

Changes in Land Use, Transportation System and the Mobility in Gifu by using Historical Map, Statistics and Personal Trip Survey Data

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History provides valuable lessons for the interplay of factors that shape urban growth and development. This study examines changes in socioeconomic indices land use, and the transportation system of Gifu City during the late 20th century and Personal trip survey data using geographical information system (GIS) methods. The data for the study were historical maps and the population census and economic statistics data from 1950 to 2000, when Japan was in a period of high economic growth. When policies were created that attached importance to construction of a road network due to the development of motorization and elimination of the city tram, the surrounding suburban area became the focus of land-use development. As a result, Gifu City is plagued by the doughnut phenomenon. It is important to identify the relationships among urban planning factors to provide for future urban and transportation planning.

Key Words : *Transportation System, Personal Trip Survey Data, Land Use, Traffic Mobility*

1. INTRODUCTION

Rapid urbanization and growing economic prosperity had brought a higher rate of motorization in developed countries and now in developing countries also. Motorization causes many problems like exhaust pollution, traffic congestion and emergence of transport poor. More and more countries and cities therefore start focusing back to public transport in their master plan. The retreat of public transport caused by over-emphasis on road construction and decentralization of land use made over-reliance on cars. Suppressing unnecessary car use, such as through the use of public transport and bicycles, calls for a shift to environmentally friendly and sustainable cities. History provides valuable lessons for the interplay of factors that shape urban growth and development.

Personal trip survey data (PT) is used popular to know present states mobility situation and make traffic demand estimation to give suggestion of environment planning¹⁾, transport planning²⁾, disaster prevention planning³⁾ and so on. There are also some researches to focus on the change of activity^{4),5)} and

the relationship of land use, environment and activity⁶⁾. Looking in the relationship of changes in land use, transportation system and mobility activity is few.

In previous study, we summarized the lessons of past transport planning in Gifu City by looking at planning and policy in the past 40 years by using historical maps, population census and economic statistics data. Because land-use, transport changes are difficult to analyze by simply inspecting documents and data, we used a popular computer method, geographical information system (GIS)⁷⁾ to create spatial maps to compare urban changes with spatial-distribution patterns over time. We make it easy to check these changes and their relationships by GIS maps.

2. DATA OVERVIEW

The target area is Gifu City in Japan, a typical middle-sized city with a population of 402,185 (**Table 1**). Gifu City is in the central area of Japan and is in the north of the third largest city in Japan,

Nagoya. The population has decreased slightly especially in central area since 1985 (**Fig.1**). The primary access to Gifu is from the south. With fewer bus users in the city, bus companies faced difficulties on maintaining services, and three bus companies merged into one. Furthermore, removal of the city tram left buses as the only public transportation within most of the city. Thus, car use has been increasing (**Fig.2**). Motorization led to the dispersion of major urban facilities such as shops and public facilities, reducing access to such resources in the central area. As a result, the residential population and the number of shops and workplaces in the central area have declined over the past several years.

In this study, we used historical documents and maps from the past 40 years to review past urban planning policies and transportation systems. We analyzed urban changes using the population census and economic statistics and examined changes in the transportation system using transportation-use statistics. The result of regional trip survey so-called “Personal trip survey” should be an essential database of urban transport planning which has recorded the trips and activities of trip makers dynamically as well as spatially for the target city. We use the first to the fourth (1971, 1981, 1991, 2001) PT⁽⁸⁾ to looking at the changes of activities in space by the 9 PT zone as center, south, east, north, northwest (surrounding), northwest (suburban), northeast (surrounding) and northeast (suburban) inside Gifu city, and from outside, there are 10 direction as Nagoya, Kakamigahara and Aichi, Seki and Mino, Yamagata and Takatomi, Kani, Ogaki, Motosu, Ginan and Hashima, Mizuho and Mie (**Fig 3**).

3. CHANGES FROM 1971 to 1981

The first master plan was created in 1973⁽⁹⁾. It clarified land use through urban planning; land use categorized into city center, industrial zone, housing zone, commercial zone, agriculture zone and green zone. The population was decreased in the central area though total population in the city increased. The Ring-road (**Fig.4**) construction was planned and construction was started. The motorization was grown fast while car owners/population was increased about 12%⁽¹⁰⁾.

We first explore the changes of commercial land use and transport around 1971-1981 (**Fig.5**). This figure illustrates the changes in commercial zones using the 1982 and 1968 data⁽¹⁰⁾. It illustrates a change in the number of stores. The number of stores was decreased in the center and north but increased

Table 1 Essential Statistics of Target City

Population	402,185	Schooling from the outside	11,772
[Central area]	74,531	Drivers license holders	247,607
[Surrounding area]	162,653	Car owners	279,177
[Suburban area]	165,001	Large size shops	64
Daytime population	426,865	Normal shops	7,585
Families	153,336	Commercial sales [ten thousand yen]	18,918
Elderly persons	73,492	Business sites	25,382
Commuters	279,224	Workers	185614

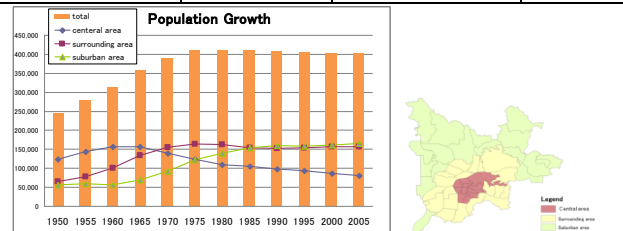


Fig.1 Population Growth of Gifu City

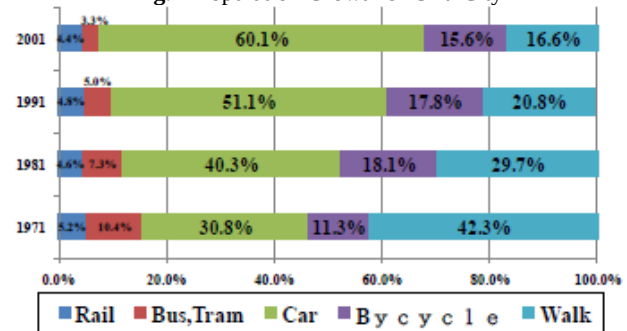


Fig.2 Mode Share of Trips in Gifu City

in northwest (suburban) and northeast (surrounding). There built four new public housings over 100 households in the surrounding area and suburban area. The red line in **Fig. 5** indicates new roads built between 1980 and 1973. The ring road construction was planned in the first master plan, and construction began from west to north.

Zone trip attraction could be counted by using PT (**Fig 6**) from 1971 to 1981. Reflecting a decrease of the number stores, the trip attraction was decreased

both in the center and the north, but increased in the northwest(suburban) and northeast(surrounding). **Fig. 6** also indicates the increase in population around west and south area, which may be because of the new road construction.

To discuss the relationship between land use and transport more in detail, we choose central area (where the trip decreased) and northwest (suburban) area (where the trip increased) to see the change of car trip attraction. From **Fig 7**, though that the total trip was decreased in the central area, the car trips increased from most of the areas. Looking at trip attraction to northwest area, the car trips increased from all zones. This coincides with the increase of the number of stores. Also in this zone, new public housing may be another reason of car trip increase.

Since the southwestern part of Ring Road was consummated, the OD trip from Gifu City to south (Ginan, Hashima) and southeast (Kakamigahara, Aichi) was increased a lot (**Fig 7**).

Are there other factors caused the trip increase in the northwest(suburban) area? We focus on the change of industrial land use and journey-to-work trip attraction. **Fig. 8** illustrates the changes in the number of enterprises using the 1980/1972 data. It is shown that in northwest(suburban) area, the number of enterprises was also increased in this period. At the same time, from all of zones, the journey-to-work trip to northwest(suburban) increased.

From above, we can summarize that the land use of commerce and industry change is affected by road network change and they affect people's traffic mobility.

4. CHANGES FROM 1981 to 1991

In the period around 1981 to 1991, the second master plan was created in 1980¹¹⁾. Land-use zones were fixed based on the first master plan, regional highway network with access to other cities was planned. The third master plan was created in 1986¹²⁾, radial ring network was planned to be the major facility construction, land use was zoned to seven zones as city center, northeast, north, northwest, west, south, and east. Each zone had a detailed delimited land-use class. As for transport system, public transportation was moved to bus as Nagara line of the city tram was eliminated. Ring road was a focus construction in road network. The motorization was grown further while car owners/population was increased about 30%¹⁰⁾.

Fig. 9 illustrates the changes in commercial zones using the 1994/1982 data¹⁰⁾ and shows a

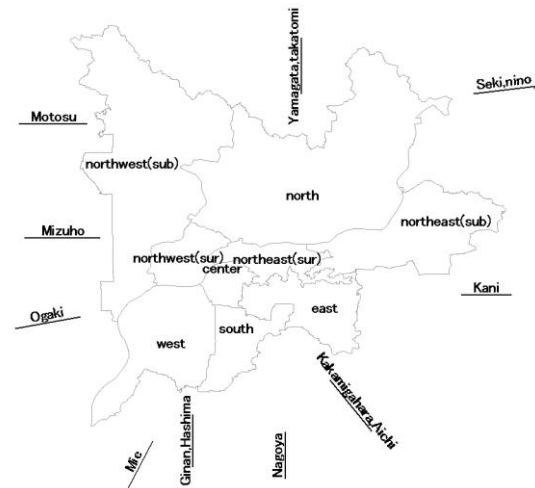


Fig.3 Zoning by PT

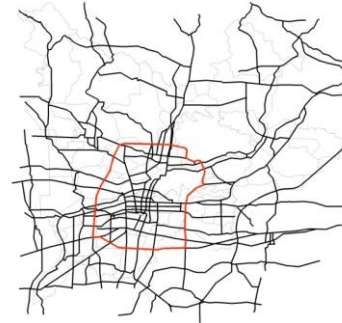


Fig.4 The Ring Road in Gifu City (Road Network in 2003)

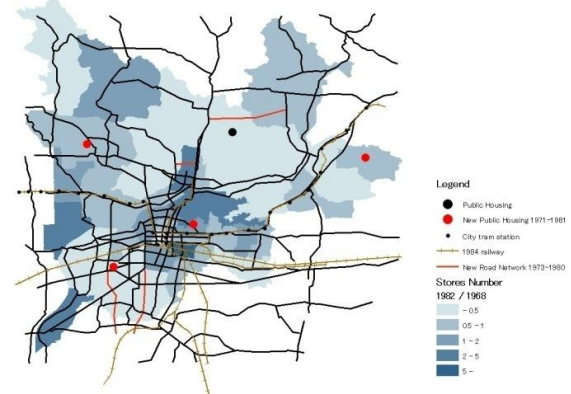


Fig.5 Change of Commercial Land Use and Transport Network (Around 1971-1981)

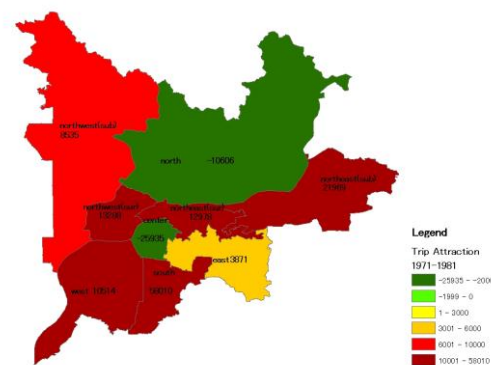


Fig.6 Change of Total Trip Attraction (1971-1981) (include from outside) to Gifu City

change in the number of stores. At all the zones commerce was grown not so well and it especially declined in the center. Many facilities were built in surrounding and suburban area. Gifu University was moved to northwest(suburban) from north near center in 1982. A new rail station (Westgifu) was opened in 1986. A new shopping center was opened in northwest(surrounding) in 1988 and a new sports studio was opened in northeast(surrounding) in 1991. Ring Road was extended and road to outside areas was also constructed in the south, the east and the west of the city.

Trip attraction volume could be count by PT (Fig 10) from 1981 to 1991. All trips increased a lot. This could be explained by the motorization and convenience of cars as road network was consummated.

We choose western area (where a new station was built) and northwest (surrounding) area (where a new shopping center was built) to see the change of car trip attraction (Fig.11). It is shown that all of the trip was increased. To the west, trips from center and west itself increased a lot. From above, we can say that by the construction of the Ring Road can be a major reason of this. From these zones to west, it was more convenient to move by car. At the same time, trips also increased a lot from center and norwest (suburban) to northwest (surrounding) caused by construction of the Ring Road.

From outside (Fig 11), all of the OD trip to Gifu City was increased especially from Kakamigahara Aichi, Nagoya, Ginan Hashima. It should be caused by the construction of road network.

A new rail station (Westgifu) was opened in west. Is that affect the rail trip to west? We make the trip attraction table to see it (Table 2). It was shown that from most of the direction, the trip by rail increased especially from Aichi, Seki Mino, Ogaki, Hashima and Mizuho. The new rail station make it convenience moving to west by rail.

The Gifu University moved out to northwestern (suburban) area in 1982. It must affect the trip of journey-to-school to northwestern(suburban) area. Fig 12 illustrates the change of Trip attraction of journey-to-school to northwest(suburban). It was shown that from most of the direction (except center south Motosu and northeast(surrounding)), the trip by rail was increased especially from Kakamigahara Aichi, Nagoya west and northwest(suburban) itself. The movement of Gifu University changed the trip of journey-to-school very well.

The biggest change in public transport in this period was one of the city tram line (Nagara Line) was eliminated. Fig 13 illustrates the change of

Table 2 Change of Rail Trip Attraction to West Area

Center	167	Nagoya	64
East	-76	Kakamigahara, etc	682
South	-24	Seki, Mino	216
West	0	Yamagata, etc	0
North	0	Kani, Tajimi	35
Northwest (surrounding)	0	Ogaki	143
Northwest(suburban)	42	Motosu	6
Northeast(surrounding)	26	Ginan, Hashima	164
Northeast(suburban)	52	Mizuho	158
		Mie	29

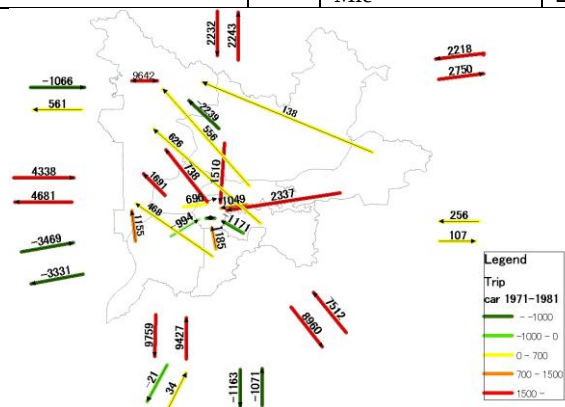


Fig.7 Change of Car Trip Attraction in Chosen Area and OD

Trip of outside (1971-1981)

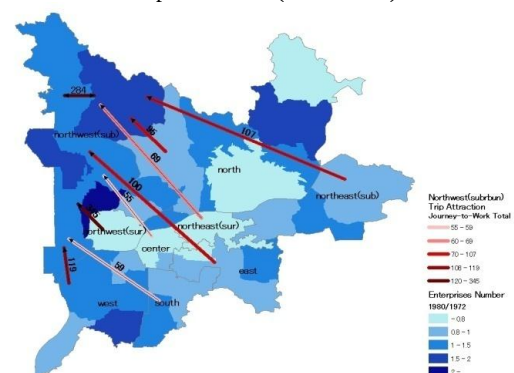


Fig.8 Change of Industrial Land Use and Journey-to-work Trip

Attraction (1971-1981)

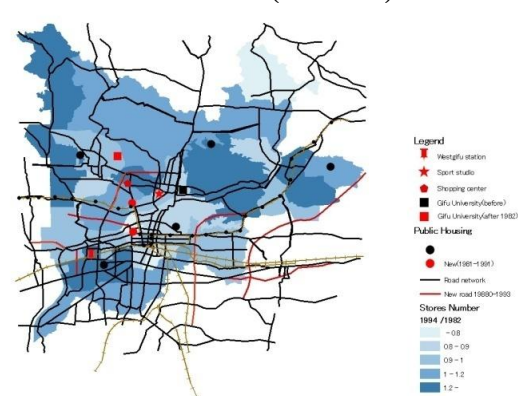


Fig.9 Change of Commercial Land Use and Transport Network
(Around 1981-1991)

public transport system and the trip attraction by bus and tram. The red lines are the new bus line from 1984 to 1993, and the gray line was the eliminated tram line. The bus line was newly designed along the Ring Road in the suburban area. It is shown that in most zones, the trips of bus and tram decreased, especially to central an northwestern (surrounding) areas. It may be caused by the tram eliminated and trip mode may shift to car.

From above, we can summarize that changes of facility affect the traffic mobility very well, and the road network and public transport system changes trip a lot.

5. CHANGES FROM 1991 to 2001

In the period around 1991 to 2001: Fourth master plan was created in 1995¹³⁾: the central area was planning to the focus activation area. Surrounding area was planned as industrial and commercial zones, and natural scenery became important. Road construction, such as the radial ring network, was also set as an important issue and an integrated transportation system was planned based on a bus network. The Ring Road construction was almost completed.

Fig. 14 illustrates the changes in commercial zones using the 2004/1994 data¹⁰⁾ and shows a change in the number of stores. The number of stores increased just in a few areas. Road network was consummate further.

Zone trip attraction volume increased a lot to the central, western and northwestern(surrounding) areas (**Fig.15**). Next, we look at the trip attraction by mode.

The car trip attraction of all nodes increased inside Gifu city (**Fig 16**). The increased zones are same as the total trip change. From outside, except Kani, all of the OD trip to Gifu City was increased, it could be road network construction made the trip by car increased.

On the other hand, trips by public transport decreased in Gifu city (**Fig 17**). Apparently, at the zone where the number of public transport trips decreased, the number of car trips increased. It illustrates the mode shift from public transport to car.

From above, we can summarize that from 1991 to 2001, the road network construction made the mode shifted from public transport to car.

6. CONCLUSIONS AND FUTHER STUDY

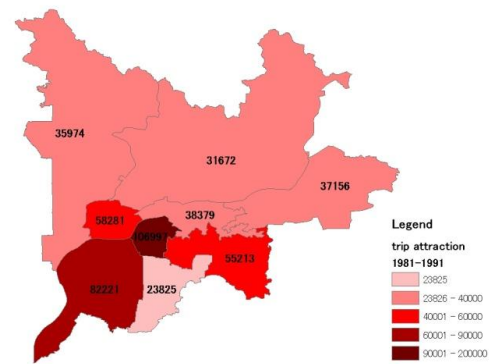


Fig.10 Change of Total Trip Attraction (1981-1991) (include from outside)

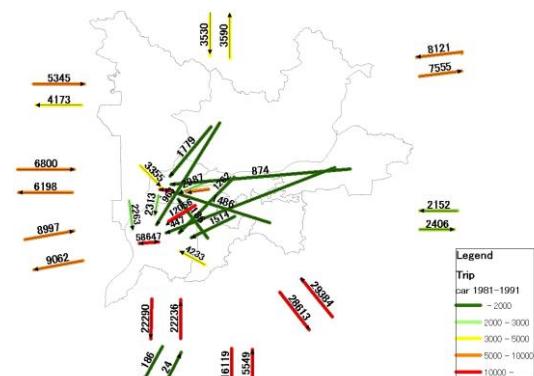


Fig.11 Change of Car Trip Attraction in Chosen Area and OD Trip of outside to Gifu City(1981-1991)

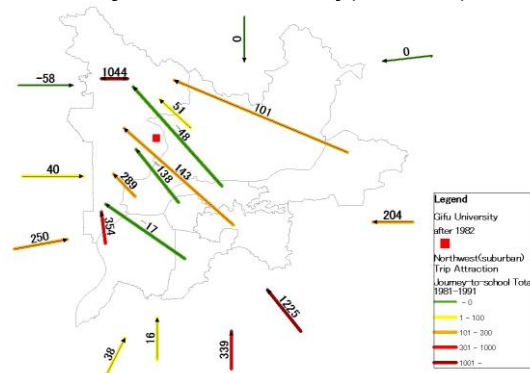


Fig.12 Change of Journey-to-school Trip Attraction to Northwest Suburban Area (1981-1991)

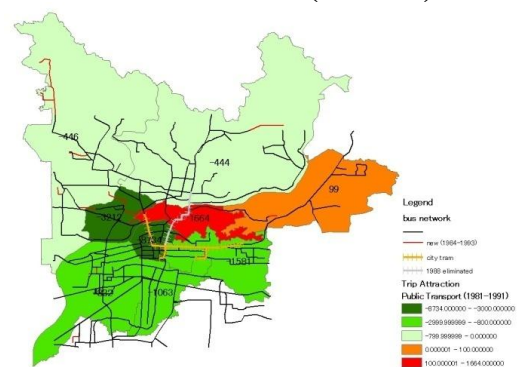


Fig.13 Change of Public (Bus and Tram) Trip Attraction (1981-1991)

We have described changes in land use, socioeconomic indices, the transportation system and traffic mobility in Gifu City during the late 20th century using historical map, census data PT data and GIS methods. We attempted to identify a relationship among urban planning factors. During these years, Gifu City focused on construction of the Ring Road network, eliminated city tram, changed city public transportation to the bus, and moved the housing and industrial zones to the surrounding and suburban areas. As a result, the travel mode moved from public transport to car more and more. Commerce and industry moved at the same time. This process was an important cause of the doughnut phenomenon. It is necessary to bring the focus back to public transportation if we are to shift to environmentally friendly and sustainable cities.

In future studies, we will use an integrated land-use transportation model to create a policy-change simulation using historical data to verify the mathematical method of analyzing the relationship among urban-planning factors.

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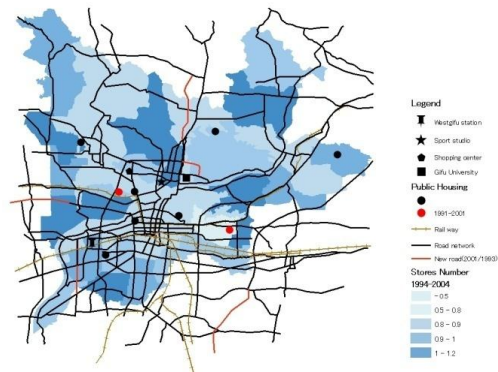


Fig.14 Change of Commercial Land Use and Transport Network
(Around 1991-2001)

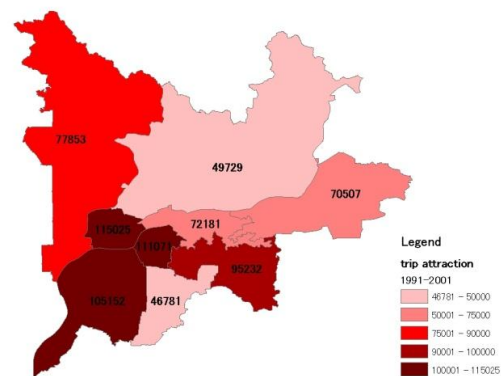


Fig.15 Change of Total Trip Attraction (1991-2001)

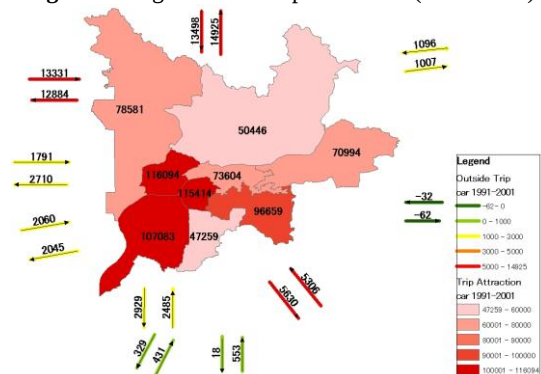


Fig.16 Change of Car Trip Attraction and OD Trip of outside
(1991-2001)

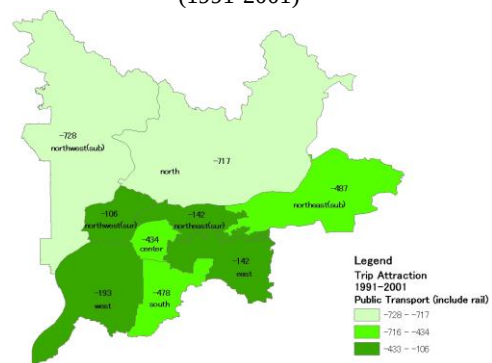


Fig.17 Change of Public (including rail) Trip Attraction
(1991-2001)

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