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DEVELOPMENT OF NON-MONETARY INDICATORS TO EVALUATE PUBLIC TRANSPORT SERVICES IN RURAL AREAS

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Abstract: This paper aims to examine the effectiveness of the complementary indicators from conventionally well-used monetary ones to evaluate public transportation planning in rural areas. Proposed non-monetary indicators for public transport services consist of "Quality of Life", "Customer Satisfaction" and "Equality of public transport services". An empirical analysis results show that the indicators are useful to evaluate the effects of improving the levels of public transport services and can consequently contribute to planning the public transportation planning.

Key Words: non-monetary indicators, quality of service, customer satisfaction, equality and public transportation

1. INTRODUCTION

Deregulation of bus services both in demand and supply respects in 2002, Japan has made private transport operators easier to withdraw from unprofitable bus routes. Most public transport users in depopulated rural areas are elderly and school age persons who cannot drive a car by themselves, so that the levels of public transport services directly and seriously affect on their living environment. Nevertheless, a simplistic monetary assessment in terms of operational efficiency led to the abolishment of public transport services, and consequently social exclusion problems that the elderly and disabled residents were forced to inconvenient travel and sometimes lost the opportunity of out-home activities came out in many rural areas.

Local governments in such depopulated areas have to take measures to maintain transport services for the residents and to supply alternative services from a broader view of not only operational efficiency. In other words, it is requited to develop non-monetary indicators to evaluate the quality of daily living services supplied by public transport, substitute for well-used monetary ones.

This paper attempts to propose complementary non-monetary indicators from conventional profitability to evaluate public transport services in depopulated areas. These indicators should be suited to assess not only traditional bus service but also Demand Responsive Transport (DRT) recently introduced in many rural areas in the world. (Naniopoulos, 2001; Brown *et al*, 2001; Westerlunf *et al*, 2000; Mageean *et al*, 2003)

2. DEFINITION OF NON-MONETARY INDICATORS

Many literatures have made an effort to develop the evaluation indicators for public good and services in various study areas (eg. Customer Satisfaction (CS), Shadow Price, Hedonic Approach, Contingent Valuation Method (CVM)). Based on the existing findings, the authors try to apply three non-monetary evaluation indicators for public transport services in this study.

The first non-monetary indicator is "Quality of Life (QOL)" defined as residents' satisfaction with overall living environment. This indicator presents the subjective value aggregated (i.e. averaged) over residents in each community. Suppose the individual QOL that is a latent (i.e. unobserved) value could be affected by the levels-of-services (LOS) for public transport and also be measured by his/her current satisfaction level. The satisfaction level is observed from a self-completion questionnaire survey as 5-scale satisfaction scores with ordinal numbers. Therefore, ordered probit model is applied to describe the cause-effect relationship between LOS and individual QOL in this study. The unknown parameters of the ordered probit model are estimated to fit the observed scores. Then, the value of QOL indicator after improving/deteriorating a service is predicted by putting its LOS into the model as can be seen in Figure 1.

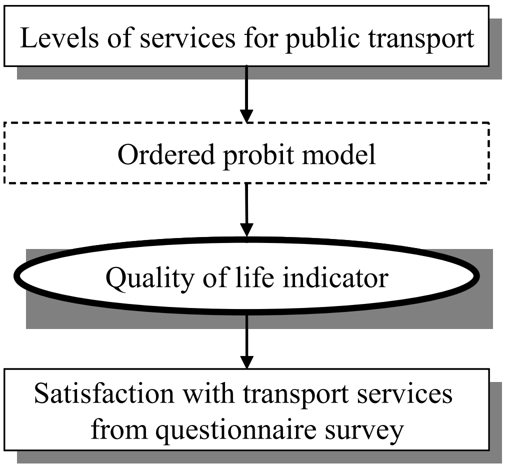

Figure 1. QOL Indicator for Residents

The second one is "Customer satisfaction (CS)", which is defined as passengers' satisfaction with public transport services. This indicator concentrates upon the subjective evaluation by public transport users rather than residents. The method to observe current indicator and to estimate future one is quite similar to the above QOL indicator.

The last one is "Equality of public transport services (EQ)" among the relevant communities in the corresponding area. This acts on evaluating the balance among communities in terms of the levels of public transport services, while the first two indicators show the satisfaction levels aggregated independently for each community. In particularly, it seems very useful to assess the social exclusion issues in rural areas. The levels of services for public transport are objectively indicated by some attributes in each community including the average distance to closest bus stops from respondent, average bus fare to hospital, average travel time to hospital, etc. The usage of GIS allows us to search and integrate these attributes.

Figure 3 outlines an evaluation flow of bus services based on traditional profitability indicators and non-monetary indicators proposed in this study. In the final step, transport planners and/or operators must synthetically judge alternatives from these points of view.

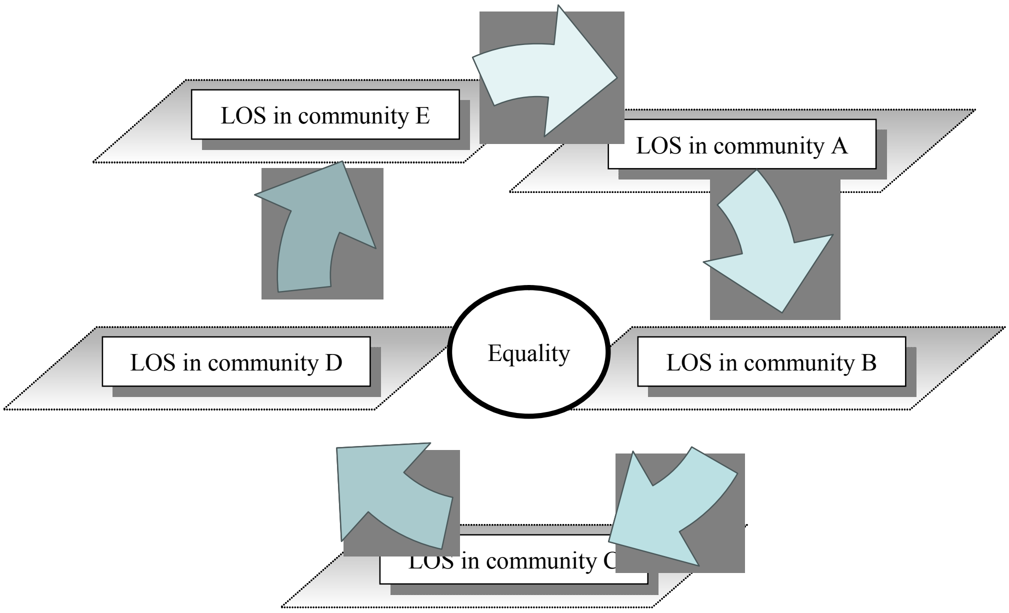

Figure 2. EQ Indicator among Communities

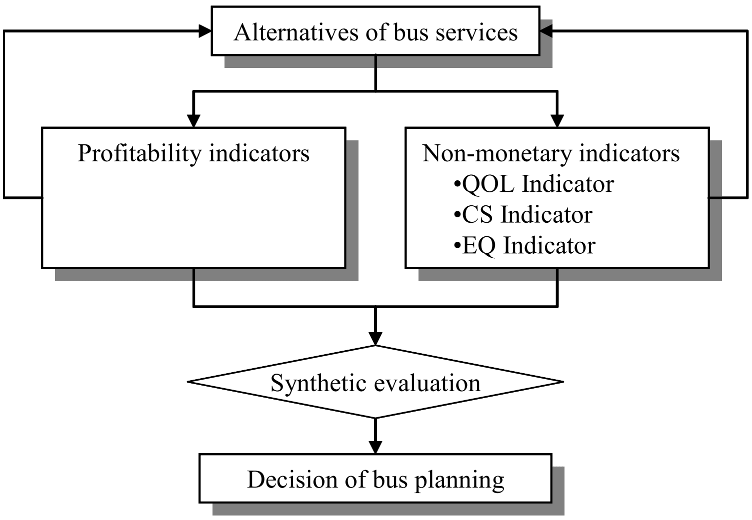

Figure 3. Synthetic Evaluation of Alternative Bus Services

3. OUTLINE OF QUESTIONNAIRE SURVEY AND DATA

As a case study, we attempted to assess a bus service in a depopulated rural area in Japan by using the indicators which were mentioned in the previous section. A total four questionnaire surveys were carried out in Unnan area consisted of 8 municipalities in Shimane prefecture. A ratio of elderly people in this area has already reached to 29.5%. The high proportion of elderly people implies that there exist fewer frequent and regular travelers (e.g., commuters), and public transport takes an important role for their daily travel behavior.

Target communities of household questionnaire survey in the area were randomly selected to include various degrees of bus level-of-service, road conditions and accessibility to public facilities. In the surveys, respondents are asked to report their individual socio-economic characteristics, travel behavior using the public transport service and 5-scale satisfaction scores with ordinal numbers for QOL and CS indicators. As a result, 3,393 questionnaires were collected as in Table 1.

Table 1. Outline of Questionnaire Surveys

Name of town	Kisuki	Kakeya	Daito, Kamo, Kisuki, Mitoya, Yoshida and Kakeya	Tonbara and Akagi	Total
Date	Sep. to Oct. 2001	July 2002	Nov. to Dec. 2002	Jan. to Feb. 2003	
# of distribution	476	641	2,925	1,096	5,138
# of response	460	496	1,576	861	3,393
Response rate	96.6%	77.4%	53.9%	78.6%	66.0%

Figure 4 shows the share of travel modes in the samples. The share of public transport including bus and taxi accounts for 34% and that of non-driving car users shows 24% of total respondents. Thus, more than half respondents in this area depend on public transport services.

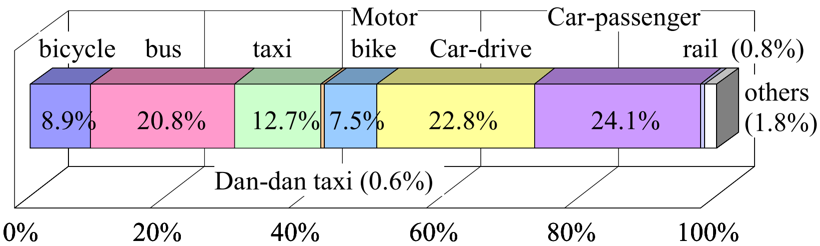

Figure 4. Share of Travel Modes

4. QUALITY OF LIFE INDICATOR

4.1 Concept of QOL Indicator

The quality of life indicator has recently been applied to evaluate transport policies and measures. For example, the new introduction of Dial-a-Ride transport service on QOL for elderly people was assessed in the North-East of England (David, 1995). The study turned out that increased mobility improved the quality of life along six dimensions: independence; loneliness; morale and life satisfaction; health and absence of pain; financial welfare; and activity participation.

Similar to the above example, this study deals with QOL to evaluate transport services, however we will focus on the effects of improvement of transport services for the quality of life of inhabitants in rural communities.

4.2 Relationship Between Level of Public Transport Service and QOL Indicator

The relationship between the levels of public transport services and QOL indicator seems not simple, because the concept of QOL means the comprehensive assessment for a variety of daily activities like medical, shopping, culture/sports and other social activities. Accordingly, the individual QOL depends on the satisfaction levels for these diverse factors. The LOS of public transport often dominates these activities, and hence it seems to directly and indirectly influence the QOL indicator.

The assumption is captured based on covariance structure model analysis. The model consists of structure equation (1) and measurement equation (2) (Jöreskog and Sörbom, 1989).

$$\eta = \mathrm{B}\eta + \Gamma\xi + \zeta \quad (1)$$

$$x = \Lambda\xi + \varepsilon \quad (2)$$

where

η : endogenous latent variables

ξ : exogenous latent variables

x : observed variables

ζ , ε : error terms

B, Γ, Λ: unknown parameter

An estimated result shown in Figure 5 expresses that the parameter of ‘distance to the community from town center’ has the most significant negative effect on ‘satisfaction with transport services’. This means that the inhabitants in communities far from town center feel inconvenience of travel. The parameters of ‘distance to the closest bus stop’, ‘bus frequency’ and ‘bus fare’ indicate all higher values. Accordingly, the synthetic satisfaction level for living environment in each community depended directly and indirectly by the level of public transport services.

All parameters of paths from ‘satisfaction with transport services’ to those with other four daily activities have positive signs and the significant values. Therefore, the improvement of mobility in the community will contribute to raising the QOL indicator.

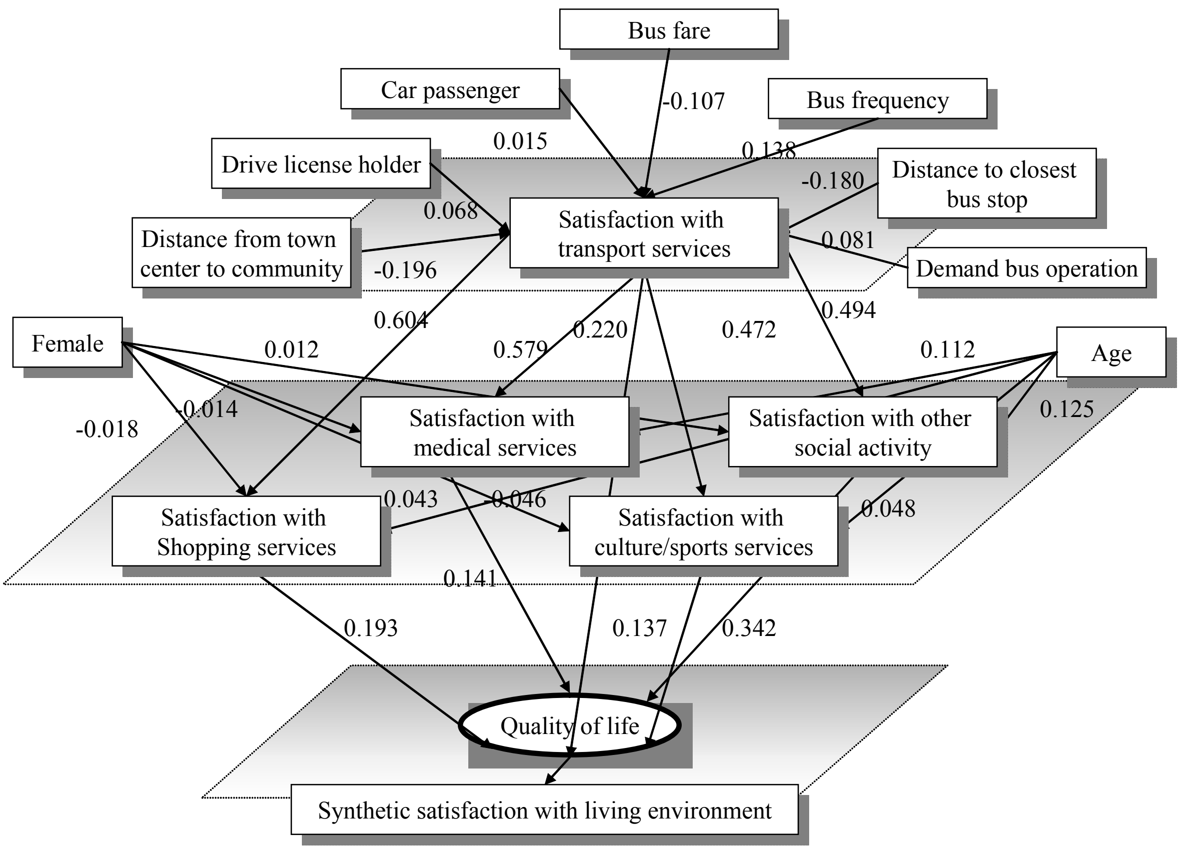

Figure 5. Relationship between Various Factors and QOL

All the parameters of paths toward ‘synthetic satisfaction with living environment (i.e. QOL)’ have positive signs. Consequently, the improvement of daily activity conditions is also effective in order to enhance QOL indicator for residents in the community. Furthermore, because the levels of satisfaction with the daily activities are affected by that of transport service, it is essential take measures of transport services to support daily activities of elderly people that can not use a car by themselves in rural areas.

4.3 Modeling Quality of Life Indicator

Referring the analysis results in the previous section 4.2, we attempt to develop a model of ordered probit type to describe the cause-effect relationship between transport service levels and QOL indicator. The model will evaluate the future level of individual’s QOL indicator after the introduction of a worsening (or improving) bus service based on the relation.

An ordered probit model has an aptitude for measuring the satisfaction levels with rating scores; for instance, the user’s satisfaction levels with a Dial-a-Ride service in North Carolina was evaluated by the model (Ben-Akiva, 1996). The model can be estimated by using the maximum likelihood method of which likelihood function can be expressed as the following equation (3).

$$P(k)=\Phi(\theta_k - V_i + V_e) - \Phi(\theta_{k-1} - V_i + V_e) \qquad (3)$$

where $\Phi(\bullet)$ is the CDF of standard normal distribution.

The endogenous variable of the model is indicated by 5-scale satisfaction scores with ordinal numbers for living environment.

Table 2. Estimation Result of QOL Indicator Model

Explanatory variables	Estimated parameter (t-statistics)
Car passenger dummy	0.115 (1.40)
Age	0.006 (3.30)**
License holder	0.008 (0.13)
Female	-0.044 (-0.73)
Distance to town center	-0.042 (-7.08)**
Demand bus dummy	0.010 (0.10)
Distance to closest bus stop	-0.180 (-4.14)**
Bus fare in 100 yen	-0.076 (-1.06)
Bus frequency	0.045 (4.34)**
Constant	1.197 (5.04)**
Threshold θ1	0.874 (20.61)**
Threshold θ2	0.936 (27.33)**
Threshold θ3	1.053 (23.35)**
Initial likelihood	-3853.28
Maximum likelihood	-2314.88
McFadden’s rho-squared	0.396
Number of samples	1,616

** 99% confident level * 5% confident level t-statistics in parenthesis

The estimation result in Table 2 shows a high goodness-of-fit index (i.e. adjusted McFadden's rho-squared=0.396). Therefore, we can confidently use the model to evaluate the QOL indicator in this study. The positive signs for all parameters drive the reasonable findings that the better levels of services can raise the QOL indicator. In particularly, the parameters of 'distance to the closest bus stop' and 'bus frequency' are statistically significant so that the flexible bus service like demand responsive transit (DRT) could be acceptable in this study area.

5. CUSTOMER SATISFACTION INDICATOR

5.1 Concept of Customer Satisfaction Indicator

Customer satisfaction (CS) of residents has recently been a well-known indicator to pre-evaluate various projects of social infrastructure development and public service. There are many applications of this evaluation method in the field of transport services planning since 1990's. For example, Wallace (1996) who dealt with paratransit customers in southeastern Michigan developed a model to assess the causal factors to customer satisfaction with the paratransit service.

The CS indicator is defined as a passengers' satisfaction with public transport services in this study. It directly represents their subjective evaluation obtained from an ordinal questionnaire survey.

5.2 Modeling Customer Satisfaction Indicator

The ordered probit model is applied to quantify the CS indicator using user's satisfaction with bus services same as QOL indicator. The endogenous variable of the model is 5-scale satisfaction scores with ordinal numbers obtained by result of four questionnaire survey data.

Table 3. Estimation Result of CS Indicator Model

Explanatory Variables	Estimated parameter (t-statistics)
Direct route to hospital dummy	0.011 (0.13)
Beginning time of operation before 8:00 dummy	0.183 (1.77)
Closing time of operation after 17:00 dummy	-0.027 (-0.03)
Age	0.009 (4.56)**
Distance to town center	0.017 (2.66)**
DRT dummy	0.484 (3.54)**
Distance to the closest bus stop	-0.174 (-3.79)**
Fare in 100yen	-0.195 (-2.88)**
Frequency	0.003 (0.30)
Constant	1.146 (4.65)**
Threshold θ1	0.670 (14.35)**
Threshold θ2	1.473 (31.97)**
Threshold θ3	0.717 (16.93)**
McFadden's rho-squared	0.449
Number of samples	1,338

** 99% confident level * 5% confident level t-statistics in parenthesis

The estimated result of the ordered probit model is shown in Table 3. The goodness-of fit index 0.449 is quite sufficient and all the parameters of levels of transport services have reasonable signs are significant excluding ‘frequency’. Therefore, an improvement of level of ‘distance to the closest bus stop’ and ‘fare’ can improve the user’s CS indicator. The positive parameter of DRT dummy implies the DRT service will contribute to improving the CS indicator.

6. EQUALITY OF PUBLIC TRANSPORT SERVICES INDICATOR

6.1 Concept of Equality Indicator

The last indicator is Equality of public transport services (EQ) among the relevant communities. To secure the equivalent opportunity to go out for all inhabitants in municipality is a non-negligible indicator as well as the QOL and CS indicators. The EQ indicator is defined as the ratio of the number of communities where the minimum level of transport services is maintained to that of all communities in the area.

6.2 Modeling Equality Indicator

Based on the previous analysis in this paper, it is assumed that the EQ indicator is measured by observable LOS variables including the distance to closest bus stops from respondent’s home, bus fare to hospital, travel time to hospital in each community. These factors are exogenously obtained from community-wide GIS.

Figure 6 shows a spatial distribution of communities that cannot access to the closest bus stop within 1km from the center. The EQ indicator was calculated 94.9% in this case, and hence it is concluded that the equality of accessibility for bus services is not low.

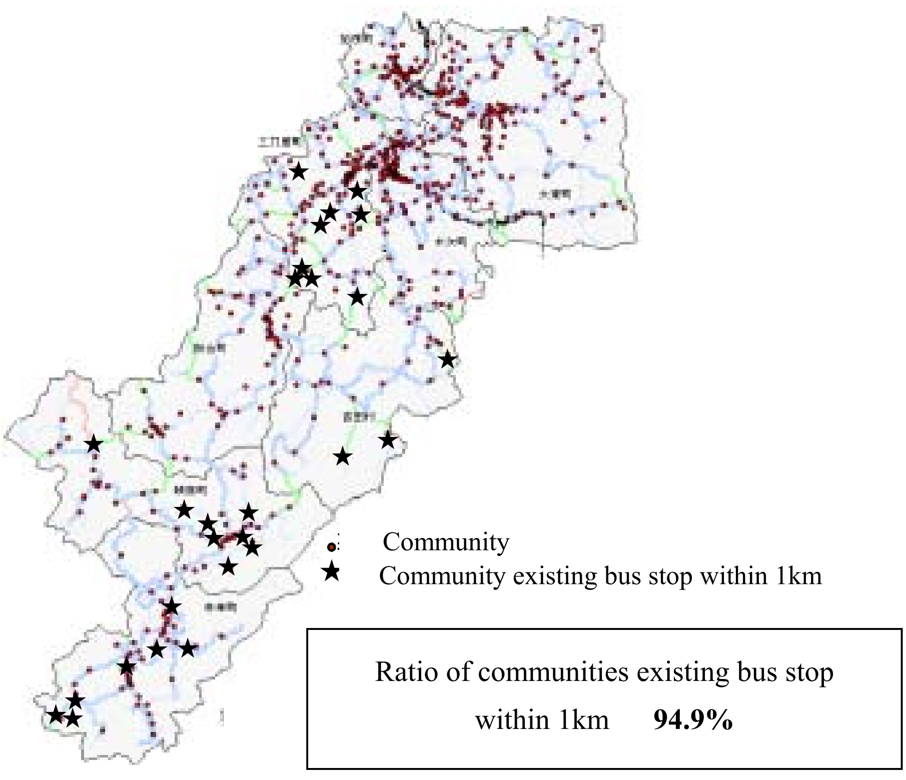

Figure 6. Spatial Distribution of Communities Accessible to Closest Bus Stop within 1km

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7. CASE STUDY IN A RURAL AREA

A case study to apply three non-monetary indicators proposed in this study is carried out in a rural town, called Mitoya in Shimane prefecture, Japan. The target five communities in the town were selected by considering the diversity of bus level-of- service, road conditions and accessibility to public facilities (Figure 7). The levels of existing bus services in this town are not adequate as usual; that is the fare is flat fare of 200 yen, while bus frequency is only 4 or 5 operations per day.

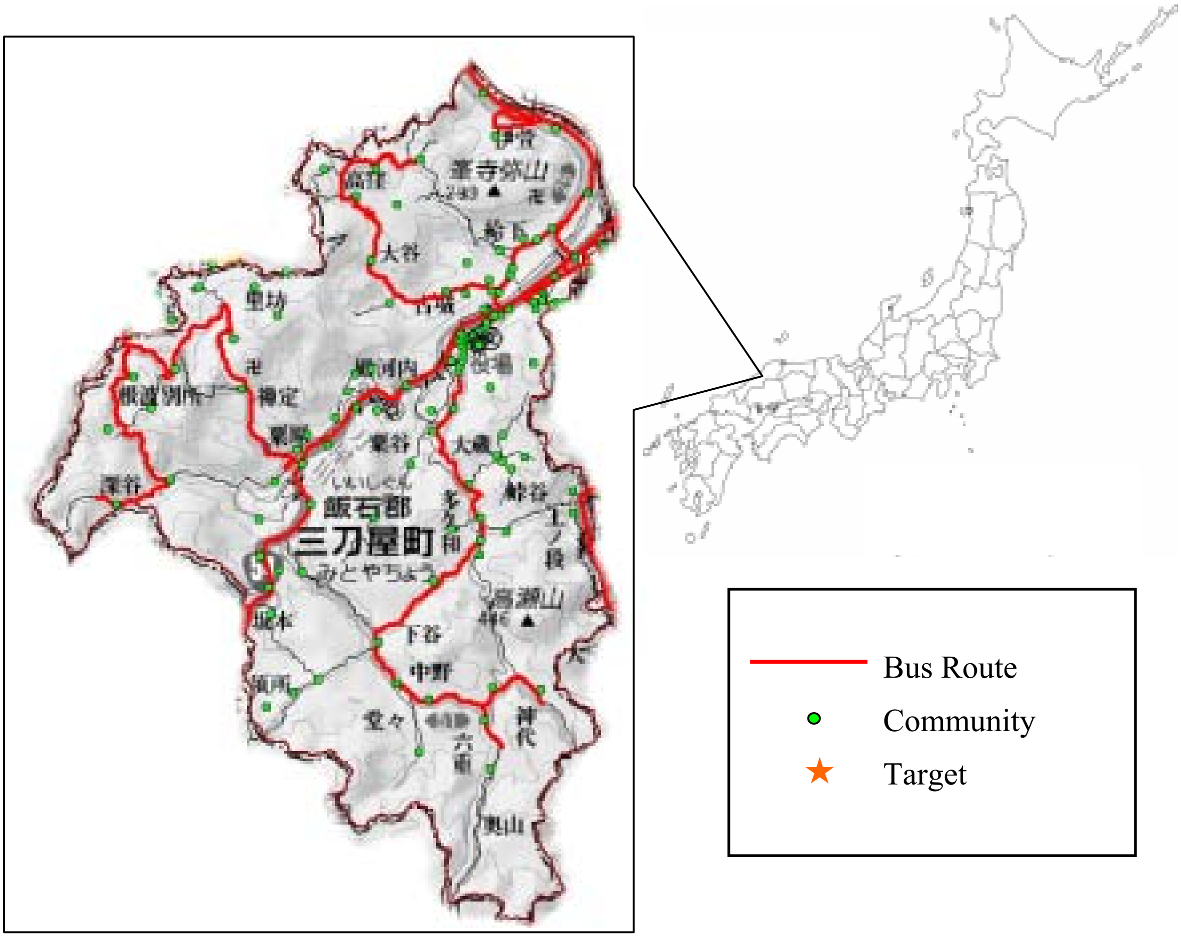

Figure 7. Distribution of the Target Communities in Case Study

In order to examine the applicability of three non-monetary indicators, we conduct simulation analysis with three different scenarios. The scenarios built in this study are shown as follows:

Senario1: current service
: This scenario is set up to evaluate the improvement of levels of the existing bus service with fixed route and time table as shown in Figure 8.

Senario2: Additional bus stops
: Several bus stops are additionally installed in some communities where the closest bus stop does not exist within 1km currently. The vehicle is coincide with that in the scenario 1.

Senario3: Demand responsive transport
: Users can make reservation by telephone to picked them up at homes (i.e. door-to-door service). The operation system and vehicle shows in Figure 9.

The fare and bus frequency are set up as constant level of current service in all scenarios; 200yen and 4 or 5operations per day, respectively.

Figure 8. Existing Bus Services of Normal Type

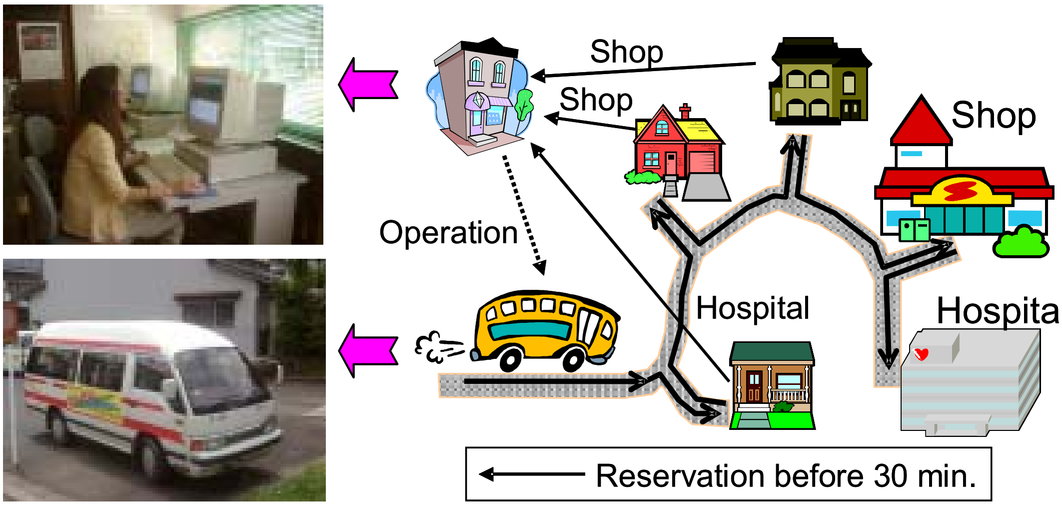

Figure 9. Operation System of DRT Service

The simulation results are shown in Table 4. The QOL and CS indicators are estimated by the ordered probit model and then they are transformed to respondent's 10-scale satisfaction scores from 5-scal ones to make comparison easier.

The estimated QOL and CS indicators are less than 5.0 with Scenario 1 of the current service level. The EQ indicated by a ratio of communities existing bus stop within 500m shows a relatively low value of 77.2%. As opposed to this, several bus routes are extended to install bus stops in some communities in scenario 2. Therefore, the EQ indicator is improved up to 90.6%. The QOL and CS indicators become higher than 5.0 in communities C, D and E. However, those of community A are not higher than 5.0, because bus stops cannot be installed additionally with restriction of road space on route. The QOL and CS indicators in scenario 3, i.e., DRT door-to-door service, present higher values in all communities by compared with the other ones. Especially, the CS indicators are improved higher than 6.0 in all communities. Moreover, the EQ indicator in scenario 3 fully satisfies with the criteria that the distance to the closet bus stop is 500m in all of communities. The small vehicle of DRT enables to operate on narrow roads in this area.

It is found in the simulation result that shortening distance to the closest bus stop can be improved the evaluation not only for public transport services but also for living environment in the community. Therefore, the distance to the closest bus stop is an important factor of equality among communities in a rural area. The simulation result of proposed three indicators allows that DRT service offering the door-to-door service is more acceptable in rural areas, in case that the profitability is acceptable.

Table 4. Simulation Result of Non-monetary Indicators

Scenario	community	A	B	C	D	E
Scenario 1	Operation freq.	4	5	4	4	4
	Dist. to BS	0.87	0.67	0.42	0.97	0.90
	QOL	4.85	5.24	4.80	4.87	4.67
	CS	4.48	4.81	4.75	4.47	4.54
	EQ	77.2% (communities existing bus stop within 500m)				
Scenario 2	Operation freq.	4	5	4	4	4
	Dist. to BS	0.87	0.03	0.08	0.35	0.08
	QOL	4.96	5.96	5.44	5.52	5.52
	CS	4.49	5.21	6.24	6.06	6.20
	EQ	90.6% (communities existing bus stop within 500m)				
Scenario 3	Operation freq.	5.5	5.5	5.5	5.5	5.5
	Dist. to BS	0.01	0.01	0.01	0.01	0.01
	QOL	5.60	5.61	5.34	5.55	5.43
	CS	6.01	6.01	6.11	6.03	6.08
	EQ	100.0%(communities existing bus stop within 500m)				

8. CONCLUSIONS

This paper emphasized the necessity of three non-monetary indicators named as 'Quality of Life (QOL)', 'Customer Satisfaction (CS)' and 'Equality of public transport services (EQ)' to evaluate public transportation planning in depopulated rural areas. Through an empirical analysis for bus services, it is found that the proposed indicators are useful to evaluate the effects of improving the levels of public transportation services and can consequently contribute to planning more thoughtful public transportation.

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