SELECTION OF BUS TRANSPORTATION ROUTES FOR REVITALIZATION OF DOWNTOWN CITY BY USING GIS

Yoshiko Imaoka

Graduate School of Science and Technology, Nagasaki University
1-14 Bunkyo-Machi, Nagasaki 852-8521, Japan
imaoka@stu.civil.nagasaki-u.ac.jp

Keinosuke Gotoh

Graduate School of Science and Technology, Nagasaki University
1-14 Bunkyo-Machi, Nagasaki 852-8521, Japan
gotoh@civil.nagasaki-u.ac.jp

ABSTRACT:

Downtown cities in Japan are facing sharp fall in customers and continued shut down of shops due to decrease of population, increase in family cars and flowing of customers into the suburban large-scale retail stores. Omura City in Nagasaki Prefecture, Japan is no exception to this. For the revitalization of the downtown, many actions have been taken to open the vacant shops. However, transportation problem is the most important one to be solved for the citizens including the elderly people having difficulty in movement. Accordingly, this study was aimed at the revitalization of the downtown by substantiality public transportation. We have attempted to develop routes from the view-point of convenience by using Analytic Hierarchy Process (AHP) and Geographic Information Systems (GIS). As a result of the study, we were able to select three bus transportation areas by incorporating qualitative factors into the analysis. Finally, the study concluded that, revitalization activities of the downtown city itself is required in addition to re-structuring of bus transportation system for the revitalization of the downtown city.

KEY WORDS: Downtown, Bus Transportation, Geographic Information Systems, Analytic Hierarchy Process

1. INTRODUCTION

Recently, in many Japanese cities migration to suburban areas are advancing in a quick pace due to availability of cheap land and increased automobile facilities. Consequently, many downtown cities in Japan are facing sharp fall in population. This also resulted into the shift of customers to the big shopping centres located in suburbs, where all the necessities can be purchased from one spot. All these change in population and customers caused abrupt reduction in the shopping street of downtowns and triggered shut down of many shops. Specially, in downtown areas of regional cities, fall in the inflow of people in the downtown cites not only forces closing down of shops but also creates an imbalance between regional cultural development and industrial growth. This hampers the basic growth of the city through underdevelopment of the city structures. For example, increase in personal cars reduces the user of public transportation and make them economically unviable. This again led to the abolishment of transportation routes. On this background, this study aimed at revitalization of the downtown city by selecting idle route for public bus transportation by considering the need of the users and factors related to downtown shopping malls using Geographic Information Systems (GIS). In doing so we have selected Omura City, Nagasaki Prefecture, Japan as the case study.

2. PRESENT CONDITION OF THE OMURA CITY

Omura City is located in central area of Nagasaki Prefecture having an area of 126.33 km^2 and population of 87,628 (Statistics of Omura, 2004). The location of the Omura City is shown in Figure 1. In addition, Omura City
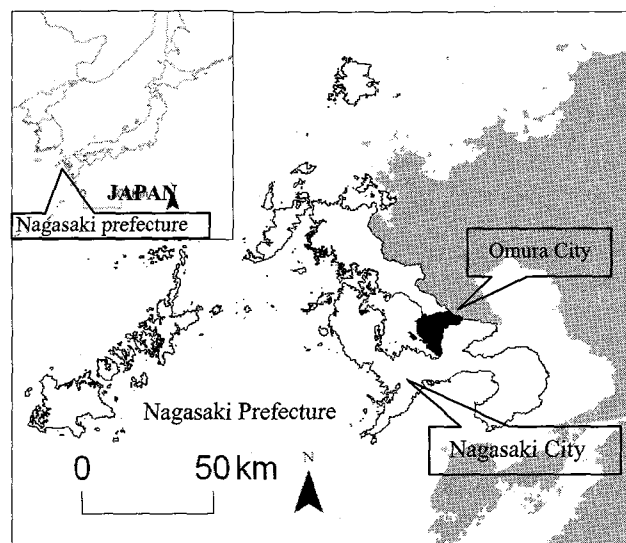

Figure 1. Location of the Omura City
in Nagasaki Prefecture

has Nagasaki Airport, an interchange of an expressway and the future location for the Sinkansen (Bullet Train) Station. Accordingly, Omura City is developing into a convenient highway traffic base.

However, the bus system of the city is beset with problems, as 76 routs out of total 85 are unprofitable. As for annual volume of the passenger transportation of the city, about 200 thousand decreased between the periods of 1998 to 2003. Eventually, discontinuance of route bus services was decided in the north district of the city. A review of the bus routes became essential in other areas for possible re-consideration.

The downtown of Omura City is a famous commercial place from the past. This area is the place that was famous as a commercial area during the Nagasaki Kaido era. Presently, in this location the Omura City centre is located having Omura Central Shopping Street. However, vacant shops are increasing in this shopping street as population is decreasing in the region and customers are gradually flowing out into the suburban large-scale retail stores.

3. ROUTE SELECTION METHOD

3.1 Flow and Variables

We have evaluated the selection of a route from convenience viewpoint of customer coming to the downtown shopping street, shop owners and people related to the downtown revitalization activities. Also a route should pass the downtown area and one lap would be 30 minutes (10km). Furthermore, we planned to use minibus mainly to make movement easier. In addition to this, the selection method followed is outlined below:

Firstly, the proposed area was decided by considering

Table 1. The variables used for GIS analysis

Town administration area	Dawn town area
Public and cultural facilities	Hospital
Population	Building
City hall and branch offices	Road
The existing bus stop	Rail station
Customers of shopping mall in downtown	

priority of town administration area. Priority decided from weighted score using AHP (Analytic Hierarchy Process) by needs of downtown concerned.

Secondly, we have inserted a high institution of needs of a bus user except a downtown area and a residential area. A rough route is decided from these data.

Thirdly, a detailed bus route is decided from the road where a minibus can pass.

The variable used for GIS analysis is shown in Table 1(ZENRIN Co., Ltd., 2005).

3.2 Rank of Each Town Using AHP

In selecting the bus routes, we have considered the expectation of the town in the revitalization of the downtown. Therefore we have picked up keywords regarded as important while we discussed in downtown area and added a weight score to it and ordered. Weight score was decided with Relative Position Measurement Approach of AHP (Mori et al., 2001). The number of respondents of the AHP questionnaire was ten (owners of shopping mall in downtown area, city hall, bus company, urban planning concerned etc.) having adequate knowledge about bus systems of Omura City and the downtown area. The respondents were requested to check the factors mentioned in the questionnaire according to the rank of importance for the revitalization of the downtown from seven keywords of Table 2. Each keyword questions had a choice level from 0 to 10.

The result of weight score of seven keywords is shown in Table 2. From this result, we have decided priority of each town for bus systems and made every town data of each keyword using GIS and calculated a ratio of each town to a value in total of all the towns. The total score is the multiplied weight score by the ratio. With the results of the rank, we have divided the area into three blocks as shown in Figure 1: Omura area, West Omura area and Takematsu area.

3.3 Route Selection Method

From the result of the AHP analysis we have selected routes for three areas. Findings of the various studies showed that there is higher comparative demand for bus stops by the users in hospital, station, public and culture institution, city hall etc (Imaoka et al, 2004.). The data

Table 2. Weight score by using AHP

| Keywords	Customers of shopping mall in Downtown	The area where buses do not	Elderly population	Infant population	Female population	Total population	Building space
No.1	0.409	0.036	0.188	0.042	0.069	0.188	0.069
No.2	0.300	0.163	0.261	0.033	0.069	0.105	0.069
No.3	0.401	0.050	0.073	0.073	0.303	0.050	0.050
No.4	0.349	0.127	0.058	0.035	0.020	0.221	0.190
No.5	0.021	0.216	0.443	0.088	0.148	0.033	0.051
No.6	0.377	0.044	0.302	0.030	0.022	0.085	0.139
No.7	0.044	0.021	0.367	0.059	0.065	0.297	0.147
No.8	0.421	0.032	0.251	0.040	0.026	0.148	0.083
No.9	0.183	0.239	0.291	0.120	0.035	0.081	0.052
No.10	0.212	0.051	0.319	0.103	0.126	0.156	0.033
AVERAGE	0.272	0.098	0.255	0.062	0.088	0.136	0.088
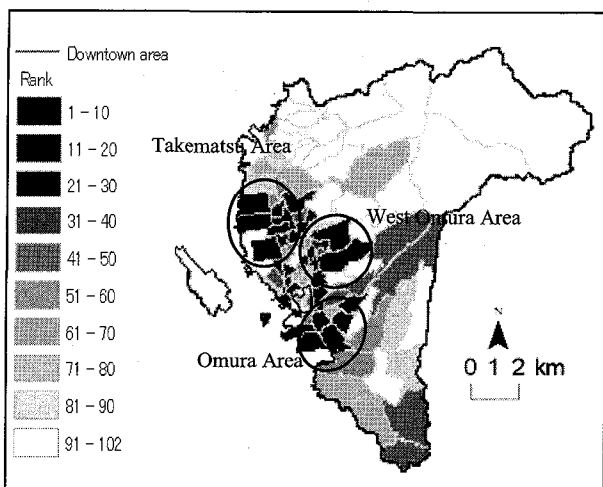
Figure 2. Rank of Each Town Using AHP

used for the route selection is these four institutions and public housing estate. These housing estates have elderly population and high evaluation point in AHP.

The condition for the selection process is outlined below:

1. A route is assumed to be a loop line and one lap would be for 30 minutes (10km).

2. Should touch the downtown area.

3. The road was extracted with total road width of 5.1m or more (two lane roads having 2.3m in each lane plus 0.5m as surplus margin) and the minibus is mainly used as a community bus. We have taken these structures by following the standard prescribed in the Section 47 of Road Act, as a standard for construction.

4. Institutions and public housing estate should be within a radius of 100m. When there are plural institutions of the same type, rank of AHP gives priority to the higher rank.

5. When two or more roads exist between facilities we have selected the road passing through the more populated areas.

As it is generally considered that, elderly people can walk up to 100m distance before resting (Tsuchiya et al, 1996).

4. RESULTS OF SELECTION

4.1 Omura Area

Omura area is the area where the result of ranking is high in terms of the result of AHP. The route selection result of Omura area is shown in Figure 3. This route length became about 9km. This area consists of a city hall and a community centre in the western area, a public housing estate and a prefecture hospital in the eastern area, and a public housing estate in the southern part. The route covers all these areas.

In addition, this area had many small roads, and there were few roads where a minibus could access. Therefore spot A in Figure 3 has to go along a road of width of 2.7m to satisfy the loop line. Accordingly, we have decided to go through this road, as otherwise the route would be a

straight line passing separately from the downtown area, connecting the southern part and the eastern part together.

B spot is congested in the morning and evening time. Hence we need to use the main road and the road which is near to the city hall effectively by considering the time rush factor. Also the road in the public housing estate is narrow and revolving is necessary among public housing estate. However, we have decided to select this route, in spite of some problems, as the number of passengers is expected to rise in this area.

4.2 West Omura Area

A higher ranking value were obtained from the result of the AHP in West Omura area surrounded by Self-Defence Force base. The route selection result of West Omura area is shown in Figure 4. One institution and public housing estate located in this area led to the high AHP ranking. This main route length became about 11km. But like the Omura area, this area also had very few roads having width of 5.1m. However, in this route we have succeeded in covering all the public facilities within a 100m radius. The C point crosses a road which is usually congested in the morning and evening. We have included this road because this road was effective for increasing the number of passenger.

4.3 Takematsu Area

After selecting a direct route from the downtown area, the Takematsu area becomes a route of about 1 hour. However, if cooperation can be received from Takematsu shopping street in the D spot, we can transfer to West Omura area route by making route in the Takematsu area. This will bring the interaction, which would be good for both shopping streets.

Therefore, we made the route, which linked West Omura route to the Takematsu area. The route selection result of Takematsu area is shown in Figure 5. The Takematsu area has few institutions and public housing estates. Spot E has few buildings for Self-Defence Force base. AHP ranking of spot F is comparatively higher. But, we were not able to make the choice of the route because there were no roads having width more than 5.1m.

Finally, we were able to make the route a loop line and resulted into a route of about 9km. However, D spot has to let the bus make a U-turn in public housing estate because the road is narrow. The transit spot in West Omura area is a place consisting a hospital and many public housing estates in the G spot. We can arrive from the G spot to the downtown area in about 10 minutes if the bus is driven anti-clock wise.

5. CONCLUSIONS

This study was aimed at the revitalization of the downtown city by re-route selection of the public bus transportation. Accordingly, we have attempted to develop routes from the viewpoint of convenience by using AHP and GIS. The findings of the study can be
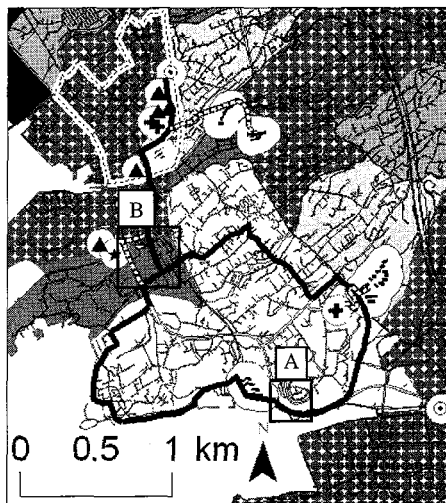
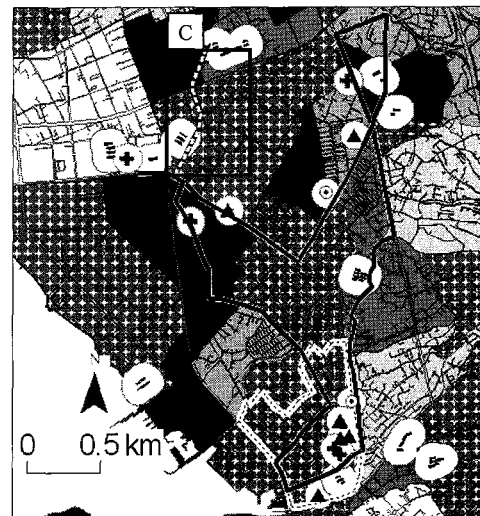Figure 3. Selection result of Omura area

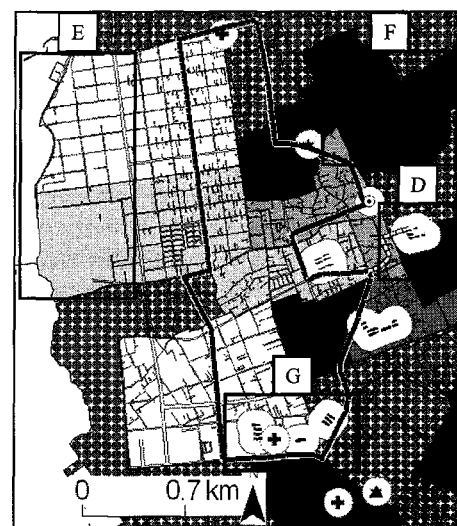Figure 4. Selection result of West Omura area

Figure 5. Selection result of Takematsu area

summarized as follows:

(1) In this study, psychological information was inserted in the GIS analysis for route selection with the AHP method.

(2) From this result, we were able to select three areas as the bus transportation area. And, we were able to make a route of Omura area and West Omura area. However, for Takematsu area a loop trip of 10km were not possible. But by connecting with the West Omura, this area can also be connected with the downtown and the institutions and public housing estates.

(3) In addition, in the Takematsu area, we were able to make a route of transit by assuming cooperation from the shopping street in this area. If this can be materialized then both shopping streets will be benefited by making a passage time when the transit is smooth.

(4) Finally, in this study we have conducted questionnaire survey among the persons who are well aware about the needs and problems of the downtowns. Thus these results should be compared with that of the general users to see whether they offer the same results. A future study needed to be conducted in this regard.

Re-routing of the bus transportation might increase the convenience of the bus users, but for the revitalization of the downtown city revitalization effort of the downtown city itself is required. This area leaves the scope for more detailed study regarding the possible ways to revitalize downtown cities scattered all over Japan, facing problem of few customers.

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