

Article

Networked Compact City Policy Status and Issues—Hierarchy and Human Mobility in Tokyo, Japan

Taichi Murooka ^{1,*}, Hiroki Shimizu ² and Mamoru Taniguchi ³¹ College of Policy and Planning Science, University of Tsukuba, Tsukuba 305-8577, Japan² Information and Systems Program, University of Tsukuba, Tsukuba 305-8577, Japan; s2020422@s.tsukuba.ac.jp³ Engineering, Information and Systems Program, University of Tsukuba, Tsukuba 305-8577, Japan; mamoru@sk.tsukuba.ac.jp

* Correspondence: murooka.taichi.sg@alumni.tsukuba.ac.jp; Tel.: +81-070-3880-4813

Abstract: As a policy to promote compact cities, Japan formulated the Location Normalization Plan (LNP) in 2014. By this plan, each municipality is promoting the establishment of Urban Function Induction-encouraged Areas (UFIA) in which life service facilities are to be provided. The role of the UFIA in the region might differ depending on the city scale and the UFIA hierarchy. For this study, using the Tokyo Person Trip survey, we specifically examined the mobility of people and clarified differences in the hierarchical nature of UFIA to ascertain the current status and issues of UFIA. Consequently, we obtained the following information for the realization of compactness. (1) The actual conditions of traffic characteristics and facilities differ depending on the UFIA hierarchy. Moreover, considering these hierarchies during the study of UFIA is important. (2) Sub-core UFIA in cities with a large population have a narrow usage area and a high ratio of traffic-sharing between walking and bicycling, which might engender the construction of compact living areas. (3) However, sub-core UFIA in cities with a small population have a high ratio of traffic-sharing of automobiles and a wide usage area, which presents challenges for compact city realization.

Keywords: urban planning; urban structure; transportation; land use; urban shrinking



Citation: Murooka, T.; Shimizu, H.; Taniguchi, M. Networked Compact City Policy Status and Issues—Hierarchy and Human Mobility in Tokyo, Japan. *Sustainability* **2021**, *13*, 13107. <https://doi.org/10.3390/su132313107>

Academic Editors: Tatsuhito Kono and Nao Sugiki

Received: 30 October 2021

Accepted: 24 November 2021

Published: 26 November 2021

Publisher's Note: MDPI stays neutral with regard to jurisdictional claims in published maps and institutional affiliations.



Copyright: © 2021 by the authors. Licensee MDPI, Basel, Switzerland. This article is an open access article distributed under the terms and conditions of the Creative Commons Attribution (CC BY) license (<https://creativecommons.org/licenses/by/4.0/>).

1. Introduction

1.1. Background

In recent years, compact cities have been attracting attention worldwide for their economic feasibility, environmental sustainability, and social equity [1]. Compact city policies have attracted attention for their highly sustainable urban structure and sprawl mitigation. Additionally, from the perspective of environmental sustainability, the compact city policy aims to reduce greenhouse gas emissions by shifting automobiles to environmentally friendly public transportation and controlling traffic congestion in massive tourist activities [2–5]. On the other hand, the Japanese social problems are not only environmental concerns but also the decline of urban centers due to sprawl and securing of mobility in a society with a seriously low birthrate and aging population.

To cope with these issues, it is urgent to form an urban structure that will make cities more compact and bring people to central areas using public transportation. The aim is to form a “networked compact city” by linking compact urban development through the induction of functions that support living and urban life with the restructuring of the public transportation network [6].

Japan is not the only country that is trying to downsize its cities. The meaning and process of shrinking cities have been discussed in many places. For example, the policy called Stadtumbau Ost [7] has contributed to the redevelopment of downsized cities in Germany. Additionally, the state of Michigan [8] has set up zones for downsizing. Therefore, it is important to clarify the status and issues of the “networked compact city” to discuss the process of shrinking cities around the world.

As a legal system to promote networked compact city policies, the Act on Special Measures related to Urban Reconstruction [9] was revised in 2014. Each municipality is promoting the formulation of a Location Normalization Plan. This system establishes Urban Function Induction-encouraged Areas (UFIA) and Residence Induction-encouraged areas (RIA) [10] (Figure 1). UFIA is an area where urban functions such as medical care, welfare, and commerce are induced to the core or sub-core areas so that these services can be provided efficiently [10]. RIA is an area in which residents should be induced to live to maintain population density in a certain area and to ensure sustainable livelihood services and communities even in a declining population [10].

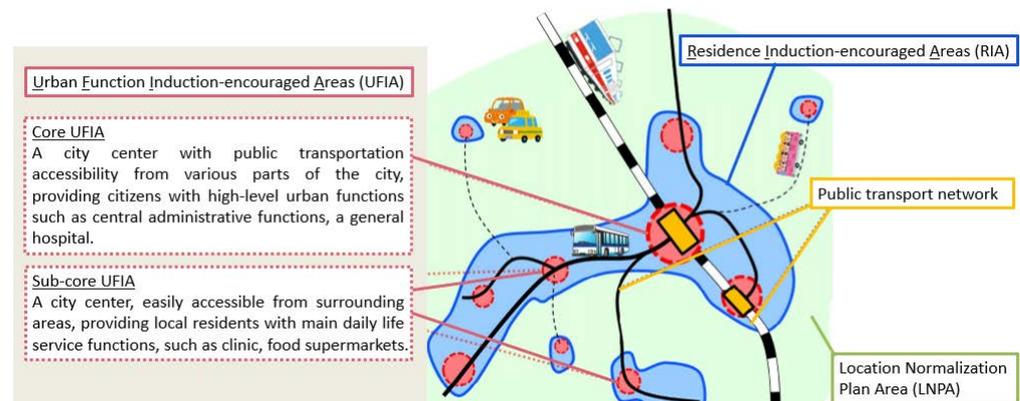


Figure 1. Overview of Location Normalization Plan. (Created based on [9]).

To formulate a Location Normalization Plan, each municipality attempts to identify issues from various aspects, such as future population estimates, land use data, and the current situation of facility locations. After identifying these issues, they consider consolidation of the facilities in the UFIA. Chiba city in Chiba prefecture, Japan, has established UFIA and RIA within the Location Normalization Plan area. Each municipality can decide a UFIA as core or sub-core [11]. The core UFIA is located at the traffic hub. From various parts of the city, it is highly accessible by rail. The sub-core UFIA is located along the railroad lines. The RIA is set up around them [11].

When examining induction facilities, UFIA, and RIA, one must consider urban development policy measures and induction policies for resolving difficulties, the urban structure as a framework, and the optimal location range of induction facilities. However, even in the same UFIA, the roles played by the core and sub-core UFIA are regarded as different [12]. The core UFIA, which has excellent public transportation accessibility from each part of the city, provides residents with higher-order urban functions such as core administrative functions, a general hospital, and a considerable concentration of commerce. However, sub-core UFIA, as sub-core centers that are readily accessible from surrounding areas, provides residents with daily life service functions such as administrative branch office functions, medical clinics, and grocery stores [12]. Furthermore, facilities needed for UFIA vary depending on regional characteristics including hierarchy composed of city-scale and municipal setting policies (core or sub-core) [12]. For instance, the role of a UFIA is inferred to be different between the core UFIA of a large city such as Chiba and that of a small city in the suburbs of a metropolitan area. Additionally, the role of UFIA seems to differ depending on the core or sub-core even in the same Chiba city. As described above, it can be inferred that UFIA plays a different role depending on the hierarchy. Thus, one must consider hierarchy according to the city scale and the role played by the UFIA when examining UFIA and facilities.

To realize the networked compact city, people must visit the UFIA regularly for the facilities in the UFIA to be used sustainably. Therefore, the differences in the hierarchy of UFIA must be clarified by particularly addressing human mobility.

1.2. Literature Review

1.2.1. Knowledge of Location Normalization Plans

In recent years, the debate on LNP (Figure 2) has begun to attract attention in the international literature. Wang et al. proposed two urban redevelopment plans to address Japan's aging society, combining various data to promote urban activities and to improve the efficiency of urban service facilities [13]. It is necessary for the periphery of cities with a large population and rural cities with aging populations [14]. The method underlying LNP policy is to identify the zoning locations of urban facilities and residential areas. Urban facilities include commercial facilities, medical facilities, welfare facilities, child-care support facilities, and cultural facilities. Based on the urban planning theory of compact cities, we recommend that these urban facilities be located near transportation stations [15].

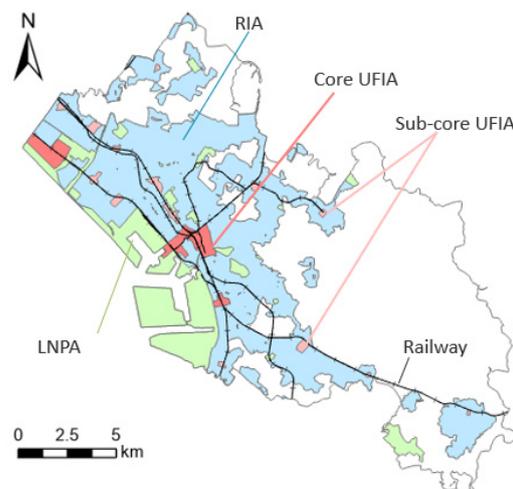


Figure 2. A Location Normalization Plan (Chiba city, Chiba pref.) (Created based on [11]).

To clarify the actual situation of UFIA settings, 25 cities were selected [15]. That study demonstrated that the induction of urban functions is most likely to be achieved mainly by targeting functions in core areas where the public sector can be involved to some degree [15]. They also found that nine cities have established independent zones related to residence in non-induction zones excluded from RIA. Many factors such as the state of development of urban infrastructure were used; the state of development of existing residential areas, population density, and the relation with higher-level plans was also used. From the RIA viewpoint, residence areas are classified based on urban functions and future population prediction, showing that LNPs are effective for sprawl clusters [16]. They concluded that the results might be useful for shrinking cities in which sprawl clusters are spreading. For example, in China, where the population is expected to decline more rapidly than in Japan in the future, the LNP policy might be useful for urban design. However, for former new town clusters and public housing clusters, the paper reports that one must consider methods other than LNP policy, referring to urban policies for shrinking cities in other countries [16].

As described above, knowledge related to LNPs is continuing to accumulate. Nevertheless, no report of the literature to date has described a study particularly addressing the UFIA hierarchy.

1.2.2. Discussion of City and Core Area Hierarchies

Difficulties of urban hierarchy planning can be resolved by facility layout models. Numerous studies have examined models of this type [17,18].

To maximize accessibility to all facilities, some studies have used post-optimization models to ascertain simultaneously which urban centers and which network links should be promoted to a new hierarchy [19]. One can argue that although the spatial connectivity of

a certain kind of urban function is complemented by the multiplicity and multilevel nature of cities, the connectivity of another kind of urban function is not spatially integrated [20].

After an extensive review of the literature describing the hierarchical location problems described above, all papers can be classified in terms of models, solutions, performance measures, and applications [21]. Some results of studies suggest further research and perspectives in the area of dynamic facility location problems. Because facility location and human mobility are similar to two wheels of a car, and because human mobility is also expected to differ in the urban function hierarchy, the next section presents a review of discussions and studies of human mobility.

1.2.3. Studies Examining Human Mobility to Core Area Plans

Although human mobility is said to change on a daily basis to accommodate work, leisure, and family relationships [22], some reports have shown predictions of human mobility in urban areas (Song et al., 2010) [23]. Consequently, many studies of recent years have contributed to the revitalization of urban centers based on the mobility of people. For example, one study identifies urban centers and their boundaries based on human mobility data obtained from social network systems (SNSs) [24]. Another study has explored the relationship between urban vitality and street core based on SNS data [25]. To optimize the spatial configuration of medical and other public facilities, spatial interaction characteristics and service areas of public facilities of different types and sizes have been identified from taxi-boarding data [26].

Although collecting conventional location-based big data (cab trajectory data, cell phone data, social media data, etc.) is easy, identifying individual attributes and different urban functions for these data is difficult. Moreover, the destinations and paths of taxis are limited to verification in a specific space because they are heavily dependent on catchment facilities such as airports and train stations. Using cab data alone (or other data from a single type of transportation) to identify patterns of the urban polycentric city at a metropolitan scale can engender several difficulties such as insufficient explanatory variables and weak spatial heterogeneity [27]. Furthermore, although cell phone data are excellent for elucidating short-term changes in amounts of human activity and spatial distribution, they entail the shortcoming of being unable to reflect the means and purposes of travel. Furthermore, because of privacy policies and data uncertainty, it has been difficult to ascertain personal characteristics such as detailed locations of residential and arrival points [27]. These are important challenges when considering the “UFIA hierarchy” described earlier herein.

1.3. Study Purpose

Based on the above background and existing studies, the purpose of this study is to clarify the status and issues of UFIA by particularly addressing the mobility of people and clarifying the differences in the hierarchy of UFIA and to provide reference information for compactness. We will conduct three types of analysis based on the principles of LNP. (1) Because it is desirable for UFIA to be located along public transportation lines, we will clarify the differences in the transportation modes to the UFIA by class. (2) As basic information for examining the facilities to be induced in UFIA, the differences in the facilities used in UFIA will be clarified according to their base hierarchy. (3) The difference in the use area by the hierarchy of centers will be shown as basic information for examining the area and size of UFIA.

1.4. Features of This Research

- (1) This research is novel because it uses empirical data of human mobility to clarify the reality of differences in the hierarchical nature of UFIA. The data enable us to ascertain the transportation modes and facilities used by individuals, which has persisted as an issue in earlier studies.

- (2) This study yields reliable evidence that quantitatively reveals actual circumstances of human mobility using high-precision data with latitude and longitude information from a major survey in Japan, including data of approximately 700,000 people.
- (3) Amid demands for compactness and the associated enhancement of transportation networks, this research is useful for identifying issues affecting UFIA based on current circumstances. That identification is possible by examining empirical data of human mobility.

2. Materials and Methods

2.1. Tokyo Metropolitan Area

Figure 3 shows the target area of this study. The Tokyo metropolitan area (Tokyo, Kanagawa, Saitama, Chiba, and the southern part of Ibaraki prefecture), the world's largest metropolitan area, plays a core role in Japan's politics, economy, and culture. Moreover, it is a place of life and activity for approximately 38 million residents (December 2020). The future urban structure of the Tokyo metropolitan area is the following: "With the advent of a society with a declining birthrate, aging population, and declining population, it is important to restructure the city into a walkable city by reorganizing and consolidating the functions necessary for daily life in the vicinity of major stations and familiar living centers, rather than spreading out urban areas" [28]. Moreover, it is important to secure access to public transportation to connect these areas. In fact, 46 municipalities within the Tokyo metropolitan area have formulated LNP (2020, 12), which is an appropriate target area for achieving the purpose of this study. As described earlier, the UFIA role and the necessary facilities differ depending on the city scale, even for the same center. Therefore, UFIA are classified according to population: the most basic city-scale indicator in this study (Table 1).

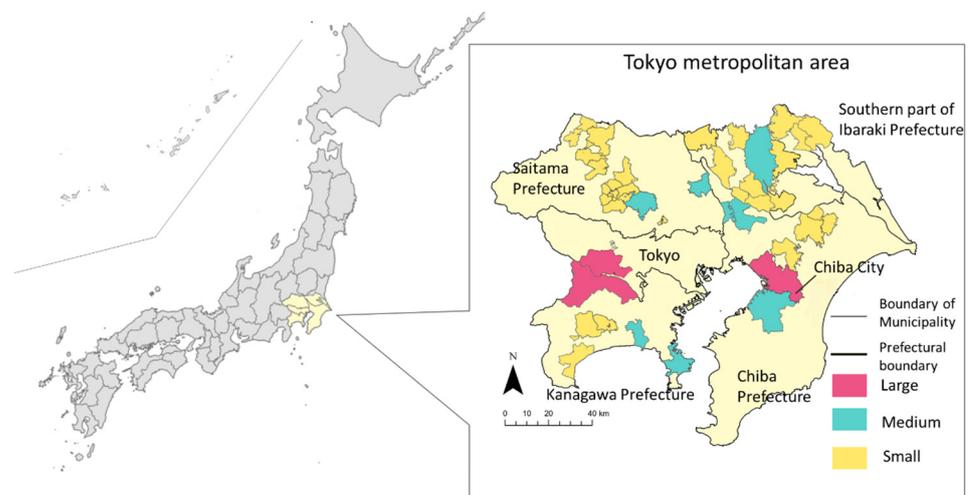


Figure 3. The study area.

Table 1. Notation of UFIA types used for this study.

Population	UFIA Type	Notation
over 500,000	core sub-core	Large-C Large-S
under 500,000 over 200,000	core sub-core	Medium-C Medium-S
under 200,000	core sub-core	Small-C Small-S

2.2. Materials

As a study producing suggestions for core area plans based on human mobility, this study faced many challenges, such as the inability to specify the means and purposes of travel using conventional data. Therefore, we use the Sixth Tokyo Person Trip Survey (Tokyo PT) conducted by the Tokyo Metropolitan Area Transportation Planning Council in 2018 (Table 2). The Tokyo PT, a major personal trip survey in Japan, surveyed about 700,000 randomly selected respondents among 38 million Tokyo metropolitan area residents [29].

Table 2. Overview of data used for this study.

Survey Data	The Sixth (2018) Tokyo Metropolitan Area PT Survey (693,084 Trips)
Survey period	September–November 2018
Survey day	One weekday from Tuesday to Thursday
Target area	Municipalities that have established a Location Normalization Plan in Tokyo Prefecture, a part of Ibaraki Prefecture, Chiba Prefecture, Saitama prefecture and Kanagawa prefecture (47,980 trip)
Survey items	transportation mode, movement purpose, Facilities used at the destination, latitude and longitude information of residence and destination
Polygon data	National Land Survey Data (Location Normalization Plan area data)
contents	The names of municipalities that formulated the plans, the scope of the plans, and the date of establishment of the zones, etc., for the planned areas for proper location, RIA, and UFIA in the national plans for proper location
Target area	Municipalities in Chiba, Saitama, southern Ibaraki, Kanagawa, and Tokyo prefectures that have established LNP by 31 December 2020

Since the sixth survey of the Tokyo PT, latitude and longitude information has been added for some trips [29]. This information provides the benefit that detailed trip lengths are calculable. Actual conditions can be analyzed in designated areas such as UFIA. These data were obtained by applying to Tokyo Metropolitan Area Transportation Planning Council.

For UFIA polygon data, we use the digital National Land Information Download Data Service [30]. They are open data developed by the Ministry of Land, Infrastructure, Transport, and Tourism (MLIT). Diverse information related to national land is available, such as administrative areas, railroads, roads, rivers, official land price announcements, land use meshes, and public facilities. For this study, we used data from the LNP. These data are polygon data in “shp” format. Therefore, the UFIA can be represented in geospatial space, with city-scale information added for each UFIA. As basic information for reproducibility, Tables 3 and 4 showed the information of variables in PT data and polygon data.

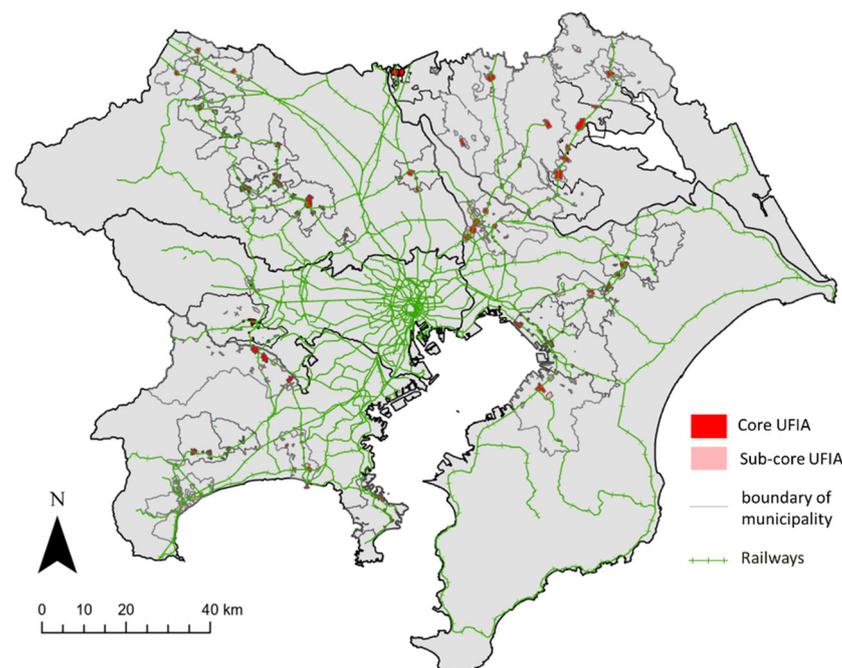
Table 3. Tokyo PT survey data used in this study.

Variable	Overview
id	Trip-id
Home address	Available at detailed points, not in city blocks
Destination address	
transportation mode	Refers to the representative mode of transportation. Train, bus, car, motorcycle, bicycle, and walking.
Facilities used at the destination	Educational, medical, welfare, park, general support, commercial(big), commercial(small), restaurant, commercial(other), public

Table 4. Data from Polygon.

Variable	Overview
id	Area-id
Pref Code	Prefecture Number defined by MLIT
Pref Name	4 Prefectures
City code	City Number defined by MLIT
City Name	46 Municipalities
Time of Announcement	Year, month, date
Area Type	UFIA, RIA, Others

Using the UFIA polygon data, the setting status of UFIA in the Tokyo metropolitan area is shown (Figure 4). The UFIAs are located along the railroad lines. Most core UFIA is connected by railroads, and public transportation network is formed. On the other hand, there are a small number of sub-core UFIA that are not located along railroad lines.

**Figure 4.** Spatial distributions of UFIA.

2.3. Method

The software used to analyze the data was ArcGIS (Esri Inc., Tokyo, Japan) and Excel Pivot Tables (Microsoft Inc., Tokyo, Japan). The specific analysis procedure is described below (Figure 5).

- (1) In the first step, create a trip data layer with latitude and longitude information at the destination. Latitude and longitude information is included in the data used in this study.
- (2) Hierarchical information (UFIA types in Table 1) is added to each UFIA using the field calculation function. By reading each LNP set by the municipality, we determined whether it was core or sub-core.
- (3) After clipping point data of the destination point with the polygon data of the UFIA, Polygon data are joined to point data using Spatial Join Function. The aim of this process is to integrate individual destination of trip and hierarchical information.
- (4) Calculate the travel distance to discuss the use area of UFIA. For this study, trip length is analyzed uniformly as a straight-line distance between the home and destination

address because the trip distance might not be determined uniquely depending on the mode of transportation.

- (5) Cross-tabulation table was used to discuss the actual circumstances quantitatively.

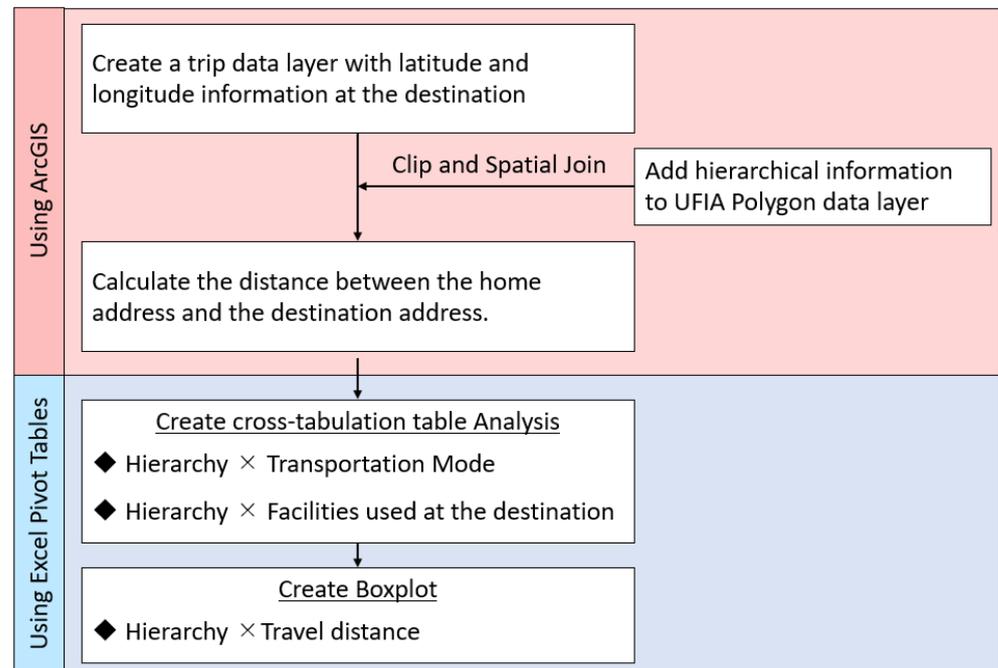


Figure 5. Analysis Flow.

3. Results and Discussion

3.1. Differences in Transportation Mode to the UFIA

To achieve the purpose of this study, it is necessary to clarify the traffic-sharing ratio to the UFIA by class. For that reason, this analysis prepares a cross-tabulation table of UFIA types and the transportation modes shown in Table 1. The statistical analysis elucidates the actual situation of transportation modes. Figure 6 shows the ratio of the transportation mode to each base level and the results of the residual analysis of the cross-tabulation table. From the table, the following points can be understood.

- (1) The residual analysis results show significant differences among all the cells. The proportions of transportation modes used to visit the sub-core and core UFIA differs greatly, even in the same guiding area. Therefore, consideration of differences in transportation characteristics attributable to the hierarchical nature of UFIA is important when designing a UFIA.
- (2) For populous cities, the greatest number of people use the train to reach the core UFIA. They walk or bicycle to the sub-core UFIA. Therefore, in populous cities, the role of the core UFIA is to complement the wide-area core function of attracting people from other municipalities by railroad, whereas the role of the sub-core UFIA is to complement daily life. In addition, compared to other areas, the areas around the sub-core UFIA in large cities share more amount of walking and bicycle traffic. This may indicate that environmentally friendly and walkable spaces seem to be formed in those areas. The populations vary greatly even within cities that have a large population. For example, Chiba City has about 970,000 people [31] and Hachioji City has about 560,000 people [32]. However, the cities that have a large population targeted in this study are unexceptionably included in “Area category 2”, which is a city designated as an ordinance or a business core city with 20% or more of the railroad sharing ratio [33]. Many of the core UFIA are located at transportation hubs (Figures 2 and 4), and their share of public transportation is expected to be higher

- than that of sub-core UFIA. Therefore, it is less likely that traffic shares will differ significantly, within a similarly scaled UFIA in cities that has a large population.
- (3) In cities with a medium-sized population, the percentage of people who use train is higher than in other areas. However, it is not as high as the percentage in cities with a large population. Most people who go to the sub-core UFIA use car.
 - (4) In cities with a small population, percentages of people using car travel to both core and sub-core UFIA are higher than other areas. Such cities present challenges for compactness based on public transportation. When regarding the percentages of people who walk and ride a bicycle, it is apparent that the percentage is higher in cities with a small population. Additionally, the percentage of walking and bicycling is higher in the core city than in the sub-core UFIA. The urban structure around the sub-core UFIA in cities with a small population might be inconvenient for the daily life on foot or by bicycle.
 - (5) In the outside area of the UFIA, the percentage of people who use the car is higher than in other areas. On the other hand, given the fact that railroad users also exist in this area, this fact suggests that some areas are not designated as UFIA, even though they are near stations.

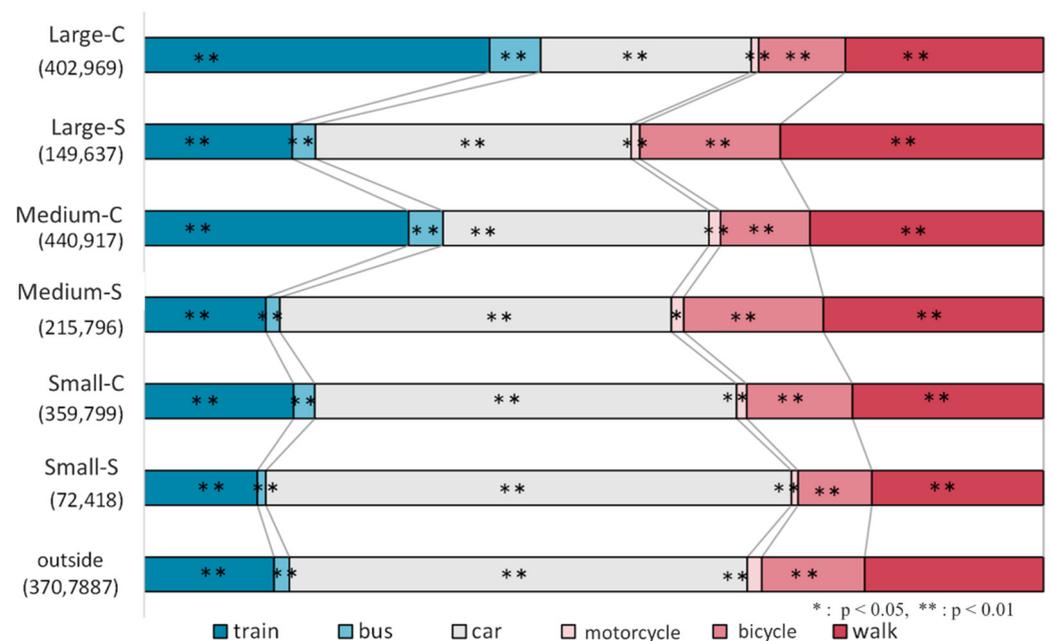


Figure 6. Ratios of transportation modes used to reach the UFIA (arrival trips after expansion).

Because of using the simple and basic indicator, population, this study has gone some way towards enhancing understanding of LNP. Significantly, transportation mode to UFIA varies by hierarchy composed of population and core or sub-core. Regarding UFIA in medium and small populous cities, not only population but also variables such as the frequency of public transportation and the proximity to Tokyo central area may affect the transportation mode to the UFIA. Further studies, which take into account more detailed population classification and variables above, will need to be performed for concrete contribution to LNP.

On the other hand, the share of transportation mode to UFIA may differ depending on the actual situation such as the condition of the transportation infrastructure and the surrounding area. By comparing the status of the municipality's plans and infrastructure with the actual status of the transportation mode, it will be possible to clarify the issues to achieve the goal of urban structure in each municipality. To further our research, we intend to examine measures that can be adapted to each type which is quantitatively classified by the characteristics of the trip and condition of each city.

3.2. Differences in the Uses of Facilities in UFIA

The types of facilities to be inducted into the UFIA vary among municipalities. Although the Ministry of Land, Infrastructure, Transport, and Tourism (MLIT) has posted an image of what specific facilities should be inducted, it has not been presented quantitatively. Therefore, for this analysis, as in 4.1, we cross-tabulate the UFIA hierarchy and the facilities currently in use to find the actual situation of the facilities used in the UFIA. Figure 7 presents the percentage of facilities used for induction UFIA at each base level and the results of the residual analysis of the cross-tabulation table. From this, the following points can be inferred.

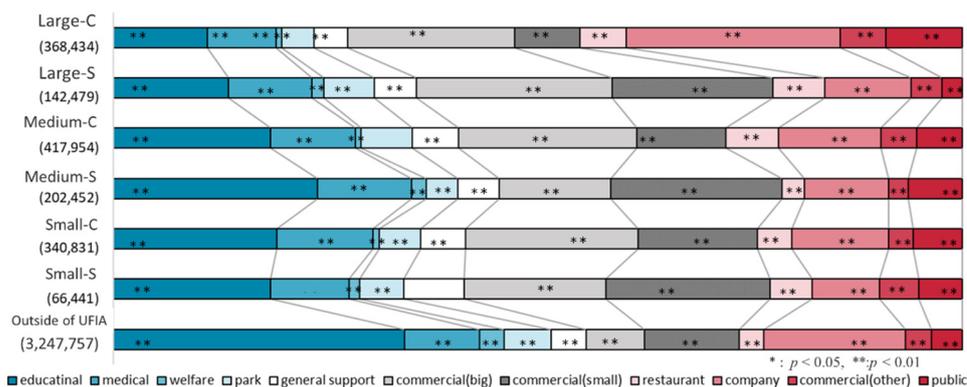


Figure 7. Ratios of facilities used in UFIA (arrival trips after expansion).

- (1) From the results of the residual analysis, significant differences were found among all cells. Therefore, the ratios of facilities used by the core base and sub-core bases differ, even in the same UFIA. Therefore, one must consider facilities to be inducted in the UFIA based on differences in the hierarchies of the center facilities.
- (2) Among cities with a large population, no significant difference was found in the proportion of large-scale commercial facilities used by core and sub-core UFIA. In other cities of different sizes, the proportion of large-scale commercial facilities used by sub-core UFIA is decreasing. In addition to earlier results, one can infer that sub-core UFIA in populous cities are in a condition that large-scale commercial facilities can be visited easily on foot or by bicycle more easily than for sub-core UFIA of other sizes.
- (3) In cities with a medium population, differences in the percentages of people using offices and companies between sub-core UFIA and core UFIA are small. No significant difference was found in the use of administrative facilities between core and sub-core UFIA. However, for commercial facilities, the proportion of large-scale commercial facilities used is high in the core base, whereas the proportion of small-scale commercial facilities used is high in the sub-core base. In other cities, the use of large-scale commercial facilities is higher in the core city, whereas the use of small-scale commercial facilities is higher in the sub-core UFIA. Small-scale commercial facilities such as supermarkets are commercial facilities that provide daily necessities to residents. Therefore, they are regarded as playing a role in providing daily life service functions in the sub-core UFIA.
- (4) In cities with a small population, when comparing core and sub-core UFIA, educational and medical facilities are used at a higher rate in core UFIA, which is the opposite of the trend in cities with large and medium populations.
- (5) The percentage of use of schools and cultural and educational facilities is high outside of UFIA. The results show that educational facilities might be located far from the UFIA to promote a good educational environment.

MLIT has proposed “large-scale commercial facilities in central locations” and “small-scale commercial facilities such as supermarkets in regional locations” as necessary facilities

for UFIA [12]. However, it was found that large-scale commercial facilities are used in regional centers and that there is a gap between the image of necessary facilities and that of the MLIT. Our research could be useful for policymakers whose goal is to form a compact urban structure because they should know the facilities in use.

In this study, we clarified the differences in transportation methods depending on the hierarchy, but as in 3.1, the facilities used within the UFIA may differ depending on the actual urban conditions. In the future, it will be possible to identify the facilities needed in the UFIA by comparing the used facilities and the level of their satisfaction with the guidance facilities targeted by local governments.

3.3. Differences in UFIA Use Areas

Results of this analysis clarify differences in the hierarchical characteristics of the use area of the UFIA as basic information for examining facilities that are necessary for the UFIA and their scale. For this analysis, the travel distance is represented by a boxplot. The boxplot enables clarification of how many people are visiting, and from how far away. Figure 8 shows the usage areas of the UFIA at the respective levels. The following points can be inferred from this figure.

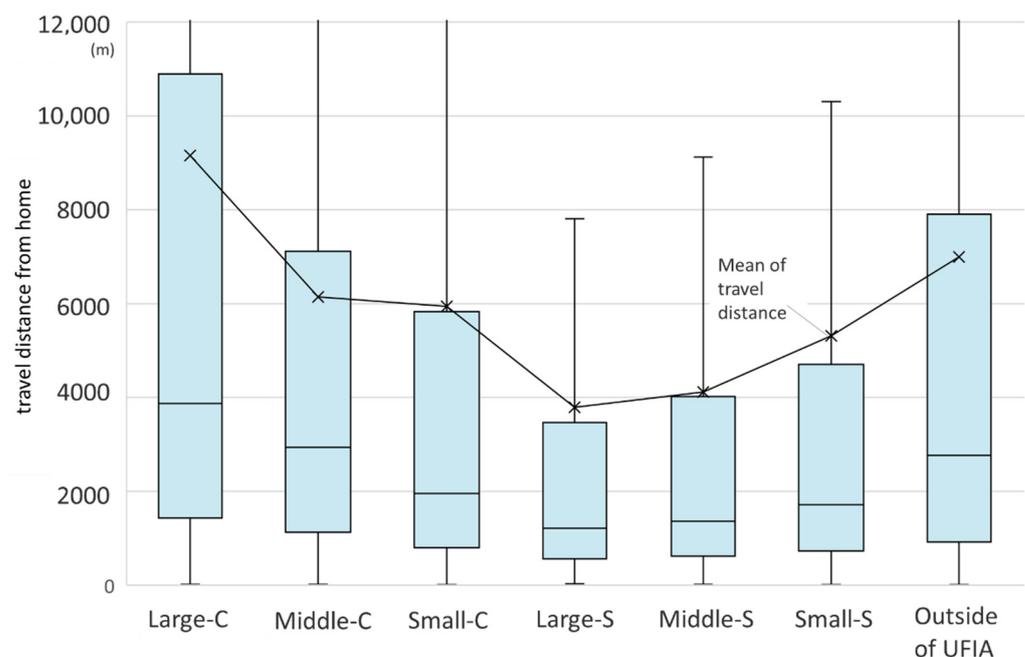


Figure 8. Travel distance from home to each UFIA.

- (1) Overall, the median value is in the lower half of the boxplot, indicating that approximately 50% of visitors come from the vicinity of the UFIA.
- (2) Travel distance varies according to the city scale. The single most striking marked observation to emerge from the data comparison was that there is an opposite trend to those of the core UFIA and the sub-core UFIA. The smaller the population, the smaller the travel distance to core UFIA. In contrast, the smaller the population, the greater the travel distance to sub-core UFIA.
- (3) The core UFIA in cities with a large population has the largest usage area. As Figure 3 shows, this core UFIA has a large use area because it has a high share of railroads and because it attracts people from other municipalities. However, the sub-core UFIA in a large city has the smallest use area. Given that a city of this type has a high rate of transportation sharing by walking and bicycles, one can infer that the urban structure of this city is such that the RIA is located around the UFIA. The example of Chiba city in Figure 2 shows that the RIAs are at a radius of about 1.5 km from the sub-core

UFIA, suggesting that a compact living area might be formed around the sub-core UFIA of a large-scale city.

- (4) The area of use of a sub-core UFIA in cities with a small population is larger than in other sized cities. Regarding the analysis of the means of transportation in Section 3.1, the percentage of people who visit the sub-core UFIA on foot or by bicycle is low. The percentage of people who use automobiles is high. Furthermore, the possibility that the guiding area and the residence area are mutually distant is regarded as a factor indicating a low number of trips by foot or by bicycle. Therefore, to achieve compactness, it is necessary to make the use area of the sub-core base of cities with a small population sufficiently compact that the travel distance will be shortened along with the induction of residence.
- (5) By visualizing the usage area in this manner, one can understand how many people will visit the area, which will make it easier to clarify the target.

As the school-age population is also declining in the world's major cities such as New York [34], the population of the world's major cities may decline and sprawl into the suburbs. In the Tokyo metropolitan area, around the sub-cores of the populous cities are well served by active transportation, and a compact living area has been established. To form an urban structure which is environmentally friendly and sustainably revitalizes the central area even under a declining population, it is necessary to develop a plan to guide residents and urban facilities to the sub-core area.

4. Conclusions

This study using the Tokyo PT survey specifically examined the mobility of people and clarified differences in the hierarchical characteristics of the UFIA to ascertain the status and issues of the UFIA. Results indicated the following information for the realization of compactness.

- (1) The actual conditions of transportation characteristics, facilities used, and usage areas differ according to the hierarchy of the core area. One must analyze urban issues based on current circumstances and must consider measures to achieve a feasible future urban structure, rather than simply imitating other municipalities when considering UFIA.
- (2) In the sub-core UFIA of cities with a large population, the proportions of walking and bicycling are large. The usage area is the smallest. The example of Chiba city in Figure 2 shows that an RIA has been established with a radius of about 1.5 km from the sub-core UFIA, suggesting that a compact living area might be formed around the sub-core UFIA of a city with a large population.
- (3) However, sub-core UFIA in cities with a small population might not have been set up with residence guidance. To promote a networked compact city, mobility management measures that convert car trips to and from sub-core UFIA in cities with a small population into public transportation trips are necessary to connect UFIA by public transportation.

For this study, we examined differences in the city scale and the UFIA hierarchy. However, in discussing the facilities needed in the UFIA, not only is consideration of the population size necessary; one must also consider the state of transportation infrastructure development and the current location of the facilities. Therefore, differences among people in terms of mobility must be examined because of traffic characteristics and the concentration of facilities as a future agenda item. In addition, the UFIA is the "receiving side" of the city. To ensure that people continue to visit in the future, it will be possible to obtain knowledge about the entire site optimization plan with an eye toward the concentration of residential areas by analyzing the current status and issues of the RIA on the "sending side."

Author Contributions: Conceptualization, T.M. and H.S.; methodology, T.M.; software, T.M.; validation, T.M. and H.S.; formal analysis, T.M.; investigation, M.T.; resources, M.T.; data curation,

T.M. and H.S.; writing—original draft preparation, T.M.; writing—review and editing, T.M. and H.S.; visualization, T.M.; supervision, M.T.; project administration, M.T.; funding acquisition, M.T. All authors have read and agreed to the published version of the manuscript.

Funding: This research was funded by F-MIRAI, JSPS Scientific Research Grant number [20H02265], and Tsukuba University’s Research Unit Reinforcement Project. And The APC was funded by F-MIRAI, JSPS Scientific Research Grant number [20H02265], and Tsukuba University’s Research Unit Reinforcement Project.

Data Availability Statement: The data presented in this study are available on request from the corresponding author. The data are not publicly available because the data contains detailed home addresses of individuals.

Acknowledgments: The preparation of this paper was supported by JSPS Scientific Research Grant (20H02265) and Tsukuba University’s Research Unit Reinforcement Project. This study is also supported by F-MIRAI: R&D Center for Frontiers of MIRAI in Policy and Technology, the University of Tsukuba and Toyota Motor Corporation collaborative R&D center. Additionally, we had the opportunity to use the Sixth Tokyo Person Trip Survey conducted by the Tokyo Metropolitan Area Transportation Planning Council. We extend our gratitude for the opportunity.

Conflicts of Interest: The authors declare no conflict of interest. The funders had no role in the design of the study; in the collection, analyses, or interpretation of data; in the writing of the manuscript, or in the decision to publish the results.

References

1. OECD. Governance: Compact Cities: The Way of the Future—OECD. Available online: <https://www.oecd.org/newsroom/governancecompactcitiesthewayofthefuture.htm> (accessed on 8 September 2021).
2. May, N. Local Environmental Impact Assessment as Decision Support for the Introduction of Electromobility in Urban Public Transport Systems. *Transp. Res. D Transp. Environ.* **2018**, *64*, 192–203. [[CrossRef](#)]
3. Nocera, S.; Cavallaro, F. The Ancillary Role of CO2 Reduction in Urban Transport Plans. *Transp. Res. Procedia* **2014**, *3*, 760–769. [[CrossRef](#)]
4. Selzer, S. Car-Reduced Neighborhoods as Blueprints for the Transition toward an Environmentally Friendly Urban Transport System? A Comparison of Narratives and Mobility-Related Practices in Two Case Studies. *J. Transp. Geogr.* **2021**, *96*, 103126. [[CrossRef](#)]
5. Cavallaro, F.; Galati, O.I.; Nocera, S. Policy Strategies for the Mitigation of GHG Emissions Caused by the Mass-Tourism Mobility in Coastal Areas. *Transp. Res. Procedia* **2017**, *27*, 317–324. [[CrossRef](#)]
6. MLIT. Compact City Planning with Everyone: Towards a City That Is Easy to Live in Forever. Available online: <https://www.mlit.go.jp/common/001195049.pdf> (accessed on 9 September 2021).
7. Bernt, M. The Emergence of “Stadtumbau Ost”. *Urban Geogr.* **2017**, *40*, 174–191. [[CrossRef](#)]
8. Hackworth, J. Rightsizing as Spatial Austerity in the American Rust Belt. *Environ. Plan. A Econ. Space* **2015**, *47*, 766–782. [[CrossRef](#)]
9. MLIT. Location Normalization Plan System. Available online: https://www.mlit.go.jp/en/toshi/city_plan/compactcity_network.html (accessed on 9 September 2021).
10. MLIT. Urban Planning: The Significance and Role of Location Normalization Plan: Promoting Compact Cities Plus Networks—Ministry of Land, Infrastructure, Transport and Tourism. Available online: https://www.mlit.go.jp/en/toshi/city_plan/compactcity_network2.html (accessed on 9 September 2021).
11. Chiba City. Location Normalization Plan of Chiba City. Available online: <https://www.city.chiba.jp/toshi/somu/documents/honpen5-20190329.pdf> (accessed on 9 September 2021).
12. MLIT. Outline of the Location Normalization Plan in the Operational Guidelines for City Planning. Available online: <https://www.mlit.go.jp/common/001148083.pdf> (accessed on 9 September 2021).
13. Wang, Y.; Fukuda, H. Sustainable Urban Regeneration for Shrinking Cities: A Case from Japan. *Sustainability* **2019**, *11*, 1505. [[CrossRef](#)]
14. Ohashi, H.; Phelps, N.A. Diversity in Decline: The Changing Suburban Fortunes of Tokyo Metropolis. *Cities* **2020**, *103*, 102693. [[CrossRef](#)]
15. Yoon, C.-J. Between the Ideal and Reality of City Resizing Policy: Focused on 25 Cases of Compact City Plans in Japan. *Sustainability* **2020**, *12*, 989. [[CrossRef](#)]
16. Kato, H. How Does the Location of Urban Facilities Affect the Forecasted Population Change in the Osaka Metropolitan Fringe Area? *Sustainability* **2020**, *13*, 110. [[CrossRef](#)]
17. Daskin, M.S. What You Should Know About Location Modeling. *Nav. Res. Logist.* **2008**, *55*, 283–294. [[CrossRef](#)]
18. ReVelle, D.O. Location Analysis: A Synthesis and Survey. *Eur. J. Oper. Res.* **2005**, *165*, 1–19. [[CrossRef](#)]
19. Bigotte, J.F.; Krass, D.; Antunes, A.P.; Berman, O. Integrated Modeling of Urban Hierarchy and Transportation Network Planning. *Transp. Res. A Policy Pract.* **2010**, *44*, 506–522. [[CrossRef](#)]

20. Burger, M.J.; van der Knaap, B.; Wall, R.S. Polycentricity and the Multiplexity of Urban Networks. *Eur. Plan. Stud.* **2014**, *22*, 816–840. [[CrossRef](#)]
21. Farahani, R.Z.; Hekmatfar, M.; Fahimnia, B.; Kazemzadeh, N. Hierarchical Facility Location Problem: Models, Classifications, Techniques, and Applications. *Comput. Ind. Eng.* **2014**, *68*, 104–117. [[CrossRef](#)]
22. Isaacman, S.; Becker, R.; Cáceres, R.; Kobourov, S.; Martonosi, M.; Rowland, J.; Varshavsky, A. Identifying Important Places in People’s Lives from Cellular Network Data. *Lect. Notes Comput. Sci.* **2011**, *6696*, 33–151. [[CrossRef](#)]
23. Song, C.; Qu, Z.; Blumm, N.; Barabási, A.L. Limits of Predictability in Human Mobility. *Science* **2010**, *327*, 1018–1021. [[CrossRef](#)]
24. Sun, Y.; Fan, H.; Li, M.; Zipf, A. Identifying the City Center Using Human Travel Flows Generated from Location-Based Social Networking Data. *Environ. Plan. B Plan. Des.* **2015**, *43*, 480–498. [[CrossRef](#)]
25. Yue, H.; Zhu, X. Exploring the Relationship between Urban Vitality and Street Centrality Based on Social Network Review Data in Wuhan, China. *Sustainability* **2019**, *11*, 4356. [[CrossRef](#)]
26. Kong, X.; Liu, Y.; Wang, Y.; Tong, D.; Zhang, J. Investigating Public Facility Characteristics from a Spatial Interaction Perspective: A Case Study of Beijing Hospitals Using Taxi Data. *ISPRS Int. J. Geo-Inf.* **2017**, *6*, 38. [[CrossRef](#)]
27. Liu, K.; Murayama, Y.; Ichinose, T. Using a New Approach for Revealing the Spatiotemporal Patterns of Functional Urban Polycentricity: A Case Study in the Tokyo Metropolitan Area. *Sustain. Cities Soc.* **2020**, *59*, 102176. [[CrossRef](#)]
28. Tokyo Metropolitan Government. The Vision of Tokyo as a City in the 2040s and the Path toward Its Realization. Available online: https://www.toshiseibi.metro.tokyo.lg.jp/keikaku/shingikai/pdf/iinkai06_08.pdf (accessed on 8 September 2021).
29. Tokyo Metropolitan Area Transportation Planning Council. The 6th Tokyo Person-Trip Survey. Available online: <https://www.tokyo-pt.jp/> (accessed on 8 September 2021).
30. MLIT. Digital National Land Information Download Data Service. Available online: <https://nlftp.mlit.go.jp/index.html> (accessed on 8 September 2021).
31. Chiba City. Population Data of Chiba City. Available online: <https://www.city.chiba.jp/sogoseisaku/sogoseisaku/kikaku/tokei/top.html> (accessed on 24 November 2021).
32. Hachioji City. Population Data of Hachioji City. Available online: <https://www.city.hachioji.tokyo.jp/hachiouji/jinko/003/p029079.html> (accessed on 24 November 2021).
33. Tokyo Metropolitan Area Transportation Planning Council. Human-Oriented Mobility Networks and Living Areas that Realize New Lifestyles. Available online: https://www.tokyo-pt.jp/static/hp/file/publicity/toshikoutsu_1.pdf (accessed on 24 November 2021).
34. 2020 Census—DCP. Available online: <https://www1.nyc.gov/site/planning/planning-level/nyc-population/2020-census.page> (accessed on 18 November 2021).