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Effects on Service Improvement of Mobility Management for Sustainable Urban Transport

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1. INTRODUCTION

Sustainability is the balance between human society and the environment for future generations fundamentally. To achieve this equilibrium, several complex problems need to be solved. Meanwhile, governance involves many organizations and stakeholders in addition to the government that takes decisions affecting others. Sustainability governance can be defined as a framework within which the global environment for future generations is discussed and then determined. Participation requires all stakeholders to have a voice in influencing decision-making. The decision-making process has been a frequent topic of discussion and has led to the introduction of strategic environmental assessment (SEA). SEA is a systematic and comprehensive process for evaluation the environmental effects of a policy, plan or program (PPP) and its alternative at the earliest appropriate stage of the publicly accountable decision-making process [7], [14].

Based on the idea of SEA, the transport planning should be promoted. Especially, a sustainable city planning including a new management for human mobility should also be discussed in terms of the environment for future generations. In these years, it has been common to argue a sustainable city or eco-city which is the city designed with consideration of environmental impact, inhabited by people devoting to minimization of required inputs of resources and outputs of waste and polluted loads [15]. Specifically, it is to create the smallest possible ecological footprint, and to produce the lowest quantity of pollution loads, to use urban area efficiently, to reduce use of the fossil fuels [21]. So an urban planning system should be reconsidered in terms of sustainable policies. Here, the sustainability in urban areas involves attempts of urban development including environmental, social and economic improvements, policies and practices on the next generation stage [12]. In most of Japanese cities and towns, transport planning is based on a point of respect for use of car vehicles.

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Accordingly the increase of automobile traffic has often occurred traffic congestion in downtown areas. As a result, traffic congestion causes the reduction of car speed and the increase of fuel for car vehicles in a downtown area, while car drivers use their car vehicles even for walking distance conveniently [13]. Therefore, it is necessary for the cities to improve the transport service in their areas including such various modes as walking, cycling, and public transit oriented system, so called the mobility management. Those traffic modes contribute to the improvement of urban sustainability positively and can give us an appropriate mobility measure. At the same time, we can also verify an appropriation of introducing such mobility management [8].

In this study, first of all, the effect on the introduction of a new public transport system, namely, an extension of tram car system is assessed. Here, the impacts on surrounding areas due to tram line extension are evaluated in view of the sustainable urban planning. The next objective is to evaluate the effects on the improvement of an underground passage, which is more convenient for pedestrian to go around the downtown area. The former measure has been planned and the latter measure has just been used in Sapporo city which is located in Hokkaido Japan in 2011. The population of the city is 1.9 millions approximately.

Finally, the results are discussed in view of urban sustainability.

2. STRATEGIC ENVIRONMENTAL ASSESSMENT FOR SUSTAINABLE URBAN TRANSPORT PLANNING

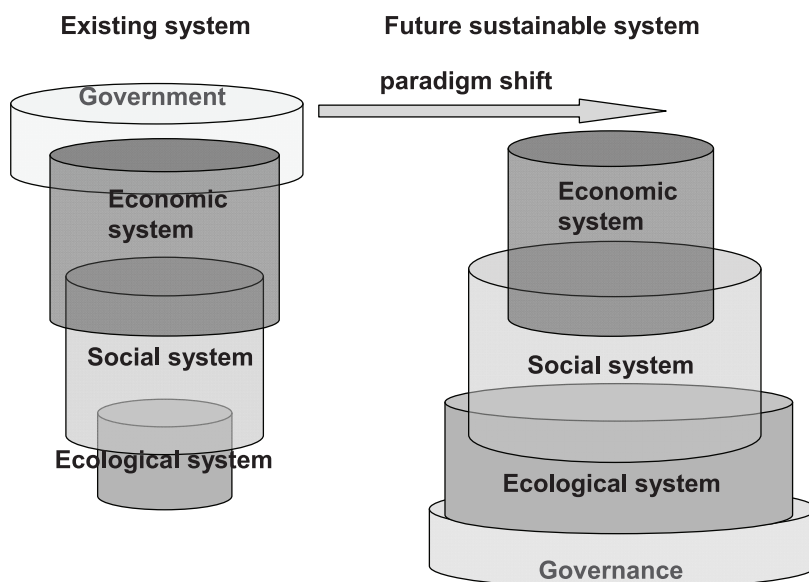


Figure 1. paradigm shift from existing system into future sustainable evolution

The 1987 Brundtland Report, *Our common Future*, defined sustainable development as development that meets the needs of the present without compromising the ability of future generation to meet their own needs. According to this report, sustainability draws on the continuity of economic, social, institutional and environmental aspects to provide the optimum outcome for human and natural environments both now and in the indefinite future. To evaluate sustainability, the decision-making process should involve the policy, plan and program (PPP) procedure and other appropriate indicators. In PPP, the policy is a broad statement of intent, comprising an objective and a broad course of action to meet it; the plan is a specific strategy outline for policy implementation; and the program lists highly specific proposals or instruments for policy implementation. The PPP creates the hierarchy of the decision-making process and also results in a tiered relationship. Thus, the SEA approach provides decision-makers with better information on the impacts of alternatives in a proactive and systematic manner [23]. Figure 1 shows a framework of nested structure to evolve the sustainability governance.

In Japan, either national or local government has undertaken infrastructure improvements, for example, in transport systems and river environment systems based on the SEA. The author has also promoted the decision-making process due to the concept of the SEA in the fields of not only transport planning but also river improvement planning. This decision-making process is shown in Figure 2. It can be divided into three groups of stakeholders: administration, community and the support groups. Efficient collaboration between these groups can enhance sustainability governance planning. This planning process also includes three procedural phases which are devised from Stage 1 to Stage 3:

Stage 1: Problem finding and checking are discussed in terms of brainstorming and morphological methods. Structural models are constructed via Fuzzy Structural Modeling (FSM) [5] at the following step. The set of models are used in a basic structure of policy-making for infrastructure planning [9].

Stage 2: during this stage, project planning is prioritizes. Several alternative plans are selected by discussing how best to achieve the project aims. Next, the most appropriate plan is determined in terms of Fuzzy Multi-Criteria Analysis (FMCA) or Analytical Hierarchy Process (AHP). The benefits are then estimated by the contingent valuation method (CVM) to confirm the economic validity of the analysis [10]. In case of transport planning some methods like a Discrete Choice Model (DCM) are used as the estimation of traffic demand on each mode.

Stage 3: The outline of the design is discussed with regard to basic factors related to infrastructure planning. Conjoint analysis is then used to evaluate several designs in terms of specific attributes. Next, a concrete design is settled upon via the governance framework,

which is composed of certain stakeholders [11]. A workshop technique is also introduced with in the governance framework for stakeholder discussions, usually involving administrative organizations, local residents, technical experts, consultants and non-profit organizations (NPOs).

Here, it is discussed that several methods in stage 2 and stage 3 are applied to sustainable transport planning focused on the mobility management.

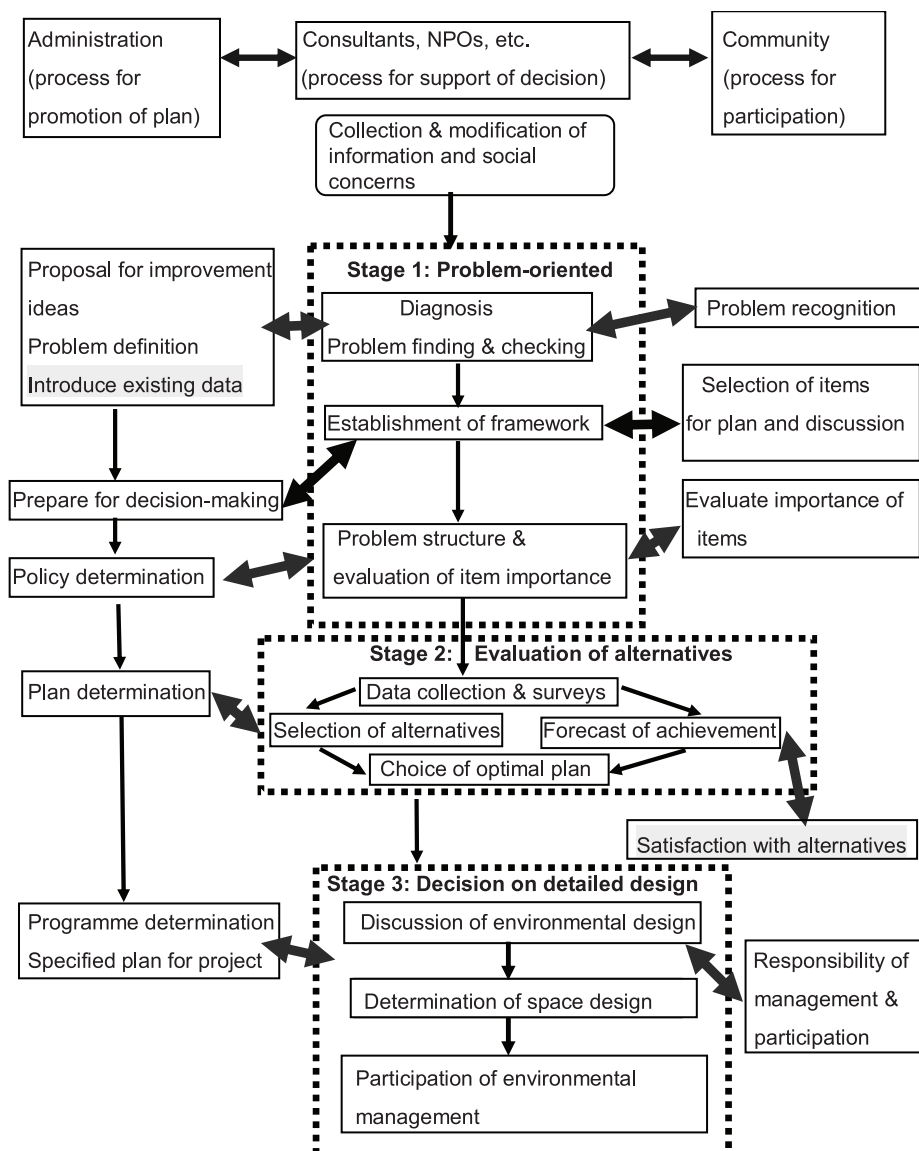


Figure 2. Proposed planning process based on SEA

3. METHODS AND ANALYTICAL PROCEDURE

3.1. Procedure of analysis

In urban transportation planning, it is popular to evaluate the appropriation of a plan on transport facilities using a monetary analysis such as the cost-benefit analysis. However, it can be limited to use such an analysis in case of downtown transport planning because of complexity of a traveler behavior and multifarious needs of inhabitants [18]. So some different methods should be introduced to analyze the assessment based on human behavior and needs for mobility directly [4], [6].

Thus, analytical procedure of this study is proposed depending on the specific measures as shown in Figure 3.

First of all, several attributes were introduced to apply Analytical Hierarchy Process (AHP) to the evaluation of alternative plans in case of the extension of tramcar line. Next effects due to the extension of tramline were compared with the existing case. Moreover, it was verified that the strength of approval toward the new plan was calculated by application of Contingent Valuable Method (CVM) [14]. That is, the residents' expectations for the effect of extension of tramline were indicated in terms of the willingness to pay (WTP). On the other hand, a model of individual choice behavior was built to catch visitors in commercial facilities due to season, weather, scale of facility and respondent's attributes. And then, the visitors' choice behaviors in commercial districts were used to evaluate effects on the use of underground pedestrian path. Finally, the synthetic effects on urban sustainability were discussed due to two new improvement of transport in downtown in view of sustainability.

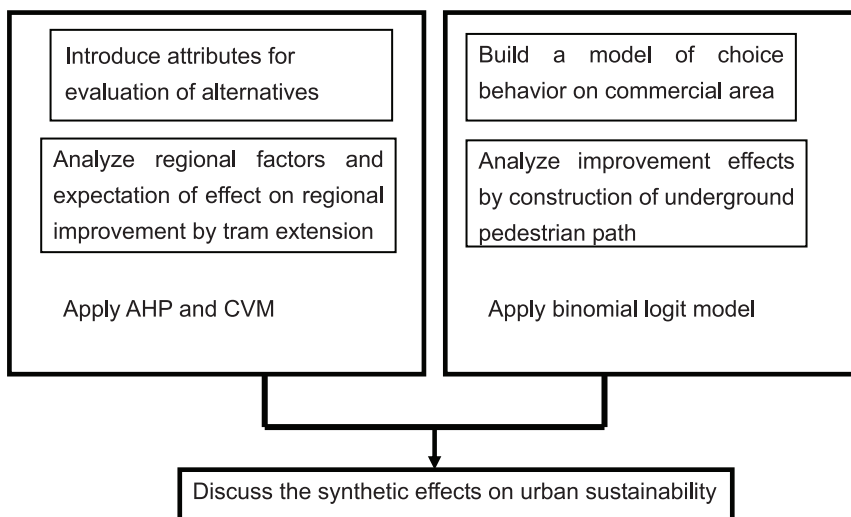


Figure 3. Analytical procedure of this study

3.2. Procedure of analysis

(1) Application of AHP

As mentioned in the previous section, AHP was introduced to indicate the attractiveness of the downtown area after the extension of tramline quantitatively. The general procedure of the method is implied as the following contents [22]:

- 1) Compose the hierarchical figure by analyzing a problem.
- 2) Assess the importance of factors in each level and make a matrix. The interrelation is examined from an upper level to a lower level orderly with a pair comparison [19].
- 3) Compute the weight of factors and consistency index (CI) in each pair of matrix.
(Two kinds of pair comparisons)
i) A pair comparison in each level and ii) a pair comparison of alternatives in every evaluated factor is shown.
(Calculation of weights)
i) Geometry mean of each factor and ii) weight based on geometry mean formulated as Equation 1 and Equation 2.

$$A_i = \sqrt[n]{a_1 a_2 \dots a_n} \quad (1)$$

$$W_i = \frac{A_i}{\sum_{i=1}^m A_i} \quad (2)$$

where a_n : surveyed importance of sample n , A_i : average importance of factor i in all respondents, W_i : weight of factor i .

(Consistency index CI) consistency index is formulated as Equation 3.

$$CI = \frac{\lambda_{\max} - m}{m - 1} \quad (3)$$

where $\lambda_{\max}$: maximum eigenvalue, m : number of factors.

- 4) Compound weights from the result of a pair comparison analysis and obtain the comprehensive weight of an alternative.

(2) Evaluation in terms of CVM

When there is originally no market on the evaluation, CVM makes a market imaginarily and intends to consider it [7].

In this method, first of all, the contents of environment and administrative service are provided for the respondents. And then, the willingness to pay is asked toward heightening a

quality level of environment. On the other hand, the willingness to accept compensation (WTA) can be calculated if environment or administrative service is declined. The WTA is indicated as the necessary money to obtain the original utility again. CVM can also evaluate both the use values and the holdover value. Direct and indirect use value and option value are measurable even in terms of usual consumer's surplus analysis and Hedonic approach which is a kind of the analyses on the non-market material. But it is only possible to evaluate the existing value in terms of CVM. The CVM is possible to estimate not only the values of substantial environment or administrative service but also their virtual values. On the basis of the questionnaire it is supposed to the imaginary situation, it is possible to ask monetary values of environment and the administration service directly. The questionnaire of WTP in CVM is divided roughly into the following four methods.

- 1) Free answer: to ask sum of payment freely.
- 2) Bid price using game mode: to ask agree or disagree with the proposed price to repeat until obtaining the answer of "No".
- 3) Payment card system: to answer the appropriate value within some alternative choices.
- 4) Pairing choice system: to ask agree or disagree with proposed price

This study adopted the payment card system.

Supposed the probability of agreement with a given WTP price to $\text{Pr}[\text{yes}]$, it is formulated as Equation 4.

$$\text{Pr}[\text{yes}] = \frac{1}{1 + e^{-\Delta V}} \quad (4)$$

where ΔV ; a difference of utility between proposed prices.

Here, it can be estimated parameters of estimate equation by maximum likelihood method as equation 5 [6].

$$\Delta V = \alpha + \beta T + \sum_{i=1}^n \gamma_i y_i + \sum_{k=1}^m \delta_k z_k \quad (5)$$

where $\alpha, \beta, \gamma, \delta$; parameters, T is a proposed price, y_i ; variables of a respondent's attributes ($i = 1, n$), and z ; variables of a respondent's awareness ($k = 1, m$).

(3) Choice behavior model for visiting facility

Choice behavior model to visit facility (district) is constructed depending on the choice structure shown in Figure 4 [1], [20]. First, the discrete choice model to visit facility in case of each different season and weather condition is constructed by using binomial logit model (NL model). Using results obtained by questionnaire, a choice behavior is modeled for selecting a district from two different districts corresponding to three objectives, namely, shopping, eating

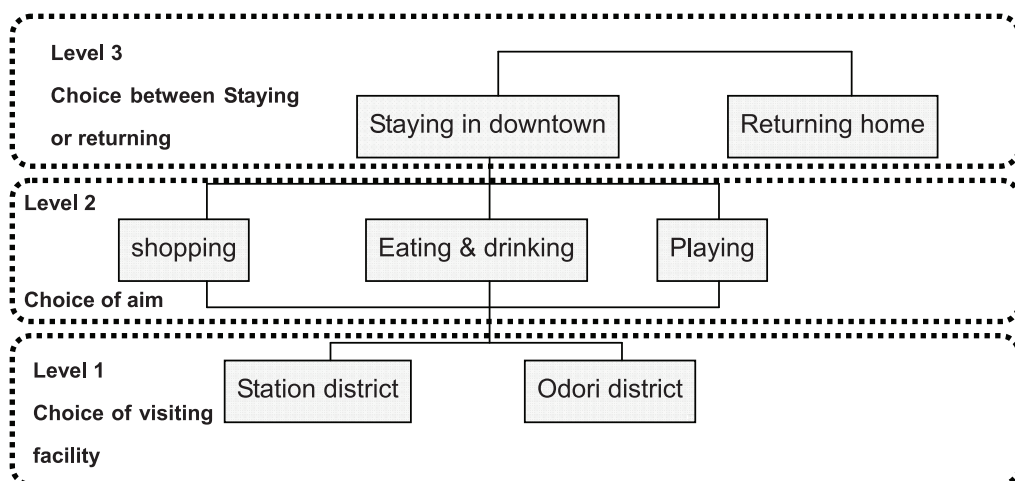


Figure 4. Structure of choice behavior model

and drinking, and playing [3].

In this study it is supposed that a main effect due to pedestrian travel through underground path is regarded as the reduction of travel time and without weather conditions. The explanatory variables are represented as each season, each weather, pedestrian time to facility, the scale of facility, and dummy variables of generations [16].

Specifically, symbols of provided equation are represented as

$g \in G$: set of generations

$w \in W$: set of weathers $\{f: \text{fine}, r: \text{rain}, c: \text{snow}\}$

$p \in P$: set of aims $\{b: \text{shopping}, e: \text{eating and drinking}, j: \text{amusement}\}$

$d \in D$: set of downtown districts $\{o: \text{Ohdori district}, s: \text{Sapporo station district}\}$

$a \in A$: set of activities $\{y: \text{staying in downtown}, n: \text{going back to home}\}$

The utility function in the model is defined as Equation 6 using above variables.

Here, v_{ypd}^k ($(\forall p \in P, \forall d \in D)$) is the utility of person k having objective p and selecting facility d , and δ_g^k is the dummy variable (generation g of person k is 1 and otherwise is 0).

$$\Delta v_{ypd}^k = v_{ypo}^k - v_{yps}^k = \sum_{w \in \{f, r, c\}} \theta_w (t_w^o - t_w^s) + \theta_m (x^o - x^s) + \theta_o + \sum_{g \in G} \theta_g^p \cdot \delta_g^k \quad (6)$$

t_w^d : walking time to facility d in weather w ,

θ_k : parameter of walking time in weather w ,

x^d : facility scale d ,

θ_m : parameter of facility scale,

θ_g^p : parameter of generation g having objective p ,

θ_g : constant (district B)

Walking time is real time in a rain. U_{ypd}^k is probability variable.

$$U_{ypd}^k = v_{ypd}^k + \varepsilon, \quad \varepsilon \sim iid \text{ (depending on Gumbel distribution)}$$

The choice probability of each facility is given Equation 7 [17].

$$P_{yps} = \Pr(U_{yps} > U_{ypo}) = \frac{1}{1 + \exp(\Delta v_{ypd})},$$

$$P_{ypo} = 1 - P_{yps} \quad (7)$$

(4) Choice behavior model for staying/ returning

If model structure as shown in Figure 2 is regarded as MNL model, log- sum variables of facility utility can be represented as the utility of each objective. This variable is represented as Equation 8.

$$v_{yp}^k = \ln\left(\sum_{d \in D} \exp(v_{ypd}^k)\right) \quad (8)$$

Choice probability is formulated as Equation 9.

$$P_{yp}^k = \frac{\exp(v_{yp}^k)}{\sum_{p' \in P} \exp(v_{yp'}^k)} \quad (9)$$

As same way, the log-sum variable obtained by utility of each objective is regarded as Equation 10.

$$v_y^k = \ln\left(\sum_{p \in P} \exp(v_{yp}^k)\right) \quad (10)$$

The utility of choice for returning home (going back to home) during staying time t is formulated in Equation 11. Moreover, the choice probability between staying in downtown and returning home is calculated by binomial logit model as Equation 12. The parameters are also estimated by binomial logit model.

$$v_n^k = \theta_t \cdot t \quad (11)$$

$$P_n^k = \frac{1}{1 + \exp(\Delta v_a^k)}, \quad P_y^k = 1 - P_n^k$$

$$\text{where } \Delta v_a^k = v_n^k - v_y^k = \theta_t \cdot t - \theta_y \cdot v_y^k \quad (12)$$

4. ANALITICAL RESULTS

4.1. Case study 1: Effects due to extension of tramline

(1) Objectives

The objectives of case study 1 are mentioned in detail. It is to investigate the indirect effect (impact on surrounding areas) of the extension of Sapporo tramline. The district with tramline extension via Station Avenue is called as Naebo district. Up to the present, when a local government examines the introduction of a new public transport system, profitability (supply and demand) of the system is main concern. However, an assessment of the impacts on surrounding areas by the system is also important from the aspect of deliberate urban planning.

(2) Questionnaire survey

The questionnaire was surveyed on the following objectives, namely, what residents in Naebo district desired in terms of extension of tramline, what they expected some effects including the residents in the surrounding district, and how much they should paid to the plan on extension of tramline as an indicator, that is, WTP.

First of all, the questions for pair-wise comparison and alternative comparison survey were provided with analyzing AHP. The alternatives were considered as the case of extension of tramline or existing case comparatively.

As the second viewpoint, the questions were made with regard to WTP using CVM. Specifically, a method of payment was introduced in order to support management after completing the extension of tramline.

The questionnaire survey was performed in the area of tramline extension and another area without the influence on its extension. Table 1 shows the outline of questionnaire contents in case 1.

Table 1 Outline of questionnaire contents

Surveying Date	December 18,19,2009
respondents	Residents in Naebo district and outside districts
Method of distribution	Direct distribution & collecting by mail
Number of distribution	1000 sheets (Naebo) and 1000 sheets (outside)
Number of recovery	504 sheets (recovery rate: 25.2%)
Questionnaire contents	Pairwise comparison between evaluation criteria, willingness to pay, personal attributes, etc.

(3) Results by AHP

For the purpose of analyzing what kind of factors relate to urban planning, Analytical Hierarchy Process (AHP) is applied. First, the results obtained by applying AHP are presented. Figure 5 shows the Hierarchy chart assumed in the present study. The valuation factors are attractiveness, affluence, activeness, and environment.

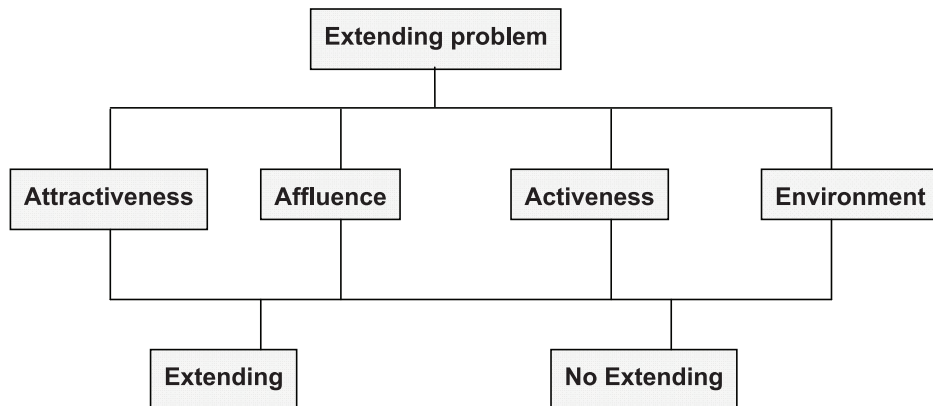


Figure 5 Hierarchy chart for AHP

Table 2 Definition of evaluation criteria

Evaluation criteria	Detailed definition
Attractiveness	This plan will increase attractiveness in the surrounding district in terms of image and symbolization.
Affluence	This plan will enhance functions in the district due to fulfillment of commercial facilities and medical facilities.
Activeness	This plan will bring activeness in the district by increase of residents opportunity for going out.
Environment	This plan will decrease environmental loads such as reduction of green house gas.

The valuation factors are explained in detail as Table 2.

From the results, Sapporo citizen in not only Naebo district with direct effects but also in the other district without direct effects expects the extension of Sapporo tramline to Naebo district due to the broad impacts in surrounding areas. According to the effect on the tramline extension, the total utility in Naebo district was increased to 2.45 times in comparison with existing condition. On the other hand, the same value in the other district was 1.47 times. The effect in the district with the directly extended plan was more remarkable than in the district without the plan. And, people living in Naebo district expect Activeness by the extension, while people living in the other districts expect attractiveness.

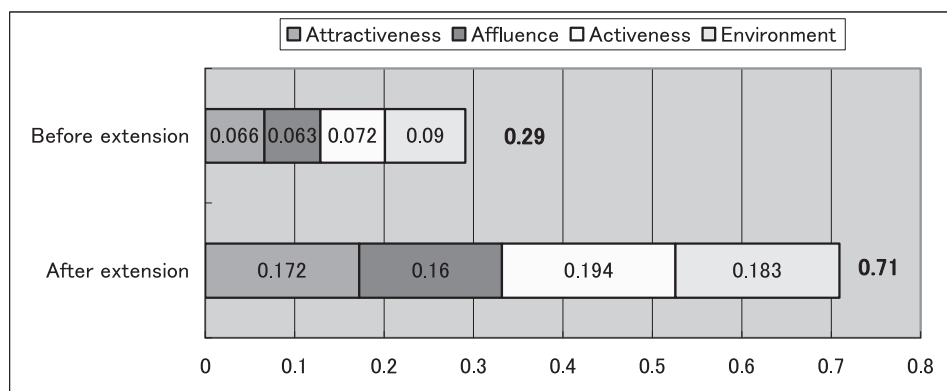


Figure6 Result of AHP (Survey on Naebo district)

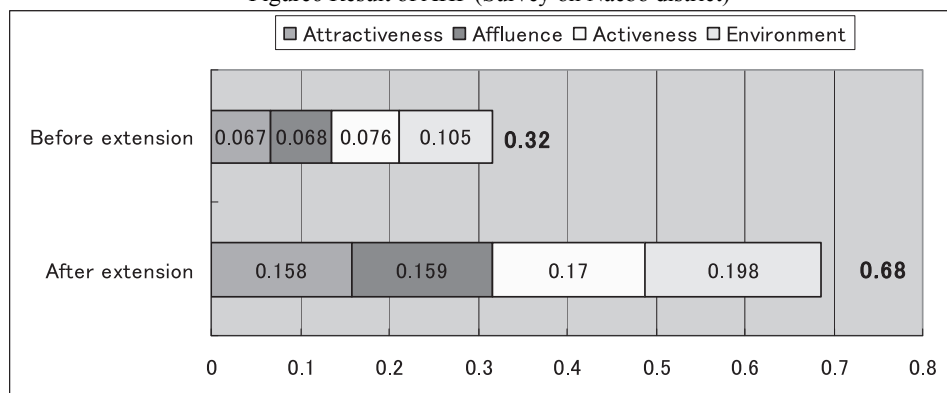


Figure 7 Result of AHP (Survey on outside district)

(4) Results obtained by CVM

Contingent Valuing Method (CVM) was applied to estimate the indirect effect by the extension of Sapporo tramline to Naebo district compared with the other districts.

the results of CVM are presented as shown in Figure 8. This Figure shows the estimation of WTP in two different districts. This result was analyzed by the effects of individual attributes on WTP. The amount of WTP and the benefit of indirect effect due to the tramline extension are estimated by the model. Figure 8 also compares real odds of willingness to pay of Naebo district to estimated odds calculated by the model. Using these results, the total value of benefit was accumulated as 13.8 million yen/year. The benefit can be divided into each criterion so that affluence, activeness and environment are 3.6 million yen/year, 3.5 million yen/year, 3.8 million yen/year, and 2.8 million yen/year respectively. Incidentally, a direct benefit in present value due to traffic demand estimation was calculated at 5.6 billion yen.

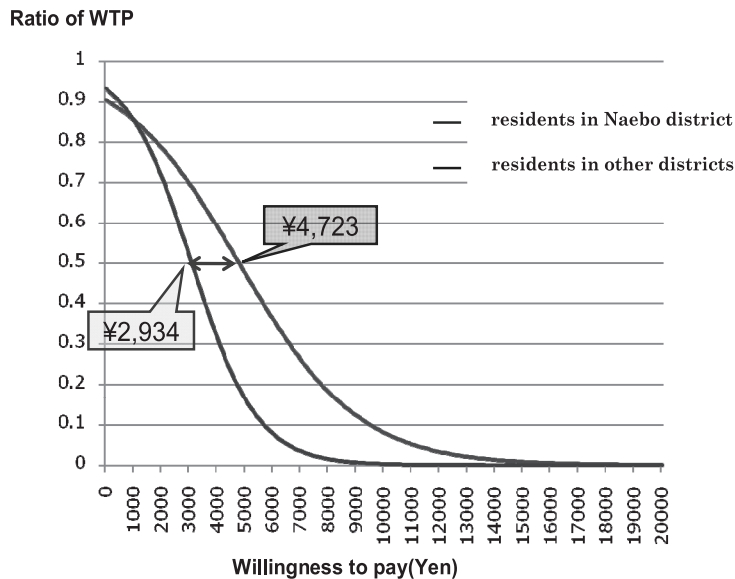


Figure 8 Estimation of willingness to pay in two different districts

Meanwhile the indirect benefit obtained by CVM was computed at 207 million yen, that is, only 3.7% of direct benefit approximately. The whole cost in present value is 5.2 billion yen. The cost benefit ratio (B/C) is 1.09 without indirect benefit and 1.14 with indirect benefit.

As above-mentioned, it was analyzed that the impact of the extending Sapporo tramline to Naebo district on surrounding areas quantitatively. This result shows Sapporo city government must address consensus-building. That is, it is shown that Sapporo citizen expects activeness and attractiveness.

4.2. Case study 2: Effects due to construction of underground pedestrian path

(1) Objectives

The road network improvement in a downtown prompts travelers to visit a new developed shopping area more frequently. For instance, the shopping area in the downtown of Sapporo is separated into two districts, that is, two commercial cores. One is the existing old shopping district and another is a new shopping district developed in recent years. Many shops have been constructed and opened in the new developed district, while the existing shopping district has declined relatively. However, the underground path was completed in 2011, so that it is easier for two shopping districts to connect with each other closely. Thus, it is more convenient for visitors to enjoy shopping requiring for attractive shops. The visitor's behavior will also change more actively.

Here, a disaggregate model was constructed to analyze visitor's behavior on shopping in the

downtown district. The factors of model include personal attributes, season and weather conditions, and scale of shopping facilities based on a questionnaire survey. At the same time the effects on building the underground path connected two shopping districts are evaluated in terms of focusing on the visitor's behavior choice for shopping facilities.

(2) Questionnaire survey

The questionnaire survey in this case study was executed on visiting aim, choice of large-scaled or small-scaled shopping facility, staying time and choice of districts in the conditions of season and weather with or without the underground pedestrian path.

The obtained data were applied to make a choice behavior model used for evaluation of effects on the measure of underground pedestrian path.

The outline of this questionnaire survey is displayed in Table 3.

Table 3 Outline of questionnaire contents	
Surveying Date	November 28, 2010
respondents	Visitors to downtown area
Method of distribution	On-the-spot distribution & collecting by mail
Number of distribution	1000 sheets
Number of recovery	339 sheets
Number of valid answer	321 sheets
Questionnaire contents	Choice of shops, activity on surveyed day, choice of facility, personal attributes, etc.

(3) Results of Choice behavior model for visitors

In general, traveling measures of a visitor in a downtown are considered multifariously. Here, only walking was introduced for giving influences on use of an underground path. A model was, therefore, based on pedestrian's behavior on it.

Pedestrian behavior choice in downtown districts was separated into three levels, namely, the first level was a choice of continuing travel activity in downtown or going back to home, the second was a choice of travel aims and the third was a choice of visiting facilities. Disaggregate model was applied to determine the choice behavior of pedestrian in downtown before and after new development of underground pedestrian path. It is supposed that visitors choose their aims and shopping facilities step by step after arriving in the downtown district.

At level 1, a binomial logit model was applied to choose the shopping site among two different districts depending upon whether the underground path is or not and weather condition. At the same time, the three objective utilities were calculated as log-sum variables of the facility utility at level 2. Finally, the binomial logit model for choosing either staying in downtown or going back to home was built based on the utility for staying and the staying

Table 4 Analysis corresponding to choice levels

Choice level	Explanatory variable
Level 3 Choice of Staying or returning	Log-sum variable Staying time in downtown
Level 2 Choice of visiting aim	Log-sum variable
Level 1 Choice of visiting facility	Walking time in summer, in raining, in snowing, scale of facilities and generation

time for each visitor at level 3. This model provides the information on time distances due to the seasonal and weather conditions and the disturbance of aim achievement and as a result, the new construction of underground pedestrian path brings effects to visitors.

The overall framework is already mentioned above in Figure 4. Furthermore, the list of explanatory variables is described in Table 4.

(4) Parameter estimation and examination

The analyses were used by free software R. Parameters estimation and examination were resulted in Table 5~7.

Table 5 Results of parameter estimation and examination in case of shopping

Aim	Explanatory variables	Parameter	T-value	
Shopping	Necessary time	summer rain snow	-0.1642 -0.1914 -0.2121	-7.6597 -6.2190 -8.9085 *** *** ***
	Constant	Odori	0.9543	6.2403 ***
	Facility scale		1.2933	12.083 ***
	Dummy of forties		0.3308	1.6941 *
	Log likelihood at zero		-736.18	
	Log likelihood		-616.20	
	Likelihood ratio		0.1969	
	Hitting ratio		0.7326	

Table 6 Results of parameter estimation and examination in case of eating & drinking

Aim	Explanatory variables	Parameter	T-value	
Eating & drinking	Necessary time	summer rain & snow	-0.2021 -0.2212	-9.0422 -9.6316 *** ***
	Constant	Odori	0.7665	5.2916 ***
	Facility scale		0.7394	7.6336 ***
	Dummy of teenagers		0.5246	1.5710
	Dummy of fifties		-0.3776	-2.1806 **
	Log likelihood at zero		-711.54	
	Log likelihood		-616.20	
	Likelihood ratio		0.1340	
	Hitting ratio		0.6537	

*** 1% of significance, ** 5% of significance * 10% of significance

年報 公共政策学 Vol. 6	Log likelihood at zero	-744.56
	Log likelihood	-632.63
	Likelihood ratio	0.1503
	Hitting ratio	0.7103
*** 1% of significance, ** 5% of significance * 10% of significance		

Table 7 Results of parameter estimation and examination in case of playing

The parameters of walking time depended upon weather condition. Namely, time resistance for waking is larger in rainy or snowy time than summer (fine) time. In view of the aim, the eating and drinking had the largest resistance. The shopping and the playing followed it. Furthermore, the larger the facility is, the larger the utility is. In particular, in case of shopping, such consideration was remarkable. The young generations were generally fond of Station district, while the old generations tend to visit in Odori district. This is because there are many old shops in Odori district which are familiar with aged people. Meanwhile, the core buildings of Sapporo station are used as their own commercial facilities in terms of new projects.

Next, the utilities of each aim and staying in downtown were calculated using the log-sum variables shown in

Table 8.

Moreover, the parameters on choice probability between staying in downtown and returning home were estimated in table 9. The hitting ratio was over 80%, so that the model was high-grade reliability.

Table 8 Utilities using log-sum variable

utility	shopping	Eating & drinking	playing
Each aim	8.5735	7.2238	8.2753
Staying in downtown	9.2740		

Table 9 parameter estimation of the model for staying or returning

Explanatory variable	parameter	T-value	
Staying time in downtown	0.0146	23.5723	***
Constant (utility of staying in downtown)	0.3712	20.6514	***
Log likelihood at zero		-1271.80	
Log likelihood		-731.45	
Likelihood ratio		0.4249	
Hitting ratio		0.8255	

*** 1% of significance, ** 5% of significance * 10% of significance

(5) Results of analysis using the model

Table 10 shows the change of the obtained choice probability in case of facilities where people visit. If the underground pedestrian path was used, the pedestrian traffic from Odori district to Station district was the increase of about 8%. Reversely, the pedestrian traffic from Station to Odori was the increase of about 15%. Odori district can obtain an advantageous condition due to using the underground pedestrian path. In view of weather condition, raining or snowing makes the increase of choice probability compared with summer (clear).

In the downtown area, Station district has large-scaled compound shopping facilities, while Odori district has small or middle-scaled shopping facilities mainly. In the next analysis, considering such a facility scale, the areas of facilities were introduced. The analytical results are illustrated in Table 11. Compared with the former analysis, the facilities in Station district obtained higher choice probability. The attractiveness of each facility in Station district can be high now because of existing large facility.

In this case study, the pedestrian choice behavior model was constructed depending on

Table 10 Choice probability change of facilities without considering the facility scale

Direction of travel	Underground path	Season & weather	Choice probability of visited facility(%)		
			shopping	Eating	Playing
Station → Odori	Without path	summer	19.80	17.67	40.4
	With path	Summer	35.90	36.96	57.42
		Rain	39.08	39.20	63.24
		Snow	41.59	39.20	68.98
Odori → Station	Without path	Summer	7.36	3.58	5.19
	With path	Summer	15.29	9.25	9.81
		Rain	17.13	10.09	12.91
		Snow	18.64	10.09	15.22

Table 11 Choice probability change of facilities with considering the facility scale

Direction of travel	Underground path	Season & weather	Choice probability of visited facility(%)		
			shopping	Eating	Playing
Station → Odori	Without path	summer	11.73	11.53	24.74
	With path	Summer	23.18	26.32	39.48
		Rain	25.68	28.21	45.42
		Snow	27.70	28.21	51.83
Odori → Station	Without path	Summer	12.87	5.76	10.18
	With path	Summer	25.09	14.36	18.38
		Rain	27.73	15.57	22.31
		Snow	29.84	15.57	27.08

weather condition, the attractiveness of facility and the attribute of visitors. The model was

applied to the improvement of underground pedestrian path. Comprehensively, the underground pedestrian path brings multi-visits to the citizens. Particularly, in raining or snowing, it is available for using such the path. It will also be expected to give a large effect due to activation of downtown.

(6) Synthetic effects on urban sustainability

Synthetic effects on urban sustainability were discussed through two case studies. Namely, the extension of tramline and the introduction of underground pedestrian path were demonstrated as the effective mobility management of transport in downtown. Basically, it is necessary for us to reduce a disparity of mobility in the downtown for future sustainability. The extension of tramline contributes to reduce the disparity of inhabitant mobility in an area with a poor public transport. This can be one of sustainable improvements for urban planning.

On the other hand, the underground pedestrian path is useful to enjoy walking in rainy or snowy weather particularly. People living in cold and much snowfall area also want to walk around downtown in winter as same as summer season. Therefore, it is important for us to promote uses of underground facility.

Both plans on mobility management are extremely available for urban sustainability.

5. CONCLUDING REMARKS

It is concluded that several important points on transport plan or management were found in view of urban sustainability through this discussion:

- 1) Transport planning should be a new method for sustaining people and their society in an urban area.
- 2) The road is not used by only car, but by pedestrian and public transport modes. Therefore, it is necessary for us to use it wisely.
- 3) Future transport planning should be made a point of mobility management, while it does not make specific facilities and establishments.
- 4) Management is to answer the needs of society, community and to devote to users as well. Transport planning should be applied to a management system with unifying with urban or community planning.
- 5) The management of tramcar should be corresponded to the needs of the district appropriately.
- 6) It is important for the opening of underground path to evaluate as one of available measure for urban sustainable in cold and snowy area. In near future, it should be discussed innovations.

As future subjects of the study, the simulation of visitors' behavior will be examined and the

possibility of comprehensive travel demand management using transit mall and so on will be confirmed quantitatively. Furthermore, the alternatives should be prepared with the agreement of inhabitants.

It is indispensable to assess the needs and concerns of the citizens to the alternatives in order to compose an appropriately sustainable plan in the future. It is also to establish the effective technique for building the transport system in downtown area corresponding to sustainability for future generations.

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Effects on Service Improvement of Mobility Management for Sustainable Urban Transport

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Abstract

In these years, the urban planning system has been reconsidered in terms of sustainable policies. The sustainability in urban areas involves attempts of urban development including environmental, social and economic improvements, policies and practices in the next generation stage. In most of Japanese cities and towns, transport planning was based on the efficiency of car vehicles use until these years. As a result, traffic congestion occurred and caused slower speeds, longer times of car vehicles in a downtown area, while car drivers used the car vehicles even for walking distance. Therefore, it is necessary for the cities to improve the transport service in their areas including walking, cycling, and public transit oriented system and so on, namely, mobility management. These traffic modes contribute to the urban sustainability positively and correspond to the appropriate mobility of the people.

In this study, first of all, the effect on the introduction of a new public transport system, namely, an extension of tram car system was examined. Here, the impacts on surrounding areas due to tram line extension are assessed in view of the sustainable urban planning. In the next objective, the effects on the improvement of an underground passage, which is more convenient for pedestrian to go around the downtown area, were evaluated. The practical research and study was examined in Sapporo City, Japan.

The results of analysis show in the following aspects: 1) the inhabitants expects the extension of tramcar in the supposed area, 2) people also expect activeness and attractiveness resulted from the extension of tram car line, 3) the pedestrians expect to be capable more choice of shop facilities, particularly, in rainy or snowy weather due to the use of underground passage, 4) the underground passage stimulates the behaviors of visitors between two commercial areas which exist separately to stay and enjoy for longer time.

Keywords

Transport planning, urban sustainability, tram improvement, mobility management

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