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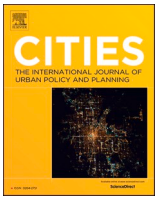

Which generation should migration promotion measures target to shortly achieve a compact structure for shrinking cities?

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ABSTRACT

Streamlining urban areas to appropriate sizes based on the current population structure is an important and urgent issue. Therefore, Japan enacted the Location Normalization Plan in 2014, and a shift toward a more compact regional structure is underway. However, this plan cannot force people to migrate to the target area. Consequently, the formation of a compact regional structure is expected to persist for several decades. It consequently is crucial to shortly convert to a compact regional structure based on the voluntary migration of residents before the living environment outside residential zones deteriorates. This study analyzed the time required for the population to reach zero in urbanization-promoting areas excluded from residential attraction, using spatial statistical analysis. We assumed that multiple generations were the targets of the migration promotion policy, and considered the differences in each scenario. The results demonstrate that >100 years would be required before the natural withdrawal of target areas, and that migration policies targeting pre- and post-retirement generations were the most effective. This paper's contribution is valuable in that it discusses the importance of promoting relocation based on the viewpoint of the shortest possible shrinkage to the compacting measures currently being undertaken worldwide in matured cities.

1. Introduction

1.1. Social background

The sustainability of urban and residential environments has long been discussed. Recently, livability has been added to coexistence with nature in discussions on compact cities (Aoki, 2023a). A shift from a car-oriented society to an urban structure centered on public transportation and walkability while maintaining appropriate urban density is desired (Aoki, 2023a). However, the concepts of compact cities and their related urban structures have different meanings in mature cities and areas of growth (Nadeem et al., 2021). During the growth stage, excessive overdevelopment must be controlled (Nadeem et al., 2021). Conversely, bases that have expanded over time in mature cities must be shrunk (Aoki, 2023a,b).

Strategic urban contraction in mature cities is an aspect of population size optimization. Many cities that expanded in the past have experienced population declines and shrinkage (Haase et al., 2014; Oswalt & Rieniets, 2006). Moreover, demographic stagnation and aging societies have challenged city leaders to confront the issues by adjusting their environments (Hamel & Keil, 2015; Kötter, 2019; Reicher & Hesse, 2015). This is particularly pressing for situations of medium- to long-term national population decline. Cities that are sized inappropriately for their population cannot sustainably cover public expenses, such as infrastructure development, as their financial resources taper off (Kutsuzawa et al., 2020; Takemoto et al., 2019). Public transportation and daily service functions may be withdrawn from areas with excessively low density (Aoki, 2022a; Jarzebski et al., 2021). Reorganization into compact conurbations appropriate for the population size is essential for the sustainability of cities.

For instance, Amsterdam has produced compact urban planning to deal with rapid urbanization and a continuous increase in mobility, while maintaining the identity and history of its previous urban planning (Gert, 1998; Inagaki, 2001). In Germany, urban shrinkage is a national challenge that is addressed by providing unique legitimacy through the Stadtumbau Ost Plan (Nelle et al., 2017). The plan is a federal program to assist municipalities suffering from shrinking cities to adjust their size of both land and population by reducing excess housing supply and preserving critical housing stock (Hattori, 2016). Moreover, Germany has attempted to incorporate the issues and interests of the

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private sector, such as the housing industry, and experimented with a hybrid urban planning approach through joint public-private partnerships (Bernt, 2017). Globally, these urban shrinkage efforts aim to identify and problematize precise conditions and create conditions that generate the political will to address and decontextualize the problem (Hattori et al., 2017; Mallach et al., 2017).

To develop compact cities with optimized densities in their centers, the urban perforation phenomenon, which is a random occurrence of localized density reduction and an obstacle to creating people-friendly and sustainable cities, should be considered (Denis et al., 2021; Hollander et al., 2009; Rink & Siemund, 2016). Low-density areas may appear in spatial patterns that differ from those anticipated by city planning (Chhetri et al., 2013). For scattered low- and unused lands, the value and opportunity of the area to attract necessary investments decline and impede compact city policies (MLIT, 2015; MLIT City Planning Division, 2018). Thus, spatial control is necessary to control low-density areas, while encouraging people to move to the designated areas.

In Japan, the population began to decrease in 2008, with a declining birthrate and gaining elder population. Cities began to shrink in size, not only due to population outflow, but also due to natural attrition. In 2014, a Location Normalization Plan was introduced to address this issue. Under this plan, each municipality could designate urban functions and residential attraction areas (Urban Affairs Bureau of MLIT, 2023). The goal was to connect compact centers through a network. However, while incentives could be provided for residing in or developing residential attraction areas, residents could not be forced to move.

Despite the differences in geographic and policy factors, other countries may also experience a scarce and complex influx of people into mature cities. Moreover, urban planners in these countries and regions must address urban compactness in societies with broadly declining populations.

Therefore, Japan, which has one of the fastest declining populations globally, can be used as a model to consider measures to optimize city size. This study focused on this dilemma in Japan, and aimed to identify policies for short term and appropriate urban contraction. Prolonged urban shrinkage increases the probability that city sustainability will decline due to financial difficulties. This study suggests the perspectives required to achieve speedy compactness.

1.2. Literature review

To achieve urban shrinkage and compactness, non-urban facility use, such as green infrastructure and agricultural lands, should be strategically included within compact urban structures (Hollander et al., 2009). If compact city planning runs appropriately, the high density caused by the plan does not always negatively affect social well-being (Mouratidis, 2019). A well-balanced urban structure and optimized density are significant goals for transforming mature cities into compact cities. Additionally, city planners argue for community resilience, urban regeneration strategies, and countermeasures for social problems while accommodating compact city theories (Martinez-Fernandez et al., 2016).

Conversely, recent studies have shown that market mechanisms have unduly influenced compact city policies, leading to redesign measures in city and town centers with high market demand and causing a decline in peripheries (Grodach & Limb, 2020). Economic development pressures have also decreased in recent years, with growth in urban areas slowing or stagnating as governments adopt land-use plans that discourage outward expansion (Angel et al., 2016; Hiramoto, 2019). The margins of urban areas have become unsustainable environments because of these social trends (Grodach & Limb, 2020; Masuda et al., 2020). Addressing the unsustainable periphery is crucial for achieving compactness in shrinking cities.

In the shrinkage methodology, governors draw boundaries for the existing urbanized area. They then facilitate continuous urban revitalization within that demarcated area and the non-utilization of land outside. They cooperate with private companies to demolish vacant lots and develop new buildings in revitalization centers (Bernt, 2007). In shrinking the fringe, the German Stadtumbau Ost Plan is restructuring urban planning in cooperation with the private sector (Bernt, 2017; Nelle et al., 2017). In contrast, Gothenburg and Helsingborg relate the concept of green structures to the core design strategy of compact city planning and development (Bibri et al., 2020). Buffalo, however, operates under a strategy based on an urban growth paradigm. It states that growth is constant, and fiscal constraints and other factors limit urban development (Silverman et al., 2015).

In urban regeneration in shrinking cities, urban renewal initiatives targeting business and economic improvements rather than people-centered social and cultural interventions are considered contributory (Mykhnenko, 2023). Nevertheless, even in most depopulated cities, the future population projections on which they base their comprehensive plans, including their regeneration strategies, are optimistic (Heim LaFrombois et al., 2023). The dialogue between degrowth theory and urban development is lacking, with urban planners ignoring the crises associated with the growth paradigm (Xue, 2021). Specifically, municipal leaders are reluctant to discuss shrinking cities and compacting (Manu et al., 2020).

Most discussions of shrinking cities in Western countries are in relation to the economic market. These social downsizing debates are assumed to have an economic focus, as they developed during the severe crisis of the industrial sector in North America and Europe in the 1970s (Fol & Cunningham-Sabot, 2010; Martinez-Fernandez et al., 2016). However, in Japan, where population decline has already occurred throughout the country and there has been little inflow from foreign regions, shrinking cities have been viewed as a spatial phenomenon related to demographic change and long-term depopulation (Döringer et al., 2020).

Shrinking cities in Japan started mainly with the problem of depopulation in rural areas. The depopulation of these regions stems from the excessive influx of people to the city centers that accompanied the high economic growth of the post-war period, which in the second half of the 20th century led to an expansion of the metropolitan areas, which then entered a period of stagnation due to years of falling birthrates, an aging population, and low economic growth rates (Aoki, 2022a). The arrival of a declining population since 2000 has spurred shrinking cities due to natural and social demographics of the past (Ohno, 2008). Today, underutilized land or areas at risk of becoming underutilized, which appear with urban perforation in the population decline society, extend to central urban areas and major station spheres in the conurbation, where a concentration of various functions is desirable (Aoki, 2022b,c). The challenge is then to replace people and urban functions from the periphery with the underutilized land that has arisen in these centers below (Aoki, 2023a). Specific directions that define groups living outside the boundaries and guide development and policies are required.

Japan's Location Normalization Plan is a countermeasure to those shrinking issues. Although the Japanese government identified this policy as the primary countermeasure for compactness, it has yet to establish residential attraction areas with enforcement power at the municipal level (Hashimoto et al., 2021). Some municipalities that established residential attraction areas aim to match current urbanization promotion areas, whereas others aim to downsize them to narrower areas (Nishii et al., 2019). Designating existing urban areas as residential attraction areas is similar to the existing system but is ineffective for promoting compactness (Motomura et al., 2020). Japanese municipalities are gradually taking steps to create appropriate cities based on population size. However, subsidy benefits at the time of relocation, the primary incentive method, must be increased to achieve compaction (Chikuma & Sato, 2017), and further strategic shrinkage measures must be considered.

Although location normalization plans were institutionalized in

2014, many municipalities took time to formulate their own plans, and only recently have they begun to guide these functions under the policy of expanding urban functions and reorganizing public facilities in central city areas (Musha, 2021). However, there are no specific examples of measures to guide people to residence attraction areas, and this is only a technical approach for establishing areas in location normalization plans (Miyazaki et al., 2019). Against this background, there is a strong cautious attitude toward implementation due to considerations of the local political context (Hashimoto et al., 2021).

Therefore, many previous studies have addressed the issue of how to make this an effective inducement measure, in addition to the above-mentioned introduction process and the current situation. They refer to how incentives should be provided to inducement areas and how to set up appropriate zones based on the ratio of population inside and outside the residence attraction area (Hoshi et al., 2021). Studies also focused on creating safer and better living environments. For instance, redefining disaster hazards within residential attraction areas is necessary from a geographical perspective (Araki, 2020). Furthermore, improving accessibility to daily service facilities inhibits the formation of low-density residential attraction areas (Fujimori et al., 2022). However, most industries, except welfare facilities, tend to withdraw from such areas, and maintaining these urban functions is essential (Okano et al., 2019).

The two trends in research to date are the trend in Western countries to develop downsizing theories that largely follow the economy and the trend in Japan to grasp the actual situation as a fundamental issue of a society with a declining population. In both cases, case studies have been used to discuss the path to plan formulation, the plan's relevance for post-planning revitalization, the factors of population movement, and concepts associated with shrinking city policies. Regarding residential guidance, there have been ongoing discussions on the appropriateness of guidance sites and the nature of environmental improvements (Hoshi et al., 2021). These discussions are mainly rooted in the future vision of the area to be induced. However, further research is warranted to explore methods of attracting people who currently live outside the residential zones. Some studies have focused on the distribution of the population and number of buildings outside the residence attraction area. However, they are limited in understanding the amount of change before and after the plan (Tamura & Tanaka, 2023).

In contrast, no studies focus on the population dynamics of the starting point rather than the destination and look at the population dynamics of multiple conurbations across the country. Therefore, this paper will take a cross-sectional view of municipalities in Japan implementing compactification measures, focus on future changes in the population living outside residence attraction areas, and refer to the possibility of earlier urban compactification. The academic significance of this paper is that it brings a discussion based on positive socio-demographic considerations to the topic of compacting and shrinking cities in Japan, which has been considered an actual theory of spatial phenomena, and that it deepens awareness of compact city policies in a society with a declining population by taking a cross-sectional view of the actual situation in an entire country, albeit a small country in Asia. The social significance of this project is that it will help promote the rapid development of compact city policies. Regarding social significance, it can lead to a financially sustainable society through earlier compactification.

1.3. Study aims

This study analyzed population transition scenarios outside residential attraction areas in Japan. We examined various target generation methods to attract people to specific areas and aimed to identify effective scenarios to aid the speedy creation of urban compactness. We primarily focused on determining which generation would be most suitable for migration promotion measures to target to achieve a compact structure for shrinking cities shortly. Thus, we simulated population change scenarios from the viewpoint of the recommended shrinkage areas. As this method was unprecedented, we considered simulations that assumed a uniform rate of change as a first step. The following hypotheses were proposed:

1. Shrinkage contribution rate varies depending on interest generation.
2. Existing migration promotion measures do not fit a particularly effective scenario.
3. Appropriate scenarios differ depending on region size.

2. Materials and methods

This study assumed a population change scenario based on the population structure of 2020 for urbanization promotion areas outside residential attraction areas. A total of 448 municipalities have designated their own plans for urbanization promotion areas as of April 2022. Of these, 154 municipalities had implemented the Location Normalization Plan with smaller residential attraction areas compared to existing urbanization promotion areas.

In the location normalization plan, the municipality draws boundaries over the existing urbanization promotion areas stated in the urban master plan. Urbanization promotion areas in Japan are urban planning areas stipulated in Article 7 of the Urban Planning Law. Based on this law, prefectural administrations can designate areas where the town has already been developed and turned into an urban area and areas that should be developed on a priority and planned basis within approximately ten years.

By contrast, location normalization plans are mainly formulated by municipal administrations. The plan aims to establish a basic policy on the location normalization plan for housing and urban function enhancement facilities as stipulated in Article 81 of the Law on Special Measures for Urban Regeneration, which was amended in 2014 to allow each municipality to formulate such a plan. In this plan, municipalities can designate residential attraction areas and define areas that they consider suitable for the future. Establishing a residence-attraction area narrower than the urbanization promotion area can contribute to the formation of a compact conurbation. The goal was to create a network of compact centers. However, it could provide incentives for living in or developing residential attraction areas but could not force residents to move. Not all the municipalities have implemented the migration promotion measures as of 2022.

Urbanization promotion and residential attraction areas in these municipalities were differentiated by QGIS, an open-source geographic information system, using publicly available data provided by the National Land Information System. The differences were then defined as target areas that should be reduced in the future. To grasp the residential population of the target area, we extracted the population in five-year age groups from the population data of the national census of small districts with center points located within the target area. The results of the 2015 and 2020 national censuses were used to determine the rate of cohort change in the population by age. Fig. 1 illustrates this scheme.

In analyzing the current migration promotion measures (Chapter “Current Migration Promotion Policies”), we focus on the 65 municipalities that have already implemented those measures. For the scenarios' estimation part (Chapters from “Distribution and Cohort Change by Generation” to “Possibility of Implementing Optimized Scenarios”), municipalities within the subject site with a population of <100 in 2020 were excluded from the analysis.

Population can be estimated using either a multiregional model or a single-region model, and a multiregional model is appropriate because there can be inter-migration of populations between specific points (Smith et al., 2005). However, given the limited demographic data available, it is easier to fit a single-region, net migration-based model (Koike, 2008). The cohort factor method is also used by the National Institute of Population and Social Security Research (NIPSSR) in Japan (NIPSSR, 2023). In the cohort factor method, the future population is

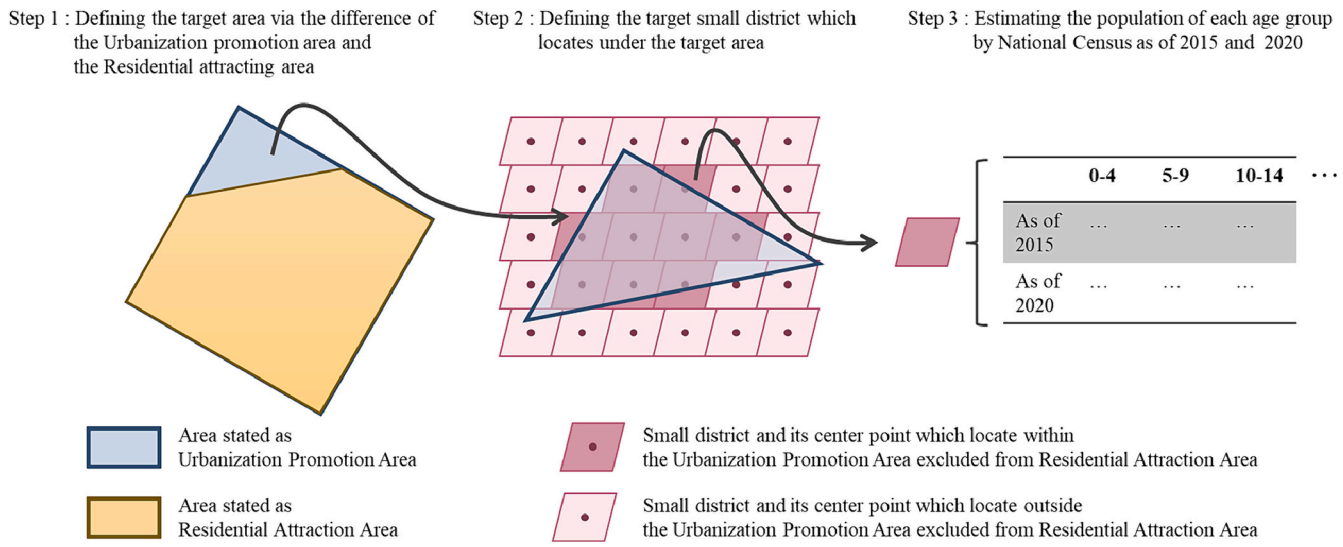

Fig. 1. Scheme for defining the target area.

obtained by calculating the annual changes that occur as the age-specific population ages for each factor. For the existing population, the future population is determined by reflecting the number of deaths and population movements that occur as the population ages. For the newly born population, the number of births in the female population aged 15–49 is divided by the sex ratio, and the number of live births and international population movements are calculated in turn and incorporated into the age-0 population for the following year. In fact, analyses of Japanese population estimates generally use the NIPSSR cohort factor method as a base (Nakanishi et al., 2011). However, for analyses targeting small areas, calculating net migration rates by sex and age can lead to extreme values, and it is difficult to establish appropriate numbers of births and deaths (Inoue, 2018).

The target areas in this paper are a limited range of areas where contraction is recommended in each municipality. These target areas have limited future population inflows, so inter-migration between different areas is difficult to envision. The study aims to examine scenarios in which shrinkage in the target areas could be achieved sooner. Therefore, the cohort factor method of the NIPSSR is used as a base but adapted to an estimation method appropriate to the objectives of this paper and the study area. In regional shrinkage, the formation of vacant land due to the withdrawal of households is as important as or more important than population. However, data on the number of households by age group and the number of births and deaths in the subregion do not exist. Therefore, the effectiveness of promoting migration by generation must be based on data on population by age group, which, if disaggregated by sex, could lead to extreme net migration rates. In this report, the net migration rate is calculated based on the most recent cohort change of the population by age, without disaggregating by sex, to reduce the possibility of such extreme values and to place more emphasis on the withdrawal of households. In addition, because the household migration of infants is basically dependent on their parents, the number of births is considered. For deaths, life expectancy and age-specific survival rates are used as references.

According to the National Institute of Population and Social Security Research (MHLW, 2022), the average life expectancy in Japan was 81.47 years for males and 87.57 years for females as of 2021. The percentage of people aged 90 years and over was estimated to be approximately 40.35 % in 2021, and it is assumed that there are almost no people in this generation over 95 years old. Therefore, the total population was calculated from ages 0 to 94 years. As the population by five-year age groups was aggregated up to age 75, the population over 75 years as of 2020 was assumed to be equally divided into age groups of 75–79, 80–84, 85–89, and 90–94. The cohort ratios among the 75 and older cohorts were then assumed to be 40 % of the 70–74 population remaining at ages 85–89, with 60 % of the population at age 75, and equally decreasing between ages 75–79 and 85–89.

The first step was to identify the population change scenarios for each municipality after 2020 based on cohort change rates. This step examined how the total population in the target area in each municipality would change, assuming that the population's most recent cohort growth rate continued. The basic formulas used in this study were:

- Cohort ratio of an age group at a municipality: $C_{ma} = P_{ma}^{2015} / P_{ma}^{2020}$
- Population of an age group at a municipality: $P_{ma}^{t} = C_{ma} \times P_{ma}^{t-5}$
- Population of a municipality at an arbitrary time point: $x_m^t = \sum_{a=1}^{n} P_{ma}^{t}$
- Population ratio in comparison to 2020: $R_m^t = x_m^t / x_m^{2020}$

C: cohort ratio
P: population
a: age group
m: municipality
t: year
x: total population
R: population ratio.

In addition to this cohort-based scenario, we assumed a case in which the inflow of new households was controlled. The intergenerational growth rate was defined as 1.0 if the cohort growth rate between 2015 and 2020 was more significant than 1.0. Population estimates were calculated according to the cohort change rate for generations showing a declining trend. In this step, the cohort ratio for all age groups was defined as $C_{ma} \leq 1.0$.

We analyzed a population change scenario that assumed the introduction of a policy to promote relocation targeting multiple generations. In this study, the life stages of Japanese people were classified into the following age groups: college enrollment rate, average age at first marriage, average age at first childbirth, average healthy life expectancy, age at retirement, and age at which people mainly need more than two grades of nursing care.

1. Age 20 (Young): Independence
2. Age 35 (Family): Beginning of marriage and child-rearing

3. Age 50 (Re-couple): Independent households with children and couples
4. Age 65 (Retired): Retirement age
5. Age 75 (Elder): Households are no longer in good health
6. Age 85 (UN-HALF): Households require nursing care.

This study assumed a scenario in which six migration promotion measures were introduced according to the aforementioned life stages. The cohort change rate for the generation in which these life-stage changes occurred was assumed to be 0.5 ($C_{ma} = 0.5$). The rate of change related to these policies is simulated at the destination of the resettlement, that is, the migration promotion destination (Maruyama & Oe, 2013). In other cases, simulations are conducted to determine the effects of promoting settlement from the perspective of maintaining a population in an area with population decline (Yoshitake, 2020). However, studies examining how quickly the population will settle in an area where population decline should be promoted as a result of resettlement promotion are lacking. Additionally, data on the number of people who have moved out of their original neighborhoods because of the current resettlement promotion measures are unavailable. Therefore, as a first step to simulate population scenarios from the viewpoint of the recommended shrinkage areas, this study assumes a pattern that has had a significant effect and uses the average of the lowest cohort rate for each generation in the target area as a reference[1]. The cohort change rate for generations other than the one targeted in each scenario was set to $C_{ma} \leq 1.0$, as in the limited inflow scenario. We examined the effectiveness of closing the target area more effectively than the scenario based on cohort increase and decrease rates.

We considered the differences in the influence of these scenarios depending on the size of the municipality. Table 1 shows the laws and population levels that formed the basis for each category and the number of applicable municipalities in this study. We analyzed the effects of a scenario in which we assume that each municipality introduced migration promotion measures targeting each life stage according to its size category.

In addition to a scenario in which only specific generations are consistently encouraged to migrate after 2025, we considered cases in which migration promotion measures shifted to those appropriate for each era. In this optimization scenario, all scenario patterns were applied for each age. The scenario that minimized R_m^t the most was assumed to be the optimal solution for that year, and P_{ma}^t at that time was used to analyze x_m^t at the next time point.

Finally, the appropriateness of the migration promotion targets for specific generations obtained in these scenarios is comprehensively considered from multiple perspectives. This paper analyzed the population volumes, which have not been discussed before and are quantitatively suitable to implement early contraction. We will then examine whether the migration promotion of the target groups that have emerged has a realistic possibility of being implemented, mainly from the perspective of migration decision-making and the financial burden on governments, based on existing discussions.

[1] The value of $C_{ma} = 0.5$ is the same as that used in the national land policy simulation model by the Ministry of Land, Infrastructure, Transport and Tourism (MLIT, 2016) and is not considered to be a significant deviation from the original value. Although the effectiveness of migration promotion measures may vary depending on the characteristics of the target region, applying a uniform value and considering the whole picture is important, as shown in the simulation by the Ministry of Land, Infrastructure, Transport and Tourism, when considering nationwide changes as the first step in the simulation. From this point of view, this study uses $C_{ma} = 0.5$ as the uniform simulation value for each municipality and scenario.

3. Results

3.1. Current migration promotion policies

We organized the current migration promotion measures to ensure the compatibility of the measures with the final scenario. We analyzed each municipality's measures to promote relocation to residential attraction areas based on the Location Normalization Plan for the primary target population and support methods. As of March 31, 2022, 65 municipalities had such measures, bringing the total number of measures to 103. Table 2 summarizes the aims and methods of these measures.

The most common measures targeting residents had no statements on specific resident attributes. Those specifically mentioned tended to target young people, households with children, and newly married households. Some cases targeted multigenerational households; however, they were ultimately intended to bring young people and older households together or closer to each other. We also identified measures that targeted building owners and businesses responsible for residential land development.

Methods of encouraging migration included rent, home acquisition, and renovation subsidies. In particular, rent subsidies were limited to the younger generations. Property tax exemptions were also limited to a small percentage. Even when measures targeting business owners were included, temporary rather than continuous subsidies were the primary method.

3.2. Distribution and cohort change by generation

Initially, we observed the age-population ratios for each municipality's target area as of 2015 and 2020. A comparison of both time points showed a shift in population distribution over the five years, but no significant change in the primary generation that comprised the population (Figs. 2 and 3). There was a peak in population volume between the late 1930s and late 1940s, and the volume tended to increase again after the age of 65 years.

Some outlier municipalities showed relatively high volumes around the age of 20 years. Most of the areas excluded from the attractive residential zones were hazard-prone areas, such as those marked on hazard maps, on the outer edges of municipalities, or in neighborhoods with factory zones. However, these land characteristics do not necessarily mean that the majority of residents in 2020 were older adults. Thus, it is anticipated that considerable time would be required to achieve closure in excluded areas and create a compact urban structure. The cohort change rate demonstrated that, while generally staying around 1.0, some municipalities saw a large influx of younger generations and a significant downward trend in the mature population (Fig. 4).

3.3. Population estimation scenarios for compacting

We examined population decline scenarios in cohort-based, limited inflow and migration promotion cases targeting specific generations. We set the population of the target areas in each municipality as of 2020 to 100.0 %, and considered the subsequent population trends.

In the population decline scenario, based on the 2015–2020 cohort ratio, slightly more than half of the municipalities would have a population of <50.0 % by 2065 (Fig. 5). Moreover, most municipalities would maintain >10.0 % of their 2020 population until approximately 2095. Some municipalities could increase their target area population by approximately 2070.

However, if the new population inflow was controlled at zero, the projected population decline significantly decreased (Fig. 6). Over half of municipalities would decrease their target area populations to below 50.0 % in 2050 compared to 2020, and below 10.0 % in 2085. Even if relocation from the target area was not actively encouraged, closing those areas would minimize the influx of new residents.

Table 1
Municipality categories based on population.

Category	Number of target municipalities	Related laws	Population level	Note
Designated cities	10	Local Autonomy Law	Cities with a population of 500,000 or more designated by government ordinance	–
Core cities	36	Local Autonomy Law	Cities with a population of 200,000 or more designated by government ordinance	–
Core-equivalent cities	10	–	Cities with a population of 200,000 or more but not the core-city	–
Medium-scale cities 1	37	–	Cities with a population >100,000 and <200,000	Ministry of Internal Affairs and Communications defines cities with population >100,000 but not either the Designated or Core city as medium-scale cities
Medium-scale cities 2	40	Local Autonomy Law	Cities with a population >50,000 and <100,000	Population must be 50,000 or more to be legally recognized as a city
Small-scale cities 1	10	Law on Special Provisions for Municipal Mergers	Cities with a population >30,000 and <50,000	Under the Law on Special Provisions for Municipal Mergers, a city is recognized as a city with a population of 30,000 or more.
Small-scale cities 2	11	–	Cities with a population <30,000	Population of <30,000 is legally designated as a town or village

Table 2
Aims and methods of current migration promotion measures.

	Rent Assistance	Housing and land purchase subsidies	Demolition, remodeling, and renovation assistance	Relocation assistance	Reduction or exemption of property tax	Information and awareness-raising	Subsidy for projects and activities	Subsidy for land and environmental improvement	Others	Total
Young adults	1	3	1	–	–	–	–	–	–	5
Households with children	5	6	2	2	1	–	–	–	1	17
Newly married households	3	3	2	1	–	–	–	–	–	9
Multi-generational households	–	3	3	–	–	–	–	–	–	6
Business owners	–	–	2	–	–	–	5	10	2	19
Specific building owners	–	4	9	1	1	1	–	–	2	18
None in particular	–	27	25	1	3	3	1	–	2	62
Total	9	46	44	5	5	4	6	10	7	

We identified the age groups that should be targeted in the early compacting process. Figs. 7 and 8 show the population reduction scenarios for cases in which targets were determined for each life stage. The cohort rate at that point was assumed to be 50.0 %. In all cases, the population decline was faster than in the suppressed population inflow case. Nevertheless, some municipalities could maintain a certain population level until approximately 2100. Approximately 50 years or more would be required for slightly more than half of the municipalities to reach <10.0 % residents number compared to 2020. However, more than half of the municipalities would have <50.0 % residents number compared to 2020 before 2050.

We examined the differences in the effects of these scenarios. Fig. 9 summarizes the number of municipalities that would reach a population of <50 % of that in 2020 for each scenario. The red dashed line in the figure indicates 80 %, which represents approximately half of the municipalities.

In the cohort-based scenario, many municipalities would not fall below a figure of 50 % until 2065. Eliminating the inflow shortened the period until the population fell below 50 % in slightly more than half of the municipalities by approximately ten years. In the scenario with migration policies, 80 % would be exceeded in 2050 in Cases 1, 5, and 6, and in 2045 in Cases 2, 3, and 4. In Case 3, >120 municipalities would achieve 50 % by 2045. By 2050, 158 municipalities would have achieved this level. However, compared to the cohort-based scenario, the other scenarios were expected to show a sharp increase in the number of municipalities achieving 50 % population levels in a given year.

The number of municipalities exceeding 10 % of the 2020 population was determined for each scenario (Fig. 10). In the cohort-based scenario, more than half of the municipalities were expected to reach 10 % by 2095, confirming the trend of a rapid increase from 2090. In the limited inflow scenario and Case 6, this period was approximately five years earlier than in the cohort-based scenario. In Cases 1 and 5, more than half of the municipalities were expected to reach 10 % by 2085. In Cases 2, 3, and 4, more than half of the municipalities were expected to reach 10 % by 2080.

The number of applicable municipalities that would reach a population ratio of <10 % increased more rapidly at a particular point in time for cohort-based municipalities than those described above. For Cases 2, 3, and 4, all 158 municipalities were expected to achieve 10 % by 2085. These results confirm the possibility of reducing the time required for shrinkage in these areas by up to 20 years for a 50 % population level and up to 15 years for a 10 % population level.

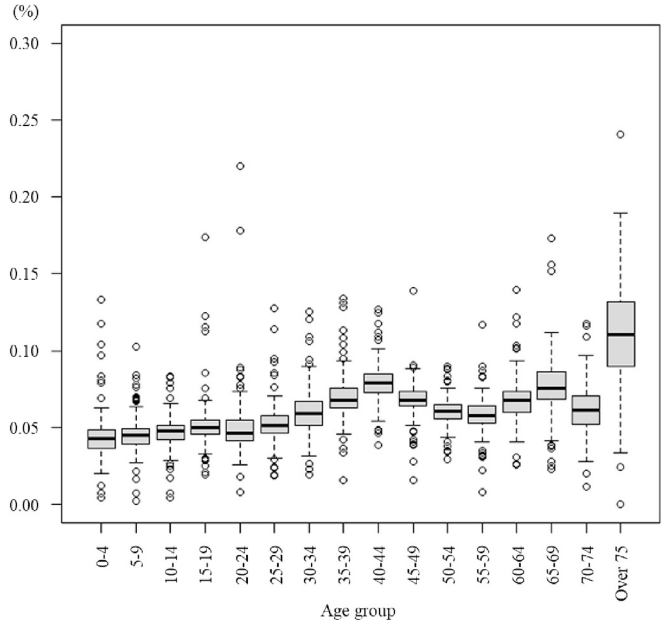

Fig. 2. Population volume of age group as of 2015.

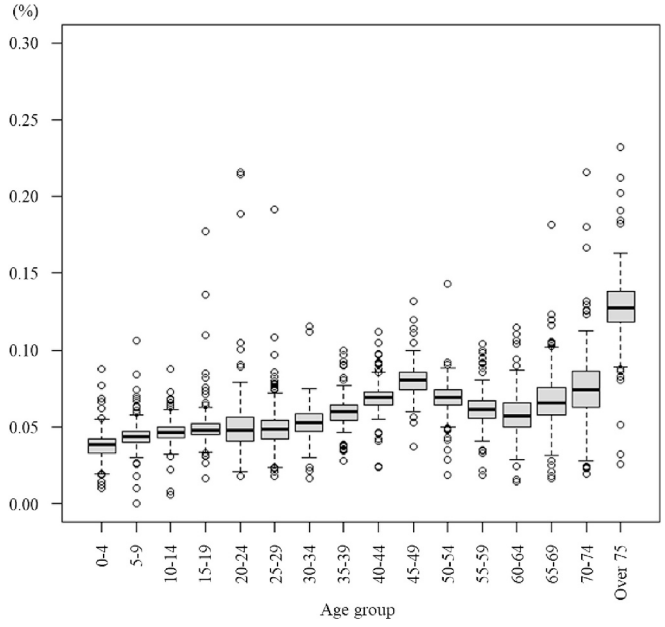

Fig. 3. Population volume of age group as of 2020.

3.4. Effective scenarios by municipality type

Practical scenarios may differ depending on municipality size. Therefore, to determine the appropriateness of each scenario, we divided the target municipalities into seven categories based on policy designations and population sizes.

The average population declining ratio compared to 2020 was calculated for each scenario and category. We then compared the limited inflow to the other scenarios. The trends in the point differences are summarized in Fig. 11. A greater point difference indicated a more effective reduction in shrinking and closing the target area than simply regulating the inflow of new residents.

For designated cities and medium-scale cities 2, Case 3 was the most effective throughout all years. For the four categories except core-equivalent cities, Case 4 was the second most practical scenario until

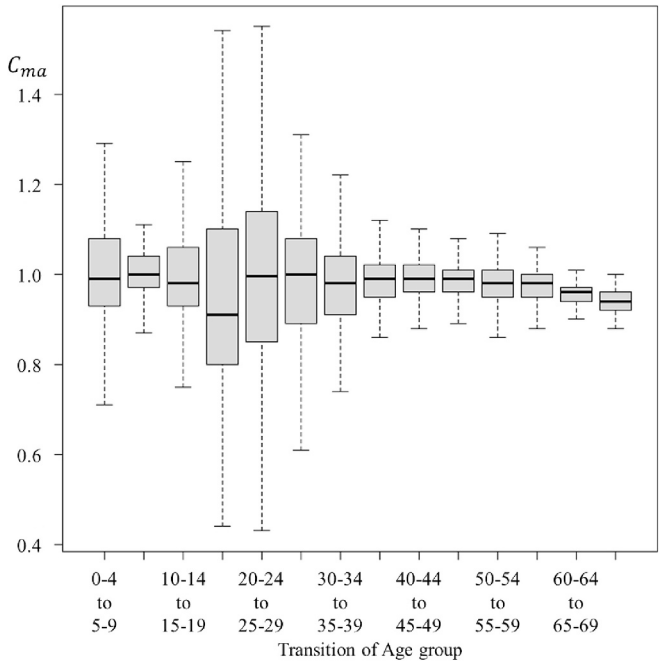

Fig. 4. Cohort ratio of age groups in 2015 and 2020.

approximately 2050, and Case 2 was the scenario with the second most prominent difference in points thereafter. In contrast, Cases 4 and 2 had similar point differences for core-equivalent cities until approximately 2050, after which Case 2 was dominant. In contrast, in smaller municipalities, there was no difference between Cases 3 and 4 until 2050. Particularly, in small-scale cities 2, the difference in points of Case 4 exceeded that of Case 3 between 2040 and 2050.

3.5. Possibility of implementing optimized scenarios

Finally, we examined how effective migration promotion could be if we switched to the appropriate scenario at different points in time and deployed it. Because promoting multiple migration promotion scenarios is difficult because of limited financial resources, we assume that only one scenario can be deployed at any given time. Therefore, the optimized scenarios for each municipality in each fiscal year are summarized by case and summarized in Figs. 12 through 18. The 100 % bar chart shows the percentage of cases that were considered the optimal solution each year, and the numbers in the chart represent the number of municipalities involved. The different effects of this optimization scenario are summarized and compared with the continuation of other single scenarios after 2025.

In main designed cities, Case 3 appeared twice, and Case 4 appeared once over 15 years. This process was repeated until 2065 (Fig. 12). After 2075, Case 3 no longer appeared, and Cases 4, 5, and 6 were the optimal scenario for many municipalities. Cases 1 and 2 occurred infrequently.

The core cities also showed a trend toward a 15-year set with Cases 3 and 4 until 2065 (Fig. 13). Between 2075 and 2085, Case 4 tended to be the optimal scenario, whereas Cases 5 and 6 were the optimal scenarios in 2090. However, Cases 1 and 2 could be the optimal scenario between 2025 and 2040, although this was limited to some municipalities. We also identified municipalities in which the scenario for the older generations was consistently more appropriate after 2060.

Unlike in designated and core cities, Case 3 was the optimal scenario for core-equivalent cities until 2075 (Fig. 14). In 2075, Case 4 was the optimal scenario for all municipalities. Thereafter, Cases 4, 5, and 6 became the optimal scenarios.

A set of Cases 3 and 4 was the optimal scenario for medium scale cities 1 until approximately 2055 (Fig. 15). In 2060, Cases 3 and 4

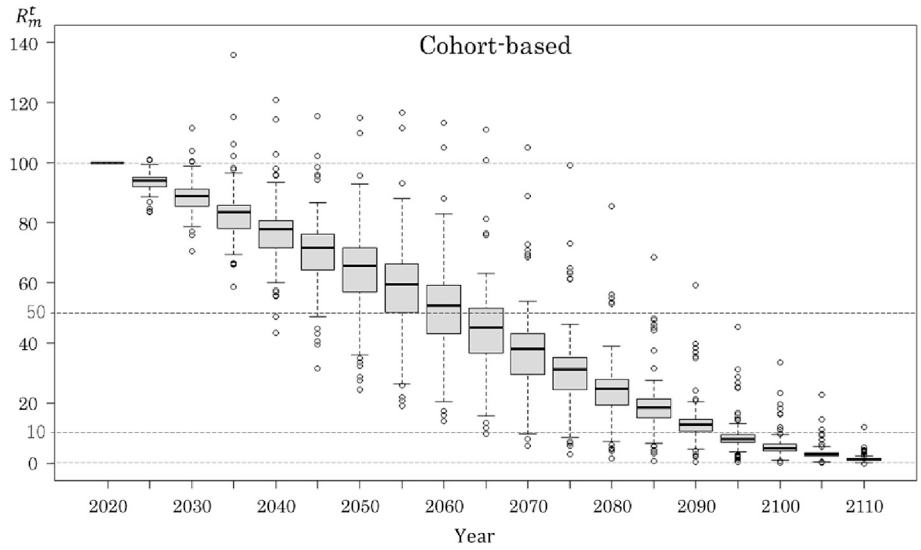

Fig. 5. Cohort-based scenario.

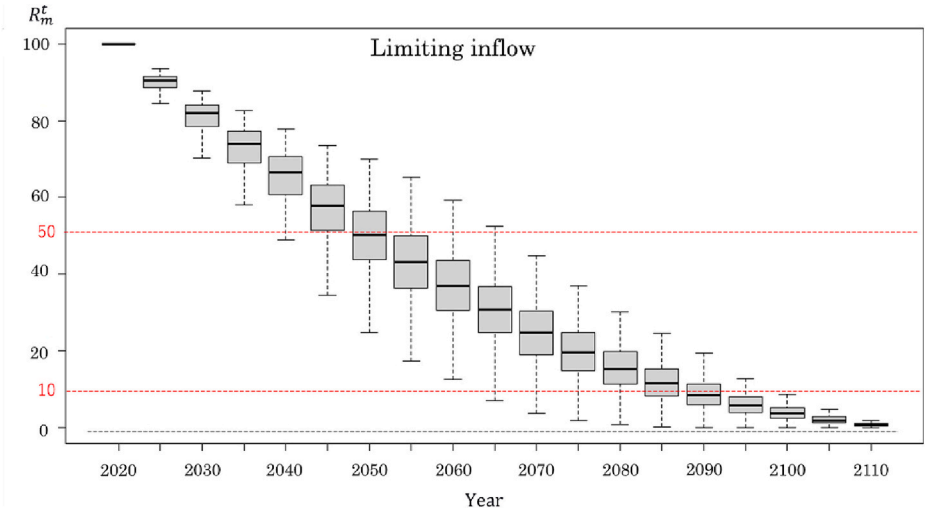

Fig. 6. Limiting inflow.

should be distributed approximately evenly. In 2070, Case 3 was the main component; however, Case 4 was the optimal scenario for most municipalities earlier than in the other categories. Moreover, for some municipalities, Cases 5 and 6 were the optimal scenario between 2050 and 2055.

In medium-scale cities 2, the optimal pattern used Case 3 twice, followed by Case 4 once, as in other scenarios (Fig. 16). However, the proportion of Case 4 use in each year was relatively large. In addition, for some municipalities, Cases 5 and 6 were the optimal scenario as early as 2055. For some municipalities, Case 2 was the optimal solution between 2025 and 2055, indicating a tendency to prioritize the migration of the younger generation.

In small-scale cities 1, there was a strong tendency for Case 4 to be the optimal scenario compared to the other categories as early as 2030 (Fig. 17). Although Cases 2, 5, and 6 could temporarily intervene, the pattern often returned to Cases 3 or 4 in subsequent years. However, from 2070, Cases 5 and 6 were the optimal scenarios.

In small-scale cities 2, Case 5 was the optimal scenario between 2025 and 2030 (Fig. 18). After 2035, Case 4 was generally the optimal scenario. Moreover, Cases 5 and 6 were optimal after 2080, which was later than the other scenarios.

Limited inflow was compared to each case and the optimized scenario. Table 3 summarizes the average point differences between the scenarios between 2025 and 2095 and differences between the averages for the optimized and single scenarios.

The optimized scenario had a higher point difference in the mean values, especially compared to Cases 1, 5, and 6. The differences in mean points between the optimized scenario and Cases 2 and 4 were − 1.00 to −3.00, respectively, suggesting that the optimized scenario was more effective than promoting migration measures for specific generations. However, there was almost no difference between designated and small-scale cities 1 in the difference between Case 3 and the optimized scenario. The optimized scenario had a greater point difference compared to Case 3 in medium-scale cities 2 and small-scale cities 2; therefore, it appeared more effective than the other categories.

3.6. Combined considerations on the relevance of migration promotion targets

First, let us analyze the migration decision-making aspect. Traditionally, migration decisions are mainly made within families, and the relative impact of personal and family characteristics has been assumed

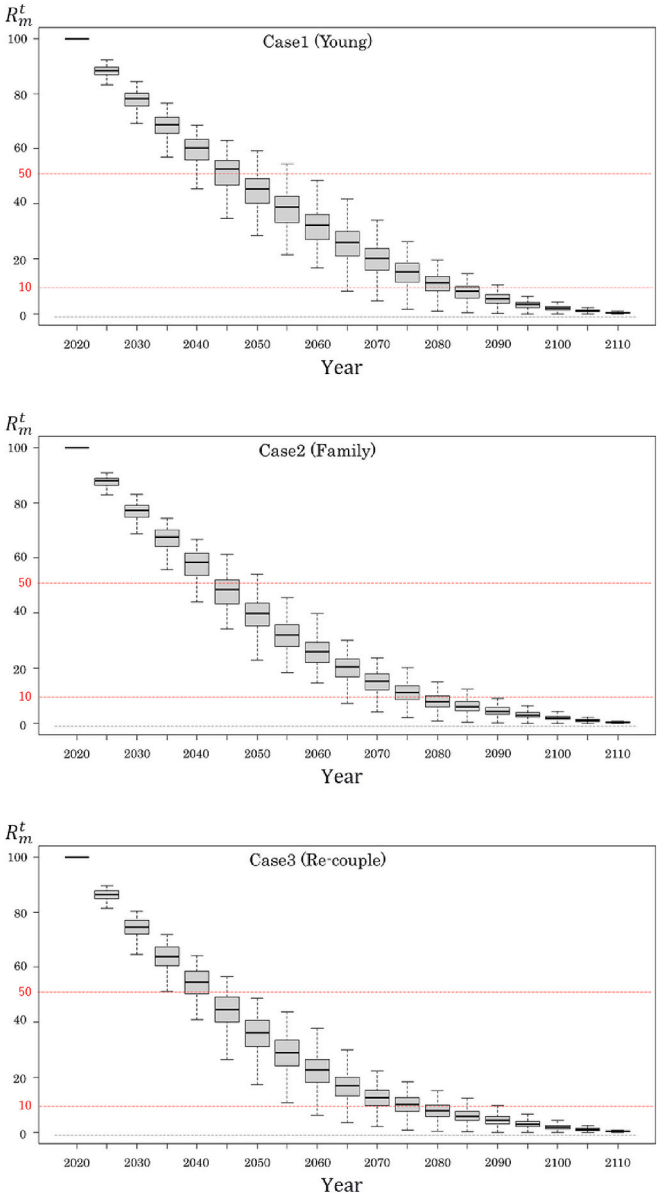

Fig. 7. Scenarios 1–3.

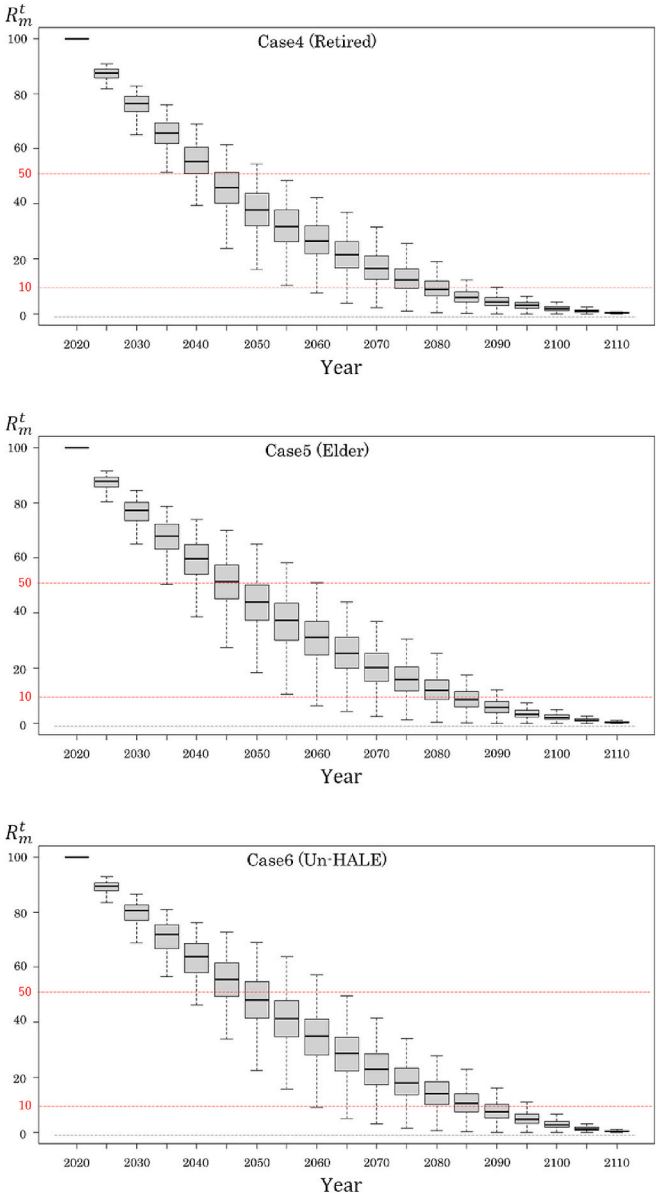

Fig. 8. Scenarios 4–6.

to vary among community members (Gubhaju & De Jong, 2009). In this context, it is unsurprising that livelihood vulnerabilities manifest themselves in the spatial structure of the marginal areas due to the increased migration to the municipal centers (Kuzawa et al., 2021). The impact of environmental changes on migration is mediated through individual and family characteristics, barriers, and facilitators of migration (Black et al., 2011). Additionally, a lack of social capital in current settlements may encourage active migration (Haug, 2008).

Moreover, deterioration of the natural and residential environment may not necessarily influence active free-will migration. Large-scale free-will migration based on environmental factors, even if associated with the natural environment's degradation, is considered rare worldwide (Black et al., 2011). In areas such as Japan, where individuals own both land and housing, a certain number of people continue to live in abandoned housing areas with low build-up rates of surrounding housing and other facilities (Yoshida, 2014). Although the living environment in these areas could be more favorable, some residents who have lived there since the first development cannot move due to factors such as household economics (Kojima, 2017; Yoshida, 2008).

In the early 2000s, a trend toward migration to areas more suited to

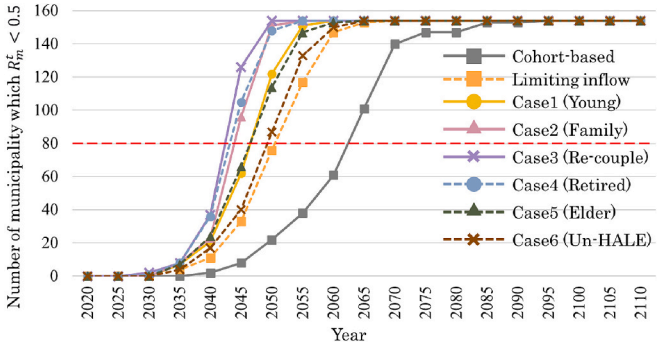

Fig. 9. Number transition of municipalities with $R_m^t < 0.5$.

their lifestyles was observed, mainly in Western countries, as people retired (Longino Jr. & Bradley, 2003). This choice of location for a better quality of life (QOL) is common for both domestic and international migration (Sunil et al., 2007). In Japan, where this study was conducted,

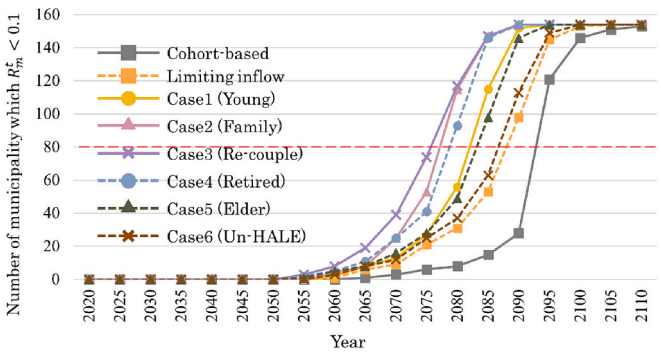

Fig. 10. Number transition of municipalities with $R_m^t < 0.1$.

migration to more livable areas upon retirement is also observed (Aoki & Kadono, 2020). In a case study in a housing complex with a declining population, significant relocation was observed in people in their 50s due to the deterioration of their living environment (Kagei & Toda, 2011). In recent years, there has been an increase in spontaneous migration among the elderly in their early years in search of a better medical environment before they require nursing care (Sugii, 2017).

Regarding the younger and older age groups, there is a tendency to limit migration. Households with children and younger generations place more importance on the commuting and child-rearing environment, which is significantly influenced by the location of jobs and children's schools (Saito et al., 2014). These factors have a more substantial influence than regional attachment and residential preference (Uno et al., 2022). Many elderly people living on the periphery cannot sell their houses because of economic aspects and the fact that owner-occupied houses tend not to be sold in terms of market principles and memories. These housing conditions force them to settle at their current residence (Kojima, 2017). Many elderly people continue to live in the land they have lived in for a long time, even if they are from a different country (Bolzman et al., 2006). As the age of the neighborhoods and houses increases, people are forced to choose to settle down even though they are dissatisfied with their living environment (Tanaka & Yuzawa, 2010).

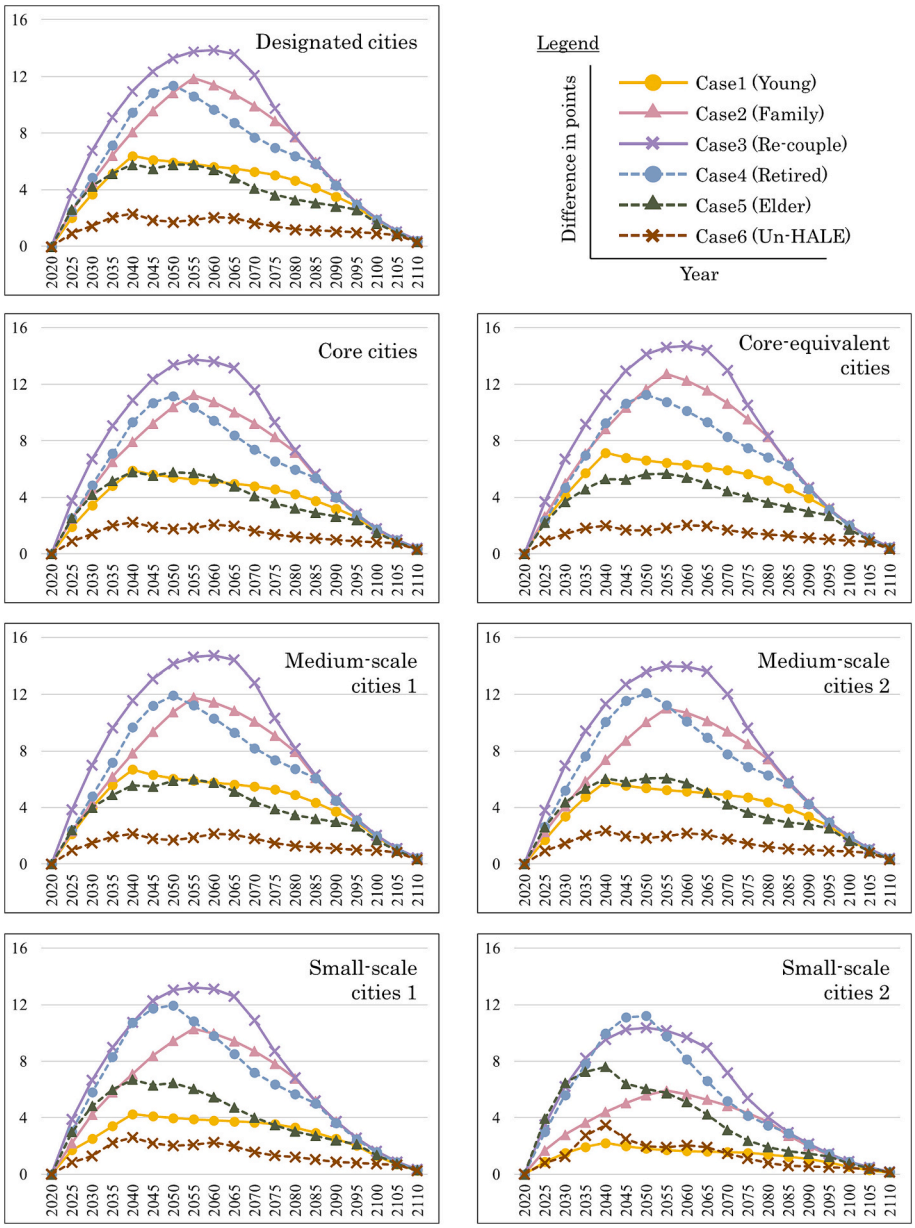

Fig. 11. Point difference by scenario and limited inflow for each category.

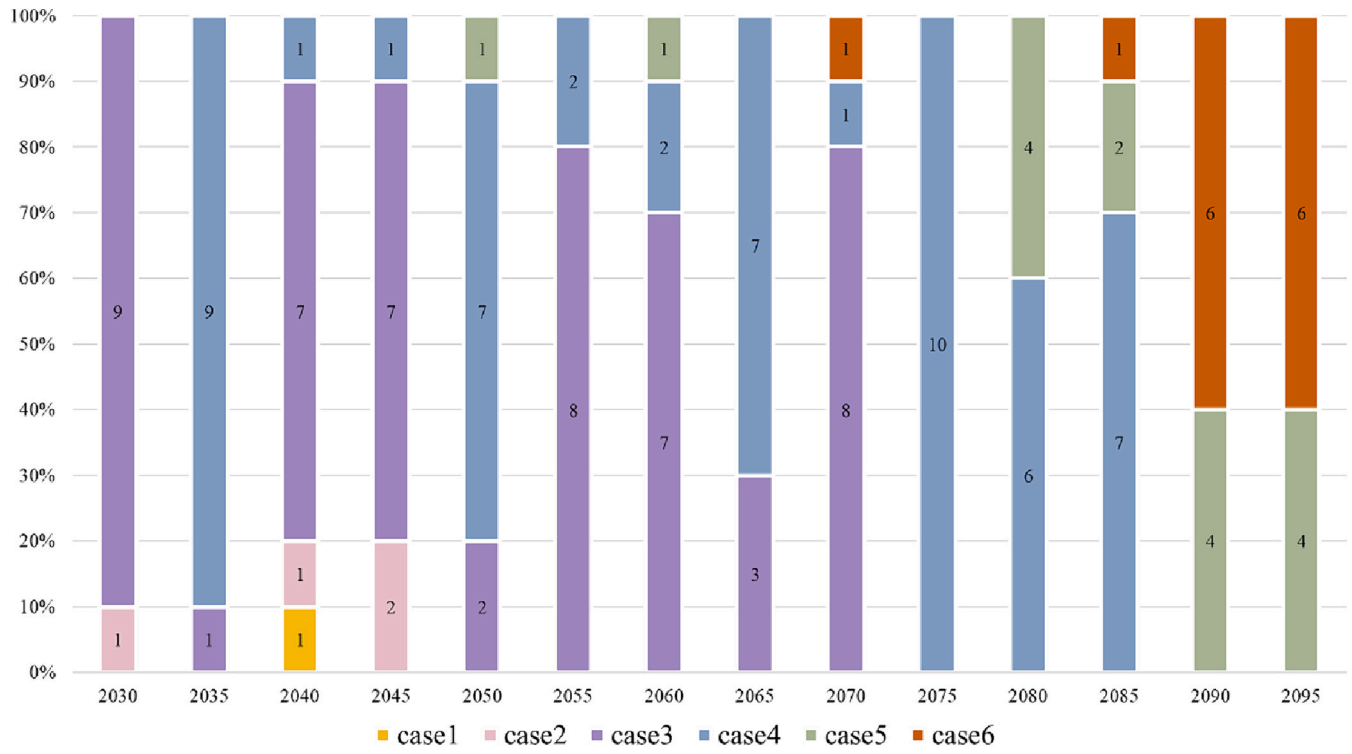

Fig. 12. Optimized scenario for designated cities (n = 10).

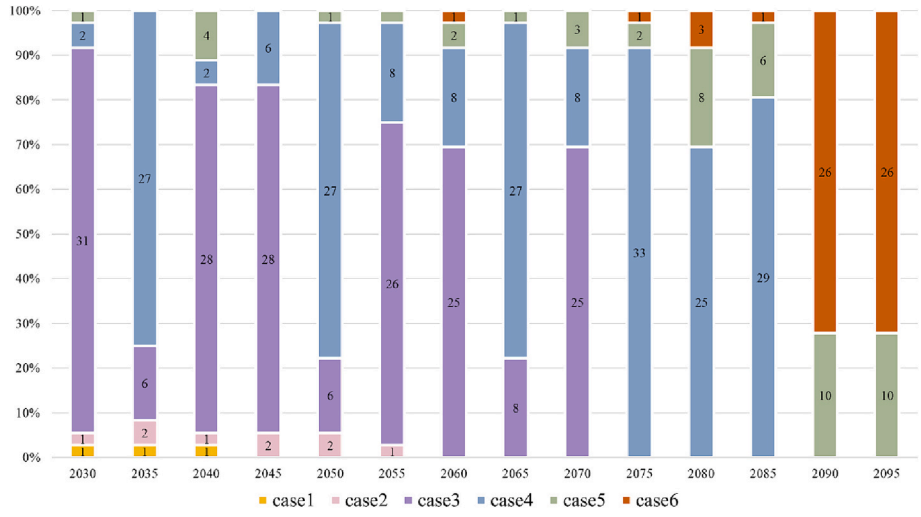

Fig. 13. Optimized scenario for core cities (n = 36).

As mentioned above, the generation before and after retirement is considered appropriate for promoting voluntary migration. What about the financial burden and other aspects? At the very least, it is challenging to develop large-scale migration policies to shrink cities in a depopulating society to reduce the financial burden (Takano & Muraki, 2020). Nevertheless, the burden of maintaining and managing water supply systems and other living infrastructure is heavy when maintaining areas that are depopulated or expected to depopulate (Masuda et al., 2020). Consequently, to truly optimize fiscal balance, compacting must be done at an earlier stage (Takano & Muraki, 2020). The result of a society with a declining population will be that the population will settle down to the pre-modern population size. However, in reality, the trend toward smaller families accompanying the development of industry and medicine has resulted in an aging population with fewer children. The social structure is estimated to make it difficult to maintain living, medical, and transportation infrastructure (Morikawa, 2015).

If the pre-retirees remain at their current residence, they will eventually become elderly. In that case, the burden on the medical infrastructure will be heavy. Currently, medical care is focused on improving QOL by supporting the elderly while curing them in the community, which requires a base in each region, resulting in prolonged treatment (Arai et al., 2015). It is complicated to maintain accessibility to healthcare infrastructure in sparsely populated areas (Weinhold & Gurtner, 2014). Even if accessibility to medical facilities were ensured, it is difficult to maintain it in a society with a declining population, especially for elderly people who have returned their driver's licenses, because it is difficult to secure enough drivers for public transportation, which is essential for them (Kojima, 2023; MLIT Regional Public Transportation Re-Design Conference, 2023).

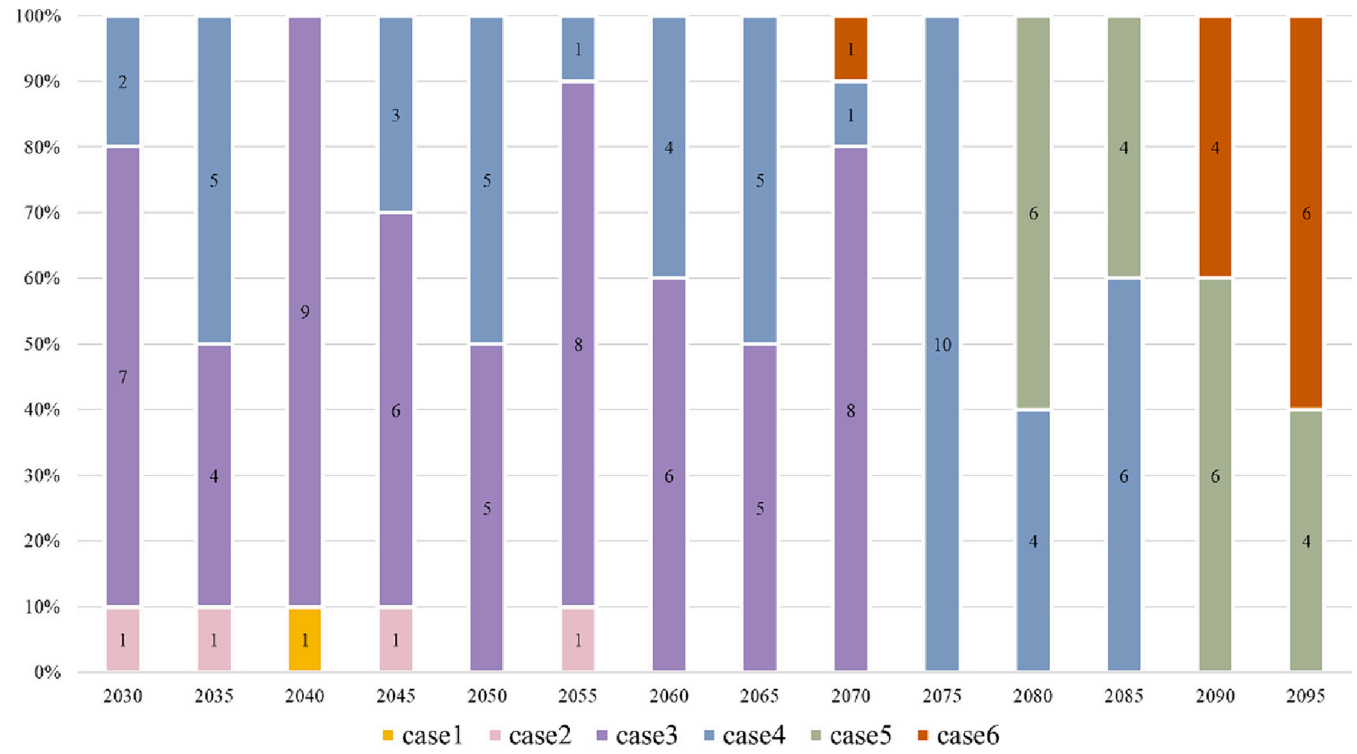

Fig. 14. Optimized scenario for core-equivalent cities (n = 10).

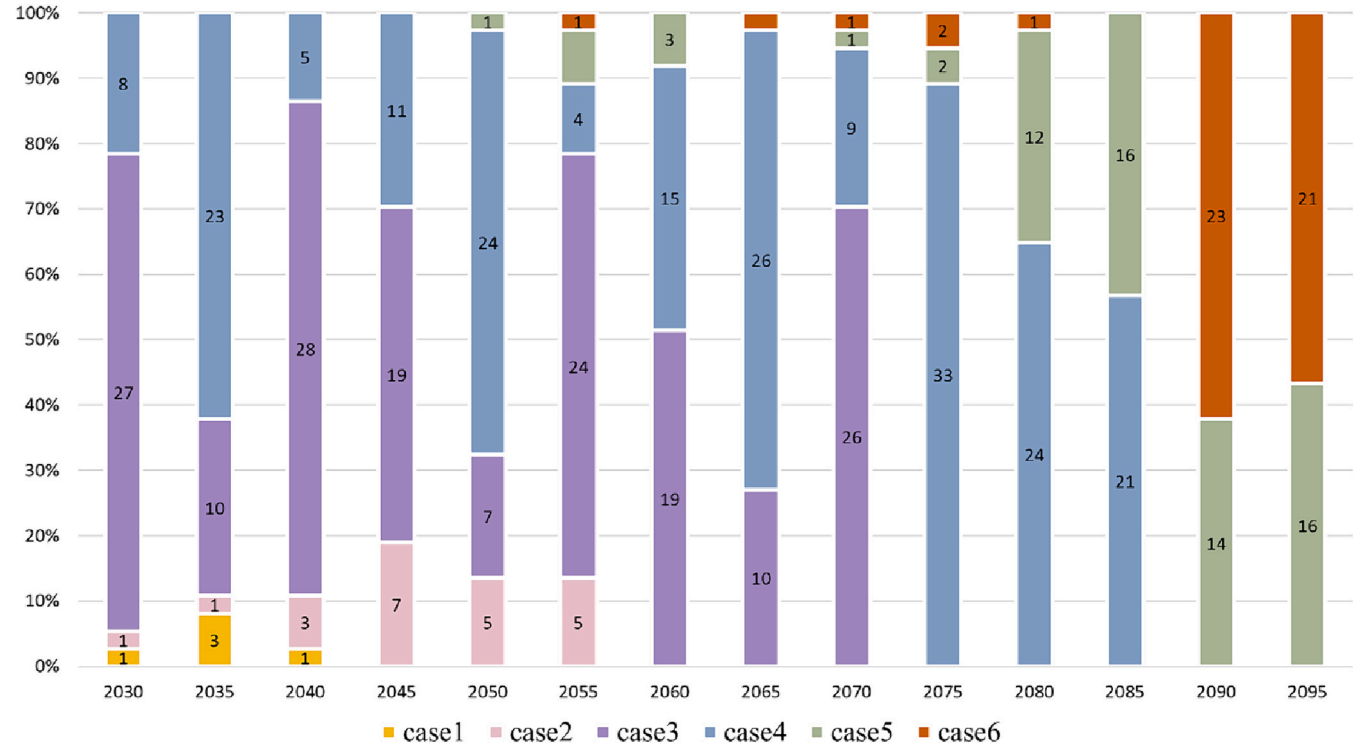

Fig. 15. Optimized scenario for medium-scale cities 1 (n = 37).

Consideration for the destinations to which they will be relocated and the expansion of urban functions will also be necessary. For the younger generation, the increasing number of households with both husband and wife working in recent years strongly demands proximity to workplaces, shared offices, and daycare centers (Nakano & Konno, 2023). For the elderly, the loss of community can lead to social isolation (Nagai et al., 2017). Although housing and occupancy facilities for the elderly exist, the tendency to fall into the category of social isolation is particularly strong among those aged 70 and over and increases significantly among those in their 80s and older (Mizuho Research & Technologies, 2021). Migration may also result in the disruption of mental health (Bhugra, 2004).

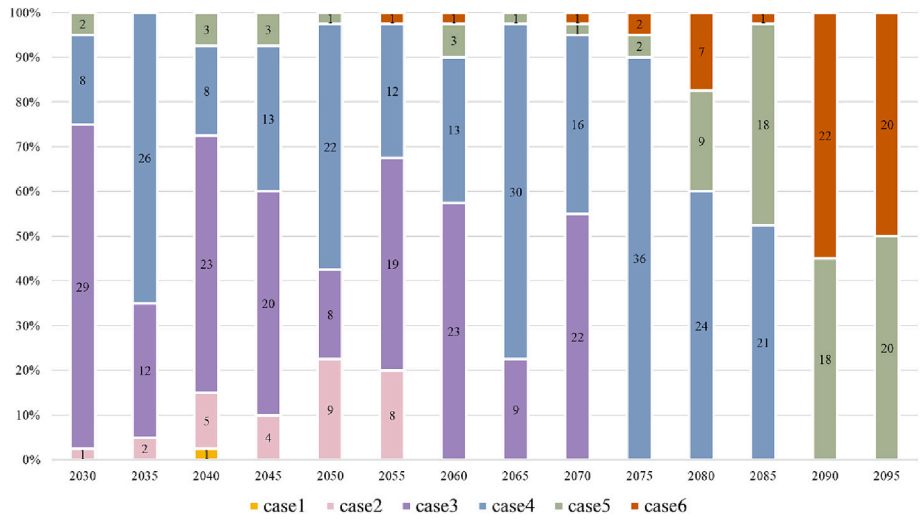

Fig. 16. Optimized scenario for medium-scale cities 2 (n = 40).

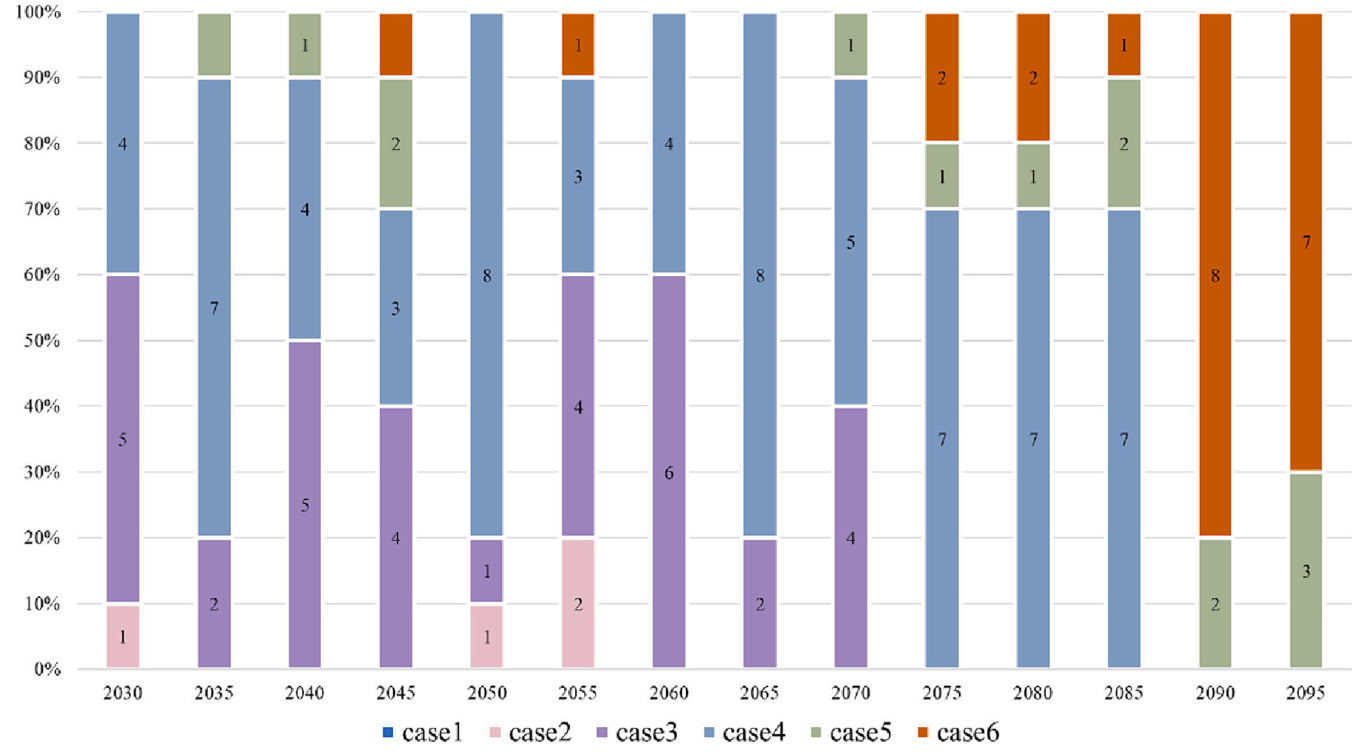

Fig. 17. Optimized scenario for small-scale cities 1 (n = 10).

4. Discussion

This study examined migration promotion scenarios that may be appropriate for shorter urban compaction in Japan, where the population is rapidly declining. As observed in the context of shrinking cities, mature cities are experiencing a phase of population decline. Compacting cities into an appropriate size is essential for future sustainability. However, systematically reducing the size of an expanded conurbation may be difficult, as this involves residents' rights.

Since 2014, Japanese municipalities have gradually introduced Location Normalization Plans. However, most drew the boundaries of residential attraction areas on the same lines as the current city scales, that is, urbanization promotion areas. Only 65 municipalities have developed measures to promote relocation to different zones. While some municipalities offered subsidies for home acquisition without specifying the target households, more accessible measures, such as rent subsidies, targeted only the younger generation. In contrast, all measures with specific target groups focused only on households around the child-rearing age, that is, households that fall under Case 2 in this study. Even in municipalities with relatively concerted efforts, current migration promotion measures require more diversity in the range of households targeted. They must strategically address the shrinkage of areas excluded from residential attraction areas based on an analysis of the current status of these areas.

The results of this study suggest that a considerable amount of time is required to achieve automatic target area closure. In addition, rather than relying on the current cohort growth rate, a significant reduction in time can be expected by curbing the inflow of new households. Effective

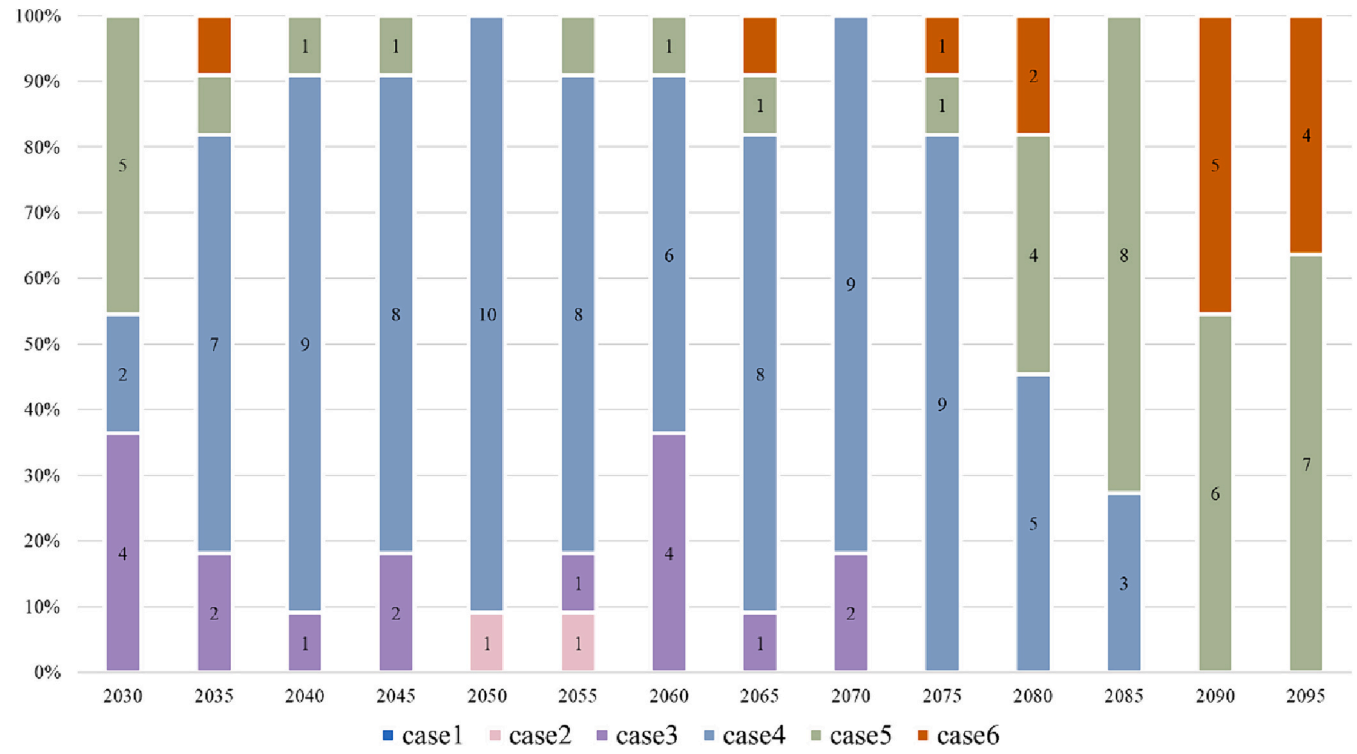

Fig. 18. Optimized scenario for small-scale cities 2 (n = 11).

Table 3
Average point difference between the optimized and single scenarios[a].

	Optimized scenario	C1 (Young)	C2 (Family)	C3 (Re-couple)	C4 (Retired)	C5 (Elder)	C6 (Un-HALE)
Designated cities	9.473	4.793	7.760	9.394	7.321	4.322	1.577
	–	*−4.680*	*−1.713*	*−0.079*	*−2.153*	*−5.151*	*−7.896*
Core cities	9.441	4.371	7.352	9.166	7.063	4.248	1.551
	–	*−5.070*	*−2.089*	*−0.276*	*−2.379*	*−5.193*	*−7.890*
Core-equivalent cities	10.223	5.344	8.330	9.855	7.461	4.258	1.549
	–	*−4.880*	*−1.893*	*−0.369*	*−2.762*	*−5.965*	*−8.674*
Medium-scale cities 1	10.137	4.982	7.723	9.898	7.604	4.386	1.601
	–	*−5.155*	*−2.414*	*−0.239*	*−2.533*	*−5.751*	*−8.536*
Medium-scale cities 2	9.901	4.394	7.238	9.453	7.560	4.434	1.614
	–	*−5.507*	*−2.663*	*−0.448*	*−2.341*	*−5.467*	*−8.287*
Small-scale cities 1	8.931	3.302	6.782	8.835	7.408	4.491	1.625
	–	*−5.630*	*−2.149*	*−0.096*	*−1.523*	*−4.441*	*−7.307*
Small-scale cities 2	7.129	1.537	3.943	6.668	6.167	4.312	1.584
	–	*−5.592*	*−3.186*	*−0.461*	*−0.963*	*−2.817*	*−5.545*

[a] n: the average point of each cases, n with italic and underline: the point difference from the optimized scenario.

measures to promote it should focus on the life stage from the end of child-rearing to just before retirement, as shown in Cases 3 and 4, as opposed to Case 2.

Households entering these life stages are at a turning point in terms of family structure changes due to their children's independence and the ease of living in their final homes after retirement. Measures should be taken to provide special incentives for them to experience the benefits of moving to residential attraction areas. In addition, compared to the cohort-based scenario, active migration promotion would rapidly increase the number of municipalities with a population that would fall to less than half of the 2020 level by 2050. During this period, municipalities in various regions would have to simultaneously take countermeasures.

Practical scenarios differ depending on municipality size. In smaller municipalities, scenarios involving migration promotion measures for older generations are more practical. This can be attributed to the fact that many of these small-scale municipalities are located in rural and urban fringe areas. Young people in Japan have concentrated in urban areas from the postwar period to the present. Consequently, the number of older households tends to be relatively higher in urban areas than that in medium- and larger-sized municipalities.

For medium-sized and larger municipalities, re-couple or retired groups should be targeted to quickly shrink the target area. However, the effects of measures targeting families, which many policymakers have recently adopted, may not become apparent until after 2050. The scenario targeting families is more effective only in core-equivalent cities, suggesting that the current mitigation promotion measures are consistent with the current situation in these cities.

The main patterns of the optimized scenario vary depending on the classification of the municipality; most municipalities fall into a combined set of Cases 3 and 4. This can considerably shorten the time until the target area shrinks compared to migration policies targeting only the younger or older generations. It would be beneficial to change migration promotion policies in accordance with the situation in the target area over time. However, if it is difficult to optimize the scenario for each period, the scenario for the re-couple generation should be continued

until approximately 2070, with a subsequent shift to policies for older households.

Compared to the younger and older generations, the pre- and post-retiree generations have fewer restrictions on where they live and have reached a milestone in their life stage. Conversely, there is a dichotomy between those who move to more livable areas as they retire and those who remain on the periphery because they cannot move due to financial considerations or adherence to home ownership. In addition to these people who can move voluntarily, it would be meaningful to approach those who cannot move.

While the deterioration of the living environment does not always promote the migration of diverse generations, the loss of social capital can increase the sense of leaving one's residence (Haug, 2008). It is assumed that many pre- and post-retiree generations have lived in the area for a long time and have high social capital. Given that the pre- and post-retirement generation tends to migrate more when their living environment deteriorates than other generations, the tendency could spread to other generations if the pre- and post-retirement generation is encouraged to migrate.

In regions such as Japan, where land and housing rights are tied to individuals, it is easier to force people to migrate if natural disasters cause severe damage. Therefore, promoting voluntary migration is crucial. However, considering the burden of infrastructure maintenance, it is desirable to encourage earlier migration. Suppose the focus is on something other than pre- and post-retirees, and they continue to reside in the target area. In that case, the period during which medical, transportation, and living infrastructure must be maintained will be extended. In addition, to move the child-rearing generation and a significant elderly population, improving the urban functions of the destination city will be essential. Current measures for the young and elderly are necessary. However, in addition to these, it may be necessary to consider initiatives based on the pre-retiree population. In addition to the convenience of their place of residence, they tend to desire a shift to a compact house size and to live closer to their children's households compared to the child-rearing stage, when the size is just right for two people (Aoki, 2021; Study Group on Urban Space Formation Strategies Responding to Residential Choice Associated with Life Stage Changes, 2020). In light of this, it would be easier for people to move if there were subsidies for moving closer to their own children's households already living in the residential zones, migration subsidies according to the appropriate house size, and support to guarantee the sale of their current residences at a specific price or higher. In this regard, hearings on specific issues should be conducted in the future.

To form a compact urban structure, voluntary withdrawal of residents from areas slated for downsizing is not optimal, regardless of ownership and other issues. Spatial patterns of understanding and interest in compacting among residents are random (Bernt, 2009). Japan has scattered cases of cohort change ratios exceeding 1.0, even in areas outside residential attraction zones. However, incentives to encourage migration targeting residents must match the optimal household groups for strategic contraction. In addition, some measures target new land developers in the induced area, although the criteria they aim for are abstract expressions, such as good landscapes and livable environments. Even in Germany, where measures related to shrinking cities are ahead of other countries, the creation of residential spaces is limited to measures that are attractive to housing companies and their fields of interest (Bernt, 2007). Thus, it is necessary to determine who the suitable living environment in a residential area is intended for. Strategies should focus on the characteristics of residents outside the residential attraction areas encompassed by each municipality, in addition to households raising children, who are easily targeted in any region.

5. Conclusions

This study examined effective short-term strategies for urban contraction based on different scenarios for each target generation. Due to Japan's high rate of owner-occupied housing and low migration mobility, spontaneous relocation over time is not expected. In addition, policies that focus solely on easy-to-imagine targets of migration promotion, such as households raising children, are not always appropriate. The present results provide a new perspective on the development policy of areas in which various urban functions are concentrated, in the fields of compact city theory and shrinking city research. In addition to the conventional generalized need to provide livable environments and migration support subsidies for young generations, a generational profile that is appropriate to the size and actual conditions of the municipality should be established, an urban environment suitable for them should be created, and support should be expanded.

The direct implications of these results are limited to Japan. However, other countries are likely to face de-population, requiring compacting strategies. Some countries may plan to shrink gradually from the outer edges of expanded urbanized areas. The same measures to promote migration that Japan has adopted in the past are not appropriate. This study demonstrated that examining the type of population in a given area of contraction and identifying methods of forming an attractive center are essential to achieve quick migration. In selecting areas for retrenching, one approach is to draw boundaries while considering compatibility with migration promotion measures. We believe that this perspective and its application to policy can be generalized globally.

As part of the academic significance of this paper, we have discussed compact cities' scope and the spatial phenomena of shrinking cities from the perspective of socio-demographic considerations. Furthermore, our study would contribute to deepening awareness of compact city policies in a society with a declining population by taking a cross-sectional view of the actual situation. The findings provide an additional view on the non-economic or non-market-related conjunction of peripheral shrinkage, which would contribute to the shrinking city context in European and American nations.

This study had several limitations, one of which is that it analyzed only residents' generations. Other characteristics, such as household composition and income, should also be considered. Obtaining detailed data on these characteristics from the standpoint of personal information and open data in small districts is challenging. In addition, the data did not capture the actual residential environment within residential attraction areas of each municipality, as we aimed to capture the trends in Japan as a whole to determine the gap between policies and the actual situation. Further, this study did not examine the psychological aspects of the desire of residents outside residential attraction areas to live amid lifestyle diversifications.

Therefore, the following four points are necessary for further research in this field:

1. The possibility of developing migration promotion measures based on more detailed household characteristics. The challenge is to obtain original data that do not rely on open data, while maintaining the confidentiality of personal information.
2. Several model cases should be established for each of the categories of municipalities obtained based on this study's classification, and the affinity between the urban environment within residential attraction and urban function attraction areas as well as the generations targeted for migration promotion should be quantified.
3. Residents' lifestyle preferences, including psychological aspects, should be clarified.
4. At this early stage, determining the benefits of the residential inducement measures is difficult. Therefore, conducting a transitional study and clarifying the change in the contribution rate to shrinkage in the recommended shrinkage areas over time rather than in the resettlement areas is required. This is especially necessary to improve the accuracy of the population scenarios in the recommended shrinkage areas in this study as the first step.

Interdisciplinary research outside the field of urban planning should also be considered. We intend to continue researching and analyzing these points in the future.

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CRediT authorship contribution statement

Takashi Aoki: Writing – review & editing, Writing – original draft, Methodology, Investigation, Funding acquisition, Formal analysis, Data curation, Conceptualization.

Declaration of competing interest

The research foundation from Dai-ichi Life Foundation mentioned as above.

Data availability

All data is available on the Portal site of official statistics of Japan (https://www.e-stat.go.jp/).

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