Evaluation Method of Alternatives for River Improvement Project with Public Participation

加賀屋誠一[1]・生駒絵里[2]・内田賢悦[3]
Seiichi KAGAYA[1], Eri IKOMA[2]and Kenetsu UCHIDA[3]

[1] Graduate School of Public Policy, Hokkaido University
[2] Koken Engineering Consultant Ltd.
[3] Graduate School of Engineering, Hokkaido University

Abstract

Recently we have discussed the alternative of river improvement which involves the nature of river as much as possible is chosen by inhabitants. However, it is difficult that the alternative puts together various awareness and ideas of the inhabitants. Therefore, workshops have been carried out as a field of opinion exchange of inhabitants and specialists. It is important to arrange the stage which collects information of the watershed in order to make the opinions of inhabitants reflect. In this study, we developed evaluation method of alternatives for river improvement project with public participation. The method includes the selection of an appropriate basic improvement plan, the concern to its improvement plan and the evaluation of specific visual alternative project, and an choice of the optimal project. The concrete procedure is composed of those methods and participation of inhabitants and workshops. The conclusions are 1) After the discussion in workshops, they agreed to determine the policy of the excavation of mid-scale riverbed in existing waterway as an appropriate improvement system. This was evaluated for the most balanced idea between the aim of flood control and that of environmental protection in terms of fuzzy integral, 2) Such an idea was recognized by inhabitants through CVM based on the questionnaire. The concerns for the policy were very high and the value of total WTP was larger than the cost of a supposed improvement project and 3) Based on such a fundamental comprehensive plan, several alternative projects composed of several factors were proposed to inhabitants. As a result, the project taking the nature friendly method in was the optimal project of all alternatives due to Conjoint Analysis. In such a way, we built the process of decision-making involving administrative organization and community, furthermore, the adjustment section- workshops. It is very important to adjust the different opinions among some interest groups. Moreover, we introduced some effective methods as supporting system of decision-making. Actually, we used fuzzy integral, CVM and Conjoint Analysis. These are appropriate to analyze the ideas or opinions from inhabitants and to guide scientific information to a common stage of decision-making.

Key Words**:** river improvement, public participation, fuzzy integral, CVM, conjoint analysis

1. INTRODUCTION

In Japan, since the new river law was established, it has been necessary to introduce the synthetic improvement scheme including river environment in addition to flood control and water use in the river development project. Planning system which reflects the opinions in the watershed should be also introduced into the aim of river environment improvement and its conservation. That is, the improvement system should be promoted in response to needs for regional inhabitant. In these years various discussions have been developed on building the methodology. The most important thing is to complete the decision process of planning and to make public participation in the process. In our past researches, some results were obtained for the establishment of new decision process of planning. However, the more detailed examination on the method for accurately catching information of the inhabitant is still needed. It is essential to study the public participation with accountability for the method of river environment improvement.

The objective of this study is to make a method of building the alternative plans and to build a procedure for determining the most appropriate improvement plan in terms of public participation.

2. PROCEDURE OF THIS STUDY

2.1 Concept of Procedure

Here, the procedure of this study was constructed as shown in Figure 2.1. The workshop promotes some discussions based on the procedure. The workshop is composed of several interest groups including residents, administration as an organizing body, planners, consultants, and NPO for regional planning etc..

First of all, several candidates of fundamental river improvement method are prepared. The appropriate method is evaluated by means of Choquet's Integral that is a kind of Fuzzy Integral.

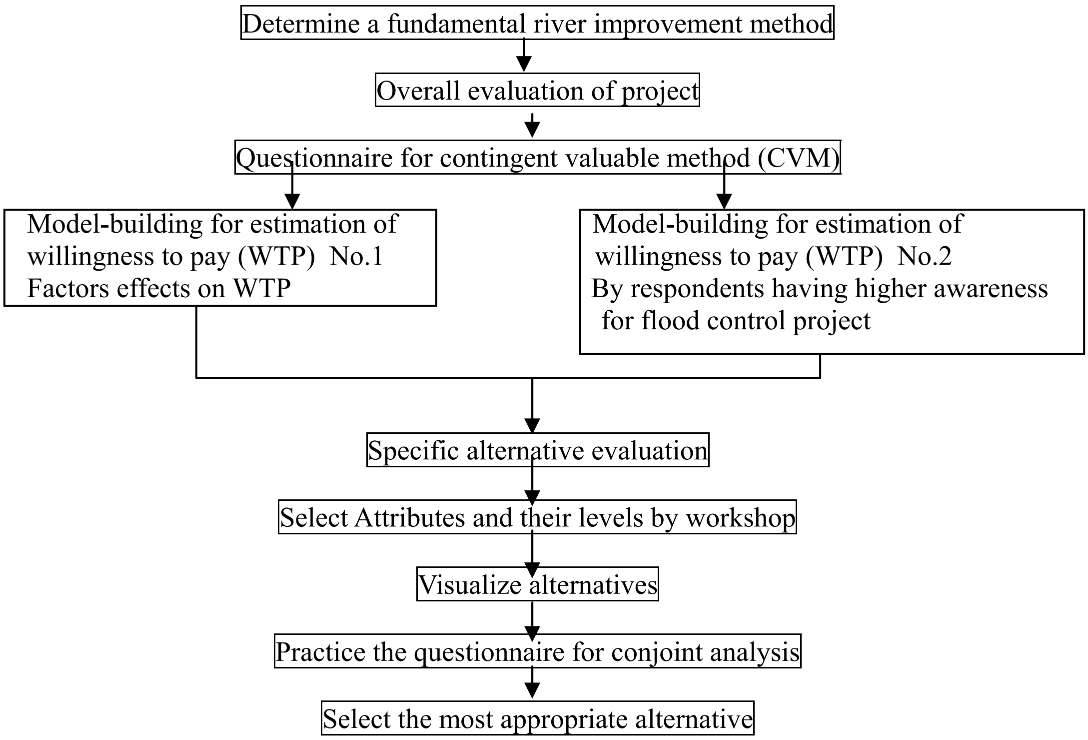


Figure 2.1 Procedure of this study

Next, we confirm the inhabitants' consequences asking the willingness to pay (WTP) for the river improvement method. The overall evaluation of the method is examined by CVM. Actually we evaluate the estimate of WTP in terms of respondents' attributes when we plan the river improvement project.

Fundamental factors composed of the river improvement are devised in order to offer information for the workshop. Next the alternative plans are composed of the factors and then are evaluated. Here, the preferential method for alternatives of the river environment improvement project is examined simultaneously.

Visual expression of an alternative plan is devised in order to give a common image to respondents. Several visual alternatives obtained are composed of montage photograph and GIS information. Using this technique, it is possible to analyze the alternatives with high-grade reliability. The bias of the evaluation on alternatives is reduced in terms of the visualization. As specific methodologies here, the conjoint analysis is introduced.

As an object area, the midstream of Tokachi River, which is called as Aioi-Nakajima District, was selected. Tokachi River is located in the east part of Hokkaido, Japan.

2.2 Public Participation of River Environmental Improvement

Usually, river environmental improvement is executed by national or local government based on the synthetic plan of a river basin. More advanced plan they have, more dependent on the execution the community is. As a result, the conflict often appears between them. Therefore, it is necessary to make a communication system for acquisition of common information with each other. This system is a kind of risk communication. We defined a workshop as a supporting group of communication. We already developed a procedure of plan making process in view of SEA. SEA is the formalized, systematic and comprehensive process of evaluating the environmental effects of a policy, plan or program and its alternatives, including the preparation of a written report on the findings of that evaluation, and using the findings in publicly accountable decision-making [1]. In this study we examine a part of procedure from stage 1 to stage 3 as shown in Figure 2.2.

Here, the role of the workshop is important to prepare some basic information as follows:

1) Determination of overall framework: Based on the motivation proposed by the government, they discuss the overall framework of project and devise the factors with relevant to it.

2) Determination of the evaluated alternatives: Based on the plan of the overall project, they select several factors and comprise several alternatives using such factors.

3) Determination and confirmation of the optimal alternative: Based on the result of inhabitants' awareness, they discuss and confirm the optimal alternative plan of river environmental improvement.

Concretely, the inhabitant interest is grasped as the river improvement project. The necessity of river improvement project is examined. And then, the effective factors which contribute to understanding of inhabitants are clarified. Moreover, the final aim is to build the decision-making system for the river improvement plan which the inhabitants expect.

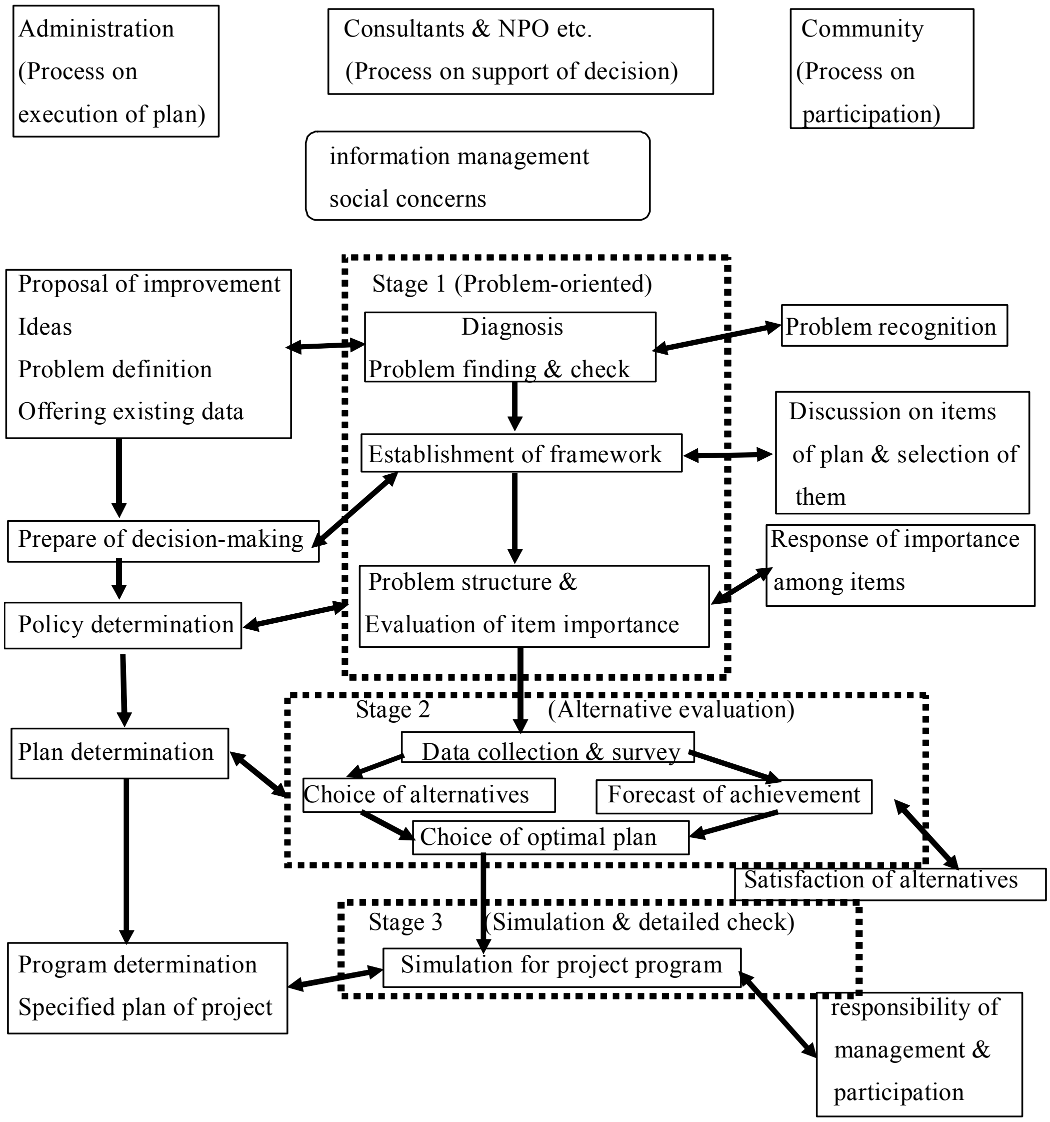


Figure 2.2 Procedure of plan making process in view of SEA

2.3 Support system in the adjustment stage

(1) Residents participation system due to the workshop

The main adjustment stage is a workshop in this method. Here, the workshop is composed of several interest groups including residents, administration as an organizing body, planners, consultants, and NPO for regional planning etc. in order to build a comprehensive plan cooperatively. The adjustment stage by the workshop was proposed as shown in Figure2.3. A purpose of the adjustment stage here is not only to propose the public participation method but also to introduce workshop in the process of plan building and specifically to utilize it for making alternatives.

1) Composition of the workshop: The workshop is composed of some groups. Here, the participants from residents in the workshop are chosen by the public recruitment. The number of participants is about 20 persons, and the final participant should be decided by the drawing from the applicants.

2) Present basic plan and its condition: The member of the administration did the information disclosure of purposes, basic concept, planned goal, scales in the plan region, some relevant constraints, etc., and the argued topics were given to workshop.
3) Execute each workshop: At first stage the contents of problem are chosen and adjusted. Specifically, ideas are thought out due to brain-storming, and KJ method (morphological analysis method) is introduced to adjust the ideas. In addition, a structural hierarchy is built by Fuzzy Structural Modeling. It is composed of the items for the general river improvement project. And then, the questionnaire is surveyed for evaluation of items. The utility analysis is executed using the importance obtained by the questionnaire results. Conjoint Analysis is introduced for the analysis. Moreover, the alternative plan is selected and those achievements are evaluated comprehensively at stage 2 and stage 3. As the result, the optimal plan is selected. Through the whole, the difference and similarity between workshop and residents around the study area is evaluated and then such information reflects the decision of the workshop.
4) Present the alternative plan: The alternative plans are composed of evaluation items obtained by the workshop. Here, the specified alternative plans are expressed in the visual form. In addition, selection and adjustment of alternative plans are also carried out based on the information such as accounted cost of a project.
5) Evaluate the alternative plan in each workshop; the information of preference is investigated through discussion and adjustment in each workshop. In this study Fuzzy integral is supposed to use as the comprehensive evaluation method. Fuzzy integral uses fuzzy measure consisted of the subjective achievement and the relative importance of attribute.

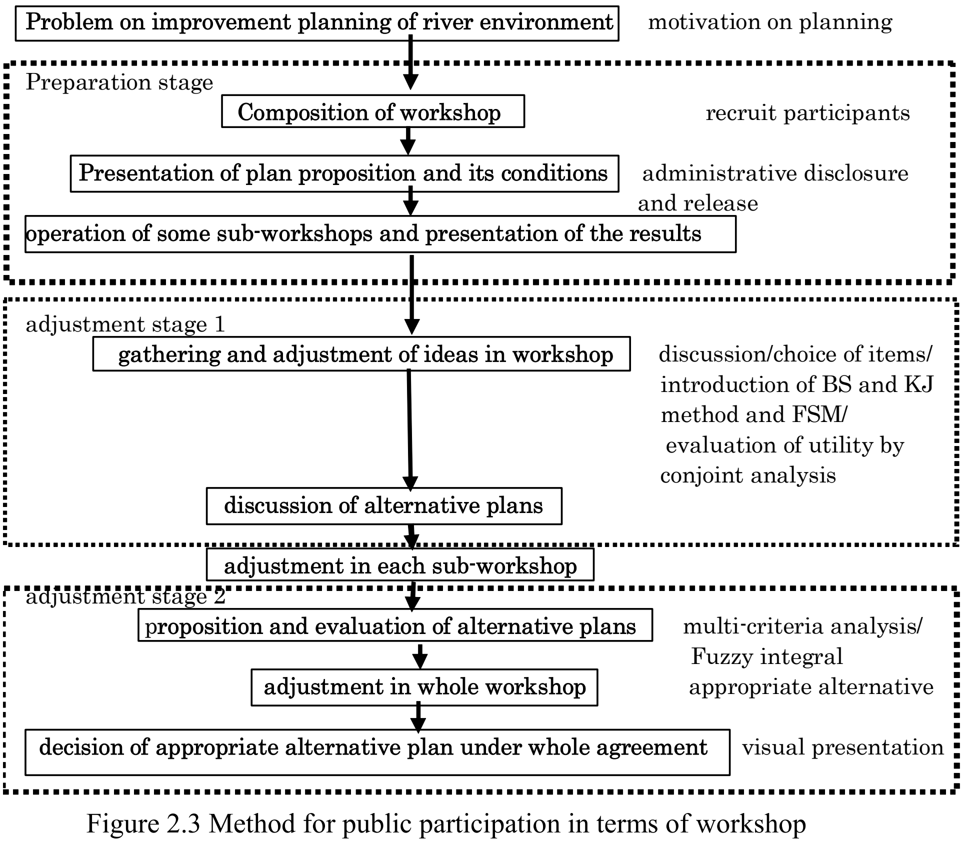


Figure 2.3 Method for public participation in terms of workshop

2.4 Existing Condition of Study Area

The capacity of the river discharged flow in the district is insufficient on present state. That is, the flow of the river is prevented in affects of the heavy rainfall, etc. in this district. As a result, the affect reaches to the upstream seriously:

1) Tokachi River around the Aioi-Nakajima district has 7,100m^3/sec as the planning flood flow. But now it secures only 3,200m^3/sec as the existing safe flow.
2)Aioi-Nakajima area is composed of a large sandbank. it is not possible that the flow run smoothly because of high land level. Therefore in the upstream, water level increase when the flooding occurs. It has a possibility of a large damage in the urban district caused by running over the levees. it is only run.
3) In Aioi-Nakajima area there is no damage in life and property directly, because the inhabitant does not live there when flooding occurs. However, it becomes necessary to execute the river improvement for prevention of overflows and reduction of the damage from flooding.
Many trees such as the willow flourish in the river would prevent the flooding flow. Moreover the large zigzag of the river smoothly would not flow in the downstream. On the other hand, it is important to reserve the forest of a special kind of willow and rich nature such as the nesting place of the rare swallow, nevertheless urban suburban area existing in Obihiro City, Otofuke town,and Makubetsu town.

3. ALGORITHM OF THIS STUDY

3.1 Method of grouped fuzzy structural modeling

In fuzzy structural modeling (FSM), the difference of importance between each item is indicated in continuous space of [0,1]. The algorithm of FSM is composed of estimating the direct and indirect relationship due to fuzzy extensive principle and drawing the results using graph theory. Here, the method was proposed to estimate the difference of importance in each item and to adjust the values developed by Zarhariev et al [2]. First of all, let us explain the algorithm of determining the preferential structure using fuzzy contributive rule. Let two preferential contents be a_i and a_j. We define the preference of a group by the following equation by using the contributory function $\tilde{C}^k$. This function represents the degree of contribution to the group preference.

$$a_i R a_j \quad \text{iff} \quad \tilde{C}_m^k(a_i, a_j) > 0 \qquad (1)$$

$$\tilde{C}_m^k(a_i, a_j) = \tilde{u}_k(a_i) - \tilde{u}_k(a_j) \qquad (2)$$

Where a relation $a_i R a_j$ means a_i is superior to or equals a_j for the decision maker k and is satisfied with connective and transitive conditions. The contributory function $\tilde{C}_m^k(a_i, a_j)$ is the degree of preference of the decision maker k in case of a_i against a_j. $\sim$ represents fuzzy number. The difference of importance in whole group is defined as minimum distance among each relationship as equation (3).

$$R^M = \min \sum_{k=1}^{q} d(R, R_k) \qquad (3)$$

Where $R_1, R_2, ..., R_k, ..., R_q$ are fuzzy preference relations that express the decision-maker's estimations and let us assume that

$$\mu_{R1}(a_i, a_j) \le \mu_{R2}(a_i, a_j) \le .... \le \mu_{Rq}(a_i, a_j) \qquad (4)$$

We can determine the fuzzy relation R^M as the group including member 1 to member k using the median among the group like the following equation:

$$\mu_R^M(a_i, a_j) = \mu_R^k(a_i, a_j), \text{ where } k = (1/2)(q+1), \text{ if q is odd,} \qquad (5)$$

$$\mu_R^M(a_i, a_j) = (\mu_R^k(a_i, a_j) + \mu_R^{k+1}(a_i, a_j)), \text{ where } k = (1/2) \text{ if } q \text{ is even.} \qquad (6)$$

Thus fuzzy relation that is the nearest in the sense of Hamming distance to given fuzzy preferential relations is determined by equation (4) to equation (6). The obtained variable $\mu_R^M(a_i, a_j)$is a median in total preferential relation and is defined as the minimum distance of every difference between preferential relations. The matrix is composed of the total items m by each obtained relation. Then, the direct or indirect influences are computed due to the Cartesian product of the matrix. Finally the relational graph is indicated.

3.2 Fuzzy Integral as a Multi-Criteria Analysis - Choquet Integral

Fuzzy evaluation is based on the fuzzy integral using the degree of importance indicated by fuzzy measure [2]. Yager developed the theoretical evaluation method combined multi-criteria [3] analysis with the fuzzy evaluation. In the fuzzy multi-criteria analysis, we should obtain both achievement of the evaluation criteria and their importance basically. Here, we introduce Choquet integral as a kind of fuzzy integral. In the case of applying multi-criteria to planning like river improvement project, the data are often ambiguity. So we should consider such characteristics. Choquet integral is generally formulated as shown in equation (7).

$$(c)\int h(x)dg = \int_0^\infty g(x/h(x) \geq \alpha)d\alpha \qquad (7)$$

Equation (10) represents the integral with the function $h: x \to [0,\infty]$.

When function h is represented as

$$h(x) = \sum_{i=1}^{n}(\alpha_i - \alpha_{i-1})\chi_{xi}(x) \quad h: x \to [0,\infty], \chi_{xi} \text{ is defined function of set } X_i, \qquad (8)$$

Choquet integral is redefined as:

$$(c)\int h(x)dg = \sum_{i=1}^{n}(\alpha_i - \alpha_{i-1})g(X_i)\cdot \qquad (9)$$

Where α_i ; achievement of each attribute, $g(X_i)$; a set of importance, and

$$0 \leq \alpha_1 \leq \alpha_2 \leq \ldots \leq \alpha_n, \alpha_0 = 0, X_1 \supset X_2 \supset \ldots \supset X_n\cdot \qquad (10)$$

3.3 Contingent Valuation Method (CVM)

(1) Environmental Value

The value of environmental quality is divided into use value and nonuse value. (sometimes we consider positive use value as use value and passive use value as nonuse value). The use value is the value which is indicated by resource utilization and spatial utilization of the environment. Moreover the use value can be classified into direct use value and indirect use value. The direct use value is the value which is brought in case of consumption of resource from environment. The indirect utility value receives the service from environment. Meanwhile the nonuse value does not relate to the value mentioned above. Typical one is existence value. The existence value does not connect with utilization at present or in the future both directly and indirectly. But it is given by individual preference such that the environment would not be lost. It is called a peculiar value. In addition, there are bequest value and option value that have both properties of use value and nonuse value. The bequest value is a value for leaving environment and resources for the future generation. It is also the value which is related to future utilization.

(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.

In this method, first of all, the contents of environment and administrative service are introduced to the respondents. And then, willingness to pay is asked toward heightening the level of environment. On the other hand, we can consider willingness to accept compensation if environment or administrative service is declined. WTA is indicated as the necessary money to obtain the original utility again. CVM can also evaluate both the use values and 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 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) Method due to free answer: to ask sum of payment freely.

2) Method due to bid price using game mode: to ask agree or disagree with the proposed price to repeat until obtaining the answer of No.

3) Method due to payment card system: to answer the appropriate value within some alternative choices.

4) Method due to a pairing choice system: to ask agree or disagree with proposed price
This study adopted the payment card system.
(3)Estimate Model of WTP

Suppose the probability of agreement with a given WTP price to $\Pr[yes]$, it is formulated as Equation(11).

$$\Pr[yes] = \frac{1}{1+e^{-\Delta V}} \quad . \qquad (11)$$

where ΔV ; a difference of utility between proposed prices.
Here, supposed that Equation (11) is transformed into Equation (12), it can be estimated parameters of estimate equation by means of maximum likelihood method [4].

$$\Delta V = \alpha + \beta T + \sum_{i=1}^{n} \gamma_i y_i + \sum_{k=1}^{m} \delta_k z_k \qquad (12)$$

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 ($k = 1, m$) .

3.4 Conjoint Analysis as Supporting Approach of Workshop

The alternatives handled in this study are combined of the multiple river improvement measures. Each service level has also been considered from various categories. The conjoint analysis is applied to planning fields, environment economics, etc. in these years [5]. The analysis procedure is summarized as following aspects briefly:
1) Evaluated Attributes: Several attributes are introduced to determine the value of plans. Each attribute is consisted of several levels. The alternatives are combined of the multiple river improvement measures to increase environmental level of river basin. Each attribute is evaluated due to utility value of some respondents. The evaluated levels of each attribute are considered as various categories.
2) Comprise Profiles: The card called a profile is prepared and used. The profile is a lattice of the factors composed of a series of attributes. This is specific plans consisted of multifactor. Each attribute value (partial utility value) is evaluated by showing this profile to the respondent, and asking the whole utility of the profile,.
3) Analyze the Obtained Data:
Equation (13) represents an estimate of the whole utility.

$$\hat{r}_i = \hat{\beta}_0 + \sum_{j=1}^{p} \hat{u}_j(k_{ji}) \qquad (i = 1,2,.....,n) \qquad (13)$$

where $\hat{u}_j(k_{ji})$; an estimate of the partial utility of the level k_{ji} in the attribute j in the profile i. $\hat{\beta}_0$; an estimate of the constant parameter β_0, and $\hat{\gamma}_i$; an estimate of the evaluation γ_i for the evaluation object (profile), and n ; a total number of the profiles, and p ; a total number of the attributes.
Moreover, importance score of attribute j for indicating the relative importance of each factor is shown in Equation (13). Here, RANGE is a difference between maximum and minimum of utility value of attribute j in Equation (14) and Equation (15).

$$IMP_j = 100 \frac{RANGE_j}{\sum_{j=1}^{p} RANGE} \qquad (14)$$

$$RANGE_j = \text{maximum of } \hat{u}_j(k_{ji}) \text{ - minimum of } \hat{u}_j(k_{ji}) \qquad (15)$$

The remarkable advantage of Conjoint Analysis is to estimate how the value changes, when it rearranged the value element of alternative plan, and when it added the new value element in it. Namely, it is not only to clarify in which part there is a problem on the whole plans but also to estimate the variation when it measures the value by the decomposition of the whole plans at the moment. Some river improvement plans are considered as the alternatives in the river basin. Based on the approach, the preference measure of the citizen was surveyed in terms of the conjoint analysis. The profiles with whole concepts are presented to the examinee.

4. EMPIRICAL RESULTS

4.1 Outline of Questionnaire Surveys

(1) Attributes of surveyed residents and participants in the workshop

Table 4.1 Outline of questionnaire surveys to the inhabitants and to the workshop

Age (%)	20-29 7(8)	30-39 20(13)	40-49 22(46)	50-59 28(23)	More than 60 24(8)
Distance between dwelling and district (%)	Less than 4km 8	4km-5.9km 17	6km-7.9km 28	8km-9.9km 23	More than 10km 25
Consequence of flood control (%)	Very important 41	Important 47	Fairly important 7	No important 5	
Consequence of natural environment (%)	Very important 52	Important 38	Fairly important 7	No important 3	

Notes: only number represents ratio of inhabitants and (number) shows ratio of workshop members

The questionnaire survey was executed to grasp the fundamental ideas from the inhabitants and the workshop members. The ratio for attribute of both residents and workshop members are shown in Table 4.1. The inhabitants were selected from almost every generation and every occupation equally. Most of them have much consequence for both flood control and conservation of natural environment. The participants in workshop are from various occupancies, but in the generation of forties [6].

(2)Analytical results of basic concepts to the general river improvement plan

On basis of the proposal of discussion and the adjustment of ideas due to KJ method, we analyzed the hierarchical structure for improvement items of the concept.

Table 4.2 result of FSM analysis

respondent	Preference structure by degree of importance
residents	A>E=F>B=C=D
Workshop member	A>E>F>B=C=D

Notes: symbol >: superior, symbol= indifference

legend: A: flood control, B: access to the river site, C: communing the river nature, D: land use in the river, E: maintenance of natural environment, F: protection of flora and fauna

Table 4.2 shows the result obtained from the survey for residents and workshop members. This shows the flood damage prevention is the most important. Both the approach of natural environmental conservation and flora and fauna protection are ranked at the next stage. It is similar to the result of the survey due to the workshop participants. Namely, both groups think that the basic items river improvement planning are significant. The items of the familiarity with river, the access to riverside and the improvement of land use in the river are ranked at the bottom.

That is to say, large difference is not seen between residents and workshop members in the fundamental attitude on the river sustainable improvement.

(3)Analytical results due to conjoint analysis

Next, the specific problem on the alternative plan was considered. We proposed basic alternatives which were built by several factors and their levels. As an analytical method, Conjoint

Analysis was introduced to find combinational optimum plan with some partial utilities. The selected factors and their levels are shown in Table 4.3. On basis of these factors and levels, the profiles of alternatives were drawn, and each profile was evaluated by full profile analysis. Factors here are four contents, namely, the improvement for flood control, the improvement for communing with river, the utilization of the land in riverside and the protective measure of flora and fauna. These factors express the basic concept of the future plan in view of sustainability, and the level consists of the specific level proposed in the discussion.

The results of analysis brought the following findings as shown in Table 4.3.

1)The relative importance of residents was different from that of workshop participants. In case of residents, the protection of flora and fauna was the most important factor but workshop members evaluated the improvement of flood control as the most important factor.

2) In case of the other factors, two groups had different ideas. That is, the residents thought that the projects for river sustainable improvement should be promoted in the study area. But workshop members thought that the area should be stood still. In other words, the environment in the river should be kept with the existing conditions.

Table 4.3 Factor and level introduced into the analysis.

Factor (attribute)	Level 1	Level 2	Level 3
Improve flood control	existing	Method of nature friendly	Conventional flood control
Commune with river	existing	Fishing and walking	Boating and outdoor sports
Improve land use	existing	Planting trees & green cover	Natural park
Protect flora & fauna	existing	Protection of flora & fauna	

Table 4.4 Results due to conjoint analysis in case of workshop members

Factor(attribute)	Level	Partial utility		Relative importance	
		Residents	workshop	Residents	workshop
Improve flood control	Level 1	-0.54	9.98	27.70	41.88
	Level 2	5.14	3.20		
	Level 3	-4.00	-13.18		
Commune with river	Level 1	-2.33	8.40	10.57	27.12
	Level 2	0.95	-6.80		
	Level 3	1.39	-1.60		
Improve land use	Level 1	-5.37	4.80	25.08	18.49
	Level 2	3.56	2.90		
	Level 3	1.71	-7.70		
Protect flora & fauna	Level 1	-6.46	-4.50	36.66	12.51
	Level 2	6.46	4.50		

4.2 Evaluation of Alternatives in Workshops

(1) Discussion of alternatives in workshop

In the Aioi-Nakajima area, workshops for river improvement have been opened since the beginning of 2002. By the discussion in the workshop, the alternatives were obtained mainly as excavation of the new waterway, excavation of the intermediate water channel, widening of the existing waterway, etc.

It is shown in Table 4.5.

Table 4.5 Alternative discussed in the workshop

Alternative plan	Contents	Demerit and merit
1.Excavation of new waterway with straight line	/Excavation with straight line /Modification of waterway width	/Impossible access to sandbank /Risk of stoppage /Risk of destruction of bird nests
2. Excavation of mid-scale riverbed in existing waterway	/Excavation intermediately with straight line /Construction of some ponds within river	/Use intermediate bed only on flooding time /Use ponds for application of flood control and water use /Possible access to sandbank
3. Expansion of existing waterway	/Expansion of existing waterway /Construction of floodwater storage area	/Deforestation /Risk of erosion in riverside /Use ponds for application of flood control and water use
4. Expansion of existing waterway and up-stream improvement	/Expansion of existing waterway /Construction of stored floodwater area /Change of waterway in upstream	/Large-scaled deforestation /Risk of erosion in riverside /Use ponds for application of flood control and water use
5.Excavation of new low-head waterway	/Excavation of new shallow waterway /water flows along waterways at usual time	/Risk of stoppage due to sedimentation /Large cost of maintenance

(2)Decision of the whole alternative project

Table 4.6 Evaluation of alternative projects due to Choquet integral

1) Important weight due to fuzzy measure

$\alpha_1 = 0.25$	$\alpha_1 = 0.20$	$\alpha_1 = 0.16$	$\alpha_1 = 0.13$	$\alpha_1 = 0.35$

2) Achievement degree of each item

Alternative project	Factor1	Factor2	Factor3	Factor4	Factor5
1.new channel excavation	0.8	0.1	0.5	0.1	0.5
2.mid-scale riverbed excavation	0.9	0.8	0.8	0.5	0.6
3.channel expansion	0.3	0.5	0.8	0.8	0.1
4.upstream control & channel expansion	0.3	0.5	0.8	0.7	0.1
5.new low-head channel excavation	0.7	0.3	0.6	0.5	0.3

3) Results of comprehensive evaluation

Alternative project	1	2	3	4	5
Evaluation value (order)	18.03 (3)	29.52 (1)	17.01 (4)	16.51 (5)	18.93 (2)

The basic ideas on river improvement plan of residents and workshop participants were grasped by discussion in workshop and support planning system. Alternative projects should be evaluated relatively. Here, the alternative projects were mainly composed of five plans. The evaluation items(factors) were selected such as i) prevention of flood damage, ii)access to the riverbed, iii)substantiality of the communing with the river, iv)substantiality of the land use in the district, and maintenance of the natural environment. Table 4.3 demonstrates these evaluation items are evaluated in the continuous interval from 0 to 1. The larger the numerical value is, the higher the expectation is. The degree of importance was also shown in Table 4.6.

The comprehensive evaluation was executed by using Choquet Integral. The results represent in Table 4.6 as well.

Alternative 2 was optimum plan as a result of analysis. That is, the mid-scale riverbed excavation should be chosen as the optimal project. On basis of the result, the evaluation by inhabitant around the study area is carried out. Another analysis mentioned that it became 1.5 billion yen for improvement cost of the optimum plan by estimate.

4.3 Analysis due to CVM

(1)Outline of survey for CVM

As mentioned in the previous section, we discussed the appropriate basic river improvement plan in workshops. As a result, we could find a optimal plan for workshops. Based on such a plan, we examined if it would be accepted by inhabitants. The following suppositions were provided for inhabitants.

1) River improvement would be promoted as a new waterway in the sandbank, which has 400 meters width and 2 meters depth.

2) A part of the budget would be provided by expense of the area in river basin for twenty years.

In this condition, we asked how much they would pay for promoting this project. On the survey, we adopted the paid card which is selected by inhabitants and all concept method for profile. The obtained WTP is regarded as the necessity of the project. We also built the Logit model based on random utility theory as the estimate model. By using this model, we can argue the inhabitant's consequences for river improvement with relevant to their attributes and awareness. In this way, the opposed answers towards expenses paid by tax were excluded.

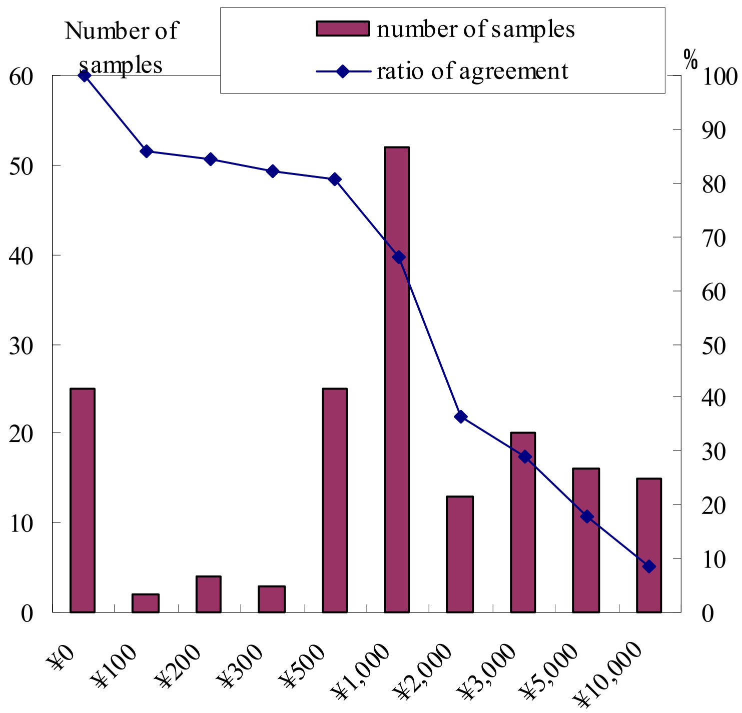


Figure 4.1 Results of calculation due to CVM questionnaire

Figure 4.1 demonstrates the distribution of respondents' WTP. The simple average WTP is provided for 2,516 yen.

The model discussed in section 3.2 was estimated by using maximum likelihood method. The result is represented in Table 4.7. In this model the proposed WTP, annual income, consciousness of flood control contributed to the model strongly. In particular, the consciousness of flood control influenced to the estimated WTP largely. In this case, smaller the discrete number represented the category of flood is, the higher the concern for flood control is.

Figure 4.2 demonstrates WTP values in the different segments, that is, high-concerning group and all the respondents. The difference between two groups is 1,235 yen as median. Inhabitants who have the high-grade concerns for flood control also value high WTP. At the same time such inhabitants have the experience of voluntary activity and flood drill activity simultaneously.

Table 4.7 parameter in the model due to CVM

contents	unit	parameter	T value	judgment	mean
Proposed sum β	yen	-0.0007	-17	***	-
Annual income γ	1 to 5	0.1727	2.253	**	2.302
Constant α	-	2.3077	6.536	***	-
Concern to flood control	1 to 7	-0.8469	-9.305	***	1.711
Age generation	1 to 5	0.1857	3.169	***	3.459
Likelihood ratio	0.481				
Hit rate (%)	84.64				

** 5% and *** 1% significance

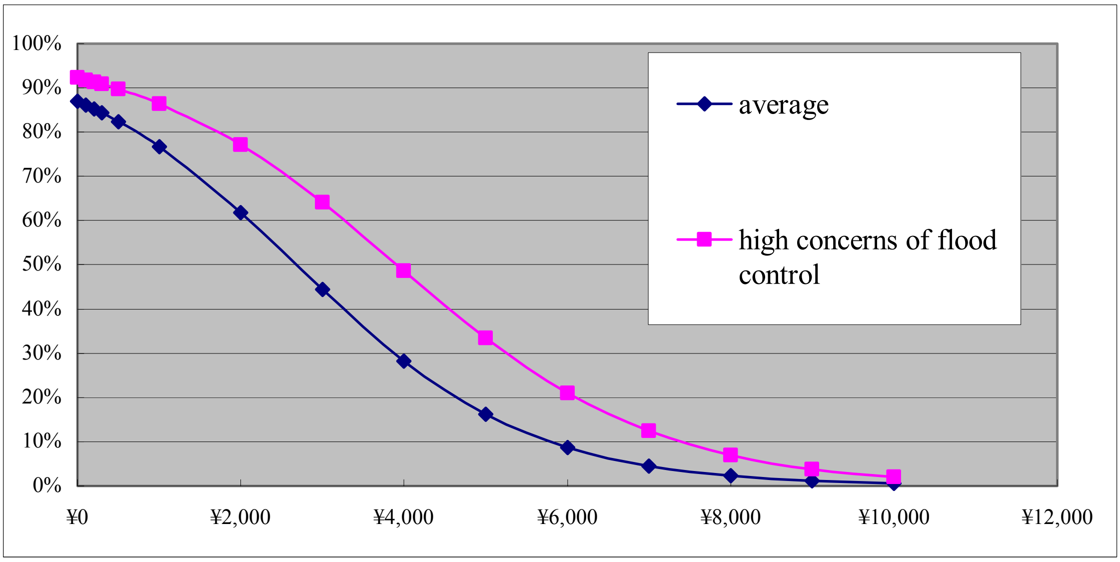


Figure 4.2 Differences of WTP between the segments of concerns of flood control

Finally, WTP was estimated for total amount in the whole municipality. Table 4.8 shows the total amount of WTP. WTP per household is 2,682 yen in a year, and 37,900 yen for twenty years. The total amount of WTP in the region is 279 million yen in a year, and 3,944 million yen for twenty years. In this connection, the total cost is counted for 1,500 million yen to complete the river improvement project. Therefore, the inhabitants require for the project, because the total WTP exceed the total cost in the long term plan.

Table 4.8 Total amount of willingness to pay(WTP)

Annual WTP per household	2,682 yen
Accumulated WTP in twenty years per household	37,900 yen
Annual total WTP of residents in the district	279 million yen
Accumulated WTP in twenty years of residents in the district	3,944 million yen

4.4 Evaluated Results of Alternatives by Conjoint Analysis

(1) Outline of Questionnaire

As mentioned above, it is necessary for inhabitants to promote river environmental improvement. Here, the specific alternatives were assumed in terms of several attributes. Table 4.9 represents four attributes and their levels of category. Using these attributes and their levels, we proposed eight alternatives combined with them to the respondents. The alternative which the inhabitants desired was grasped in terms of this analysis. In this survey, the alternatives visualized were adopted to be understood more easily.

Table 4.9 Attributes and their levels of Conjoint Analysis

Attribute (factor)	Level 1	Level 2
A. forests along riverside	Nature friendly method	Conventional method
B. trees in a waterway	Nature friendly method	Conventional method
C. ponds in waterway	Nature friendly method	Conventional method
D. roads along riverside	Nature friendly method	Conventional method

(2) Analysis of Results by Questionnaire

Figure 4.3 shows the partial utility of each attribute. In all attributes, the inhabitants evaluated utilities for method of nature friendly.

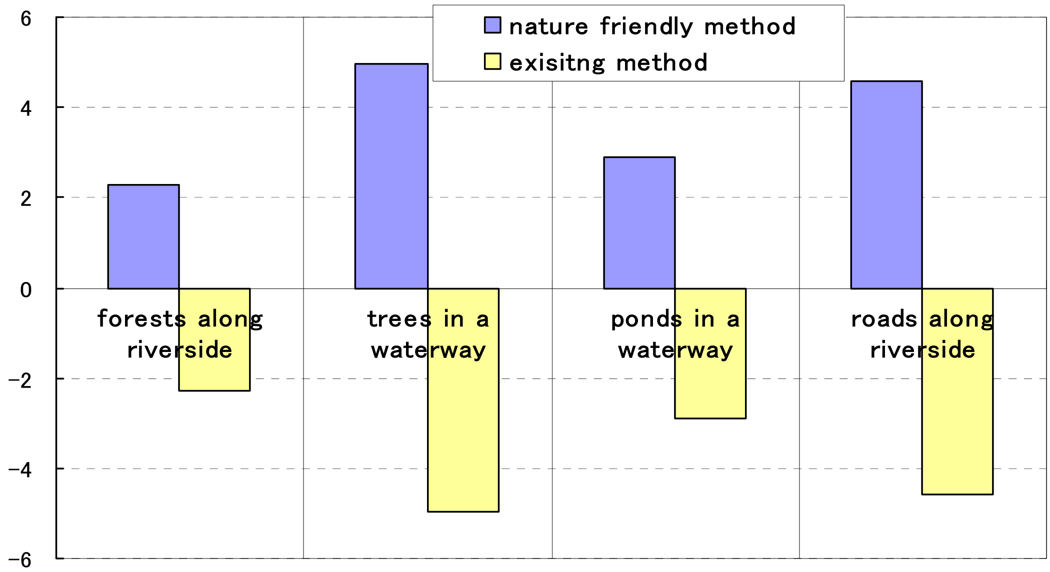


Figure 4.3 Partial utility of each attribute

Considering the importance of each attribute, trees in a waterway (B) and roads along riverside (D) is evaluated for higher concerns. At the same time, the utility of Nature friendly method is higher in every attribute than that of conventional method. Figure 4.4 represents the importance of each attribute in terms of difference of flood drill activity. When inhabitants experienced flood drill activity, they have more importance for forests along riverside and roads along riverside. On the other hand, when respondents do not have experiences of flood drill activity, they have more important for trees in a waterway compared with the other attributes.

Figure 4.5 shows importance of attributes in terms of the difference of river environmental improvement. The respondents who selected much of nature friendly method evaluated forests along riverside for more importance, but ponds in a waterway for less importance relatively. The respondents who have same rank for two methods evaluated trees in a waterway for more importance, but forests along riverside relatively. Moreover, the respondents who preferred the conventional method evaluated road along riverside for more importance.

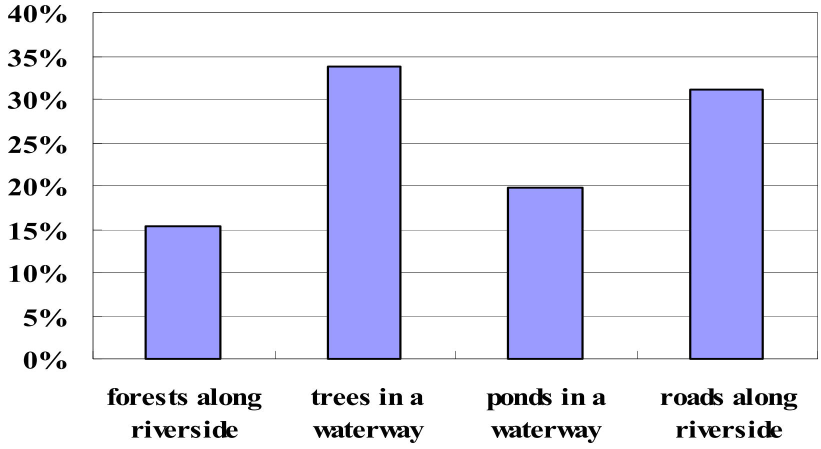
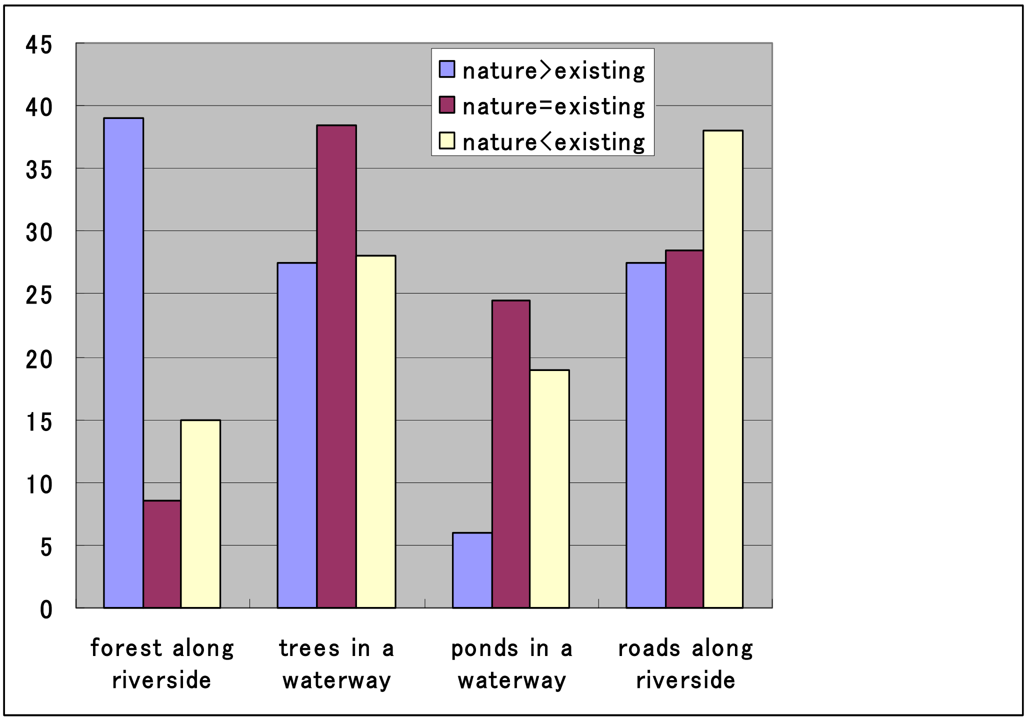


Figure 4.4 Importance of each attribute



nature>existing: the concern of nature friendly method is larger than that of existing method
nature=existing: both concerns are almost same.
nature<existing: the concern of nature friendly method is smaller than that of existing method.

Figure 4.5 Importance of each attribute among segments of idea for river improvement

5. CONCLUSION

In this study, we developed evaluation method of alternatives for river improvement project with public participation. The method includes the selection of an appropriate basic improvement plan, the concern to its improvement plan and the evaluation of specific visual alternative project and the choice of the optimal project. The concrete procedure is composed of those methods and participation of inhabitants and workshops.

Analyzing and adjusting the specific river environmental improvement, we concluded the following contents:

1) After the discussion in workshops, they agreed to determine the policy of the excavation of mid-scale riverbed in existing waterway as an appropriate improvement system. This was evaluated for the most balanced idea between the aim of flood control and that of environmental protection in terms of fuzzy integral..

2) Such an idea was recognized by inhabitants through CVM based on the questionnaire. The concerns for the policy were very high and the value of total WTP was larger than the cost of a supposed improvement project.

3) Based on such a fundamental comprehensive plan, several alternative projects composed of several factors were proposed to inhabitants. As a result, the project taking the nature friendly method in was the optimal project of all alternatives due to Conjoint Analysis.

In such a way, we built the process of decision-making involving administrative organization and community, furthermore, the adjustment section- workshops. It is very important to adjust the different opinions among some interest groups.

Moreover, we introduced some effective methods as supporting system of decision-making. Actually, we used fuzzy integral, CVM and Conjoint Analysis. These are appropriate to analyze the ideas or opinions from inhabitants and to guide a scientific information to a common stage of decision-making.

In the future study, the pilot system should be advanced and refined, adding more discussion stage and more useful methods. And then, the risk communication in the field of river improvement should be established in terms of the comprehensive system simulation.

REFERENCES

1) R.Theruvel, M.R. Partidario: The Practice of Strategic Environmental Assessment, Earthscan, pp.1-14, 1996.
2) S.Zahariev: Group Decision Making with Fuzzy and Non-Fuzzy Evaluation, Multiperson Decision Making Using Fuzzy Sets and Possibility Theory, pp.188-197, 1991
3) R.R.Yager: Criteria Aggregations Function Using Fuzzy Measure and the Choquet Integral, International Journal of fuzzy Systems, Vol.1, No.2, 1999.
4) W.H.Hanemann: Welfare Evaluation in Contingent Valuation Experiments with Discrete Responses, American Journal of Agricultural Economics, Vol.66, No.3, pp.332-341, 1984.
5) J.J.Louviere:Conjoint Analysis, in R.P.Bagozzi,ed. Advanced Method of Marketing Research, Blackwell, pp.223-259, 1994.
6) S.Kagaya, K.Uchida and T.Hagiwara: Dialogue system of decision-making for sustainable planning in river basin improvement, Sustainable Planning 05, 2005.