of local surveys on shopping behaviour among the residents of the two study areas show similar trends. A 2011 survey report of Hodogaya residents (Hodogaya Ward, 2012) points out that about 90% of the approximately 1,700 respondents selected supermarkets for daily use. However, respondents in the older age brackets tended to use small grocery stores more frequently, but did also use supermarkets. When deciding where to buy goods, respondents placed emphasis on 'location of stores, proximity, or stop-off' rather than on 'price' or 'wide variety of goods'. Although this report does not indicate residents' preferences for travel modes for shopping, it does indicate that residents emphasize proximity to food retailers; in this sense, the survey results align with those of the Yokohama City (2016)

survey. Thus, elderly respondents lacking access to automobiles tend to use small grocery stores, which are closer, rather than more remote supermarkets.

In a survey of Izumi residents (Izumi Ward, 2015), more than 80% of about 1,600 respondents selected supermarkets as their primary shopping destinations, and this finding aligns with the results of the other surveys. In particular, respondents in their twenties and those aged over 60 years tended to shop by walking (40%) or using automobiles (37%). On the other hand, respondents in their thirties, forties, and fifties largely used automobiles for shopping. The preference of older people to walk suggests that they either cannot afford to maintain automobiles or find it difficult to drive due to old age. Additionally, the results of the Izumi survey might point to an inadequate food environment for its residents: approximately 58% of all respondents answered that they were satisfied with a store near their home for their daily shopping needs, but respondents aged 60 years and over desired a substantially greater number of food retailers to obtain fresh food nearby. These results suggest that older people do not obtain adequate food that meets their needs from the food stores they currently use – or, they have difficulty in accessing existing food retailers (i.e. they use distant food stores to purchase preferred items, either by walking a long distance or by using public transportation at an additional cost).

Therefore, based on the results of these three surveys, the prevailing view is that the consumers in the study areas strongly prefer supermarkets as their primary source of fresh food, and that walking is the most popular travel mode, especially among elderly people. Nevertheless, this does not mean that elderly residents are satisfied with the status quo for fresh food shopping; they may be having problems accessing adequate food. These points serve as useful entry points in analysing the food desert situation in Yokohama.

Data Sources and Methods

This study uses several sources of statistical data that are compatible with GIS analysis. First, it utilizes basic population census data based on the minimum units of the Japanese census tract. This census captures age-specific population data among the individual minimum units. Second, the prefectural administration provided geographic information data concerning building locations, including such information as the polygon of each building and the architectural floor area of each storey. Third, retailer point data were gathered from online business directories such as i-town page. Fourth, the location data of produce stands and farmers' markets were drawn from a Hodogaya Ward produce stand map created by a local non-profit organization; location information for those produce stands was drawn from public relations material generated by J.A. Yokohama (an agricultural cooperative) and the municipality. In addition, location data for the produce stands and farmers' markets in Izumi Ward were obtained from the local administration and an agricultural cooperative. Fifth, transportation route network data were analysed through the use of ArcGIS Network Analyst (a GIS software programme) to calculate travel distances. All these datasets were processed to make them suitable for GIS analysis.

To understand the current state of food accessibility among elderly populations and evaluate the effectiveness of various food outlets by using local resources, this study conducts two-step GIS calculations by comparing the two study areas. First,

information on elderly people's accessibility to food retailers was derived for the minimum units of the Japanese census tract. The number of people in food deserts was estimated, based on the precise location data and square footage of buildings (i.e. their homes). Data on the architectural areas of every residential building in each minimum unit were aggregated and divided by the population of that minimum unit. By multiplying the numbers in the minimum unit by the area of each building, it was possible to obtain the number of residents per building. This calculation method for the population per building provided the study's basic data. The minimum units in block population statistics are as large as a 500-metre grid in total; thus, 500-metre mesh data from previous studies were not suitable for our small study area. Therefore, the number of people per building was directly estimated. Detailed data in each census tract clearly show those areas with severely poor access to food stores, as well as the number of elderly people who live in these food deserts. Second, the alleviation effect was calculated against the aforementioned estimation. This calculation gives rise to detailed numbers of elderly people who use agricultural outlets closer to their homes, in preference to more remote supermarkets. By comparing the two study areas – which have very different agricultural situations – it is possible to understand better the benefits of urban agriculture on the food environment.

In these two-step calculations, a benchmark distance of 500 m was set to measure walking distance from residential buildings to food stores (i.e. from home). As commonly ascertained in previous studies, 500 m is considered a comfortable distance for people to walk to a food retailer; this distance is roughly a 10-minute walk each way (Furey et al., 2001; Wrigley, 2002; Larsen and Gilliland, 2009; Hirai and Minami, 2012; Iwama, 2013). Conversely, a food desert is defined as an area where people have little access to a food retailer within 500 m by foot from their homes. Network analysis using GIS identified the actual routes that people could take to access food retailers within 500 m by walking. These 500-metre buffers were created for each food retailer, and those buildings outside the buffers were defined as food desert locations, where residents were compelled to walk more than 500 m to access a food store.

Measuring Elderly People's Accessibility to Food Retailers

Figure 2 shows the locations of food retailers, the aforementioned 500-metre buffers, and buildings in Hodogaya and Izumi. Based on the GIS dataset, the numbers of residents outside the food retailer buffers were estimated for each study area. In Figure 2, each building shape contains the estimated population. Of course, food retailers are located around residential buildings, but this figure shows that their buffer zones do not cover many buildings, each of which contains a large number of residents. Figure 3 classifies the population rate in food deserts in the minimum units; specifically, the food desert population rate is the population rate in areas identified as a food desert, per population in each minimum unit. The minimum census tracts covered by the 500-metre buffers indicate a low food desert population rate overall. Nevertheless, the minimum units outside these buffers largely exceed 90% of the food desert population rate in Hodogaya, and are mostly 50% or higher in Izumi. Therefore, many of the minimum units in Hodogaya have no food retailers

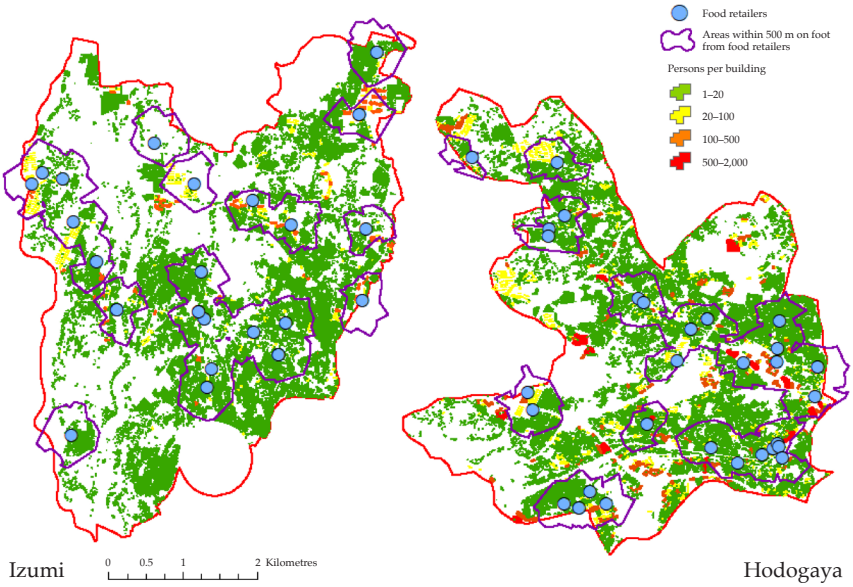

Figure 2. Food environment of Izumi and Hodogaya.

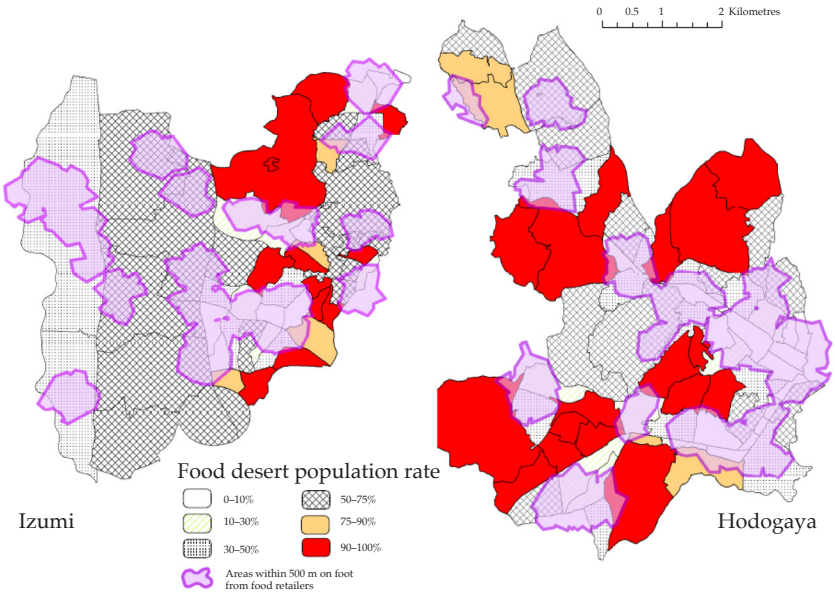

Figure 3. Food desert population rate of Izumi and Hodogaya.

within their buffer areas.

Table 1 shows the estimation results for 61 minimum units in Hodogaya. Surprisingly, 16 minimum units (26.2% of all units) have desert population rates approaching 90% or higher, and another 12 minimum units (19.7%) have rates ranging from

Table 1. Results of GIS estimation of food deserts and agri-oases.

	Food desert population rate	Minimum units of the census tract		Total population			Population in food deserts			Population in agri-oases		
		No.	%		65+	75+		65+	75+		65+	75+
Hodogaya	>90%	16	26.2	60143	13405	6,508	58772	13064	6,347	5,950	1,537	708
	75–90%	3	4.9	14405	3,576	1,445	11727	2,954	1,193	819	249	100
	50–75%	9	14.8	54198	12405	5,718	36493	8,239	3,817	7,868	2,025	882
	30–50%	11	18.0	36920	7,620	3,540	15441	3,171	1,478	928	196	87
	10–30%	10	16.4	19505	4,441	2,010	3,667	832	385	129	31	11
	<10%	12	19.7	21463	4,209	1,873	556	118	54	0	0	0
	Total	61	100	206634	45656	21094	126655	28378	13275	15693	4,038	1,788
Izumi	>90%	11	26.2	22976	5,451	2,483	21891	5,202	2,369	7,469	1,854	810
	75–90%	4	9.5	7,827	1,461	604	6,383	1,181	488	2,182	430	184
	50–75%	8	19.0	69419	15320	6,453	47616	10512	4,422	25941	5,949	2,500
	30–50%	7	16.7	35780	8,739	3,526	16167	3,945	1,584	10134	2,525	1,014
	10–30%	6	14.3	12077	2,443	1,165	2,332	484	232	1,392	298	142
	<10%	6	14.3	7,574	1,580	688	234	50	22	52	7	3
	Total	42	100	155698	34994	14919	94622	21374	9,118	47170	11062	4,654

50% to 90%. In particular, most units are likely to have people with poor access to food stores: those 16 and 12 minimum units, for example, have 58772 and 48220 people, respectively. Of course, these figures contain people across multiple generations, and some have no health concerns relating to access to shops. Therefore, while this estimation may be somewhat aggressive, the results nonetheless indicate that food deserts can spread everywhere.

GIS calculations show that in Hodogaya, 126655 residents live outside the buffers. In other words, 61.2% of the population lives more than 500 m from the closest food store. The number of elderly people aged 65 years or more was estimated by multiplying the population rate in food deserts by the elderly population rate in each minimum unit. This yielded a total of 28378 (13.7% of the total population). Thus, 62.1% of elderly people in Hodogaya live in food deserts. In particular, 13275 of those aged 75 years or more (6.4% of the total population) have poor access to food retailers, and this generation is likely to experience the most difficulty in walking to food stores. Although these estimations do not necessarily mean that all 28000 elderly people have problems walking to food stores, more than a few may be at a high risk of being unable to do so independently.

As Table 1 shows, 11 minimum units in Izumi (26.2% of all 42 units) reached a food desert population rate of 90% and more, and another 12 units there (28.5%) had a food desert population rate ranging from 50% to 90%. Like Hodogaya, Izumi has a number of people who do not live within walking distance of a food store. The 21891 people within the 11 aforementioned units as well as the 53999 people in the aforementioned 12 units live in a food desert. Thus, 94622 people reside in food deserts, and this figure corresponds to 60.7% of the entire population. The number of people aged 65 years or more (75 years or more) was estimated at 21374 (9,118), or 13.7% (5.8%) of the total population and 61% (43.2%) of the aged population. Although Hodogaya is closer than Izumi to Yokohama's downtown area, and life in Hodogaya seems to be more convenient than that in Izumi, the results of this estimation show that the food desert problem in Hodogaya is quite serious. Nonetheless, the degree of seriousness is almost the same for, in both, large numbers of elderly people find it physically challenging to access adequate food. Some of these elderly people can use automobiles without difficulty, but as the results of the aforementioned city and ward surveys show, many people prefer to walk to meet their daily shopping needs.

The current study estimates that up to 28000 and 21000 elderly people in Hodogaya and Izumi live in food deserts, respectively. Currently, they manage to obtain their daily food from relatively distant stores that offer a wide range of good-quality products; however, as mentioned, many find it inconvenient to shop at these stores.

Discovering Agri-oases in Food Deserts

Urban Agriculture in a Megacity

To alleviate the problem in Yokohama of a poor shopping environment for fresh, nutritious food, alternative outlets are needed. This study discusses a new way by which consumers can utilize local urban agriculture. While Yokohama is a megacity with a huge population and a concentration of companies in the heavy chemical and light manufacturing industries, it also has a vibrant agricultural sector. In fact, even

as rapid land development for housing has overexploited the area's vast farmland since the 1960s – a period of rapid economic growth in Japan – the city government has embarked on an effort to prevent urban sprawl and conserve farmland, in order to enhance the living environment and provide more green space. Under these urban development policies, agriculture has been promoted in Yokohama to encourage farming in the future (Tashiro, 1991). Current levels of agriculture within the inner city or on the fringes of Yokohama are outcomes of these policies and of farmers' patient endeavours. Most farmers in urban areas receive real-estate income from converted farmland, and it is not an overstatement to say that this income can substantially support farmers' household economies. Income from agriculture might not necessarily be their main source of revenue, and it does mean that most farmers in Yokohama are, in a sense, part-time farmers. Thus, much farmland is in danger of being converted to urban facilities, depending on the decisions of farmers about whether to continue to work in agriculture. In addition, the levying of heavy inheritance taxes on farmland in urban areas impedes the continuation of agriculture by farmers. While high land prices in urban areas can derive a good real-estate income as a secondary income for farmers, such prices can also result in the imposition of heavy farmland taxes.

Urban agriculture is loosely defined as the cultivation of food in metropolitan core areas (Lovell, 2010; Golden, 2013; Santo et al., 2016; Horst et al., 2017). It encompasses various activities: school gardening, rooftop farming, indoor farming, urban farming, community gardening, and backyard gardening, inter alia. Urban agriculture is practised at various places, ranging from balconies where a few plants are grown to community gardens in public spaces. A wide range of people – including farmers, non-farmers, and urban residents – engage in urban agriculture (Santo et al., 2016; Horst et al., 2017). However, in the case of Japan, urban agriculture is mainly understood as farming in urban farmlands by farmers. Many urban residents in Japan do grow agricultural products on their balconies or in their own gardens; however, these activities are not generally considered parts of urban agriculture. This point should be stressed so as to clarify the difference between how 'urban agriculture' is understood in Japan versus the way it is understood in other countries. Urban agriculture in Yokohama supplies its urban citizens with various kinds of fresh and nutritious fruits and vegetables. To continuously conserve farmland, avenues for agricultural income should be developed to sustain farmers' household economies. For this very reason, many farmers have attempted to find effective ways of increasing their agricultural sales, such as direct-to-consumer sales.

In 2015, Hodogaya had 118 farming households and 72 ha of cultivated land, while Izumi had 375 farming households and 284 ha of cultivated land; thus, the amount of agricultural land in Izumi is approximately three times that in Hodogaya. Farmers mainly grow vegetables outdoors, including cabbage, a radish variety, spinach, tomato, and Japanese mustard spinach. Although farms are relatively small and cover less than 1 ha of farmland per farmer, most farmers cultivate a variety of high-quality crops; in fact, some farmers produce more than 80 different crops each year. They transport most of their fresh vegetables directly to their own produce stands or to farmers' markets, and sell their produce at affordable prices, thus taking advantage of their proximity to a large metropolitan population. However, they also transport some of their products to wholesale markets.

The current case study shows that local agriculture in a megacity can contribute to the provision of fresh, nutritious, and affordable food to urban people, via not only

food retailers but also agricultural outlets. As Moore et al. (2008) point out, much of the food desert literature hinges on the assumption that people can obtain healthful food only at supermarkets. While the proliferation of food deserts can be attributed to the collapse of food supply systems, the role of agriculture and the relationship between agriculture and food deserts have not been examined sufficiently. Some studies – such as those of Larsen and Gilliland (2009) and Bader et al. (2010) – focus on the role of alternative sources of healthful food to supermarkets, including smaller outlets, such as fruit and vegetable markets and farmers' markets. When these agricultural outlets are used as alternatives in obtaining adequate food, difficulties inherent in shopping at distant stores can be somewhat alleviated. Therefore, in megacities, urban agriculture can serve as an effective tool in the fight against food deserts. The use of urban agriculture to combat food deserts is referred to as the establishment of 'agri-oases' in food deserts (Ikejima, 2015).

Benefits of Agri-oases

To examine the potential benefits of urban agriculture through agri-oases, the location data of agricultural outlets (i.e. produce stands and farmers' markets) are added to the dataset, which enables calculations of how many people live in food desert areas but within the buffer zones of alternative outlets. The results show that Hodogaya has 19 agricultural outlets (18 produce stands and a farmers' market), while Izumi has 74 agricultural outlets (70 produce stands and four farmers' markets). Farmers' markets are located in the offices of agricultural cooperatives or close to train stations, and have little storage space for large volumes of produce. Produce stands, which are often built next to farmland, mostly have only small shelves or desks to display agricultural products. These agricultural outlets are popular with local people, because they allow for the purchase of various fresh products at marginally cheaper prices close to home. With the ageing of farming households and the levying of high inheritance taxes, both the number of farming households and the extent of cultivated acreage have been in decline year over year, and so produce stands have been disappearing. However, agricultural outlets function as prospective sales channels and as places where farmers can communicate directly with urban consumers. These outlets symbolize urban agriculture in Yokohama, but urban agriculture remains relatively unknown to many urban people.

Figure 4 shows the effects of agri-oases in food deserts in Hodogaya and Izumi. Dots within the buffers of each agricultural outlet represent buildings within a 500-metre walking distance of residents' homes. This means that people living in buildings in agri-oases can easily access fresh, nutritious food, even if their buildings are more than 500 m from existing food retailers. In addition, although agricultural outlets around supermarkets have a smaller effect on food deserts, those far from food stores have a significant impact; in fact, agri-oases were found in both areas to have an effect on food deserts. While agri-oases have a relatively small effect in terms of access, they may have more significant effects in terms of offering cheaper and fresher agricultural products.

The GIS calculations, derived through a similar method, show that in Hodogaya, 15693 residents have good access to agricultural outlets outside the buffers of food stores. Thus, agri-oases affect the equivalent of 12.3% of the population in food de-

serts. On the other hand, 47 170 residents who lived in food deserts in Izumi were found to have better access to local vegetables on account of these agri-oases; this is equivalent to 49.8% of the food desert population there.

Elderly people find agri-oases most helpful in obtaining fresh food. In Hodogaya, the number of people aged 65 years or above in agri-oases is 4,038 (i.e. 14.2% of the population), while for people aged 75 years or older, that number is 1,788 (13.4%). Izumi, in comparison, has 11 062 (4,654) people aged 65 years and over (75 years and older) who live in agri-oases, and this is equivalent to 51.7% (51%) of the population aged 65 years and over (75 years and over). Although agri-oases might not offer the greatest impact on the minimum units with the highest food desert population rates, as shown in Table 1, agri-oases do benefit a very large percentage of the food desert population, depending on farm location. In particular, in Izumi, approximately one-half of the elderly people who live in food deserts can easily obtain fresh food by accessing agricultural outlets within 500 m of their homes.

Figure 5 is a three-dimensional representation of the effects of agri-oases. Each minimum unit is classified in terms of its food desert population rate. Buildings in agri-oases are denoted with vertical bars whose height is based on the population per building, as estimated previously. Buildings with higher populations are mostly housing complexes containing more than 150 residents each. While many higher-population buildings in Izumi are not located in severe food desert areas, those in Hodogaya are located in areas with high food desert population rates. With regards to the population impacted by agri-oases, the population in Izumi to reap the benefits of agri-oases is larger than the one of Hodogaya, as reflected in the number of agricultural outlets. Indeed, in Izumi, urban agriculture offers more opportunities to access fresh and healthful local food than in Hodogaya. However, establishing agricultural outlets in Hodogaya's severe food desert areas would be an effective

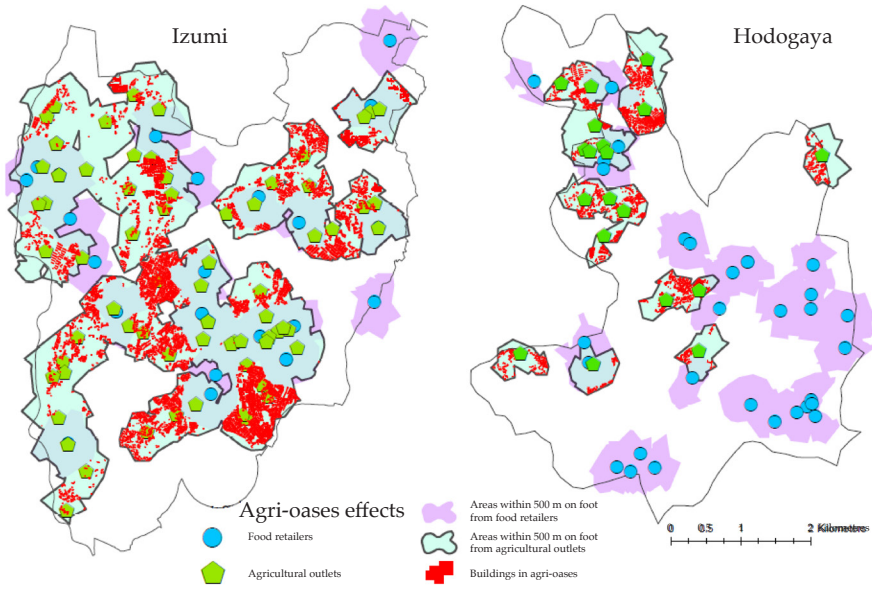

Figure 4. Effects of agri-oases of Izumi and Hodogaya.

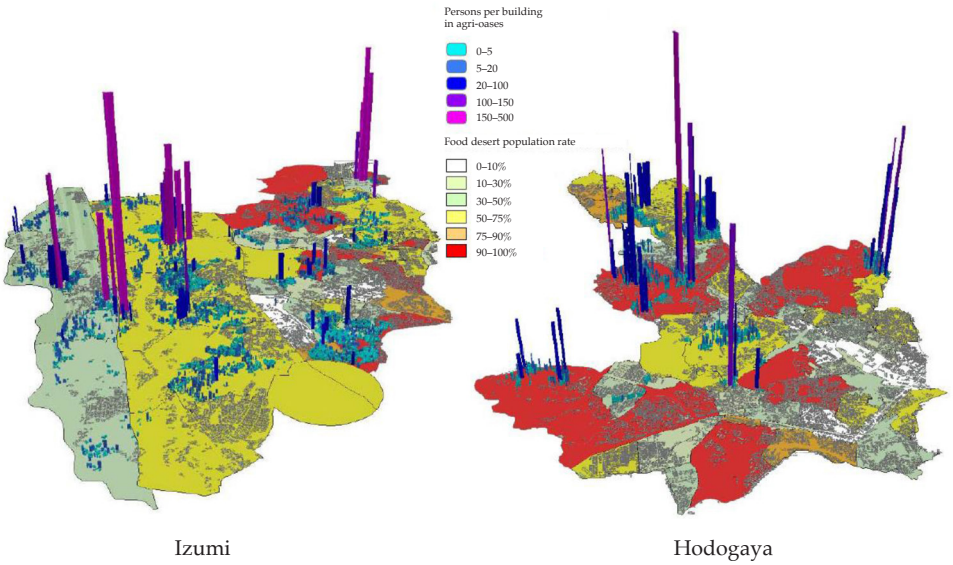

Figure 5. Buildings in agri-oases of Izumi and Hodogaya.

measure.

The concept of agri-oases illustrates the need to create opportunities for residents to access fresh food easily. Therefore, this concept does not help in verifying whether residents can actually alleviate their challenges in accessing adequate food through the use of agricultural outlets. At any rate, by using three-dimensional maps, one can discern the potential effects of agri-oases spatially, and urban agriculture could be helpful in ameliorating poor access to adequate food within food deserts, without incurring among residents any additional costs. Of course, although people cannot meet all their food needs through local agricultural outlets and will need to purchase necessities other than agricultural products at other stores, urban agriculture does have the potential to positively affect the food environment in food deserts.

Discussion

This study examines food access among elderly people in a megacity, and determines the visible benefits of urban agriculture in improving residents' access to fresh food. Specifically, this study measures how many elderly people live with inadequate access to healthful food; it also investigates how urban agriculture – in the form of agri-oases – can provide these residents with benefits and alleviate the challenges they face in accessing healthful agricultural products.

This study's first finding, derived through the use of GIS calculations, is that more than 28 000 elderly people (i.e. aged 65 years or more) in Hodogaya, and more than 21 000 in Izumi, live more than 500 m from the nearest food retailer. These numbers represent approximately 60% of the elderly residents in those areas. Additionally,

it was found that 13 000 and 9,000 individuals aged 75 years or more in Hodogaya and Izumi, respectively, do not have food retailers within a walkable distance from their home.

These results suggest that large numbers of elderly people find it physically difficult to access adequate food, and that ageing itself could be a barrier to carrying out their own shopping. Elderly people try to keep themselves healthy by accessing food outlets, even when they find it difficult to reach such stores. Even in environments that feature insufficient community nutrition, elderly people find it difficult to access the food outlet they chose as their primary grocery outlet, and this does not result in a worse consumer nutrition environment. Previous research has examined the association between the food environment and health outcomes, and tends to assume that those who live in food deserts either belong to ethnic minority groups or have a low income (Beaulac et al., 2009; Charreire et al., 2010; Caspi et al., 2012; Hilmers et al., 2012; Black et al., 2014a; Helbich et al., 2017; Lytle and Sokol, 2017). Additionally, much of the food desert literature focuses on recognizable problems, such as state of health and dietary patterns. However, in changing the research focus from shopping outcomes (e.g. dietary patterns) to difficulties in shopping itself (e.g. the burden of going to stores), previously unknown problems related to food deserts and urban food security come to the fore. As such, this study fills a lacuna in the food desert literature. In a sense, its focus on elderly people helps reveal new aspects of the food desert phenomenon that would likely have remained unnoticed otherwise.

A second finding of this study is that, among the residents of food deserts in Japan, urban agriculture can help offer adequate access to healthful food. Agricultural outlets are used as alternative outlets by which to obtain fresh and healthful agricultural products and processed food. In this study, 500-metre buffers from local agricultural outlets were set as the range within which residents could easily access fresh agricultural products on foot. GIS calculations demonstrated that in Hodogaya and Izumi, 4,000 and 11 000 people aged 65 years or over, respectively, had access to agri-oases. These numbers translate into 14% and 51% of the elderly population of Hodogaya and Izumi, respectively.

These findings may have important implications for urban agriculture, especially in the context of food justice. As indicated by the survey report on consumer behaviour in Yokohama City (2016), most of the consumers there obtain fresh and healthful food from supermarkets. However, because supermarket locations are influenced by corporate strategies, food retailers in less-profitable areas tend to close their stores. This gives rise to food deserts, and to food insecurity among elderly people who live in areas with fewer stores. Indeed, access and consumption-related disparities are 'hot' topics in the food justice literature (Horst et al., 2017).

Improving access to fresh food through the use of local agricultural outlets is one of the advantages of urban agriculture. In identifying the impact of improving food access via urban agriculture, this study quantitatively verified, using a real-world case, that it is possible to pinpoint the beneficial effects of urban agriculture against social disparities. This mode of quantitative analysis may pioneer new ways of evaluating the role of urban agriculture.

Conclusion

The study examined the food desert situation in detail, using the minimum units

of two wards in Yokohama, Japan; it measured the potential benefits of alternative urban agriculture outlets in creating so-called agri-oases. According to this study's results, in both areas, approximately 60% of those aged 65 years or more reside far from food stores for daily shopping. Although Hodogaya and Izumi have different populations, they face roughly similar food desert conditions. The analysis shed light on the difficulties that many face in shopping; in this sense, it is different from other studies that address visible health-related problems or undertake debates on food deserts and urban food security. Simultaneously, this study's findings vis-à-vis the effects of agri-oases on food security among urban elderly people point to urban agriculture's contribution to environments with insufficient food supplies. As a result, one conclusion drawn here is that physical mobility – that is, elderly people's accessibility to food outlets – will become increasingly significant as Japan's society becomes 'super-aged'.

Despite its contributions to the literature, this study – like any study – does have limitations. One of these is that this study did not investigate actual consumer behaviour in detail by using the GIS-based methodology. Interviews with agricultural outlets and supermarkets revealed that many urban people cite distance from their homes as a reason to not buy fresh and high-quality food at affordable prices from a particular outlet.[4] Additionally, because farmers are proud of their product quality, they tend not to consider that consumers choose outlets on account of proximity to their places of residence. On the other hand, urban consumers often use distant supermarkets, as they find them convenient in purchasing daily necessities, including vegetables, in a single trip, even though they recognize that nearby agricultural outlets provide good-quality vegetables. These limitations should be addressed in future studies.

Notes

1. These food access dimensions are proposed by Penchansky and Thomas (1981) to conceptualize the food environment. 'Availability' refers to the adequacy of the supply of healthful food. 'Accessibility', meanwhile, refers to the location of the food store and the ease of getting to that location. 'Affordability' refers to food prices and consumers' perceptions of worth relative to cost. 'Acceptability' refers to consumer attitudes and personal standards vis-à-vis the local food environment. Finally, 'accommodation' refers to store hours and the types of payment accepted (Caspi et al., 2012).
2. A brief comparison of the two study areas shows that Hodogaya covers an area of 21.81 km^2 while Izumi covers an area of 23.56 km^2, according to 2015 Yokohama City statistics. Hodogaya has 31 food stores, while Izumi has 27, as listed in a 2015 business directory. Hodogaya has 144 farmers and 82.54 ha of farmland, while those numbers for Izumi are 461 farmers and 296.58 ha, according to a 2010 agricultural census. Hodogaya has 19 agricultural outlets and Izumi has 74, based on 2013/2014 data. Thus, Izumi's agricultural sector is approximately three times larger than Hodogaya's, although they have almost the same geographical size and number of food stores.
3. Interviews with staff members of food retailers were conducted from 2012 to 2014 to confirm corporate behaviour affecting the food environment around the stores. In many cases, residents wanted the food retailers to continue operations. Chain stores often decided to close their locations, while independent stores tended to continue to operate.
4 Interviews with shoppers and farmers were conducted from 2012 to 2014, to collect information about the local food environment. Twenty shoppers in Hodogaya and 10 shoppers in Izumi answered questions about their shopping behaviour. They specifically answered why they purchased fresh and healthful food at supermarkets or agricultural outlets. Thirteen farmers in Hodogaya and 19 farmers in Izumi answered questions about their farming and about consumer responses to their agricultural products.

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