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**Article**

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# Relationship between population change and resident characteristics: The case of the Nagasaki Prefecture in Japan

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## ABSTRACT

Population decline is currently a serious problem in Japan. In this study, the population change rates of municipalities in the Nagasaki Prefecture were examined using a classification of the resident characteristics of small areas. A total of 14 variables were selected from the small area data of the 2015 census to examine the resident characteristics of the small areas, and these variables were analyzed via factor and cluster analyses. As a result, the variables were classified into six resident characteristic clusters. The classified resident characteristics are Cluster 1: urban professionals, Cluster 2: nuclear families with children living in rental housing, Cluster 3: areas without residents, Cluster 4: blue-collar workers, Cluster 5: manufacturing and industry workers, and Cluster 6: typical farmers. We conducted a regression analysis using the population change rate in each municipality as a response variable and each of the six regions classified in the municipalities as the explanatory variable. We found that Cluster 2 has the greatest influence on the population growth rate. We examined the distribution of each regional classification. It is suggested that the areas classified as Cluster 2 are often distributed in areas outside densely inhabited districts and that emerging residential areas for nuclear family households with children are formed in the suburbs of cities. Municipalities with a high proportion of Cluster 2 are likely to be commuting towns in the Nagasaki and Sasebo employment metropolitan areas, suggesting that the population reduction rate is low due to the accumulation of residents from surrounding areas.

## 1. Introduction

Population decline is currently a serious problem in Japan. The total population of Japan continued to grow continuously after World War II but is currently on a downward trend having peaked at 128 million people in 2008. According to the midterm estimate of the National Institute of Population and Social Security Research, the total population will fall below 100 million in 2050 and will be below 50 million in 2100. The declining birthrate is a cause of the decrease in the total population. The total fertility rate in 1947 was 4.54, while in 2005 it was 1.26. (MLIT-Ministry of Land Infrastructure Transport and Tourism in Japan 2015). Fig. 1 shows the total fertility rate by prefecture in Japan in 1950 and 2010. In 2010, the total fertility rate was less than 2 nationwide. The Tohoku region and Hokkaido, which had the highest birth rates in 1950, had lower rates in 2010.

The declining birthrate and population flow to urban areas are factors contributing to the declining population in regional areas in Japan. After World War II, during the period of high economic growth following the 1950s, a rapid population increase in metropolitan areas was seen as young people in rural areas moved to metropolitan areas for employment and to receive higher education. As a result, in nearly half of prefectures, the natural increase was surpassed by social outflows and the population declined. In

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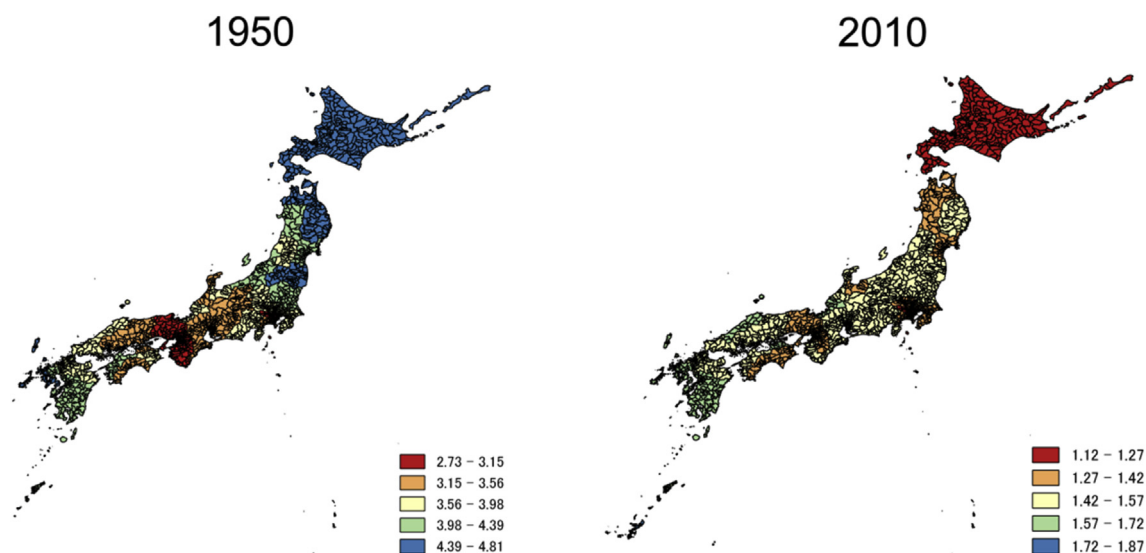


Fig. 1. Distribution of the total fertility rate in 1950 and 2010. Source: National Institute of Population and Social Security Research (2019).

1970, as the economic growth rate decelerated, the outflow trend from regional areas converged, and in 1974 the number of prefectures where the population decreased became zero (Mera, 1977).

When entering the “bubble economy” in the mid-1980s, the movement of people to the Tokyo area increased and the population decline rate in regional areas increased. In the early 1990s, when the “bubble economy” collapsed, the population migration to the Tokyo area temporarily decreased. However, in the mid-1990s, there were factors such as decreasing land prices and the population movement to the Tokyo area increased again. The decreasing population trend in such regional areas is continuing to this day (MLIT-Ministry of Land Infrastructure Transport and Tourism in Japan 2015) due to the relocation to urban areas from regional areas that has been occurring since the mid-1990s. However, it has been pointed out that factors related to natural decline are increasing (Yamagami, 2009). Fig. 2 shows the amount of population inflows and outflows by prefecture in 1960 and 2010. In 1960, Tokyo, Osaka, and the Nagoya metropolitan area were overall accepting population inflows from regional areas. In 2010, while the amount of inflows from regional areas decreased, there was basically no change in the inflow trend. Meanwhile, Osaka and the Nagoya metropolitan area became outflow regions.

The population distribution and its influence factors is a major field of research in population geography, and analyses have been conducted using various methods. Studies targeting the national level include that of Beeson, Dejong, and Werner (2001) who examined the location and growth of the U.S. population using county-level census data from 1840 to 1990 via multiple regression analysis. In addition, there is a study that explains the change in the population density at the county level in China from 2000 to

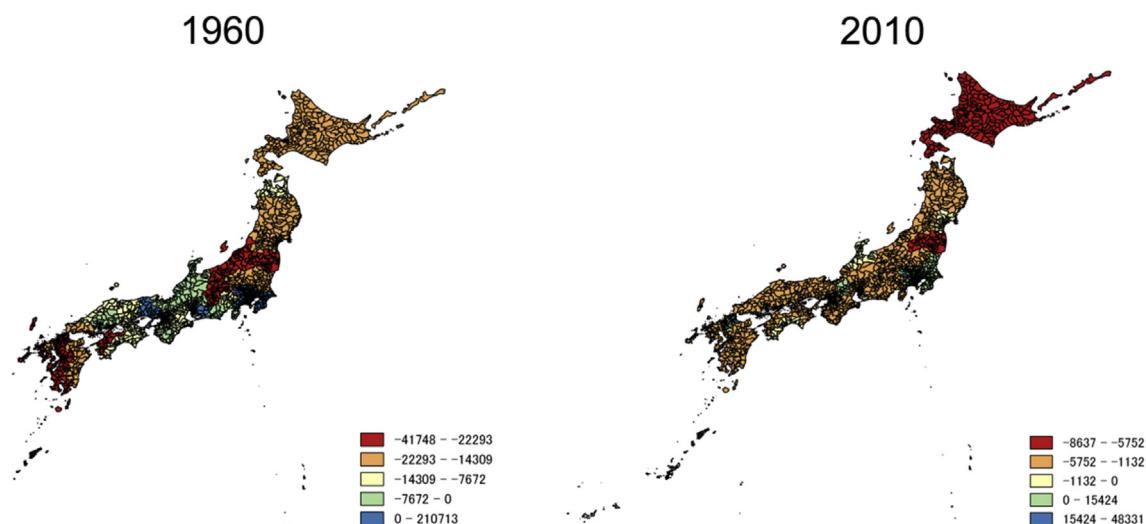


Fig. 2. Distribution of the amount of population inflow and outflow in 1960 and 2010. Source: National Institute of Population and Social Security Research (2019).

2010 using partial least squares regression and reveals that socioeconomic factors such as GDP density and the number of hospital beds influences increases in the population density (Wang, Feng, & Yang, 2015). In another study, Xu and Ouyang (2018) analyzed the population distribution in China using geographically weighted regression. As a result, it was found that road density, GDP, temperature, and the arable land ratio are major factors influencing the interregional population distribution.

Conversely, from the viewpoint of urban planning and housing policy, research has also been conducted to examine the mobility of urban residents focusing on the environmental characteristics of cities. For example, Silverman, Yin, and Patterson (2013) used multiple regression analysis to reveal that the important factors in vacant residential areas in Buffalo, NY, are elevated poverty rates, higher percentages of renters receiving rental assistance, and long-term vacancies. In addition, in a study of seven cities in Korea, the preference for household mobility could be explained by multilevel analyses of survey-based and census data and the economic condition, the degree of education, transportation elements, social ties, environmental perception, and place-based characteristics were found to contribute to residential mobility preferences (Kim et al., 2015). Further, in a case study on Japan's compact city policy, Sakamoto, Iida, and Yokohari (2018) investigated the distribution of residential inheritors and immigrants and the residential district characteristics (e.g., the residential area development year, road width, and traffic access) in the city of Utsunomiya. The results show that the number of inheritors has a positive relationship with the age of the residential areas and access to railway transport and downtown areas. Conversely, migrants revealed a tendency to be distributed randomly compared to inheritors.

There is a technique to explore the relationship between the characteristics of the residents in an area and the phenomena in a specific area. Methods using small area census data to examine the characteristics of the residents in an area are primarily used in the field of marketing research (Farr & Webber, 2007; Leventhal, 2003; Webber, 2007). In some countries, geographical data based on census data are sold as a package. Such data have also been used in the field of public health to investigate geographical and demographic relationships with diabetes (Grubestic, Tony, & Murray, 2014), influenza (Kimura et al., 2011), and morbidity and smoking rates (Sharma, Lewis, & Szatkowski, 2010). In the field of education, Xiang et al. (2018) classified areas in Beijing according to the characteristics of residents to examine inequalities in education based on the average travel distance to elementary and junior high schools in the five classified districts.

Regional resident characteristics provide a powerful method to investigate the cause of a phenomenon; however, there have been no studies examining the relationship between the population change and the characteristics of residents in small areas of the municipalities. Examining this relationship is useful to establish effective urban planning and housing policies to counter the population decline problem. The purpose of this study is to examine the relationship between the characteristics of residents classified according to the small area census data and population change.

## 2. Material and methods

### 2.1. Study area

In this study, the population changes of 13 cities and 8 towns constituting the Nagasaki Prefecture of Japan were examined. The Nagasaki Prefecture is located in the northwest corner of the Kyushu district of Japan and is the prefecture with the largest number of islands in Japan, including the Goto Islands, Iki Island, and Tsushima (Fig. 3). The Nagasaki Prefecture is lacking in flat areas, and its coastline is formed from many peninsulas, capes, bays, and coves. The total population of the Nagasaki Prefecture is approximately 1.34 million, and the total area is 4132.20 km<sup>2</sup> (Nagasaki Prefecture 2017). The city of Nagasaki is the prefectural capital and has the largest population in the prefecture. Sasebo is the central city in the northern part of the Nagasaki Prefecture and has the second largest population in the Nagasaki Prefecture. The population is decreasing in most municipalities in the Nagasaki Prefecture and is increasing only in the city of Omura and the town of Saza (Table 1).

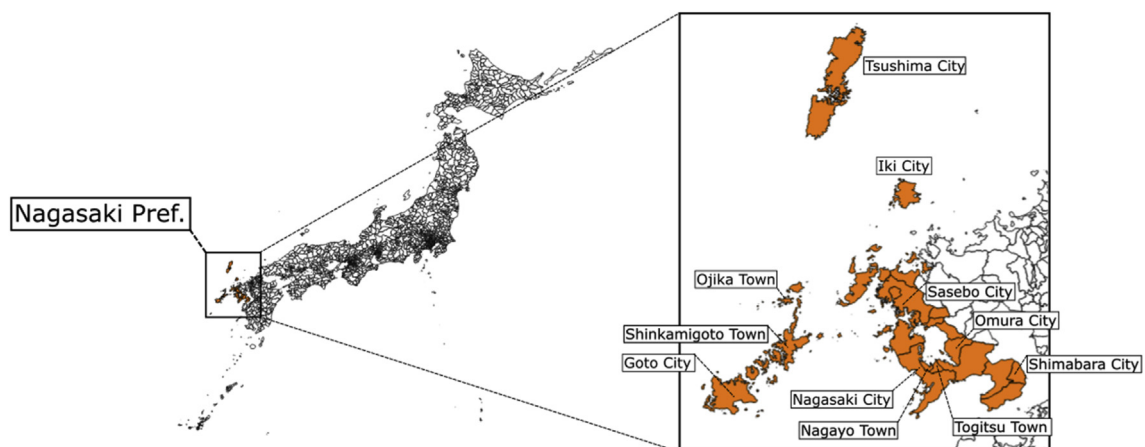


Fig. 3. Location of the study site.

**Table 1**Population and population change ratio of cities and towns in the Nagasaki Prefecture. *Source: Nagasaki Prefecture (2018).*

City and Town names	Population (2018)	Population (2008)	Population change ratio (2008–2018)
Nagasaki City	416,419	445,822	−0.066
Sasebo City	249,628	263,917	−0.054
Shimabara City	43,903	48,512	−0.095
Isahaya City	135,285	141,866	−0.046
Omura City	94,460	89,683	0.053
Hirado City	30,242	36,043	−0.161
Matsuura City	22,272	25,639	−0.131
Tsushima City	29,913	35,508	−0.158
Iki City	25,841	29,898	−0.136
Goto City	35,429	41,729	−0.151
Saikai City	27,291	32,227	−0.153
Unzen City	42,472	48,152	−0.118
Minamishimabara City	43,852	51,615	−0.150
Nagayo Town	41,913	42,234	−0.008
Togitsu Town	29,717	30,010	−0.010
Higashisonogi Town	7921	9240	−0.143
Kawatana Town	13,691	14,804	−0.075
Hasami Town	14,614	15,039	−0.028
Ojika Town	2390	2922	−0.182
Saza Town	13,742	13,600	0.010
Shinkamigoto Town	18,443	22,991	−0.198

## 2.2. Data description

In this study, we used small area data from the Nagasaki Prefecture census conducted in 2015. Small area data are aggregated into survey area units within the municipalities. The Nagasaki Prefecture is divided into 3920 areas. Regions in which the number of surveyed subjects is small and individuals are identified are not disclosed as they are confidential areas. Confidential areas were excluded from the analysis in this study. The variables included in the small area census data are population by gender, number of households, population by age, household members, family type of household, type of residence, ownership of residence, and the number of employed persons by industry (Statistics Bureau, Ministry of Internal Affairs and Communications in Japan 2015).

## 2.3. Analysis methods

In this study, we used a factor–cluster analysis to classify the resident characteristics in the small census areas. When choosing variables, the correlation coefficient between each variable was taken into consideration. The 14 variables of the adopted small area data are 9 variables related to the occupations of the residents in the small areas, the variables related to the classification of the residence (owned housing or private rental housing), the variables related to the age of the household members (e.g., under 18 years old and over 65 years old), and the variables related to non-nuclear family households. Each variable was converted to a ratio with respect to the number of households in each small area. To facilitate the interpretation of each factor, an axis rotation was performed using the varimax method. Only variables with eigenvalues of each factor greater than 1 and factor loadings greater than 0.5 were adopted. Score values of the extracted factors for each small area were calculated using the Bartlett method, and each small area was classified into six categories via a cluster analysis based on the score value of each factor. We used the Ward method for the cluster analysis and the Euclidean distance for the distance. To examine the relationship between the population change rate of each city or town and the region classification, a multiple regression analysis was performed on the composition ratio with the regional classification as a variable. A stepwise method was used for the variable selection. The variable selection criterion we used was the Akaike information criterion. We performed these statistical processes using the R language (R Core Team, 2015). We used QGIS 2.8.3-Wien to display the classification result.

## 3. Results

### 3.1. Resident characteristics

Table 2 shows the factor analysis results for the small area census data. As a result of the factor analysis, six resident characteristic factors were generated that explain 61.2% of the variance in the data. F1 was interpreted as a factor indicating a typical family-run farm from the characteristics of an elderly household and agricultural, forestry, or fishery workers. F2 was interpreted as a factor representing rental housing regions because the factor loading of the rental housing was as high as 0.910 and the factor loading of an owner's house was negative. F3 was interpreted as a factor indicating nuclear family households with children because the factor loading of households under the age of 18 was high and the factor loading of households over the age of 65 was negative. F4 was interpreted as a factor representing professionals who reside in the city center because the factor loading of professionals and

**Table 2**  
Factor analysis results with varimax rotation for the small areas of the census.

Item statement	Factor loading					
	F1	F2	F3	F4	F5	F6
<i>Factor 1: Typical farmers</i>						
Household members over 65 years old	0.755					
Housing owner	0.736					
Agriculture, forestry, or fishery workers	0.694					
<i>Factor 2: Rental residential area</i>						
Private rental housing		0.910				
Incapable of classifying occupations		0.543				
Housing owner		−0.536				
<i>Factor 3: Nuclear family with children</i>						
Household members under 18 years old			0.957			
Household members over 65 years old			−0.541			
<i>Factor 4: Urban professionals</i>						
Professional and technical workers				0.917		
Agriculture, forestry, or fishery workers				−0.454		
<i>Factor 5: Manufacturing industry</i>						
Production process workers					0.993	
<i>Factor 6: Blue-collar workers</i>						
Construction, mining workers						0.501
Conveyance, cleaning, packaging workers						0.487
Transportation, machine operation workers						0.487
Sum of square of factor loadings	1.897	1.822	1.333	1.235	1.152	1.128
Variance (%)	13.5	13.0	9.5	8.8	8.2	8.1
Cumulative variance (%)	13.5	26.6	36.1	44.9	53.1	61.2

technical workers was as high as 0.917, while the factor loadings of agriculture, forestry, and fishery workers were negative. F5 was interpreted as a factor expressing the manufacturing industry because the factor loading of manufacturing process employees was 0.993. F6 was interpreted as a factor of blue-collar workers because the factor loadings of construction, industry, cleaning, and machine operation workers were high.

The factor scores for each of the six resident characteristics in the small areas were calculated using the Bartlett method. Based on the obtained factor scores, six clusters were found via cluster analysis. The averages of the scores constituting the clusters are shown in Table 3. Based on the averages of the scores, the resident characteristics indicated by each cluster were interpreted as follows: Cluster 1: urban professionals, Cluster 2: nuclear families with children residing in rental houses, Cluster 3: areas without residents, Cluster 4: blue-collar workers, Cluster 5: manufacturing and industry workers, and Cluster 6: typical farmers. The average values of all factor scores were negative for Cluster 3. The actual distribution of Cluster 3 is shown in Fig. 5 and included regions with no residents, such as mountainous areas. Therefore, we classified it as areas without residents.

Table 4 shows the number of areas by their resident characteristic classification according to each municipality. Fig. 4 displays a stacked graph showing the composition ratio of the regional classification according to each municipality. Fig. 5 shows a map in which the small areas are divided according to each area classification. Urban professional areas are located in the center of each city. It is observed that the residential areas of nuclear family households with children, blue-collar workers, and typical farmers tend to surround the outer edges of the urban professional areas. The manufacturing industry areas tend to be concentrated locally.

### 3.2. Ratio of population change and resident characteristics

Table 5 shows the regression analysis results for the number of each area classification and the population change in each municipality. As a result of variable selection via the stepwise method, Clusters 1–5 were selected as variables. The coefficients were positive except in the areas without residents (Cluster 3). The coefficient for the nuclear family households with children living in

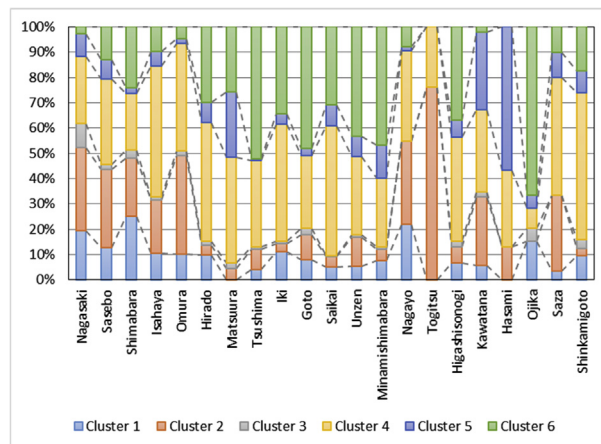
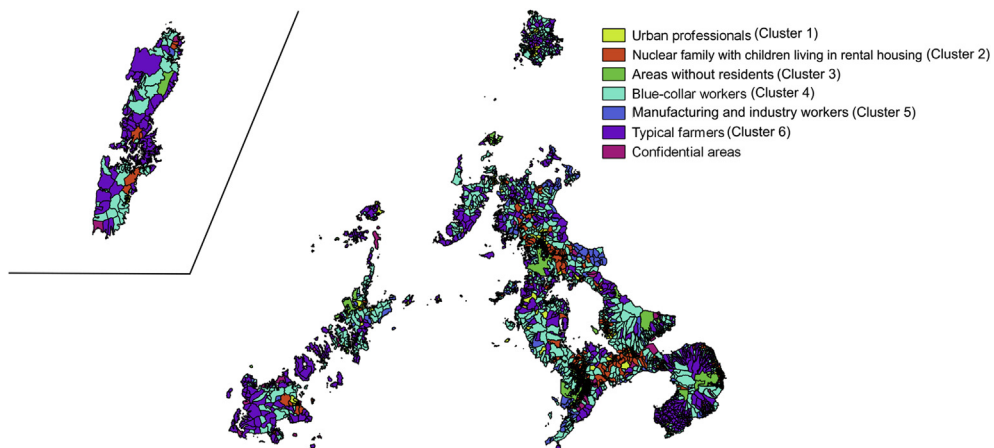
**Table 3**  
Cluster analysis results of factor scores for the small areas of the census.

Classification	Score Average					
	F1	F2	F3	F4	F5	F6
Cluster 1: Urban professionals	−0.201	0.093	−0.121	1.676	−0.278	−0.266
Cluster 2: Nuclear families with children living in rental housing	−0.328	1.539	0.373	−0.002	0.193	−0.176
Cluster 3: Areas without residents	−4.704	−1.370	−1.256	−1.677	−1.321	−1.959
Cluster 4: Blue-collar workers	−0.030	−0.380	0.212	0.042	−0.055	0.694
Cluster 5: Manufacturing and industry workers	−0.050	−0.385	−0.531	−0.151	2.008	0.123
Cluster 6: Typical farmers	0.977	−0.294	−0.224	−0.616	−0.450	−0.648

**Table 4**

The number of each regional classification in each municipality.

Name of municipality	Cluster 1	Cluster 2	Cluster 3	Cluster 4	Cluster 5	Cluster 6
Nagasaki	110	187	54	150	51	15
Sasebo	59	145	9	158	37	60
Shimabara	46	42	6	41	4	44
Isahaya	35	70	4	172	19	32
Omura	11	42	2	46	2	5
Hirado	22	9	4	106	18	68
Matsuura	0	4	2	37	23	23
Tsushima	5	10	1	42	1	64
Iki	28	8	3	117	11	87
Goto	16	20	5	58	6	97
Saikai	13	11	1	136	22	81
Unzen	11	23	2	63	16	88
Minamishimabara	21	12	3	74	36	128
Nagayo	14	21	0	23	1	5
Togitsu	0	16	0	5	0	0
Higashisonogi	3	3	1	19	3	17
Kawatana	3	14	1	17	16	1
Hasami	0	3	0	7	13	0
Ojika	6	0	2	3	2	26
Saza	1	9	0	14	3	3
Shinkamigoto	17	5	6	103	15	31

**Fig. 4.** The ratios of the regional classifications in each municipality.**Fig. 5.** Distribution of the resident characteristic clusters.



**Table 5**

Regression results of the population change ratio of each municipality based on the number of each regional classification.

Dependent variable	The population change rate of each municipality (2008–2018)			
Independent variables	The number of each regional classification in each municipality.			
Goodness-of-fit				
R2 = 0.7689				
Adjusted R2 = 0.6919				
Standard error = 0.03915				
Variable in the equation				
Independent Variable	Estimate	Std. Error	t value	
Urban professionals (Cluster 1)	0.33130	0.16683	1.986	.
Nuclear families with children living in rental housing (Cluster 2)	0.33419	0.05115	6.534	***
Areas without residents (Cluster 3)	−0.70920	0.49331	−1.438	
Blue-collar workers (Cluster 4)	0.11062	0.08155	1.356	
Manufacturing and industry workers (Cluster 5)	0.20135	0.07768	2.592	*
(Intercept)	−0.23346	0.04441	−5.256	***
Significance codes: “***” indicates 0.001, “**” indicates 0.01, “*” indicates 0.05, and, “.” indicates 0.1.				

rental houses (Cluster 2) was the largest, followed by the coefficient for the urban professionals (Cluster 1). It was found that the population growth rate increased with the number of areas classified into these two clusters.

## 4. Discussion

### 4.1. Emerging residential areas

As shown in Fig. 4, it was found that the composition ratio of the regional classification showing the resident characteristics for each municipality could be characterized. The regression analysis revealed that larger numbers of areas classified as nuclear family households with children living in rental housing (Cluster 2) increases the population growth rate of municipalities. First, we examined the classification region distribution of Cluster 2. Fig. 6 indicates the densely inhabited districts (DID) in the Nagasaki Prefecture with a light blue line. The definition of DID in this study is the following definition from the census: districts with a

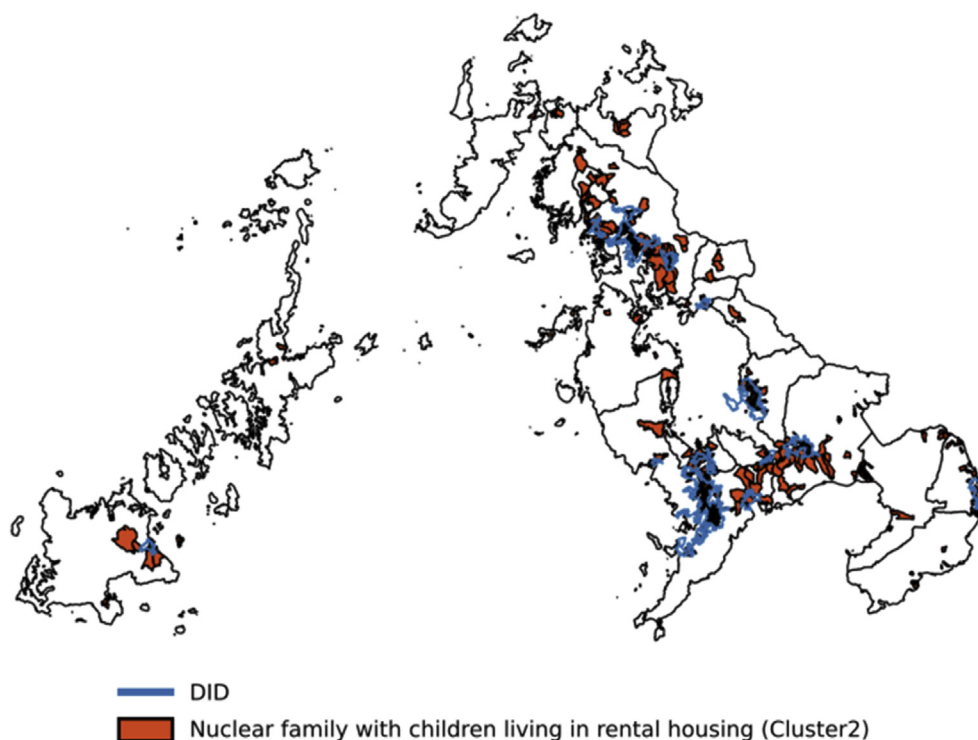


Fig. 6. Distribution of the DIDs and areas classified as Cluster 2.



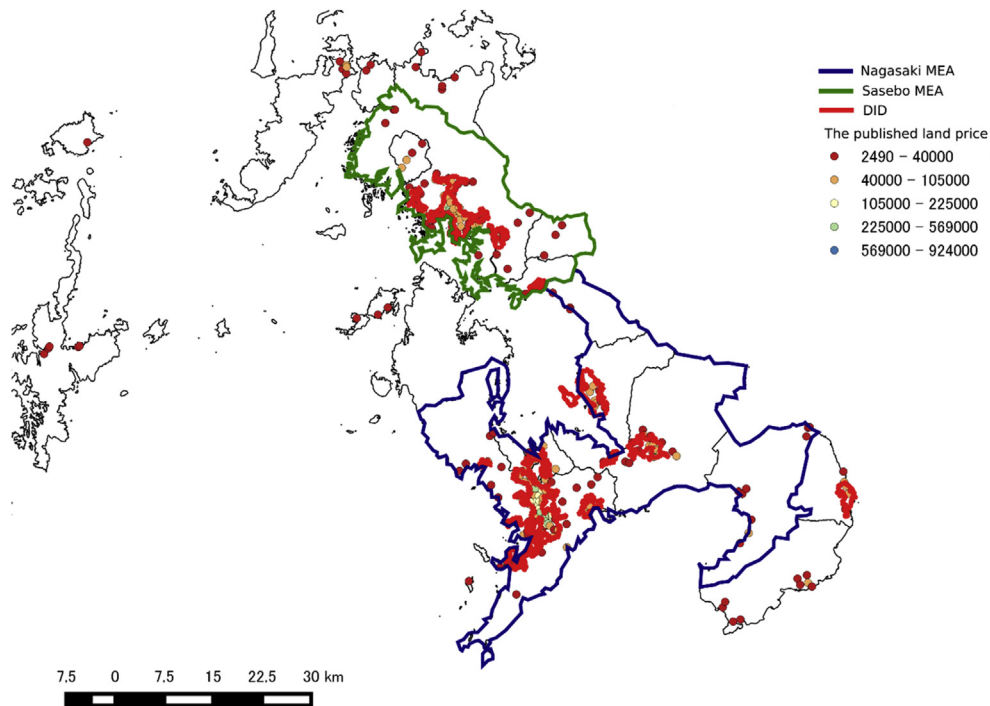


Fig. 7. The densely inhabited districts (DID), metropolitan employment areas, and the published land prices in the Nagasaki Prefecture, 2018. Source of the published land prices: MILT in Japan (2018).

population of more than 5000 people due to the adjacent survey areas with population density of about 4000 people/km<sup>2</sup> or more. In the distribution map of Cluster 2 shown in Fig. 6, Cluster 2 is classified in areas outside the DID in many areas. This suggests that these areas are formed in emerging residential areas for nuclear families with children in suburbs.

The distribution of land prices can be considered to be a factor for forming new residential land in urban suburbs. Fig. 7 shows the distribution of the published land prices in the Nagasaki Prefecture in 2018 in yen/m<sup>2</sup>. The tendency is for the land price to become cheaper toward the outer edge of the observed DID. In particular, most of the regions outside DID have a price range of 2490–40,000 yen/m<sup>2</sup>, which are the lowest prices available. This indicates that the development of emerging housing occurs in the suburbs where the price of land is cheap.

The concept of a “metropolitan area” shows the relationship between a central city and its surrounding areas. Kanemoto and Tokuoka (2002) designated the DID in the census as being the central city, and municipalities with a commuting rate to the central city of 10% or more were designated “metropolitan employment areas.” Fig. 7 shows the Nagasaki and Sasebo employment areas. The Nagasaki employment area consists of Nagasaki as the central city and Togitsu Town, Nagayo Town, Isahaya City, Omura City, Unzen City, and Higashisonogi Town as the surrounding areas.

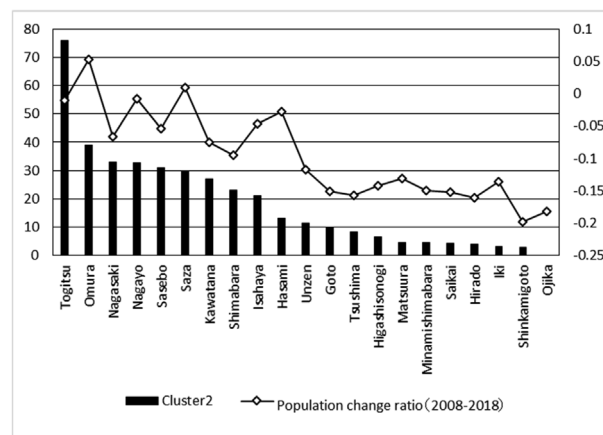


Fig. 8. The ratio of Cluster 2 in each municipality and the population change ratio.

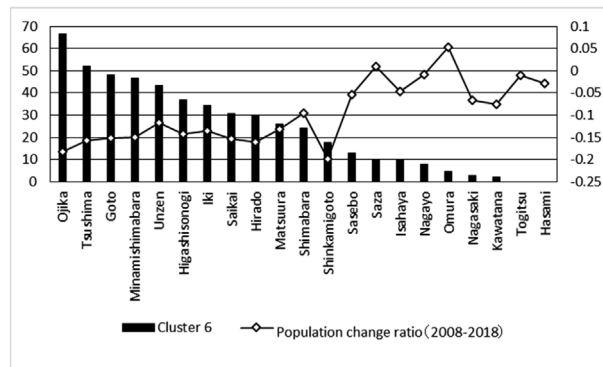


Fig. 9. The ratio of Cluster 6 in each municipality and the population change ratio.

The Sasebo employment area has Sasebo as the central city and Saza Town, Kawatana Town, and Hasami Town as the surrounding areas. Fig. 8 shows the composition ratio of Cluster 2 and the population change rate in each municipality. Municipalities with a high percentage of Cluster 2 tend to have a declining population decreasing rate. The top five municipalities with the highest proportion of Cluster 2 (excluding Nagasaki and Sasebo) are Togitsu Town, Omura City, Nagayo Town, Saza Town, and Kawatana Town. These municipalities are commuting towns in the Nagasaki and Sasebo employment areas, suggesting that their population decrease rate is low because these areas accumulate residents from the surrounding areas.

It has been pointed out that, in emerging residential areas, the age group of residents is fixed and the aging rate will be higher in the future than in the surrounding areas (Miyaki et al. 2018). We believe that distribution support for second-hand houses and the rehabilitation of vacant houses are important for the sustainable development of such areas.

#### 4.2. Agricultural areas

Regions in which the resident characteristics are classified as typical farmers (Cluster 6) are often found on isolated islands and in peninsular areas (Fig. 5). In addition, most of these areas are located outside the Nagasaki and Sasebo employment areas, as shown in Fig. 7. The Japanese agriculture, forestry, and fishery industries are family-managed industries, and it is difficult to attract occupants from other areas. Fig. 9 shows the composition ratio of Cluster 6 and the population change rate in each municipality. Lower composition ratios of Cluster 6 tend to be correlated with higher observed population growth rates. Measures to maintain the populations in these areas could include improvements in the accessibility to urban employment areas via improvements to the transportation infrastructure.

#### 4.3. Manufacturing areas

Regions in which the resident characteristics are classified as manufacturing workers (Cluster 5) are found around the industrial aggregation areas in each municipality (Fig. 5). For example, shipbuilding industry integrated areas in Nagasaki, Sasebo, and Saikai are classified as Cluster 5. In addition, many areas in the town of Hasami are classified as Cluster 5 due to the ceramics industry factories located there. Fig. 10 shows the composition ratio of Cluster 5 and the population change rate in each local governmental area. There is no clear correlation between the population change rate and the composition ratio of Cluster 5.

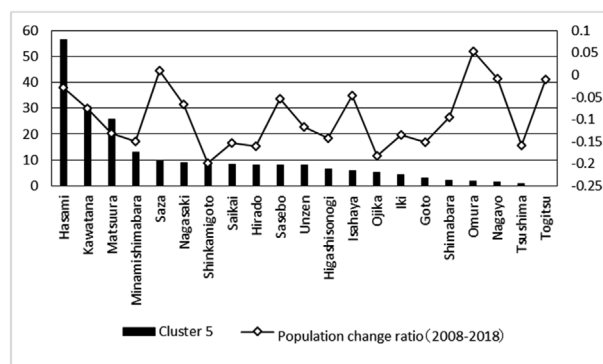


Fig. 10. The ratio of Cluster 5 in each municipality and the population change ratio.

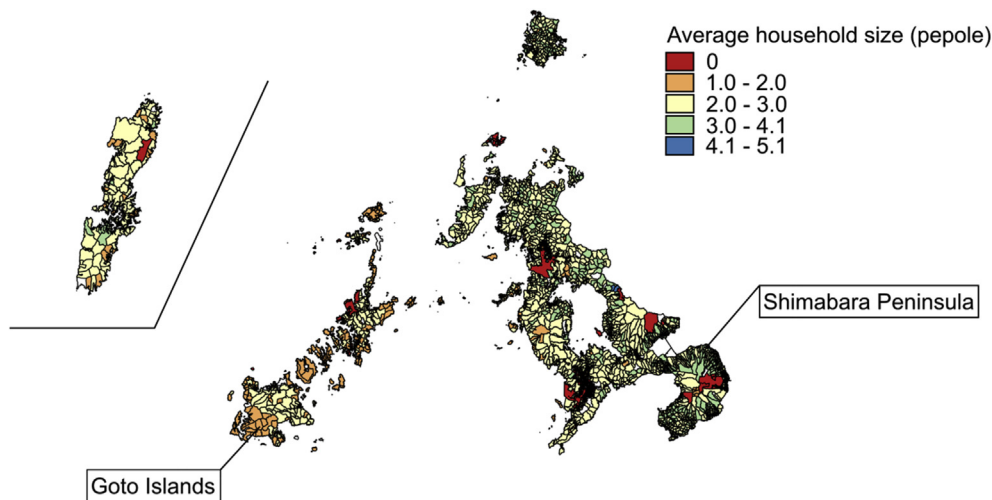


Fig. 11. Distribution of the average household size in the Nagasaki Prefecture in 2015. Source: Statistics Bureau, Ministry of Internal Affairs and Communications in Japan (2015).

#### 4.4. Household size and resident characteristics

Household size is an important factor that describes resident characteristics. Fig. 11 shows the distribution of the average household size in the Nagasaki Prefecture in 2015. Table 6 shows descriptive statistics of the average household size according to the resident characteristics classified in this study. Even though there is a tendency for the Cluster 2 areas (nuclear families with children living in rental housing) to be distributed outside the DID (Fig. 6), the average household size in these areas is 2.0–3.0 people (Fig. 11). The average household size for Cluster 2 is 2.23, which is the lowest except for the non-resident area, Cluster 3. The characteristics of the Cluster 2 area are that there are many residents with nuclear family households and rental housings; however, it is thought that the household size of a nuclear family, being small, reduces the average household size.

On the other hand, on the Shimabara Peninsula, where there are many Cluster 6 areas (typical farmers), areas with an average household size of 3.0–4.1 people are common. The average household size for Cluster 6 is the highest at 2.60, which is consistent with the habitation characteristics of a family-run farm. However, in the Goto Islands, the average household size of the area classified as Cluster 6 is 1.0–2.0, suggesting the existence of elderly households living alone.

#### 4.5. Distribution of population density and resident characteristics

The analysis so far suggests that the population growth factor in municipalities in the Nagasaki Prefecture is increasing in new residential areas for nuclear families around the central city. The process of urban development has been described via modeling using urban population density functions. Clark (1951) proposed a negative exponential model based on the rule of thumb that the population density decreases with distance from a city center. The scope of application of this model is the suburbs excluding the city center. Subsequently, Newling (1969) developed a new model and proposed an exponential model considering the change in the population density in the urban center, which added a negative quadratic term. Fig. 12 shows the process of urban development according to the Newling model. It shows decreasing population density in the city center with the development of the city, and the population density in the suburbs increases. Here Fig. 13 shows the time-series changes in the distribution of households from 1995 to 2015 in the Nagasaki Prefecture. One mesh represents approximately 0.25 km<sup>2</sup>, and only meshes that contain 500 households or more are displayed in Fig. 13. The distribution of households expanded outwards from 1995 to 2015. This trend conforms to the Newling model. The household distribution expansion areas from 1995 to 2015 and the Cluster 2 areas in this study roughly coincide, suggesting that the increase in emerging housing areas is a factor in the expansion of the population distribution.

Table 6  
Descriptive statistics of the average household size by resident characteristic cluster.

	Cluster 1	Cluster 2	Cluster 3	Cluster 4	Cluster 5	Cluster 6
Average	2.26	2.23	0.00	2.59	2.44	2.60
Median	2.27	2.22	0.00	2.59	2.40	2.61
Mode	2.00	2.00	0.00	3.00	2.00	3.00
Variance	0.12	0.17	0.00	0.21	0.20	0.35
Minimum	1.00	0.00	0.00	1.37	1.42	1.10
Maximum	3.82	3.50	0.00	4.40	3.86	5.08

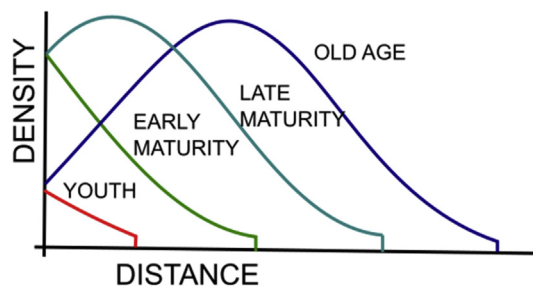


Fig. 12. Pattern of population density change.

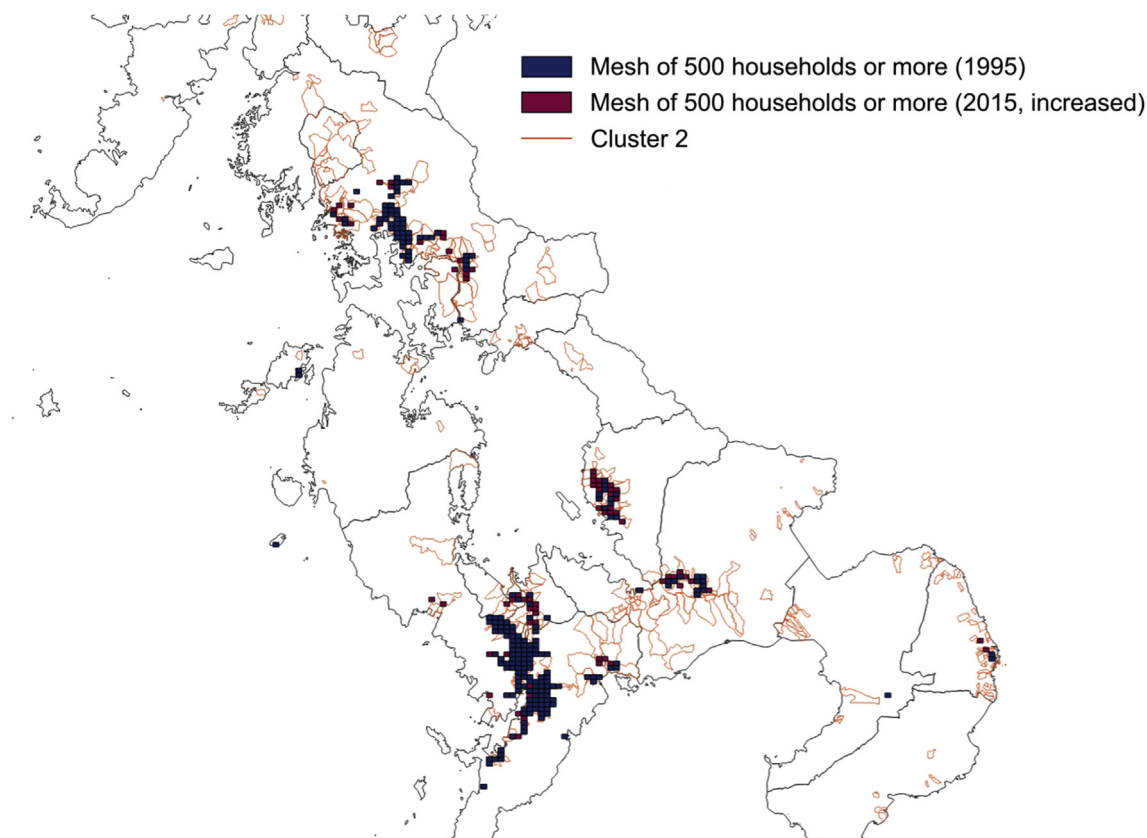


Fig. 13. Time-series changes in the household distribution from 1995 to 2015.

The Clark model and the Newling model assume that the population is concentrically distributed from the city center. However, most cities have directionality in their distributions. From the point of view of a directional model, [Steen \(1986\)](#) devised a model that takes into account the effects of elliptical cities. In addition, [Kingsley and Milton \(1973\)](#) formulated a model that considers the effects of railway networks. In particular, there have been empirical analyses in Japanese cities taking into account surface trend analyses of the population density in Hiroshima ([Morikawa, 1976](#)) and applying the expanded Clark model with directionality to the population density distribution in three metropolitan areas ([Yamagami, 2001](#)). These studies analyzed the population density distribution based on distance and direction and did not consider influence factors that cause the population distribution to be biased. As revealed in this study, resident characteristics affect the population distribution bias. In future studies, the urban structure could be captured dynamically by constructing a population density function that takes into account the time-series change in the resident characteristic distribution.

Source: Statistics Bureau, Ministry of Internal Affairs and Communications in Japan 1995, 2015.

## 5. Conclusions

Population decline is a serious problem in today's Japan, especially in regional areas. In this study, we analyzed how the

distribution of resident characteristics in each municipality that composes the Nagasaki Prefecture affects population change. As a result, we found that Cluster 2 (nuclear families with children living in rental housing) has the greatest influence on the population growth rate. It is suggested that areas classified as Cluster 2 are often distributed outside DID and that emerging residential areas for nuclear family households with children are formed in the suburbs of cities. Municipalities with a high proportion of Cluster 2 form commuting towns in the Nagasaki and Sasebo employment metropolitan areas, suggesting that the population reduction rate is low in these regions due to the accumulation of residents from the surrounding areas.

## Declaration of interest

None.

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