

Application of GIS for the Visualization of Urban Demography in Kitakawachi Region, Japan.

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Abstract: This study investigates the spatial patterns of distributed population in terms of population density, age structure, sex structure and family structure in Chou (smallest political city boundaries) of seven cities of Kitakawachi region. This displays the population dynamics of those cities from 1955 to 1995. It demonstrates how the populations of the cities are distributed with topography and with respect to the train stations. The demographic characteristics of the cities are visualized utilizing Arc View GIS capabilities with new visualizing technique in 3D environment based on data from Pasco Digital Map 2000.

Keywords: Arc View 3D GIS, Visualization, Urban Demography, Kitakawachi region.

software with extension 3D Analyst for displaying the demographic characteristics with different perspectives and extruding the feature themes in 3D scenes [1], which has visualized urban demography of the region more clearly and understandably.

This paper thus investigates the demographic characteristics of distributed population in the region and exhibits how the GIS can help for demographic analysis and visualization in an impressive and effective way. It allows for easy understanding of spatial population distribution patterns and its characteristics in different cities of the region, which in turns will become reliable bases for city planning to the planners.

1. Introduction

Reliable demographic study of the cities is vital for the land use planning and the provision of facilities & physical infrastructures to the people. The importance of demographic studies is obvious in the cities of Japan, where more than 3/4th of the population has been already living in urban areas. Hence, the study is carried out for analyzing and visualizing the demographic situation of seven cities of Kitakawachi region that is close to the Osaka city — the economic center of western Japan. Kitakawachi area is small but “a trend towards few children” and “a trend towards aging society” is different and classified accordingly the seven cities into three groups as: 1. Hirakata city and Daito city 2. Moriguchi city, Neyagawa city and Kadoma city 3. Shijonawate city and Katano city [3]. Unlike the population trend study of the cities in time series, this paper tries to analyze and visualize how the population structure distributed in the seven cities of region and tries to find out possibility of grouping of the cities.

Conventional 2D GIS maps support a range of application but are incapable of giving the intuitively comprehensive 3D representation [5]. The development of techniques to analysis and model demographics as 3D will offer analysts the chance to see as the same time various demographics relationship influences, impacts in relation to their magnitude and location [4]. This study has therefore utilized the Arc View 3.2

2. Objectives

This paper has two major objectives:

1. To investigate the spatial demographic characteristics of distributed population in the cities of Kitakawachi region.
2. To visualize the urban demographic characteristics of the region with new visualization technique using Arc View 3D Analyst.

3. Methodology

The methodologies adopted for this study consists two parts as described below:

1) Investigation of spatial population distribution

It makes a case study of Kitakawachi region based on data and information available in the book [2], Internet, Pasco Ortho Photo and Pasco Digital Map 2000 consisting 1995 Census data. The available data and information is used and analyzed utilizing the Capabilities of Arc View 3.2 software with 3D Analyst extension. The results are displayed in the form of maps, tables and charts using GIS & Excel. Aerial photographs (Pasco Ortho Photo) are also used for verification of land uses and as a supporting means

where-ever necessary in the study.

2) Visualization of demographic characteristics

For visualization of demographic characteristics of the region, Arc View 3.2 software is used. The population distribution patterns in different contexts are visualized in 2D environment. The new technique of visualizing age structure of spatially distributed population in 3D environment is also presented in this paper using Arc View extension 3D Analyst.

4. Study Area

Japan is an East Asian island country with four major islands (Fig.1.) and about 70% of nation's entire surface area covered with forests. The area under study is located in the northeast part of Osaka prefecture of Japan (Fig.2.). It has the area of 177.37 km² and consists of seven cities (Fig.2 & Fig.3) namely: 1. Moriguchi city, 2. Hirakata city, 3. Neyagawa city, 4. Daito city, 5. Kadoma city, 6. Shijonawate city and 7. Katano city in the order of city designation by year. Moriguchi city, was the first city of the region, designated as 11th city in 1946 of the Osaka prefecture and Katano city was the last in recognizing as city of this region. In early days, the construction works of Yamato River at the beginning of 18th century had a great impetus for the cultivation in the farm villages of this area and economy of this region was developed. After World War II, with the beginning of rapid economic growth in Japan; the cities of this region had undergone a rapid rate of urbanization with the advantage being close to the big cities like Osaka city and Kyoto city. Fig.3 demonstrates the visualization of population dynamics of the region from 1955 to 1995 by extruded heights in all the cities of the region.

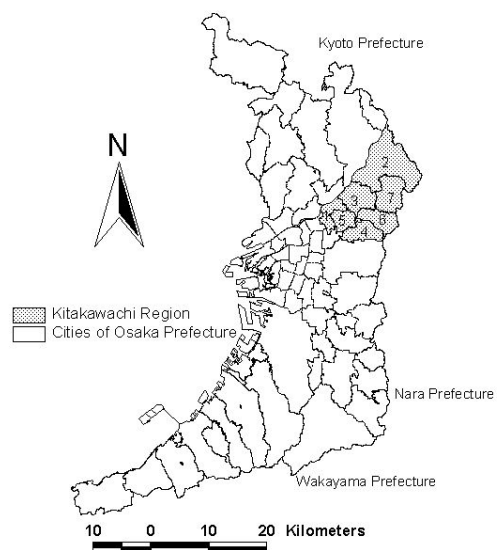


5. Del Fig.1. Japan and its main four islands.

Discussion

1) 3D visualization of age structure of seven cities

Fig.4. exhibits the age structure of the population distributed in seven cities of Kitakawachi in 3D environment by extruding the heights. Age structure of population consists of the ratios of the number of people in three age groups 1) 0-14 years 2) 15-64 years 3) 65 and more years, out of the total population. This has created a new way of visualizing the demographical characteristics with the capability of Arc View 3.2 with extension 3D Analyst. It is observed that there is more or less uniformity in age group composition of total population among the cities of Kitakawachi except slightly higher percentage of old age group in Moriguchi city, being oldest city of the region. The average percentage of 0-14 years, 15-64 years and 65& more years observed in the Kitakawachi are 15.62%, 74.70% and 9.68% respectively. This indicates that working age population is 5% higher and old age population is 5% lower in Kitakawachi in comparison to the national average. Age structure of the population in seven cities is further examined through two indices 1) Dependency ratio and 2) Ageing index. The average dependency ratio (indicator of child population and aging population with respect to working population) and ageing index (indicator for the aging population with a lesser number of children) observed in the Kitakawachi region is 33.87 and 61.99 respectively while national average is 43.90 and 91.22. This also indicates comparatively the more working population and less old age population with respect to population under 15 in Kitakawachi than national average and Japan. This structure of different age groups population has an important role for examining the demand of educational facilities, institutions, facilities for old age people and working centers.



2) Po1 Fig. 2. Kitakawachi in Osaka prefecture.

The population density (population/km²) of Chou in

whole Kitakawachi is visualized in Fig.5; distinguishing 3 categories: 1) < 6800 (average population density of Kitakawachi) 2) 6800-10000 3) >10000 (High population density). It is observed that 399, 191 and 528 Chou fall on the respective categories. This means nearly half of the Chou of Kitakawachi has densities more than 10000 population/km².

In Japan, the lands with more than 300m from sea levels are put in the category of mountain. To investigate population distribution by topography, the study is carried out with the help of contour lines distinguishing into three elevation levels. 1) 0-140m 2) 140m-300m and 3) >300m. It is observed that the land up to 140m from the sea level is more than 80% whereas land which is more than 300m is less than 2% of total area of the Kitakawachi. The elevation in Kitakawachi is observed increasing from west to east, as further illustrated by 140m and 300m contour lines in the Fig.5. The population density in the western part is found high while in the eastern part is low. A typical land use pattern in residential area consisting of private residential houses as well as high rise apartment buildings is as seen in Photo 1.

3) Sex structure and Family structure

For examining the sex structure of Kitakawachi the sex ratio i.e. the ratio of male and female population are calculated. The 1042 Chou of Kitakawachi, which contains data are analyzed for its population sex ratio. The Chou is categorized into three categories depending upon the values of sex ratio as visualized in the Fig. 6. The numbers of Chou belonging to the categories 1) <96 2) 96-104 3) >104 are respectively 450, 344 and 248 are observed, indicating imbalanced sex structure in majority of Chou. The average sex ratio of the region is observed as 98.11 while the value in Kadoma city (industrial city and highly urbanized city) is maximum with the value of 101.76 and minimum in Katano city (comparatively less urbanized city) with the value of 95.65.

The family structure is examined by two ways. 1) Average household size 2) Types of households categorized in 5 groups depending upon the number of family members in the households: i) One member family households ii) Two members family households iii) Three members family households iv) Four members family households v) Five or more members family households. Out of total number of households 103214, 99695, 89184, 98561 and 44633 respectively belonging to those categories are investigated as demonstrated in Fig. 11. The average household size calculated in the Kitakawachi as 2.76. The increasing popularity of small household size is becoming the reason for additional new housings demands. This has been causing the loss of remaining agricultural lands.

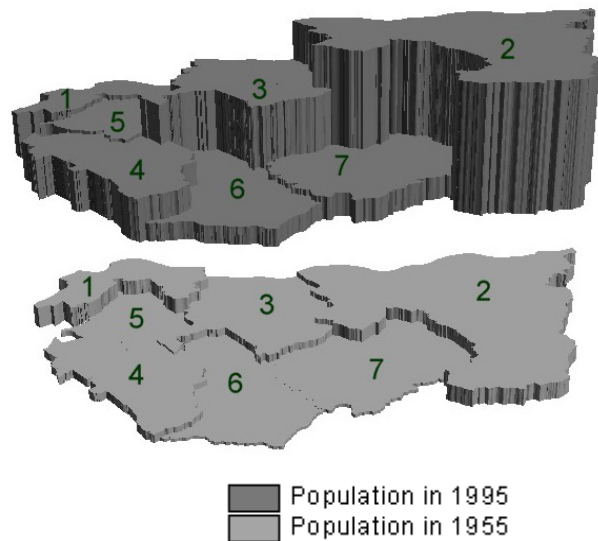


Fig. 3. Population dynamics of Kitakawachi region.

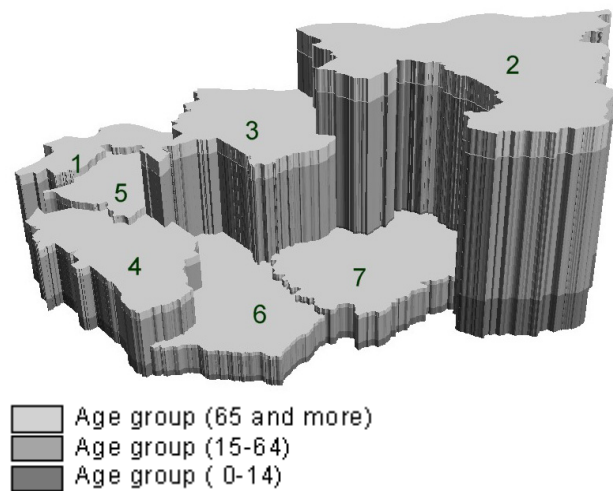


Fig. 4. Visualization of population by age groups.

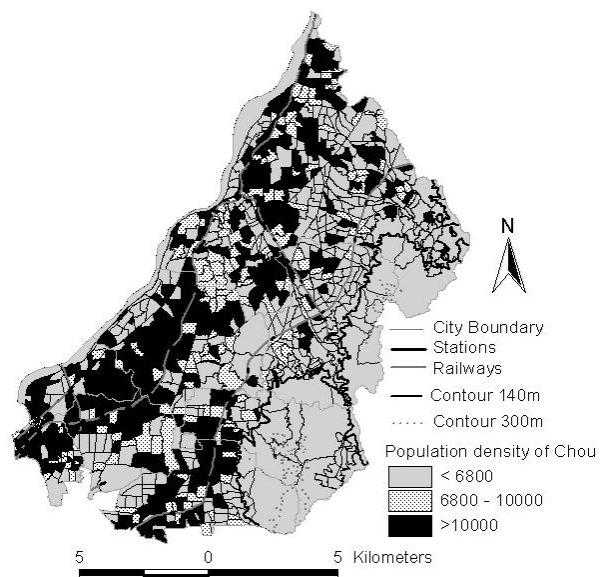


Fig. 5. Population density of Kitakawachi region.

A typical example of an approaching residential housing area near to the small remaining agriculture land is shown in Photo 2.

4) Chou near to the train stations

From the stand point of analyzing, how is the urban demography with respect to train stations? & are there any remarkable differences in demographical characteristics of population living near to the stations and far from the stations?; Chou up to 500m are considered as Chou near to the train stations and these Chou are further classified into four groups: 1) Chou (up to 125m) 2) Chou (125m-250m) 3) Chou (250m-375m) and 4) Chou (375m-500m). The classified Chou is visualized in Fig.7. As shown in the figure, there are total 472 Chou identified as near to the total 49 train stations in the region. 181, 101, 100 and 90 Chou are respectively belong to those four classes. Fig.8 illustrates the almost equal level of average population in Kitakawachi region and other groups of Chou near to the train stations but dissimilarity of average population density among them. It points out unequal distribution of population among the Chou and also shows the population density in the Chou near to the stations is higher than average value of the region. Comparatively higher population density noticed in Chou from stations (125m-250m) and Chou from stations (375m-500m).

Fig. 9 shows the comparative demographic characteristics of Japan, Kitakawachi and four classified Chou groups near to the train stations with respect to sex ratio, dependency ratio and aging index. Regarding the sex ratio, there is not any remarkable changes in values, although it seems slightly lower in the Chou from station (up to 125 m) as compare to other groups. The average values for dependency ratio in Kitakawachi and Chou near to the stations are also more or less equal. A notable observation is in the context of aging index in the Chou from the stations (up to 125m) and (125m-250m). The aging index values are observed remarkably high in those Chou, hinting out the larger proportion of the aged population group (65 years old and above) with respect to population under 15 at those Chou. Most of the old age people rarely drive their own vehicles likely to live near the station areas for their traveling conveniences.

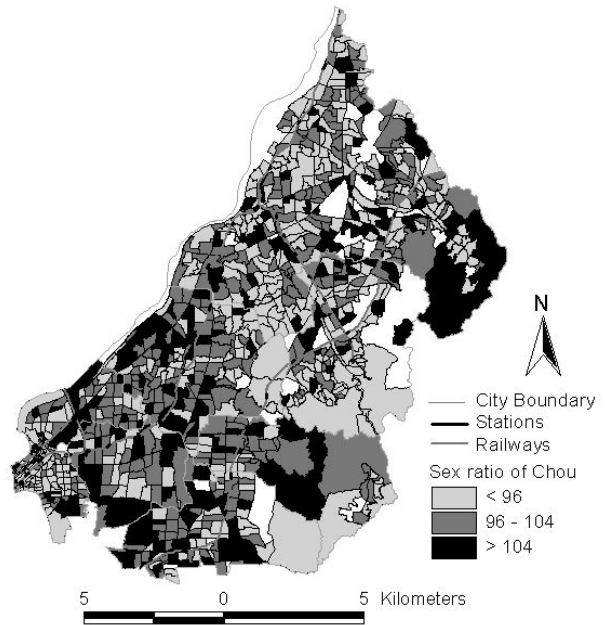


Fig. 6. Sex ratio in Chou of Kitakawachi region.

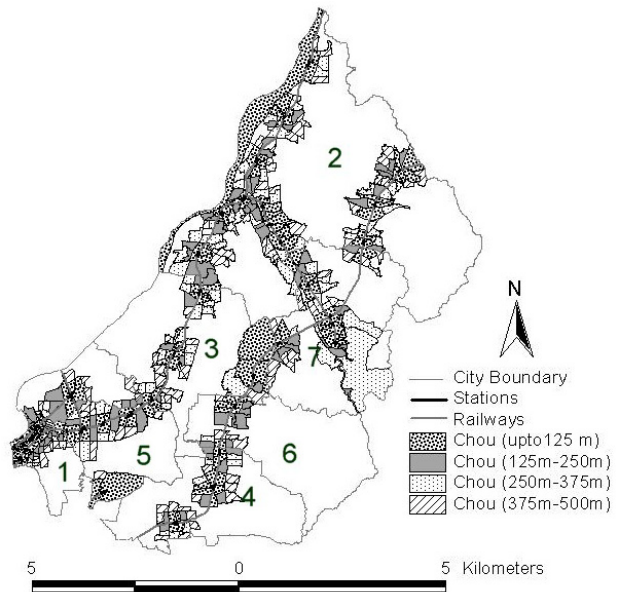


Fig. 7. Chou at various distances from train stations.



Photo 1. Aerial photograph of residential Area in Daito city.



Photo 2. Glimpse of private residential houses area in Daito city.



Photo 3. Apartment building near to a train station in Daito city.

The large aging index near to the stations has raised the further research curiosity so that old age people's households in Kitakawachi and those classified Chou near to the stations are analyzed, which are tabulated in the Table 1. It is observed that 9% of the total households and 18% of total single member family households belongs to the old age people. The more interesting investigation is that 75% of total old age people's single member family households belong to female. The percentage of single old age female households out of total single old age people households Chou wisely with three groups: i) 50% ii) 51%-75% iii) 76%-100% are analyzed. It is noticed that out of 944 Chou containing data, there are 108, 329 and 507 Chou belongings to each group respectively. This shows the majority of Chou possesses remarkably high share of female in single old age people households in Kitakawachi, which is demonstrated in GIS map as Fig.10.

The total composition of household sizes in Kitakawachi is presented in the Fig.11. It is noticed that in the Chou near to the stations (up to 125m) and (125m-250m) are found many single households, more by about 7% than the regional average value. Photo 3 shows the newly developed high rise apartment housing near to the train stations as an indicator of demands for housing units near to the stations.

The existing heterogeneous orders of the cities based on the various demographic characteristics are tabulated in the Table 2. The order starts from 1 to 7 representing the bigger to smaller values of the corresponding parameters. The order based on population density if grouped as i) the cities with orders 1 & 2 ii) the cities with orders 3, 4 & 5 and iii) the cities with orders 6 & 7; the grouping will be similar to the groups formed on the basis of population trends[3]. But the orders examined through other demographic indicators like sex ratio, dependency ratio and aging index of the distributed population (analyzed with 1995 census population data) within the cities of the region do not support the same order and groups.

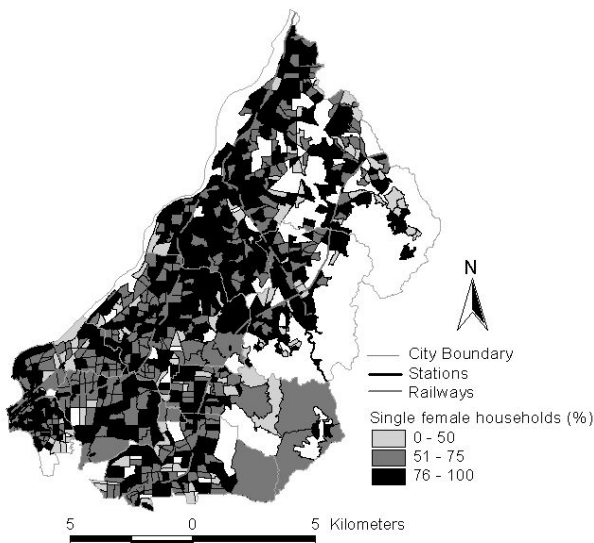


Fig.10. Single female households.

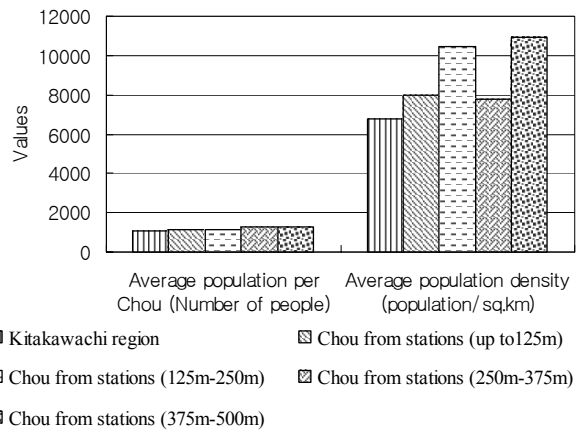


Fig. 8. Comparative population distribution.

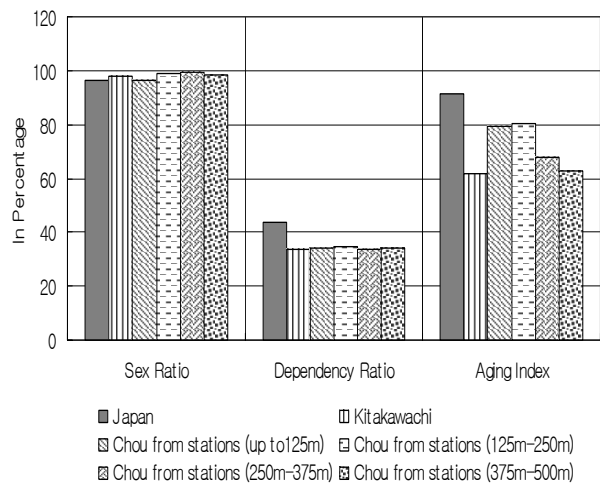


Fig. 9. Comparative demographic characteristics.

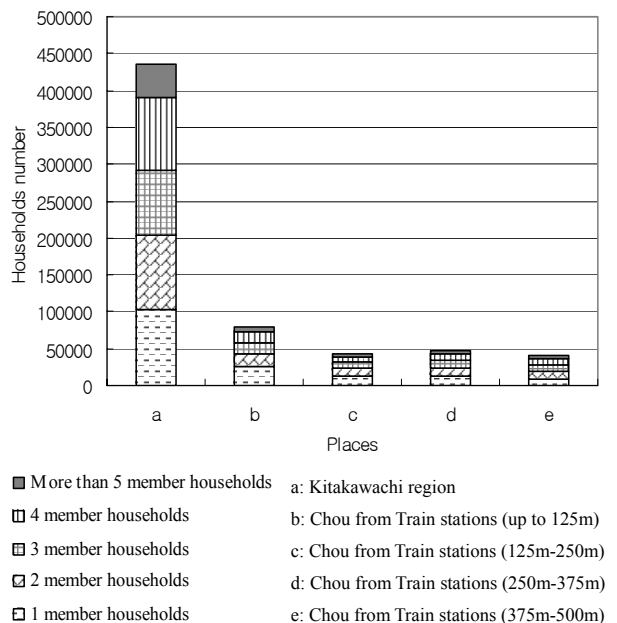


Fig.11. Household size and household number.

6. Conclusions

This paper has carried out the investigation of urban demography in Kitakawachi region and visualized in 2D and 3D environment using GIS. It has the following concluding remarks.

1. The demonstration presented in this paper for visualizing the population dynamics of the cities during the period of 40 years and age structure of those cities's population in the 3D environment has offered a chance for analysts to see both magnitude and location at the same time. This has created striking impact for easy understanding the situation in a more realistic way. Thus, it has opened up the new visualization technique using Arc View 3D Analyst in Demographic analysis.
2. The cities can be grouped into three categories in terms of population density as 1) Highly populated cities (>10000/km² e.g. Moriguchi city, Neyagawa city and Kadoma city) 2) Medium populated cities (>5000/km² <10000/km² e.g. Daito city and Hirakata city) 3) Low populated cities (<5000/km² Shijonawate and Katano city) similar as categorized in terms of population trends [3]. But the homogeneous demographic characteristics among the cities based on the analysis of sex structure, age structure and family structure observed exhibits demographic similarities among the seven cities of the region as a regional identity. In Japan, there is merging trend of two or more cities or two or more villages into a city to form a big city. The uniformity of demographical characteristics among the cities or villages as investigated in the cities of Kitakawachi region could be the pre-assessment criteria for the merging process, so that sustainable development and social equity in the merged city can be achieved under the similar types of planning and development approaches.
3. The study has investigated the imbalanced sex structure and population density among the Chou of the region. It has also demonstrated the change of population density with topography. The population density of Kitakawachi is found compara-

tively high with nearly half of the total Chou possessing more than 10000 population/ km². It is observed that old age population is comparatively lower and working age population is higher than average of Japan. The summation of single and two member households constitutes about half of total households number indicates the remarkable existence of fragmented households. This study finds that nearly one fifth of the total one member household belong to the old age people, among them 75% are female, revealing the notable fact of family-less situation for female at their old age.

4. The analysis result shows that the concentration of old age (>65 years) people and single family households are found comparatively at higher percentage in those Chou which are near to the train stations. Regarding sex ratio and dependency ratio, more or less homogenous values have been observed at the Chou irrespective to the distance from the train stations.

Acknowledgement

The authors would like to thank Japanese government Monbukagakusho (MEXT) for supporting with scholarships to conduct this research as a part of Ph. D. Research programme.

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Table1. Old age people households.

Old age people's Households Category	In total Chou of Kitakawachi	In Chou from stations (up to 125m)	In Chou from stations (125m-250 m)	In Chou from stations (250-375 m)	In Chou from stations (375 m-500m)
Male single	4369	1016	552	603	413
Female single	13781	3358	1845	1823	1266
Total single	18150	4374	2397	2426	1679
Couple	20813	4039	2234	2256	2039

Table2. Cities order in Kitakawachi.

City Designation	Area	Population	Population density	Sex Ratio	Dependency Ratio	Aging Index
Moriguchi city	6	3	1	5	1	1
Hirakata city	1	1	5	7	4	6
Neyagawa city	3	2	3	3	6	4
Daito city	5	5	4	1	3	3
Kadoma city	7	4	2	2	7	7
Shijonawate city	4	7	6	4	5	2
Katano city	2	6	7	6	2	5