The Changes in Population and Residential Distribution through Depopulation in Japanese Local Cities: A Case of Eastern Part of Tottori Prefecture

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Abstract: Japan is now facing with the long-term decline in population. Depopulation also brings with scattered housing in urban area which sometimes lowers quality of life of the area. These effects must appear more clearly in small towns/villages and their local society as a whole. Japanese government implements policies such as 'Settlement and Independence Area Plan' and 'Compact plus Network' in National Spatial Panning so as to secure a minimum variety of urban functions necessary for daily lives. Their basic idea is to maintain minimum population and its density of central areas, by inducing urban residents from surrounding area and by enhancing the transport network connecting with surrounding towns. This study clarifies the changes of urban population density and connectedness of surrounding towns by the transport network in last two decades. Tottori City and its surrounding areas are used as the case study.

Keywords: Population Distribution, Compact City, Road Travel Time, Population Census

1. INTRODUCTION

Recent depopulation in Japan casts a shadow on the quality of life in Japan especially in local rural areas (Sampaio *et al.*, 2013). It also threatened the existence of local urban areas that provide many urban life services to the local municipalities including surrounding rural areas (Muramatsu and Akiyama, 2011). The local urban area covers over 40 % of population, and therefore, securing the safe and comfortable life in these local urban areas is one of the national serious issues.

Many Japanese local urban areas especially their central areas, had evolved by increasing population and sprawling. If the urban areas that entered the new era of long-depopulation can take the reverse process of the urbanization, the decreased urban residents will relocate and concentrate in the central areas, and eventually compact and efficient urban formations will appear. Unfortunately, as research by Klaassen *et al.* (1981) shows by investigating 148 European urban areas in 1960 and 70s, no process of re-urbanization is found. In current

depopulating local urban areas in Japan, many aspects show that by depopulation and reverse-urbanization (concentration of population on suburbs) prevail, and new urban shapes with lower population density and wider residential area are appearing.

Of course, Japanese Government as well as Japanese local governments has regarded this issue as one of the most critical one for sustainability. Japanese Ministry of Internal Affairs and Communication has posed the national policy called 'Settlement and Independence Area Plan' that provides subsidy to local governments that try to form the wider settlement and independence area with neighboring municipalities. The area is expected to be safe and comfortable living area by the cooperation and sharing among a central city with urban functions and surrounding rural municipalities with industry, agriculture, and fishery. In 2016, over one hundred areas have been applied and designated as the settlement and independence areas; our case-study city, Tottori City, along with the neighboring Shin-Onsen Town in Hyogo Prefecture, is one of them (registered in 2010).

Japanese Ministry of Land, Infrastructure, and Transport, also announced the 'Grand Design of National Land 2050' in 2014 (Land, Infrastructure and Transportation Ministry, 2014), and claimed the maintenance of local urban functions and life support by forming living base areas in rural regions. Moreover, the ministry had revised Act of Special Measures concerning Urban Reconstruction, and had established a new policy frame named Location Adequacy Plan that aims at inducing 'compact cities'. Their basic idea is to maintain minimum population and its density of central urban areas, by inducing urban residents from surrounding area and by enhancing connecting transport network with surrounding small local towns. The idea is named 'Compact plus Network'. The Location Adequacy Plan has been already prepared in some front-running municipalities; as of July 2017, 112 municipalities had already publicized their plans and another 13 municipalities are on progress of preparation. Tottori City, the central municipalities of our study area, is one of the 13. Tottori City had consolidated with the surrounding seven towns and two villages in 2004. The idea of consolidation and therefore wider new city to work functionally is 'Multipolar Compact City', and the city is now on process of preparing its urban master plan based on the enhancement of this original concept with the new Location Adequacy Plan.

This research chooses Tottori City and its surrounding area (the eastern area of Tottori Prefecture) in Japan as the case study area as a typical sample area of many depopulating Japanese local urban areas. The changes in distribution of population of the area in the two time-periods (namely, the final five-years of population increase from 2000 to 2005, and the following five-years of depopulation era from 2005 to 2010) are clarified. More specifically, this research analyses the tendencies in change of centralization/dispersion of residents' location towards the local and/or regional centers. By so doing, we can verify whether the actual change in relocation of residents has followed the national policy such as 'compact city with multiple network'.

2. POPULATION AND RESIDENTIAL DISTRIBUTION

The target area of this study is the eastern area of Tottori Prefecture in Japan. This study area, 'Eastern Tottori' for short in this paper hereafter, is located in western Japan facing Japan Sea to the north (Figure1). Eastern Tottori consisting of five municipalities including Tottori City with 190 thousands populations (as of December, 2016) is the typical Japanese local living-sphere that has Tottori City as its industrial, commercial and social center. Tottori Prefecture in Japan is conventionally divided into the three areas of eastern, central, and western areas. Generally speaking, this division is regarded as indicating three natural living-spheres of Tottori

Prefecture. For example, Tottori Prefectural Office has three Headquarters each of which looks after each of these three areas. Also, Large Area Administrative Unions that the cities and towns in Tottori Prefecture constitute with neighboring ones for effective administrative services have the three division. So, the eastern area of Tottori Prefecture that consists of one city and four towns is chosen as the study area. However, in order to define the study area precisely, we check the rate of residents of each local area in the prefecture commuting to Tottori City. More precisely, the rate of commuting to Tottori City over 25 percent means the member of the living-sphere of Tottori City, namely, the eastern area of Tottori Prefecture. As described in Table 1, there is a clear gap in terms of this rate of commuting between Chizu Town, which has the lowest rate among the eastern area, and Yurihama Town, which has the highest rate outside of the eastern area. The map of each town in the eastern area of Tottori Prefecture is shown in Figure 2. The area consists of Tottori City, Iwami Town, Yazu Town, Chizu Town, and Wakasa Town. This area is a typical local living sphere in Japan. In 2004, former Tottori City and neighboring eight towns were merged into the current city, and in 2005, three towns are absorbed into Yazu Town. As shown in Figure 2, we devide the study area into these former one city, 12 towns and two villages and study these 15 municipalities.
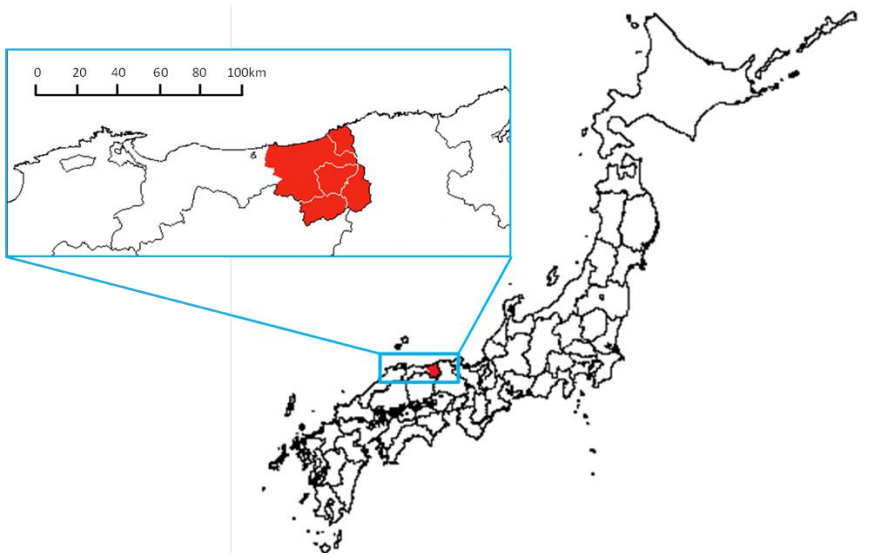

Figure 1. The eastern area of Tottori Prefecture in Japan

Table1. The rate of commuting to Tottori City (in 2010)

	The rate of commuting to Tottori City (%)
Tottori City	90.19
Yazu Town	47.01
Iwami Town	45.50
Wakasa Town	35.34
Chizu Town	29.98
Yurihama Town	6.60
Shinonsen Town	5.46
Misasa Town	2.57
Nishiawakura Village	1.21
Nagi Town	0.12
Mimasaka City	0.05

Figure 2. Study area

The major transportation infrastructures in the study area are depicted in Figure 3. There is National Route 9 running East to West along the coast of Japan Sea. Sanin Expressway, which is the bypass of Route 9, is still under construction and is partly available along Route 9. Sanin Line of Japan Railway (JR) also runs along Route 9. These road and train rail connect the area to neighboring prefectures (Hyogo Prefecture to the east and Shimane Prefecture to the west). For North-South direction of the area, Tottori Expressway, National Routes 52 and 29, JR Imbi Line, and Chizu Rail Company Line run and they connect the area to the two southern neighboring prefectures of Okayama and Hyogo. There is another private company train line of Wakasa train line from Central Tottori City towards the south east which ends inside of the area. Focusing on transportation network consolidation from 2000 to 2010, the section between Hawai Interchange (IC) and Aoya IC of Sanin Expressway (the blue line in Figure 3) had opened for traffic in 2002. Also, Tottori Expressway (the yellow line in Figure 3) that used to reach up to Chizu Town from the south had eventually reached Tottori City Center in 2010.


Figure 3. The major transportation infrastructures

Table 2 shows the populations of the study area as a whole as well as of each town and city in 2000, 2005, and 2010. The area had reached the peak of population between 2000 and 2005, and then has been keeping in depopulating. For each town, except for former Kokufu Town and former Ketaka Town of Tottori City, the population of the towns had decreased from 2005 to 2010. Especially, former Yazu Town has the quickest drop in population.

Table 2. Populations of Eastern Area of Tottori Prefecture in 2000, 2005, and 2010

Municipality/ Year			2000	2005	2010
Eastern	Tottori Prefecture		249,153	250,178	238,984
Tottori City			200,804	201,797	198,432
	former	Tottori City	150,316	153,649	151,886
	former	Kokufu Town	9,001	8,820	8,874
	former	Fukube Village	3,451	3,285	3,098
	former	Kawahara Town	8,218	7,875	7,442
	former	Mochigase Town	4,230	3,953	3,659
	former	Saji Village	2,835	2,549	2,290
	former	Ketaka Town	10,025	9,548	10,013
	former	Shikano Town	4,573	4,453	4,220
	former	Aoya Town	8,155	7,665	6,950
Iwami Town			13,723	13,114	12,157
Wakasa Town			4,998	4,176	3,770
Chizu Town			9,383	8,650	7,718
Yazu Town			20,245	22,441	16,907
	former	Koge Town	10,009	11,549	10,024
	former	Funaoka Town	4,664	5,446	2,290
	former	Hattou Town	5,572	5,446	4,593

3. APPEARANCE AND DISAPPEARANCE OF RESIDENTIAL AREA

This study analyzes the population distribution and the residential location of the study area by mapping Census data on residents in 2000, 2005, and 2010, on GIS as the half-size fourth-degree mesh (500m square) expression. Figures 4 and 5 depict the increase and decrease of residents between the time periods of 2000 and 2005, and 2005 and 2010, respectively. Figure 4 depicts that many meshes show increase in the number of residents. This happens more remarkably near the train lines. Figure 5, which is the change after the one of Figure 4, however, shows decrease in residential areas in many meshes except for former Tottori City area. In former Tottori City area, the areas close to Tottori Station (which is the central downtown area of the city) loses population, while the surrounding areas gains more population.
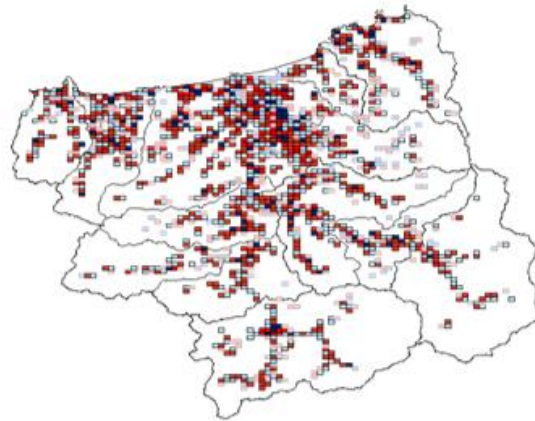
: ~-100 people   : -100~-10 people   : -1 person~-10 people

: 1 person~10 people   : 10 ~100 people   : 100~ people

Figure 4. Increase and decrease in population from 2000 to 2005
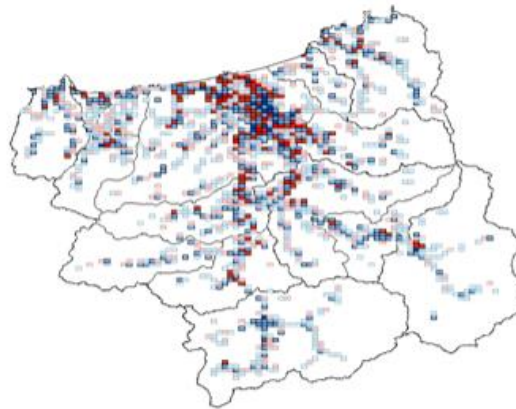
: ~-100 people   : -100~-10 people   : -1 person~-10 people

: 1 person~10 people   : 10 ~100 people   : 100~ people

Figure 5. Increase and decrease in population from 2005 to 2010

These two 5-year periods show different tendency in the change of size of residential areas. The meshes where someone starts residing are named 'appeared residential mesh' and depicted in red, while the ones where all residents disappear are named 'disappeared residential mesh' and depicted in black in Figures 6 and 7. Figure 6, which shows the change from years 2000 to 2005 indicates many 'appeared residential meshes' (627 red meshes in the figure) while limited number of 'disappeared residential meshes' (20 black mesh). Totally, 1510 net meshes had existed during this period. On the other hand, Figure 7 which shows the change from 2005 to 2010, has quite limited number of increase in 'appeared residential meshes' (35 red meshes) but more 'disappeared residential meshes' (38 black meshes). Totally, only three net meshes had disappeared. Recall that the population of the study area as a whole decreased from year 2005 and 2010. If this fact is considered along with the fact of Figure 7 that indicates almost no disappearance and appearance of residential areas in this time period, the residents of the eastern area of Tottori Prefecture faced with the decrease in population density.
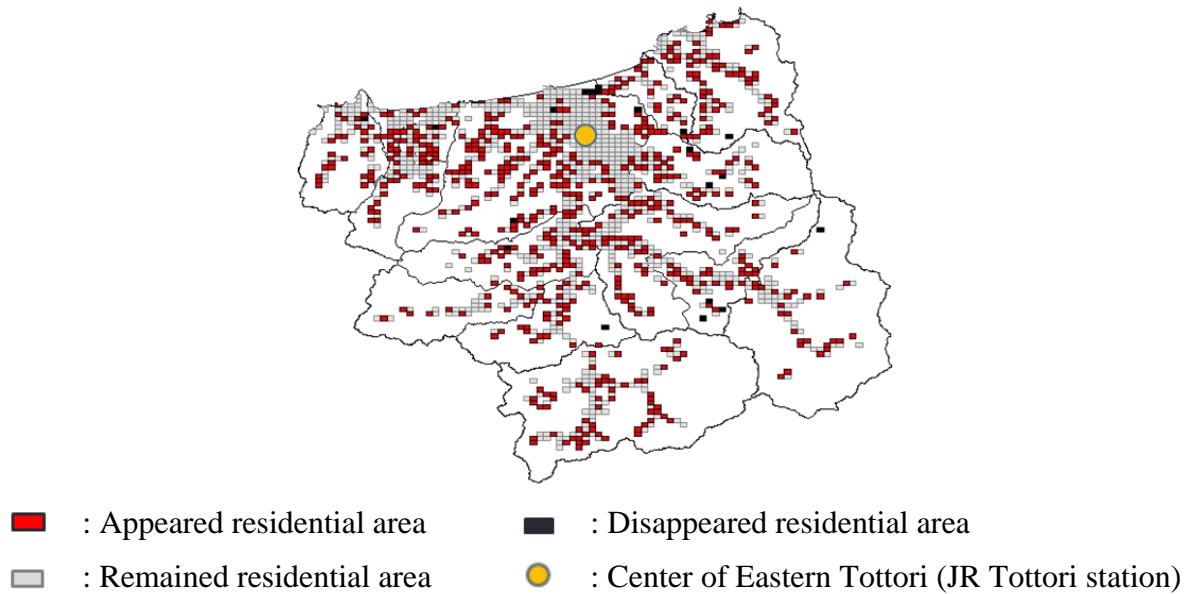
: Appeared residential area   : Disappeared residential area

: Remained residential area   : Center of Eastern Tottori (JR Tottori station)

Figure 6. Area of the residents occurred and disappeared from 2000 to 2005

: Appeared residential area   : Disappeared residential area

: Remained residential area   : Center of Eastern Tottori (JR Tottori station)
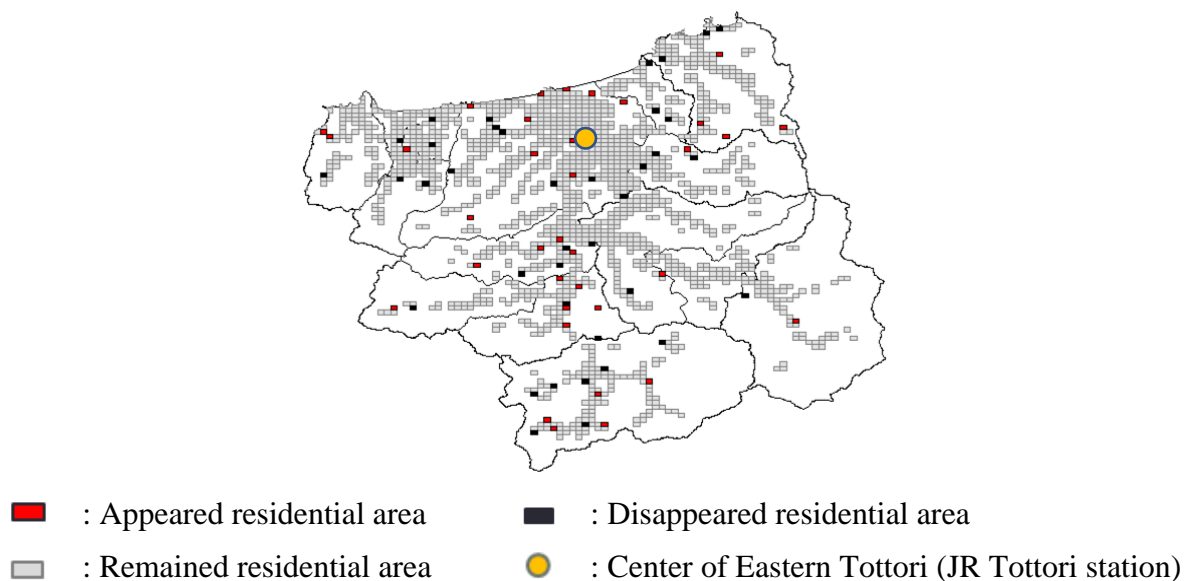
Figure 7. Area of the residents occurred and disappeared from 2005 to 2010

4. TRANSITION OF DISTRIBUTION OF POPULATION

4.1 Distribution of Population of Eastern Tottori

By depicting the whole distribution of population of Eastern Tottori for different years, its tendency is clarified. Tottori JR Station is regarded as the center (CBD) of the Eastern Tottori (we call it simply the 'ET center' hereafter).

We use ArcGIS and calculate road travel time as time from the population gravity centers of meshes to the ET center. Travelling mode is set to "driving". We call the road travel time time-distance hereafter. The relationships between the time-distance from the ET center and

population for three different points in time are depicted in Figure 8. Figure 9, on the other hand, depicts the relationships between the time-distance from the ET center and the number of 500m-square meshes where at least one or more residents exist for the three different points in time. In Figure 8, while there is little difference in the distribution from 2000 to 2005, there are some remarkable changes from 2005 to 2010 including the following two major changes. The residents living from five to fifteen minutes from the ET center had increased and the ones living far more than forty minutes had decreased. Additionally, Figure 9 shows that areas of residents had increased regardless of the distances from the ET center from 2000 to 2005. It also indicates that from 2005 to 2010 the areas of residents in ten to twenty minutes from the center had increased while the ones in over-forty minutes from the ET center had decreased remarkably. As explained in the former chapter, the main reason is that the residents and also residential areas of over-forty minutes from the ET center had decreased mainly because of the consolidation of transportations (roads) (see Figure 3).
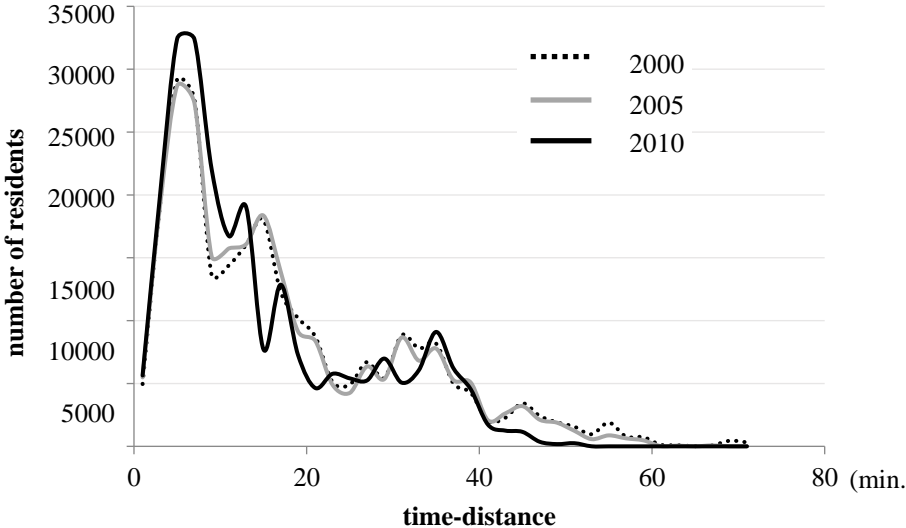

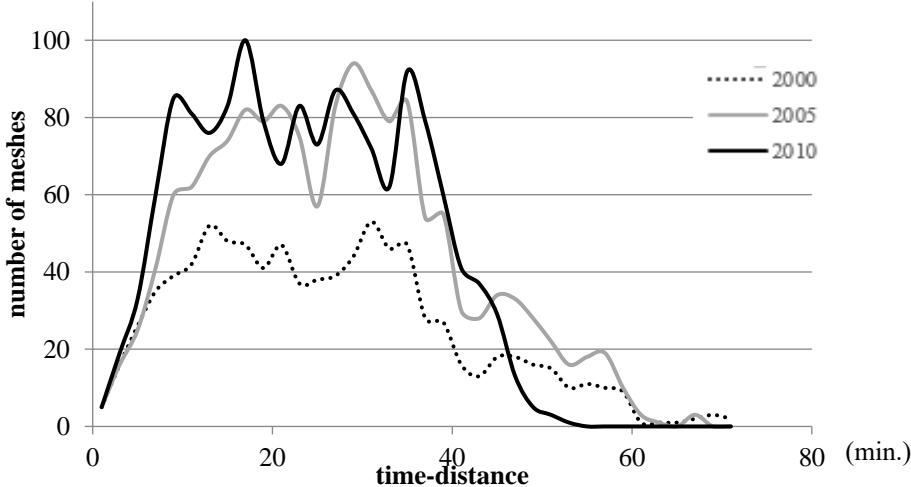Figure 8. The distribution of residents (time distance to the ET center)

Figure 9. The distribution of residential areas (time distance to the ET center)

4.2 Distribution of Population of Each Local Area: Toward the Center of Tottori City

In order to grasp the concentration/dispersion phenomena of each local area from the ET center, distributions of residents and residential areas from the ET center are clarified for three different timings of years 2000, 2005, and 2010. Figure 10 shows the four indices of the average, standard deviation, maximum and minimum on distributions of population for each of all fifteen local areas for years 2000, 2005, and 2010. The straps in the figure show the minimum and maximum time-distances to the ET center of the local areas, and the average is the point of changing color, and the error bars indicate the standard deviation. At the majority of the local areas, shortening of time-distance over the time can be recognized. Especially, the straps had been becoming shorter for the western areas of Eastern Tottori, namely, the former Aoya, former Ketaka, and former Shikano Towns. Considering that in these western areas of Eastern Tottori no remarkable rerouting, transport consolidation, or other improvement of accessibility to the ET center from 2000 to 2010 had implemented, there must be relocation of residents so as to become closer to the ET center. On the other hand, the eastern part of Eastern Tottori, including Iwami Town where the time-distance had become slightly shorter, the change in these time periods is limited. As a whole, the change in distribution of population towards the ET center, had generally different tendencies by areas especially from the east to the west. Also, Chizu, former Mochigase, and former Saji Village, that constitute the southern area enjoying the great effects of opening of the new Tottori Expressway, show shortening of the time-distance to the ET center. The high time-distance to the ET center of Wakasa Town is because of the lack road network data for some area of the town and therefore to be ignored for analysis.

Among fifteen local areas constituting Eastern Tottori, three typical local areas are especially picked up as examples. They are the former Aoya Town of Tottori City located at the west part of Eastern Tottori area, the former Saji Village of Tottori City located is the southern part, and Iwami Town located in the eastern part of Eastern Tottori.

The distributions of population of these three local areas of the former Aoya, former Saji and Iwami Towns, are depicted in Figures 11, 12, and 13, respectively. All three figures show that population distributions at all three local areas had become closer to the ET center from 2000 to 2010. This change is more remarkable for the southern local area of former Saji Village from 2005 to 2010 (Figure 12). This is because of the construction of Tottori Expressway opened in 2009-2010. The former Aoya Town has relatively small change comparing to the other two towns but also had experienced some population increase even from 2005 to 2010.
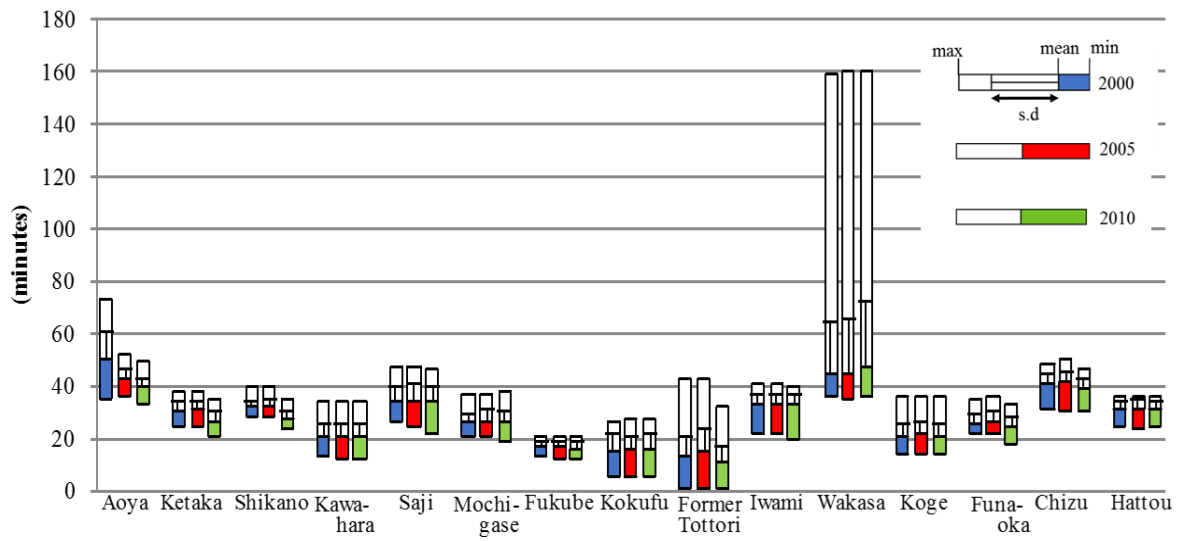
Figure 10. Time-distance of each local area to the ET center
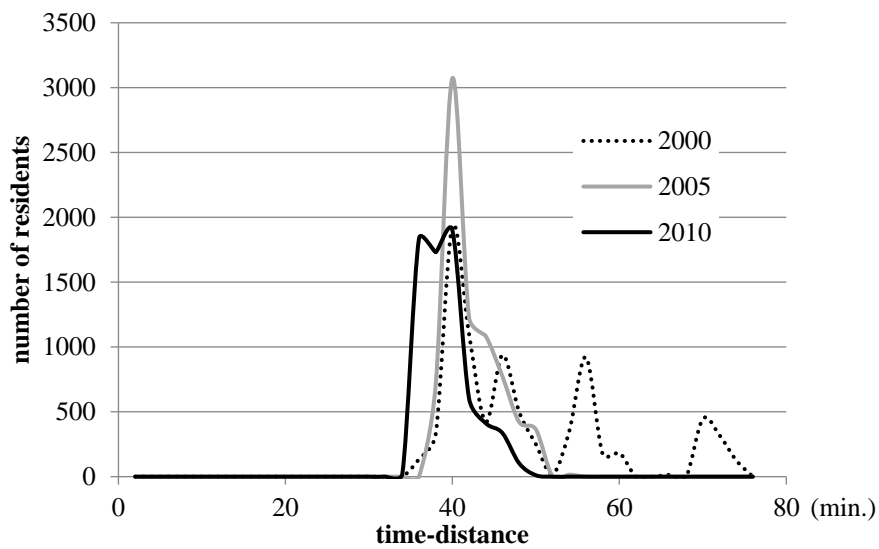(average, standard deviation, minimum, and maximum of time distances)

Figure 11.   Distribution of residents to the ET center:
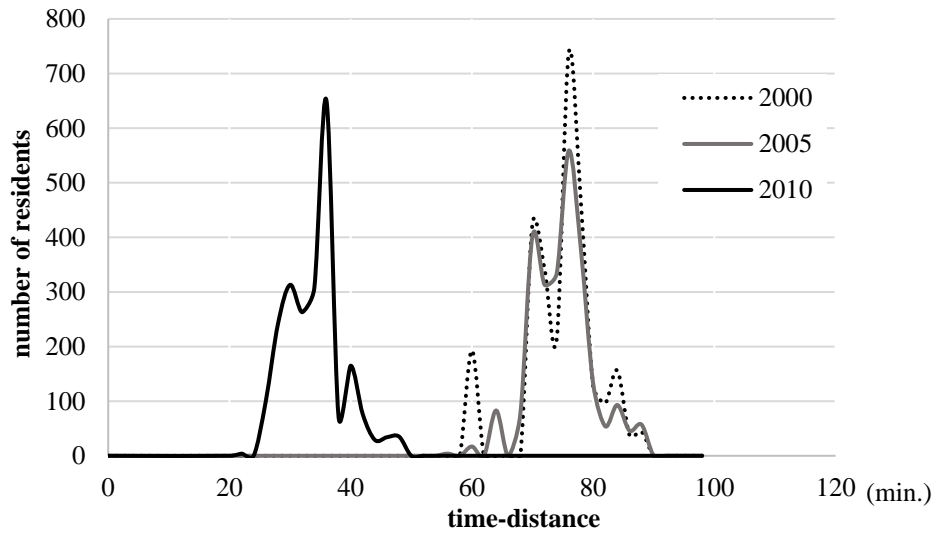former Aoya town (in the western part of Eastern Tottori)

Figure 12.　Distribution of residents to the ET center:
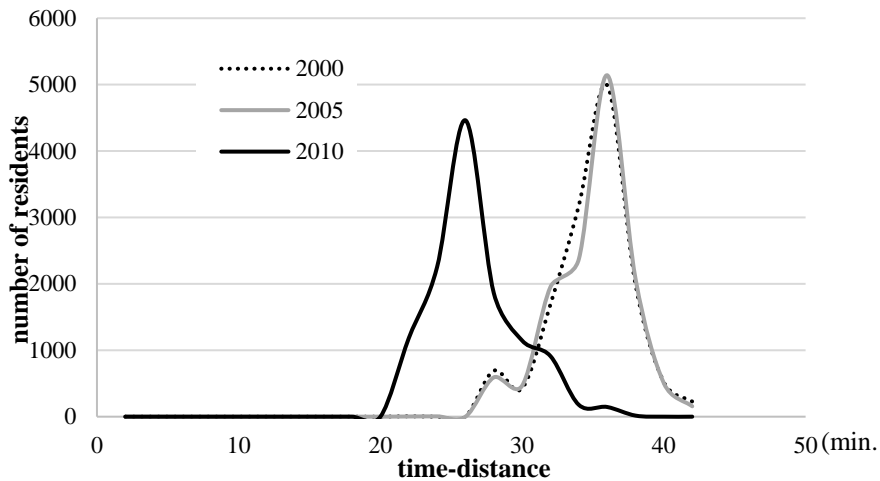former Saji village in the southern part of Eastern Tottori)

Figure 13.　Distribution of residents to the ET center:
Iwami town (in the eastern part of Eastern Tottori)

4.3 Distribution of Population of Each Local Area: Toward the Area Center

In the previous section, we look into the centralization/dispersion of local areas towards the ET center. In this section, we check the distribution of population of each local area as whether it is centralized or decentralized 'within' the local area, by calculating time-distance from each center of mesh to centers of the region.. Comparing to larger cities like Tottori City, local municipalities are difficult to designate their 'centers of the region'. In this research, the location of the (former) municipal office of each local area is assumed to be the center of the area, and is hereafter called the Municipal center or the M center. This setting is an approximation, but in most of the cases in Japan, city/town/municipal offices are located in the heart of activities of its governing areas. Here, among fifteen local areas, the four areas that had already mentioned in the previous section, are picked up to look at separately. Figures 14, 15, and 16 show the distributions of population of the former Aoya, former Saji, and Iwami Towns, respectively. These figures show that distributions of population have little change for the ten years, except

for the lowering the peaks of the distributions. In general, the distribution of population within the local area shows dispersion which appears as lowering of the distribution peak. Figures 11, 12 and 13 show substantial changes in the time-distance to ET center, while figures 14, 15 and 16 show slight changes to the M center. This is because of the improvement of Tottori Express way and the section between Hawai Interchange (IC) and Aoya IC of Sanin Expressway towards ET center.

Figure 17 shows the average, standard deviation, minimum, and maximum of the residents' location from the M center. The ways of showing these four indices in the figure are similar to the ones in Figure 10. The average time-distance to the M center increases for the local areas from years 2000 to 2010 except for the two areas of former Hattou and Wakasa Towns. The former Ketaka, former Saji, former Mochigase, Iwami, and Wakasa Towns have some changes in the maximum time-distance of the residents, while the other ten local areas have no or little changes in the maximum distance. These local areas where the average increases but the maximum has no or little changes can be interpreted as showing some sort of de-urbanization (dis-localization).
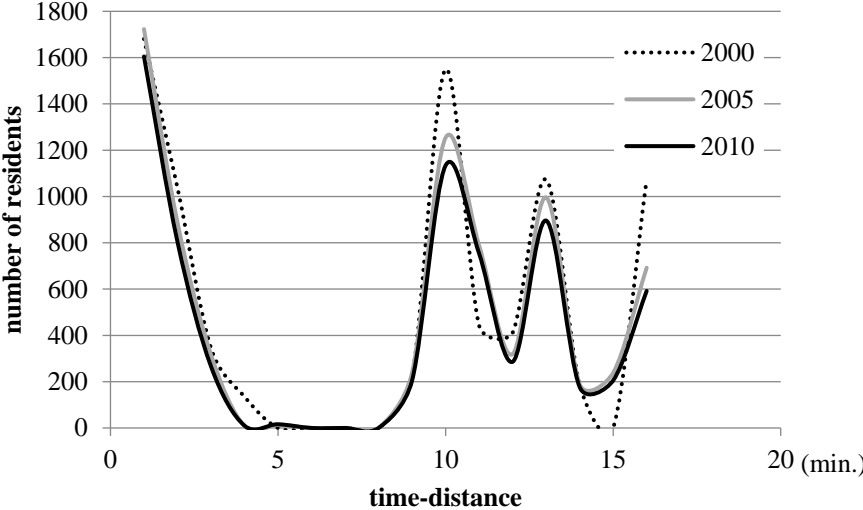

Figure 14. Distribution of residents to the M center:
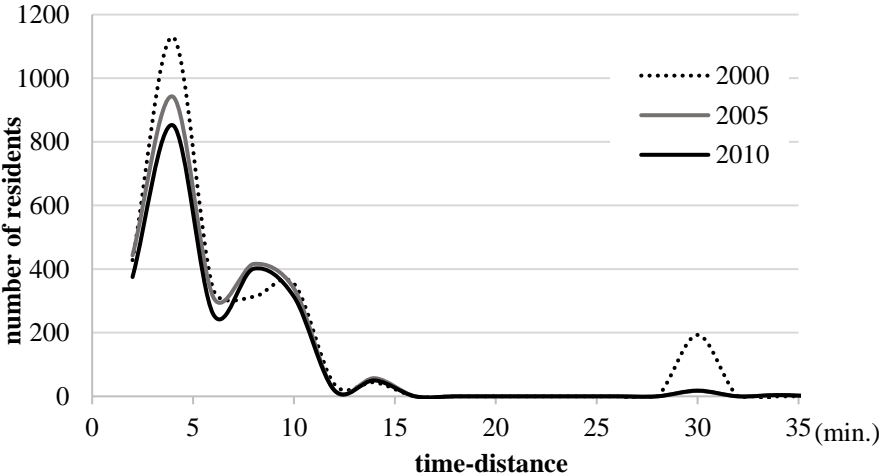former Aoya town (in the western part of Eastern Tottori)

Figure 15. Distribution of residents to the M center:
former Saji village (in the southern part of Eastern Tottori)
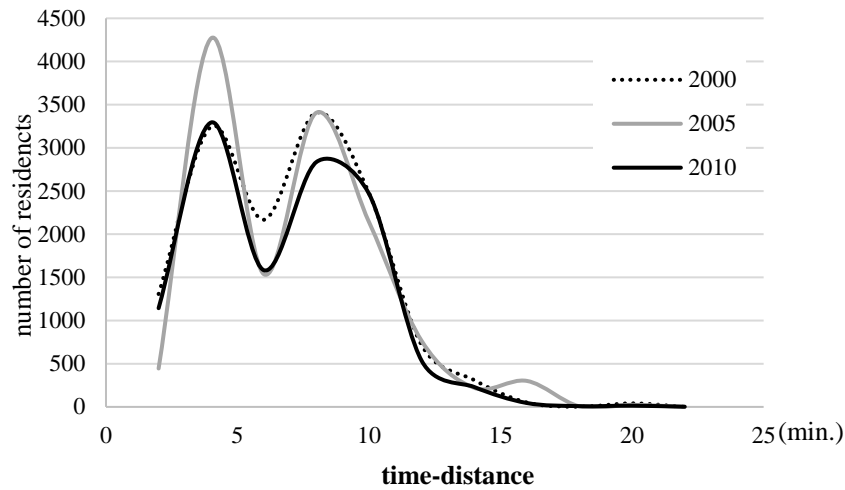
Figure 16. Distribution of residents to the M center:
Iwami town (in the eastern part of Eastern Tottori)
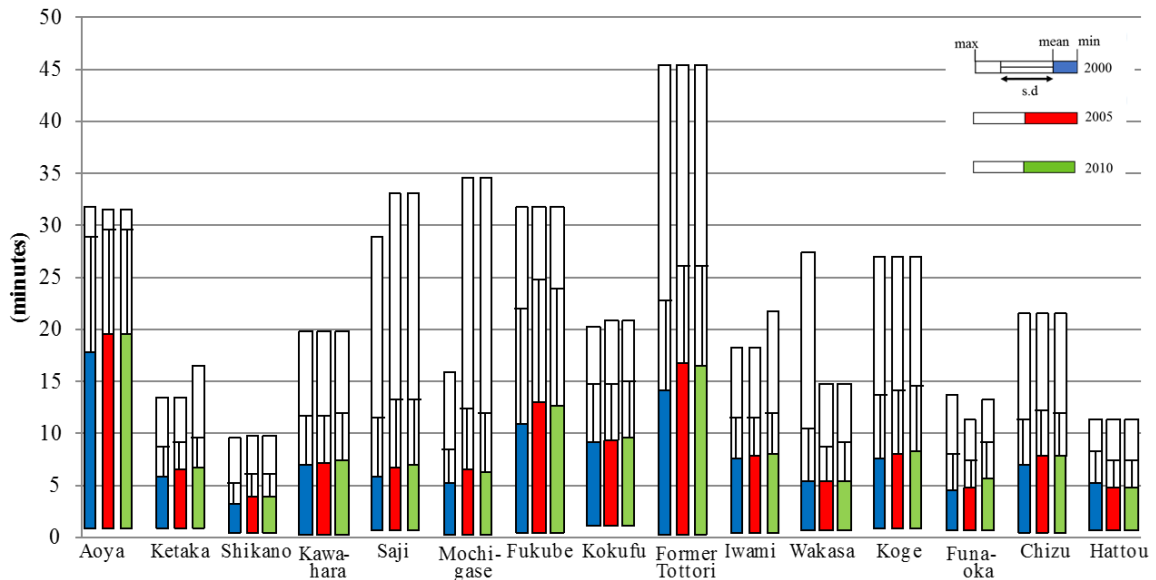
Figure 17. Time-distance of each Local area to the M center
(average, standard deviation, minimum, and maximum time-distance)

4.4 Concentration/Scattering of Each Local Area

The four indices of the average, standard deviation, skewness, and kurtosis of the distribution of population are calculated for time-distance from the ET center and the M center. The results are given in Tables 3 and 4, respectively. The skewness indicates the location of the centroid (and therefore if the value is positive and large, it skews toward the original point), while the kurtosis reflects the degree of concentration (and therefore if the value is large, it means concentration at some location).

From 2000 to 2005 that is the time period of the final phase of the increase in population, at the former Aoya Town, the time-distance towards the ET center had decreased but the one towards the M center had increased. The skewness and the kurtosis had decreased from 2000

to 2005. All these facts mean that at the former Aoya Town in the period from 2000 to 2005, the centroid of population had left from the ET center and the residents had dispersed in the area. On the other hand, the time-distance to the M center at the same time period shows that the average had increased, the skewness is negative and its absolute value had increased, the kurtosis is negative and the absolute value had decreased. These indicate that in Aoya the residents far from the M center had increased relative to the area near the M center.

At the same area of the former Aoya Town, but at the next five-year period from 2005 to 2010 which is the time period of depopulation, the indices toward the ET center show that the average had decreased, the skewness is positive and its absolute value had increased, and the kurtosis is negative and the absolute value had decreased. All of these changes mean that residents had more skewed toward the ET center. About the time-distance to the M center in this time period of depopulation at Aoya, the average had increased, and therefore the residents had relatively increased far from the M center. As a result, at the former Aoya Town for the ten years from 2000 to 2010, the centralization toward the ET center overwhelmed the one toward the M center.

If the other local areas are considered in the similar manner, in the first five-year-period from 2000 to 2005, the time-distance to the both centers show the decrease in skewness and kurtosis. Simultaneously, in many municipalities, the standard deviation of time-distance towards the M center had increased. These results show that in the final phase of population-increasing period (from 2000 to 2005), the lowering residential density and dispersion for both toward the ET center and the M center.

On the other hand, in the depopulation-starting period (from 2005 to 2010), the time-distance distribution varies depending on the location of the municipalities in Eastern Tottori. Let's look at the municipalities along Route 9 which runs east to west. The former Aoya and Ketaka Towns located west to the ET center have skewness on time-distance towards the ET center increased, while the former Fukube and Iwami Towns located east of the ET center have the skewness decreased. This difference indicates that in the western part of Eastern Tottori the population had agglomerated towards the ET center, while in the eastern part of Eastern Tottori it had done towards the M center. If we also consider the fact that in this time period the population had decreased in total, the findings above can be interpreted that in the western part depopulation had progresses near the local center, while in the eastern part the same had happened but around their marginal areas. Moreover, at the former Shikano Town, that is a neighbor of former Aoya and former Ketaka Towns, and the former Fukube Village and former Kokufue Towns, that are neighbors of Iwami Town, the skewness and kurtosis of both from the ET center and the M center had decrease in this period in time. Namely, in these areas the centroids had departed from the area center as well as from the center of the Eastern Tottori, and dispersion of the local residential areas had progressed. In these local areas, no major transport constraction or refinement of the roads had implemented, and therefore, if this tendency of change in residential distribution continues, there may be a risk of emerging 'desert' areas where reaching to life-related services is very difficult for the residents (In the former Fukube and Iwami Towns, however, the express road has been constructed after 2014). The similar tendencies of the former Shikano and former Kokufu Towns can be found for Wakasa and former Saji Towns, which are relatively apart from the ET center. Especially, for former Saji Village, completion of Tottori Expressway had made its skewness on time-distance to the ET center increased, and therefore the centroid of the population had approached to the ET center, but its standard deviation of time-distance to the M center has tendency to increase its value similar to the cases of Shikano and Kokufu Towns, meaning lowering of population density.

The increased skewness of time-distances to both the ET center and the M center in Chizu

and the former Kokufu Towns is the indication of improved access to the ET enter by the newly opened Tottori Expressway and also of processing concentration to the M center.

Table 3. The four indices of the average, standard deviation, skewness, and kurtosis of the distribution of population to the ET center

		average	standard deviation	skewness	kurtosis
former Aoya Town	2000	50.17	10.75	0.71	-0.54
	2005	42.71	3.76	0.33	-0.74
	2010	39.50	3.70	0.48	-0.42
former Ketaka Town	2000	30.65	3.42	0.08	-1.00
	2005	31.00	3.42	0.02	-1.15
	2010	26.94	3.26	0.09	-0.79
former Shikano Town	2000	32.05	2.43	1.41	2.52
	2005	32.54	2.83	1.06	0.53
	2010	27.58	2.85	1.04	0.48
former Kawahara Town	2000	20.46	5.20	0.94	0.28
	2005	20.62	5.24	0.71	-0.26
	2010	20.58	5.33	0.74	-0.28
former Saji Village	2000	34.66	5.50	0.52	0.03
	2005	34.56	5.95	0.41	-0.59
	2010	34.13	6.22	0.35	-0.40
former Fukube Village	2000	26.18	3.60	1.24	2.48
	2005	26.91	4.19	1.05	0.61
	2010	26.31	4.41	0.94	0.73
former Mochigase Town	2000	16.71	2.09	0.25	-0.54
	2005	16.89	2.24	0.00	-0.76
	2010	16.30	2.25	-0.15	-0.68
former Kokufu Town	2000	15.36	6.03	0.36	-1.12
	2005	15.68	5.65	0.39	-0.91
	2010	15.80	5.71	0.34	-0.98
former Tottori city	2000	13.41	7.90	1.24	1.88
	2005	15.45	8.59	0.89	0.47
	2010	11.74	5.34	0.63	0.21
Iwami Town	2000	33.29	3.61	-0.51	0.42
	2005	33.11	3.85	-0.49	-0.03
	2010	32.86	3.89	-0.57	0.32
Wakasa Town	2000	44.64	19.86	5.64	33.22
	2005	45.21	20.64	5.31	28.26
	2010	47.51	25.41	4.21	16.8
former Koge Town	2000	20.87	4.77	1.43	2.47
	2005	21.54	4.67	1.09	1.40
	2010	20.74	4.84	1.48	1.94
former Funaoka Town	2000	25.91	3.54	1.44	1.59
	2005	26.42	4.18	0.92	-0.22
	2010	24.74	4.04	0.41	-0.85
Chizu Town	2000	40.86	4.37	0.07	-0.80
	2005	41.53	4.28	-0.14	-0.64
	2010	38.73	4.20	-0.07	-0.86
former Hattou Town	H12	30.98	3.35	-0.31	-0.78
	H17	31.23	3.56	-0.37	-1.00
	H22	31.28	3.29	-0.30	-0.96

Table 4. The four indices of the average, standard deviation, skewness, and kurtosis of the distribution of population to the M center

		average	standard deviation	skewness	kurtosis
former Aoya Town	2000	17.81	11.01	-0.44	-1.32
	2005	19.55	9.96	-0.75	-0.73
	2010	19.63	9.91	-0.78	-0.70
former Ketaka Town	2000	5.95	2.70	0.38	0.01
	2005	6.39	2.63	0.04	-0.56
	2010	6.74	2.79	0.24	0.37
former Shikano Town	2000	3.14	2.06	1.25	1.99
	2005	3.78	2.23	0.94	0.59
	2010	3.79	2.25	0.93	0.54
former Kawahara Town	2000	22.03	4.62	1.10	-0.65
	2005	21.55	4.47	1.15	-0.50
	2010	21.62	4.55	1.15	-0.50
former Saji Village	2000	5.76	5.67	2.85	10.57
	2005	6.82	6.31	2.78	9.39
	2010	6.90	6.37	2.69	8.84
former Fukube Village	2000	10.87	3.32	0.99	-0.74
	2005	13.06	5.88	0.57	-1.51
	2010	12.48	5.58	0.46	-1.37
former Mochigase Town	2000	21.77	11.09	2.09	2.57
	2005	33.80	11.65	1.17	-0.64
	2010	33.66	11.45	1.17	-0.64
former Kokufu Town	2000	9.08	5.70	0.47	-1.12
	2005	9.31	5.38	0.51	-0.90
	2010	9.44	5.45	0.46	-0.99
former Tottori city	2000	14.1	8.67	1.27	1.75
	2005	16.62	9.51	0.82	0.21
	2010	16.52	9.45	0.85	0.28
Iwami Town	2000	7.56	3.88	0.63	0.37
	2005	7.72	3.78	0.66	0.34
	2010	7.95	4.06	0.77	0.61
Wakasa Town	2000	5.47	5.04	2.48	8.53
	2005	5.31	3.42	0.90	0.16
	2010	5.50	3.65	0.82	-0.25
former Koge Town	2000	7.55	6.19	1.53	2.00
	2005	8.11	5.98	1.42	1.53
	2010	8.34	6.31	1.29	0.98
former Funaoka Town	2000	4.44	3.48	1.26	0.97
	2005	4.82	2.60	0.39	-0.60
	2010	6.90	6.37	2.69	8.84
Chizu Town	2000	33.37	4.31	1.78	1.87
	2005	37.54	4.27	1.61	1.19
	2010	35.42	4.26	1.66	1.39
former Hattou Town	2000	5.22	3.05	0.07	-0.95
	2005	4.82	2.60	0.39	-0.60
	2010	42.66	2.56	0.40	-0.45

4.5 Characterization and Categorization of Local Areas

The fifteen local areas constituting the Eastern Tottori are categorized into groups according to the characteristics on change of population distribution clarified in the previous section. Namely, the four indices on population distribution of average, standard deviation, skewness, and kurtosis, of each local area towards the own town center (M center) and also towards the center of Tottori (ET center) given in Tables 5 and 6 are utilized as the characteristics of the areas by looking at their time change rates. These data allow us to consider the process toward compact

city towards the area center and the centers of Tottori. The rate in change is calculated by (1) and (2).

$$(\text{the rate in change } \text{I}) = \frac{n_{2010} - n_{2005}}{n_{2005}} \quad \cdots\cdots\cdots\cdots\cdots\cdots(1)$$

$$(\text{the rate in change } \text{II}) = \frac{n_{2015} - n_{2010}}{n_{2010}} \quad \cdots\cdots\cdots\cdots\cdots\cdots(2)$$

'Downsizing (towards compact city)' in this analysis means residents live closer in terms of time-distance by improvement of transportation infrastructure and/or relocation of residents. The decreases in average time distance and its standard deviation toward the center of Tottori (or the own town center) mean more people living closer to the center of Tottori (or the own town center), while increases in skewness and kurtosis both also mean the same.

The cluster analysis, especially Ward method, is applied to the eight indices (four toward the own town center and four toward the center of Tottori) of each local area for time period of depopulation that is between years 2005 and 2010. The result of cluster analysis is shown in Table 7. Here, the value of the change rate of eight indices is regarded as a dummy variable; it takes 1 if the change is positive, while it takes -1 if the change is negative. Table 8 indicates the average of each group.

Tables 7 and 8 show that Group A consists of the five areas including former Tottori City (which is the center of the whole area) and Chizu Town (which is famous of many town revitalization   activities such as 'Forest Kindergarten' and '1/0 resident activity'). All indices of the local areas in this group show downsizing so they are progressing towards 'compact city' both towards each local area center and towards the center of Tottori. Group B consists of former Aoya Town and former Ketaka Town, both of which locate on the west of former Tottori City. Their rates of change in indices show downsizing towards the center of Tottori, and decentralizing towards the own local area centers. Group C consists of former Shikano Town, former Kawahara Town, and Iwami Town, and they are all neighbor to former Tottori City. Their seven indices out of eight show decentralization. Especially, the skewness and kurtosis both indicate decentralization and therefore it implies lowering population density in these local areas. Former Kokufu Town, former Saji Village, former Koge Town, former Funaoka Town, and Wakasa Town constitute Group D. Their all eight indices show decentralization, meaning leaving from the own local area center as well as from the center of Tottori City.

If the construction and improvement of transportation infrastructure are considered simultaneously, the following insights can be induced. Local areas in Group A have relatively high level of transportation infrastructure such as National Route and Train Line that together bring about convenience to access to the local area centers and also to the center of Tottori. The towns in Group B, on the other hand, have improved their accessibility to the center of Tottori due to the consolidation of roads in 2002. Groups A and B had downsizing towards compact city for the center of Tottori due to the good transportation situation.

Groups C and D, however, consist of towns with relatively poor National Route and Train Line infrastructure level. The towns in Group C disperse toward the own town centers. Group D, that is much far from the center of Tottori, shows strong decentralization both towards the ET center and towards the M center. With all the consideration above, it can be said that the infrastructure provision level might affect the downsizing/decentralizing of the areas.

Table 5. The rates in changes of the four indices of time-distance to the ET center

Areas	Period	Average	Standard deviation	Skewness	Kurtosis
former Tottori City	I	12.39	12.31	-6.50	-18.66
	II	-0.86	-2.96	1.32	4.50
former Aoya Town	I	-11.07	-84.53	-13.97	16.72
	II	-5.14	-16.79	-1.08	-21.55
former Ketaka Town	I	-0.17	3.24	-6.38	-27.79
	II	-0.71	-3.28	-0.57	2.71
former Shikano Town	I	1.87	36.75	-10.70	-44.10
	II	-0.52	1.77	0.02	-1.83
former Kawahara Town	I	0.56	2.58	-7.96	-23.84
	II	1.09	2.62	1.05	-0.16
former Saji Village	I	-0.28	18.53	-4.51	-30.44
	II	0.06	9.47	-2.75	12.11
former Mochigase Town	I	2.74	37.82	-5.48	-41.31
	II	-1.84	0.32	-4.81	6.94
former Fukube Village	I	2.42	106.45	54.04	177.83
	II	-0.18	-43.78	-30.85	-72.07
former Kokufu Town	I	2.10	-10.91	1.53	22.00
	II	1.38	1.29	-1.93	-6.20
Iwami Town	I	1.05	2.88	-5.70	-0.74
	II	1.99	1.38	0.81	-0.47
former Koge Town	I	1.32	-1.25	-5.32	-17.13
	II	1.91	7.39	-2.39	-10.79
former Funaoka Town	I	2.45	28.24	-10.10	-34.58
	II	3.24	1.91	-5.90	-19.70
former Hattou Town	I	0.89	12.84	-4.20	-24.61
	II	0.92	-11.73	4.58	10.44
Chizu Town	I	1.52	-2.21	-10.18	15.69
	II	-6.27	-10.07	6.32	-16.48
Wakasa Town	I	0.51	-9.63	-12.95	-30.26
	II	1.24	-2.40	-0.91	-3.25

(Period I: 2000-2005, Period II: 2005-2010)

Table 6. The rates in changes of the four indices of time-distance to the M center

	Period	Average	Standard deviation	Skewness	Kurtosis
former Tottori City	I	17.85	20.55	-35.00	-88.22
	II	-0.60	-1.18	3.59	37.11
former Aoya Town	I	9.75	-17.36	-70.23	44.65
	II	0.42	-0.99	-3.63	4.90
former Ketaka Town	I	7.39	-4.37	-88.22	-8865.20
	II	5.49	12.17	446.13	166.77
former Shikano Town	I	20.43	18.96	-24.26	-70.11
	II	0.30	1.41	-1.77	-9.69
former Kawahara Town	I	2.84	-5.76	-10.85	-114.70
	II	0.80	3.54	-2.07	-149.67
former Saji Village	I	18.29	25.66	-2.60	-11.18
	II	1.21	1.67	-3.29	-5.83
former Mochigase Town	I	29.29	218.79	71.74	193.60
	II	-4.43	-9.86	11.32	25.12
former Fukube Village	I	20.15	12.81	-41.93	-104.82
	II	-4.43	-3.49	16.81	9.18
former Kokufu Town	I	2.45	-10.06	8.62	19.51
	II	1.45	2.32	-10.86	-9.47
Iwami Town	I	2.14	-4.65	6.00	-7.57
	II	3.01	15.25	15.44	80.63
former Koge Town	I	7.50	-5.51	-6.88	-23.82
	II	2.79	10.85	-9.14	-35.63
former Funaoka Town	I	8.66	-47.30	-65.84	-159.51
	II	14.20	87.54	14.78	-3.36
former Hattou Town	I	-7.68	-26.63	452.07	36.95
	II	-2.61	-2.71	3.39	24.98
Chizu Town	I	11.87	-1.25	-39.51	-188.54
	II	-0.63	-0.48	2.63	17.06
Wakasa Town	I	-2.83	-53.41	-63.87	-98.10
	II	3.46	14.05	-8.92	-256.92

(Period I: 2000-2005, Period II: 2005-2010)

Table 7. Grouping of local areas by results of the cluster analysis

groups	Constituting local Areas
Group A	former Tottori City, former Fukube Village, former Mochigase Town, former Hattou Town, Chizu Town
Group B	former Aoya Town, former Ketaka Town
Group C	former Shikano Town, former Kawahara Town, Iwami Town
Group D	former Kokufu Town, former Saji Village, former Koge Town, former Funaoka Town, Wakasa Town

Table 8. The result of the cluster analysis

	To the ET Center				To the M Center			
	Average	Standard deviation	Skewness	Kurtosis	Average	Standard deviation	Skewness	Kurtosis
Group A	-0.6	-0.6	0.2	0.2	-1	-1	1	1
Group B	-1	-1	-1	0	1	0	0	1
Group C	0.33	1	1	-1	1	1	-0.33	-0.33
Group D	1	0.6	-1	-0.6	1	1	-0.6	-1

5. CONCLUSION

This research clarifies in details the changes of population distribution of Eastern Area of Tottori Prefecture in Japan based on Census data of years 2000, 2005, and 2010.

As the results, the population distribution in western area tends to change so as to approach to the central Tottori, and also to leave from the local area centers. On the other hand, the population distribution in eastern area tends to concentrate more on the local area centers rather than central Tottori. Finally, the southern area that the Tottori Expressway (which had opened between 2005 and 2010) had brought better access to the central Tottori rather shows the decrease in population density.

The future research should include the explicit consideration of distribution of life-related facilities' locations such as supermarkets and hospitals, and their effects on population distribution of urban areas with decreasing population. Also, accumulation of similar analyses on other local urban areas in Japan must allow us to induce more general statements on tendencies of population distribution in Japanese local urban areas with decreasing population.

REFERENCES

Sampaio, P.Y.S, Ito, E., Sampaio, R.A.C. (2013) The association of activity and participation with quality of life between Japanese older adults living in rural and urban areas, *Journal of Clinical Gerontology & Geriatrics*, 4, pp.51-56.

Muramatsu, N., Akiyama, H. (2011). Japan: Super-aging society preparing for the future, *Gerontologist*, 51(4), pp. 425-432

Klaassen, L.H., Bourdenz, J.A., Volumuller, J., (1981), *Transport and Reurbanisation*, Gower.

Land, Infrastructure and Transportation Ministry (2014), *Grand Design of National Spatial Development towards 2050.*

Ministry of Internal Affairs and Communication (2008), *Settlement and Independence Area Plan*, Retrieved on January 20, 2017, from http://www.soumu.go.jp/main_sosiki/kenkyu/teizyu/ (in Japanese).