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Public Preference and Willingness to Pay for Flood Risk Reduction

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1 Introduction

Floods are one of the oldest, most frequent, and most severe natural disasters to which human beings are exposed. In Japan, floodplains hold about 49% of the population and 75% of property, and flooding is a serious natural hazard. The need to reduce flood risk by applying not only "hard" measures, such as dams and levees, but also "soft" ones, such as early-warning systems and measures to heighten awareness of flood risk, is thus widely accepted. Unfortunately, the severe economic recession in Japan and public concern with the need to preserve the environment have recently put a brake on investment in large-scale public works, including flood prevention schemes such as dikes and dams.

In these early years of the 21st century, floods have occurred frequently in Japan, causing disastrous loss of life and property. The Tokai Flood in 2000 caused damage amounting to 978.3 billion yen, with 10 dead and 115 injured. The Niigata-Fukushima Flood on July 13, 2004, left 16 people dead or missing, 22 buildings destroyed, 156 severely damaged, 85 partially damaged, 4,022 inundated above ground, and 22,620 inundated below ground. The frequency of flooding provides adequate evidence to support advocates of large-scale flood disaster prevention schemes.

Zhai *et al.* (2003) conducted an efficiency analysis of Japanese flood prevention investment vs. total flood losses including death, injuries, and intangible effects and showed that, since the 1980s, investment has changed from an efficient mode to an inefficient one in terms of both the economic standpoint and total savings on flood losses, including loss of life, with the ratio of total benefits to total costs, elasticity, and the marginal rate of substitution for flood loss decreasing in relation to investment in flood prevention.

The objective of this paper is to answer important five questions by conducting a survey in the Toki-Shonai River region of Central Japan: What are the main public preferences regarding river management in Japan? What is the public flood risk acceptability? What is the willingness to pay (WTP) for flood risk reduction? What are the relationships among the attributes of flood risk reduction like economic damage reduction, human loss reduction, and environmental protection?

2 Theoretical Framework for Estimating WTP

Water quality, river landscaping, flood control, and similar issues have no market price tag. These are called non-market goods in economics. Information obtained by assessing the public's interest in, and willingness to pay for flood control and ecological restoration is critical for municipal planners and policy-makers who desire to vote on legislation according to their constituents' wishes. The numerous techniques available for estimating WTP can be broadly divided into two categories: revealed preference and stated preference methods. The former, such as the travel-cost and hedonic price methods, determine the demand for goods or services by examining the purchase of related goods in the private market place, while the latter, such as the contingent valuation method and choice experiment techniques, measure demand by examining the individual's stated preference for goods or services relative to other goods and services. The choice of method for a study depends on several criteria, including the purpose of the study, availability of data, and particular economic values required (use and/or non-use values). For example, the revealed preference method is still generally preferred for certain types of non-market goods like recreational fishing, while the stated preference method is applied to other types of non-market goods such as estimating discount rates in developing countries (Bateman *et al.*, 2002). Shabman and Stephenson (1996) showed that the contingent valuation method (CVM) produces the smallest mean estimates, implying that CVM is the most conservative estimation technique and is thus least likely to overestimate actual benefits based on the property damage avoided, hedonic price, and contingent valuation techniques for the same study area (Roanoke, Virginia, USA). As highlighted by Daun and Clark (2000), however, CVM has rarely been specifically applied to the estimation of flood control benefits (Thunberg, 1988; Shabman and Stephenson, 1996; Clark *et al.*, 2002). On the other hand, the choice experiment approach has not been applied in the flood risk analysis as far as we know.

CVM involves posing a hypothetical market to a sample of respondents and asking their opinion on the values of public environmental goods or services (e.g., WTP for a change in the supply of an environmental resource) under specified contingencies (Carson and Mitchell, 1989; Freeman, 1993; Bateman and Willis, 2001; Bateman *et al.*, 2002; Zhai *et al.*, 2006b). CVM is the most flexible of the methods available for measuring both direct and indirect monetary benefits of non-market commodities like environmental resources. If respondents answer a CVM question, as assumed by economic theory, the elicited value corresponds to the economic value of the goods (resource) as measured by the Hicksian compensating surplus (Carson and Mitchell, 1989). The estimated value for a natural resource can then be used as an input to a cost-benefit analysis.

The choice experiment approach is based on the idea that any goods can be described in terms of its attributes, or characteristics, and their levels (Bateman *et al.*, 2002). For example, a bus service can be described in terms of its cost, timing, and comfort. Likewise, flood prevention measures can be described in terms of hard measures such as internal and external flooding measures, soft measures such as early warning systems, and concern about the environmental protection of rivers.

WTP for flood and environmental risk reduction may depend on factors such as risk perception, resource limitations, personality (individual characteristics), current risk levels, and acceptability of risks. Whether an individual acts or not depends on whether his utility reaches a maximum, which is strictly confined to the addressed factors. Figure 1 shows the theoretical framework used in this study for estimating WTP for flood risk reduction. The hypothesis for the theoretical framework was tested using CVM and the choice experiment approach.

3 Survey Design and Implementation

3.1 Survey area

The survey area was the Shonai-Toki River basin in Central Japan (Fig. 2). The upper and the lower reaches are called the Toki River and Shonai River, respectively. The main stream is 96 km long. The basin has an area of 1,010 km^2 and is home to about 4 million residents. The upper reaches area is quite different from the lower one in terms of both natural environment (climate, geographical features) and socio-economic patterns (urbanization, population, and property accumulation). Therefore, the Kita ward of Nagoya City, Aichi Prefecture, in the lower reaches area, and Toki City, Gifu Prefecture, in the upper reaches area, were selected as survey areas to examine whether public preferences regarding flood control would differ with location.

Disastrous floods frequently occur in the survey area, e.g., during the last 50 years, Typhoon Isewan in 1960, Typhoon No. 17 in 1971, floods in 1989 and 1994, and the Tokai Flood in 2000. In particular, the Tokai Flood, resulting from heavy rainfall of up to 97 mm per hour with a total precipitation of 567 mm, inundated the Tokai area, including the city of Nagoya, home to 2.1

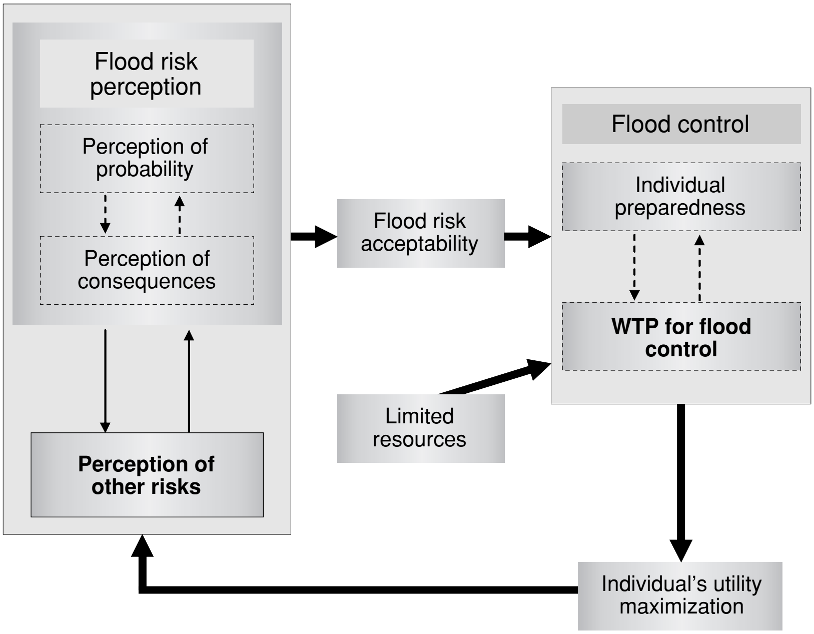

Fig. 1. Theoretical framework for analyzing WTP for flood control.

million residents. This storm, regarded as a "once in over 200 years" event, caused 10 deaths, serious injury to 20 people, and ¥978.3 billion in direct economic losses. It was one of the most serious flooding disasters in Japanese history according to Ministry of Land, Infrastructure, and Transport (MLIT) statistics.

3.2 Survey implementation

For CVM to yield useful information, careful survey design is critical. The survey purpose determines the accuracy of the results and survey mode. Desvousgaes *et al*. (1998) pointed out that there are different levels of WTP accuracy required depending on the end use. These were ranked, in descending order of accuracy, as compensable damage/externality cost, policy decisions, screening or scoping, and fact finding. The ultimate implications of this survey include possibly helping to improve policies for flood control projects in Japan and gaining a better understanding of theoretical issues such as the effect of providing information in questionnaires on WTP. The purposes of this survey thus belong in the two latter-ranked categories. Therefore, a mail survey was considered appropriate, rather than more expensive face-to-face

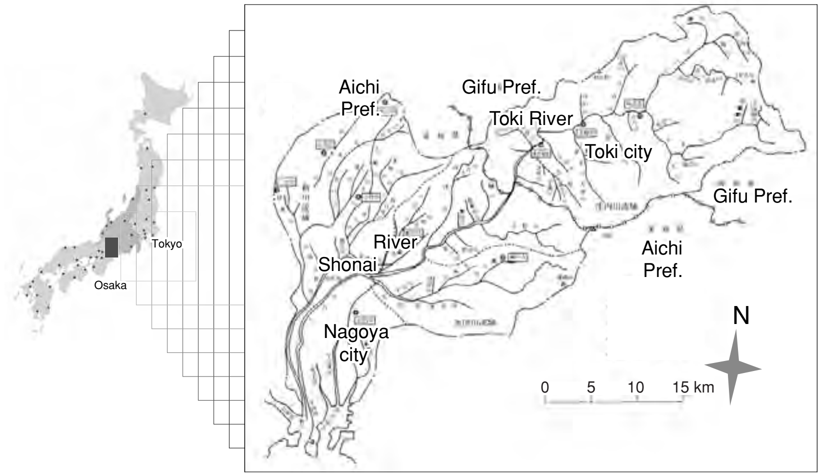

Fig. 2. Location of survey area.

interviews, as proposed by Arrow *et al.* (1993).

The survey was conducted from the end of March to the beginning of April, 2004, before the start of the rainy season (June to September). The survey followed the Total Survey Design Method (TSD), which attempts to achieve an optimum balance across all effort areas. TSD was developed by Mangione (1995) and has been successful in securing high response rates from general and special samples. The survey procedure was as follows.

First, brief descriptions of flooding, the current status of flood control measures, and methods of preventing flooding were presented. In particular, for ease of understanding, illustrations were used to present the relationship between property damage and flood inundation, and to describe external flood control measures, internal flood control measures, and early-warning systems. To provide respondents with a further incentive to answer the questionnaire beyond involving them in cooperative thinking on measures for flood risk reduction, they were asked to write their name and address on the questionnaire if they wanted a summary of the survey report.

Second, in addition to thorough discussion of the questionnaire draft within the project team, six people were asked to formally pre-test the questionnaires. Based on the information returned, the questionnaire was revised.

Third, the questionnaires were sent to 1,000 selected households by mail with a covering letter giving details of the institute and instructions for completing the survey; a stamped addressed envelope for returning the survey and a packet of flower seeds as a small gift were also enclosed. The covering letter was signed by the Project Director. The 500 households were randomly chosen from a commercial phone directory database, Kurofune 2004 (Datascape & Communications Inc., 2004) for Toki City in the Gifu prefecture, and the Kita ward, Nagoya City in the Aichi prefecture. In all cases, the replies to the surveys were anonymous except that respondents gave their name and address if they wanted a summary of the survey report.

Fourth, a reminder postcard was sent to all recipients of the sample approximately two weeks after the initial mailing. The postcard thanked those who had already responded and requested a response from those who had not yet responded. Fifth, a new covering letter, also signed by the Project Director, a questionnaire, stamped addressed envelope, and packet of flower seeds were sent to those who said they had not received the questionnaire and would like to respond. As a result, of a total of 962 surveys that were validly distributed (479 in Kita ward, Nagoya City and 483 in Toki City, respectively), questionnaires from 428 households (201 from Kita ward and 227 from Toki City) were received by mail, for a response rate of 44.5%. Finally, a summary of the survey report, with a letter of thanks signed by the Project Director, was mailed to those who had requested it in late June, 2004.

The questionnaire included 26 questions, and 148 detailed items (Table 1). The questions concerned household characteristics, flood experience, risk perceptions, flood preparedness, willingness to pay to prevent flood damage, and choice experiments on flood prevention policies. To improve the response rate on important individual survey items that survey respondents are often unwilling to answer, such as household income and age, intervals were used rather than exact values. Respondents were asked to express WTP values for internal flood measures, external flood measures, and early-warning systems. Internal and external flood measures relate to structural modifications to waterways, while early-warning systems relate to non-structural measures. Because appropriate measures for external flood risk reduction differ between the two cities, this issue is discussed separately below.

3.3 Basic statistical results

Males accounted for 76.5% of all respondents. The range from 40 to 70 accounted for 71.6% of all respondents. Single-family houses accounted for 84.5% of the dwellings (compared to 57.5% for all of Japan in 1998). Wooden houses totaled 67.2% of the dwellings (53.5% for all of Japan in 1998), and houses with embankments composed 13.2% of the total.

The residence periods in the study area were distributed as follows: less

Table 1. Items in questionnaires.

Category		Item and definition
WTP	CVM	Internal floods: floods due to reduced sewage and pumping capacity during rains. External floods: floods due to collapse or overflow of dikes and/or dams as a result of rain exceeding that expected on the basis of probability Early-warning system: system for predicting an imminent flood and warning those in the area of risk
	Attributes of choice experiment	external flood reduction internal flood reduction early warning systems environmental protection willingness to pay for countermeasures
WTP factors	Residentsí attributes	Age: at 10 year intervals: 10s, 20s... Income: at 2 million yen intervals: less than 2 million, 2.01 - 4 million yen... Number of people in household: persons Occupation: Residence period: years Education: junior high school, high school, college school, university, graduate school
	Characteristics of house	Style: single family or multi-family Structure: wooden or non-wooden Ownership: rental or private Distance from river: 1) less than 100 m, 2) 100 - 500 m, 3) 500 m - 1 km, 4) 1 - 2 km, 5) 2 - 5 km, 6) more than 5 km
	Flood risk perception	Experience of flood disaster: yes or no Perceived frequency of flood risk: 0, 1,..., 6 corresponding to, once for 5 years, 10 years, 20 years, 50 years, 100 years, more than 100 years, and never respectively Perceived consequences of flood risk: 0 for not worried,..., 10 for very worried
	Perception of other risks	*The 25 items below were evaluated using 0 for not worried,..., 10 for very worried* Natural disasters: earthquakes, volcanoes, thunderstorms Environmental risks: pollution, global warming, endangered species Disease risks: cerebral apoplexy, cardiac insufficiency, AIDS, SARS, BSE Urban risks: gas explosions, fires, traffic accidents Traditional risks: labor accidents, robbery, murder High-technology risks: nuclear accidents, GMO, Internet damage
	Flood risk acceptability	Acceptability of above- and below-ground inundation
	Disaster preparedness	*The 18 items below were evaluated using yes (1) or no (0)* Insurance, evacuation kits, embankments, evacuation, familiarity with disaster maps, etc.
	Information provision	Effects of flood control works on environment: yes or no Local budget for public facilities like firefighting: yes or no
	Regional features	Upper reaches: Toki City Lower reaches: Kita ward of Nagoya City

than 10 years for 9.9% of the respondents, 10–20 years for 19.3%, 20–30 years for 21.1%, 30–40 years for 18.3%, 40–50 years for 12.2%, 50-60 years for 9.4%, and more than 60 years for 9.7%.

The distribution of annual income per household was as follows: 9.2% with less than 2 million yen, 24.9% with 2–4 million yen, 27.2% with 4–6 million yen, 13.7% with 6–8 million yen, 8.7% with 8–10 million yen, 5.9% with 10–12 million yen, 4.8% with 12–14 million yen, and 5.6% with more than 14 million yen.

The education levels of the respondents were distributed as follows: 18.5% had graduated from junior high school, 49.6% from high school, 11.7% from junior college, 18.5% from college, and 1.3% from graduate school.

4 Public Preferences for River Management

Respondents were asked to answer the question: "Although dams and dikes and so on are constructed to prevent flood occurrence, flooding occurs somewhere every year. What do you think of current flood prevention measures? Please choose your favorite ONE AND ONLY ONE measure from those below." Analysis of the results showed the diversity of people's interests in river management, although most (82%) thought that some flood control measures should be taken (Fig. 3). Respondents in Toki City had a greater preference for external flood measures (28.2%) than those in Kita ward (19%), while those in Kita ward had a greater preference for internal flood measures (48.1%) than those in Toki City (25.7%) (Fig. 4).

5 Flood Risk Acceptability

5.1 Perceived probability of house flooding in the future

In the survey, two questions dealt with residents' perceived a probability of their houses flooding in the future. The questions were worded as follows: "How often do you think your house will be flooded below (above) ground in the future? Please choose the most appropriate answer from the choices below. Once in 5 years, 10 years, 20 years, 50 years, 100 years, or more than 100 years; absolutely never; don't know." Because the recurrence of a 100-year flood or a 200-year flood may have been difficult for respondents to understand, the probability of a flood occurring within the next 50 years was also included in the survey. Of 391 and 364 valid responses to the questions of below- and above-ground inundation, respectively, the respective percentages of respondents answering "don't know" were 30% and 34%. If the "don't know" responses are excluded, the results (Fig. 5) indicate that nearly 60 and 70% of respondents did not correctly perceive the probabilities of below- and above-ground inundation, respectively. Among the group that did correctly perceive the probability of flooding, the median below-ground inundation probability was once in 50 years and once in 20 years (both 11.4%), while the median above-ground inundation probability was once in 100 years (9.6%).

5.2 Acceptable flood probability

Regarding the acceptable flood probability, the survey asked the following question: "What do you think about flood occurrence? Please choose the

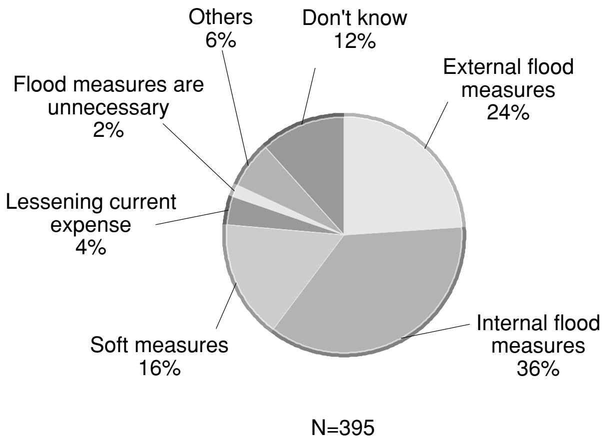

Fig. 3. Public preferences for river management.

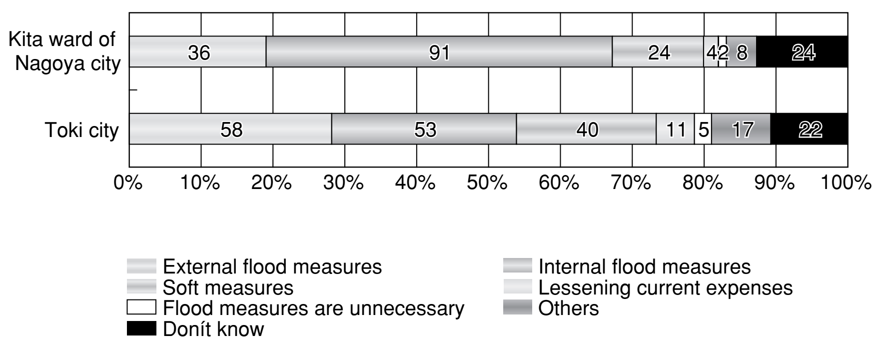

Fig. 4. Difference in public preferences according to regions.

most appropriate answer from the choices below. A. Although I live in a flood-prone area, I consider absolutely no flood occurrence acceptable. B. Because I live in a flood-prone area, I have no choice but to accept flood occurrence to some extent. C. Don't know." Of 312 valid responses, "absolutely unacceptable," "acceptable to some extent," and "don't know" constituted 37, 25, and 38% of the responses, respectively. Excluding the "don't know" group, more than half of the respondents accepted flooding to some extent. Of the "acceptable to some extent" group, residents accepting below- and above-ground inundation no more frequently than once in 100 years accounted for 88 and 77%, respectively (Fig. 6). The median below-ground inundation acceptability was once in 50 years (23%), while the median above-ground inundation

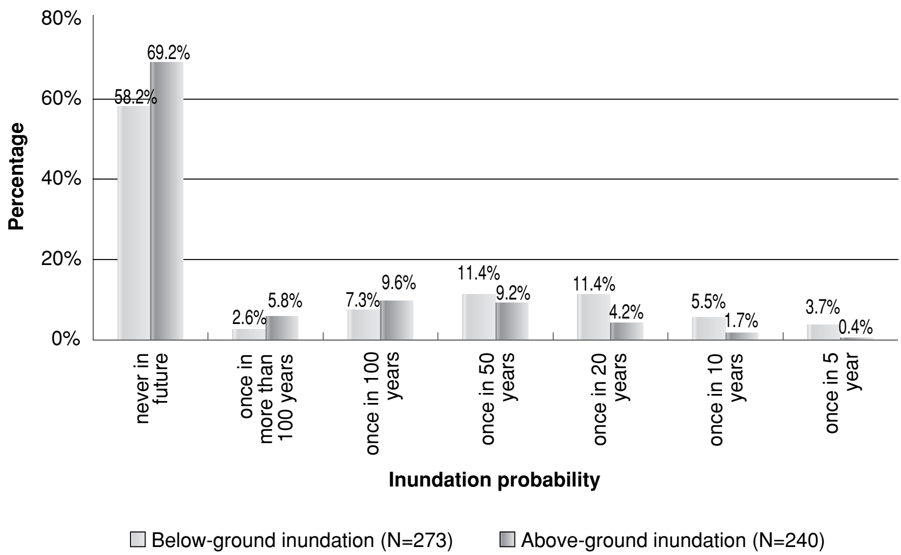

Fig. 5. Perceived probability of house inundation.

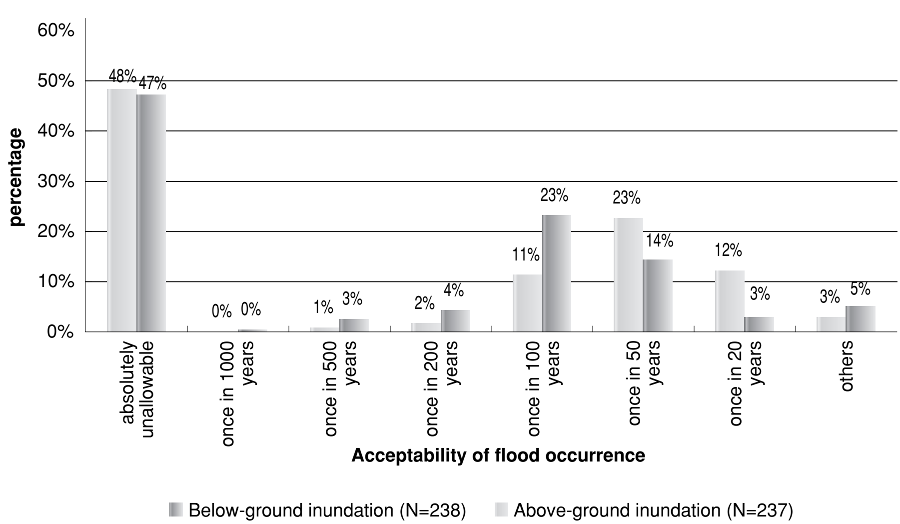

Fig. 6. Distribution of acceptable flood probability.

acceptability was once in 100 years (23%).

6 WTP for Flood Risk Reduction

As a matter of common sense, countermeasures against internal and external floods and early-warning systems should be implemented. These are defined in Table 1. First, respondents were asked to give answers for five scenarios: two scenarios each for internal and external floods, and one scenario for early warning systems (Table 2). The current sewage systems in Toki and Nagoya were designed for about a 5-year internal flood, while the levees and banks were designed for a 100-year flood in Toki and a 200-year flood in Nagoya. Planning flood control projects for higher levels requires an understanding of residents' WTP thresholds.

In addition, to examine WTP for environmental risks from flood control projects, information about potential damage to the river environment from the construction of flood control projects was either included in the survey or not. Here, environmental effects were dealt with as external factors; that is, when flood control projects are constructed, the environment may be damaged. However, Clark *et al.* (2002) treated them as internal factors; that is, when flood control projects are constructed, efforts might be made to minimize effects on the environment. The effect of providing financial information was considered in the same way.

Because the recurrence of floods at specific levels, i.e. 100-year or 200-year floods, may have been difficult for respondents to understand, the probability of a 50-year flood was also included in the survey in the same terms as once every 200 years (i.e., a probability of 22.2% within 50 years).

After indicating that the hypothetical projects would last for 20 years, respondents were asked to give their WTP values for each project. Because payment cards and dichotomous choice formats like a referendum approach are recommended and the former are more informative and cheaper to implement than the latter (Bateman *et al.*, 2002), payment cards were used in the survey.

The payment vehicle may affect WTP. There is some evidence that WTP in the form of tax is less than that in the form of donations (e.g., Andreoni, 1989; Champ *et al.*, 1997; Carson *et al.*, 1999; Chilton and Hutchinson, 1999). However, Hidano and Kato (2000) reported that the mean WTP for a tax format was higher than that for the donation format often used in Japan, because respondents could increase their utilities from just paying taxes; i.e., a "warm-glow of giving" effect existed in the tax format. Thus, to establish a more realistic WTP for flood control measures, even though they are typically financed

Table 2. Scenarios for flood control measures.

Region	Reaches	Scenarios for flood control measures			Number of samples (validly distributed)	Number of observations (response rate)
		Structural measures		Early warning systems		
		Internal floods (status quo: 5-year flood)	External floods (status quo: 100-year flood for Toki; 200-year flood for Kita ward, Nagoya City)	Fatality ratio (status quo: 1/10,000)		
Kita ward, Nagoya City	Lower reaches	10-year flood	500-year flood	1/20,000	500 (479)	201 (42%)
		20-year flood	1,000-year flood			
Toki City	Upper reaches	10-year flood	200-year flood		500 (483)	227 (47%)
		20-year flood	500-year flood			
Total					1000 (962)	428 (44.5%)

Q: If an early warning system for floods was established, the fatality ratio of a 50-year flood would decrease from one in every 10,000 people to one in 20,000. If a foundation was established for the specific purpose of implementing this early warning system, how much would you donate to it every year? (Choose one please)

1.	¥0	5.	¥2,000	9.	¥7,000	13.	¥25,000
2.	¥200	6.	¥3,000	10.	¥10,000	14.	¥30,000
3.	¥500	7.	¥4,000	11.	¥15,000	15.	¥35,000
4.	¥1,000	8.	¥5,000	12.	¥20,000	16. Other: ¥	

Fig. 7. Question asked in survey.

by the government, payment by donation was used in the survey (Fig. 7).

Because the status quo protection levels provided by levees in Nagoya (200-year flood) and Toki (100-year flood) cities differ, the WTP for external flood control measures for the two areas is discussed separately. Table 3 shows a statistical summary of the WTP for each scenario. The WTP levels for different measures range from ¥2,887 to ¥4,861 in terms of the mean and from ¥1,000 to ¥2,000 in terms of the median. Regarding the scenarios for flood control measures listed in the table, external scenario 1 refers to a measure that would improve the protection level from the status quo of a 100-year flood to that of a 200-year flood for Toki or from the status quo of a 200-year flood to that of a 500-year flood for Nagoya. External scenario 2 would improve the protection level from the status quo of a 100-year flood to that of a 500-year flood in Toki or from the status quo of a 200-year flood to that of a 1000-year flood for Nagoya. Internal scenario 1 refers to a measure that would improve the protection level from the status quo of a 5-year flood to that of a 10-year flood, while internal scenario 2 would improve the protection level to that of a 20-year flood.

6.1 Determinants of WTP for flood risk reduction with multivariate regression

Items in Fig. 1 differed in terms of indices and data sufficiency in the questionnaire. Some items, like limited resources, had only one index, while others, like individual preparedness, perceived flood probability, and consequently, had several indices. Therefore, it was necessary to decide which method to use, and which dependent variables to construct to test the hypothesis for the theoretical framework in Fig. 1. Here, the framework was first tested by multivariate regression, the dependent variables of which were the WTP for each measure for reducing flood risk with the independent variables being flood experience, flood perception (probability and consequences), perception of other risks, acceptability of flood risk, limited resources (income

Table 3. Statistical summary of WTP for each scenario (¥ per respondent per year).

			Mean	95% confidence interval of mean	Median
Scenarios for flood control measures	External flood control measure scenario 1	Kita ward, Nagoya City (from status quo 200-year flood to 500-year flood)	3,932	2,838 - 5,027	2,000
		Toki City (from status quo 100-year flood to 200-year flood)	4,665	3,516 - 5,815	2,000
	External flood control measure scenario 2	Kita ward, Nagoya City (from status quo 200-year flood to 1000-year flood)	3,674	2,438 - 4,910	1,000
		Toki City (from status quo 100-year flood to 500-year flood)	4,861	3,573 - 6,150	2,000
	Non-structural measures (from status quo 1/10,000 to 1/20,000)		2,887	2,346 - 3,418	1,000
	Internal flood control measure scenario 1 (from status quo 5-year flood to 10-year flood)		2,927	2,409 - 3,443	1,000
	Internal flood control measure scenario 2 (from status quo 5-year flood to 10-year flood)		3,152	2,557 - 3,748	1,000

per capita), individual preparedness, etc.

Due to high correlations between perceived probability of under- and above-floor inundation (0.914), the perceived under-floor inundation probability was selected as one of the independent variables (PP) of WTP. Individual preparedness (IP) was assessed from 18 sub-items, like preparation of survival food, potable water, hazard map, and so on. If the answer was YES to the preparation of a sub-item, then 1 mark was given. If all answers were YES, the individual preparedness mark was 18. The degree of worry about other risks (WO) and perceptions of the consequences of flood risk (CP) were averaged by degrees of worry ranging from 0 (not at all) to 10 (very worried) from 25 non-flood-related risks (excluding typhoons, storms, river flooding, and landslides) and 12 sub-items of flood impacts, respectively. Income per capita (INCO) was used to represent limited resources. In addition, flood experience (EXPE), the effects of providing environmental and budget information (PEI and PBI) on WTP, and the distance from a river (DIST) were tested in the models. A multivariate regression model was run with SPSS 10.0J for Windows (SPSS Inc., 1999a). The results are shown in Table 4.

First, the goodness of fit to the models was 0.40–0.45 for external measures, 0.22–0.23 for internal measures, and 0.126 for non-structural measures. This suggests that the framework in Fig. 1 is most applicable to external measures.

Second, each variable did not necessarily play the same role in each model,

Table 4. Results of multivariate regression analysis (Significance probability in parentheses).

Variables	Assumed signs in models	Scenario 1 for Kita ward, Nagoya City	Scenario 1 for Toki City	Scenario 2 for Kita ward, Nagoya City	Scenario 2 for Toki City	Non-structural measures	Internal flood control measure scenario 1	Internal flood control measure scenario 2
Constant	±	88.5 (0.988)	16520.6 (0.218)	522.2 (0.940)	-4685.1 (0.791)	460.0 (0.870)	4353.1 (0.165)	5594.4 (0.156)
IP: Individual preparedness	+	287.5 (0.397)	438.5 (0.480)	477.3 (0.275)	347.7 (0.591)	76.2 (0.666)	311.5 (0.106)	286.8 (0.224)
INCO: Income per capita	+	5.3 (0.455)	11.8 (0.393)	2.3 (0.801)	20.1 (0.174)	3.0 (0.406)	**7.0** (0.072)**	**8.2** (0.089)**
PP: Perceived probability of under-floor inundation	+	-15.0 (0.977)	-393.8 (0.668)	293.8 (0.648)	78.9 (0.934)	-123.9 (0.597)	23.8 (0.928)	120.1 (0.727)
FA: Flood risk acceptability	-	603.2 (0.169)	620.7 (0.264)	429.5 (0.452)	9.7 (0.986)	160.9 (0.358)	5.7 (0.978)	-65.6 (0.799)
CP: Perceived consequences of flood	+	-1013.3 (0.162)	-1196.1 (0.401)	-501.9 (0.530)	424.1 (0.818)	13.6 (0.956)	-219.5 (0.420)	-254.9 (0.459)
WO: Worry about other risks	-	1018.3 (0.175)	-341.5 (0.738)	436.1 (0.583)	829.6 (0.427)	**540.1** (0.058)**	150.8 (0.661)	16.8 (0.968)
EXPE: Flood experience	+	**5309.1* (0.046)**	-4715.5 (0.171)	**6318.1* (0.039)**	-1247.3 (0.747)	29.4 (0.976)	-780.7 (0.474)	369.9 (0.783)
PEI: Providing environmental information	-	-2882.2 (0.165)	-2857.0 (0.307)	**-5162.2** (0.070)**	-3675.7 (0.191)	-956.0 (0.260)	**-2779* (0.004)**	**-4088.6* (0.001)**
PBI: Providing budget information	±	1319.9 (0.504)	1361.1 (0.720)	-1782.3 (0.500)	-1019.8 (0.793)	298.7 (0.738)	417.6 (0.671)	-1035.6 (0.399)
DIST: Distance from river	-	**-1783.6* (0.038)**	887.7 (0.481)	**-2123.4* (0.022)**	-137.6 (0.918)	**-586.2* (0.041)**	-378.4 (0.273)	-532.8 (0.231)
R -squared		**0.446**	**0.456**	**0.405**	**0.423**	**0.126**	**0.219**	**0.235**

Note: * and ** denote statistically significant levels of 0.05 and 0.01, respectively.

and so was not necessarily consistent with the assumptions in the framework. IP, INCO, and PEI had the same signs in the seven models, while the other factors did not. This suggests that WTP may increase with individual preparedness and income per capita, but may decrease after negative information on flood control measures is provided, which is consistent with the common assumptions. Of the variables with different signs in the models (PP, FA, CP, WO, EXPE, PBI, and DIST), some were interrelated—for example, flood risk acceptability depends on the trade-off between flood risk perception and the perception of other risks. This implies that another method (e.g., a covariance structure analysis) is needed to obtain a general and integrated evaluation.

Finally, the main factors with a statistically significant level of 0.1, all for Kita ward, Nagoya City, were EXPE and DIST for external measures;

EXPE, PEI, and DIST for internal measures; WO and DIST for non-structural measures; and INCO and PEI for internal measures. However, there were no statistically significant factors for either external or internal measures for Toki city.

6.2 Covariance structure analysis

As mentioned, the multivariate regression analysis showed slightly different results for the determinants of individual WTP for each flood risk reduction measure. To discuss the general determinants of a synthesized WTP for flood risk reduction, which are measured indirectly by means of observable indicators, such as individual WTP, a covariance structure analysis (CSA) was used here.

CSA is an extension of the regression model and is used to test the fit of a correlation matrix against two or more causal models being compared (e.g., Krzanowski and Marriott, 1998; Wakui and Wakui, 2003). CSA originated from physiology, and has been widely applied in business, marketing, and human resource management. In CSA, the researcher uses the existing knowledge/theory/framework to generate hypotheses of how the system functions. These hypotheses are explicitly stated in the form of a causal model that depicts pathways, both direct and indirect, by which (latent or observed) variables influence each other. The researcher's theoretical model can be evaluated by assessing the extent to which covariances among variables in the model are consistent with those occurring in the actual data. To test the theoretical framework shown in Fig. 1 through CSA, two latent variables, general WTP and perceived flood risk, were introduced. The general WTP represents the resident's fundamental attitude to paying for a reduction in flood risk and determines the specific WTP for each measure, while the perceived flood risk is conceptualized from perceptions regarding the probability and consequences of flood risk.

Amos 4.0 for Windows (SPSS Inc., 1999b) was used to conduct the covariance structure analysis of WTP for flood control measures, and the results of the direct effects for each factor in WTP are shown in Fig. 8. Here, each effect is denoted by an arrow with the tail at the cause and the head pointing to its direct effect. A direct effect is represented by a single arrow, whereas indirect effects involve paths of two or more linked direct effects. Spurious effects (non-causal correlations) between variables of flood risk perception and perception of other risks are indicated by double-headed arrows. The values above the line show the degree of direct effects or non-causal correlation of variables, while those in parentheses below are the significant probabilities of

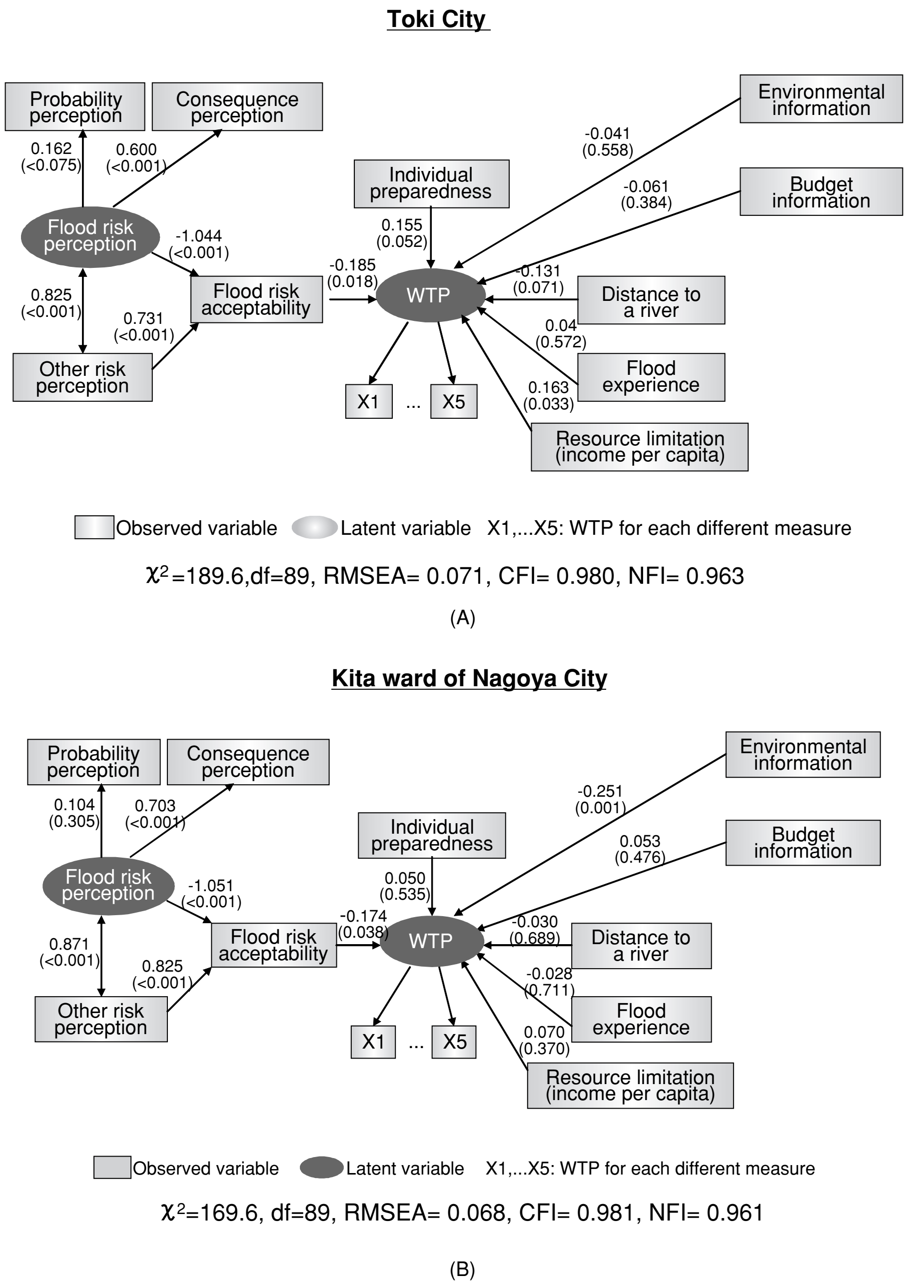

Fig. 8. Simplified path diagrams of WTP for flood control measures.
Note: Covariances and error terms associated with endogenous variables have been omitted from the diagrams for clarity.

the effects (standardized regression weights) or the correlations.

First, the proposed models for both Toki City and Kita ward, Nagoya City appear to be supported. The root mean square error of approximation (RMSEA), comparative fit index (CFI), and normed fit index (NFI) are approximately 0.070, 0.98, and 0.96, respectively. In addition, the chi-square to degree of freedom ratio ranges from 1.91 to 2.13. Together, these fitting statistics suggest that the model fits the data reasonably well[1].

Second, the signs for the effect values of the variables are consistent with the assumption in Table 4, implying the validity of the framework in Fig. 1. That is, in relation to the direct effects of the variables, WTP for flood control measures may increase with income per capita, individual preparedness, and flood experience, but may decrease with distance to a river, flood risk acceptability, and the provision of environmental information. Providing budget information with different signs showed different impacts on WTP in Toki City and Kita ward, Nagoya City. However, in relation to indirect effects, the signs of the variables imply that WTP increases with perceived flood risk and decreases with perception of other risks.

Finally, the most important determinants of WTP for flood control measures are slightly different for both areas. For Toki City, the most important determinants were acceptability of flood risk, individual preparedness, income per capita, and the distance to a river, while for Kita ward, they were acceptability of flood risk and the provision of environmental information, at a statistically significant level of 0.1. Furthermore, the acceptability of flood risk depends (at a statistically significant level) on perceived flood risk and perception of other risks. The effect values suggest that perceived flood risk plays a slightly more important role in the acceptability of flood risk than perception of other risks.

7 Multi-Attribute Evaluation with Choice Experiment Approach

7.1 Framework for evaluating multi-attribute flood prevention measures through a choice experiment

In a choice experiment, respondents are presented with a series of alternatives and asked to choose those that they most prefer. A baseline alternative, corresponding to the status quo, is generally included in each choice set. Usually, each alternative is defined by a number of attributes, which vary among the different alternatives. Aggregated choice frequencies are modeled to infer

[1]The magnitudes of the fitting statistics should be interpreted in light of the fact that individual items were analyzed rather than multi-item composites, which would more closely satisfy the assumption of multivariate normality.

the relative impact of each attribute on choice, and the marginal value of each attribute for a given option is calculated by statistical methods like the multinomial logit model. Along with the attributes, individual characteristics such as income and age may also influence the choice. The mixed logit model can be used to deal with these characteristics (Greene, 2003).

The main theoretical support for the choice experiment technique is the random utility theory (Thurstone, 1927; Mcfadden, 1973; Manski, 1977), according to which consumers maximize their utility function (subject to a budget constraint), whose random term is supposed to have a specific distribution:

$$u_i = v_i + \varepsilon_i, \tag{1}$$

where U_i is the utility when the ith scenario is chosen, V_i is the deterministic component, and ε is the random term.

Supposing that the random terms have an extreme-value (Gumbel) distribution, the probability of choosing the ith scenario from a choice set Y follows a logistic distribution and leads to what is called the conditional logit model (Mcfadden, 1973; Greene, 2003):

$$P(i/Y) = \exp(\lambda V_i)/\sum_j \exp(\lambda V_i). \tag{2}$$

An important implication of the standard logit model is that selections from the choice set must obey the property of independence from irrelevant alternatives (IIA), which states that the relative probabilities of two options being selected are unaffected by the introduction or removal of other alternatives (Luce, 1959).

To estimate the indirect utility function, the following linear form is often applied:

$$V_{in} = A_i + \sum_j \beta_j x_{ij} + \sum_h \alpha_h z_{hn}, \tag{3}$$

where A_i is an alternative-specific constant (ASC), β_j is the parameter of the jth attribute of the ith alternative represented by the variable x_{ij}, and α_h is the parameter of the hth characteristic of person n represented by z_{hn}.

As a measure of the benefits resulting from changes in an attribute, the marginal willingness to pay (MWTP), which is widely discussed as a main research consideration in the fields of transportation and environmental studies, can be rewritten as

$$\mathrm{MSR}_i = -\frac{\partial V/\partial x_i}{\partial V/\partial \text{ price}}. \tag{4}$$

The price level used here was the mean payment increase proposed in each survey scenario, while V is the marginal indirect utility for attribute i.

In a manner similar to MWTP, another measure, the marginal substitution ratio (MSR), provides the marginal substitution of one attribute due to a change in another one. Because of the specific functional form of the indirect utility function, MSRs have to be calculated as

$$\mathrm{MSR}_{j->i} = -\frac{\partial V/\partial x_i}{\partial V/\partial x_j}. \tag{5}$$

The implementation of the choice experiment approach proceeds in several steps, as described in a later section. We can already specify that flood prevention measures must first be described by their main attributes and can take different respective levels. The attributes and levels are then combined (using a statistical design) to create scenarios, which are formed into choice sets that are presented to respondents at the time of the survey.

7.2 Valuation question card

As a matter of common sense, countermeasures against internal and external floods and early warning systems should be implemented to prevent flood damage, yet at the same time, the environment should be protected at the lowest possible cost. Therefore, we utilized five criteria (attributes) comprising different public preferences for flood prevention measures: external flood reduction, internal flood reduction, early warning systems, environmental protection, and willingness to pay for countermeasures. These criteria were represented as the occurrence of disastrous floods, inundation depth, fatality rate, environmental improvement ratio, and annual additional expense per capita, respectively. Four levels were assigned to each attribute (Table 5).

To help individuals understand each attribute, brief explanations were provided in the survey questionnaires. The chance of disastrous flood occurrence was defined as the probability of floods due to the collapse or overflow of dikes and dams (i.e., an external flood) as a result of rains exceeding those that would be expected on the basis of probability. At the moment, the dikes in Nagoya city are built to withstand 200-year rains, while those in Toki city are built to withstand 100-year rains. The levels for this attribute were defined as -10, -20, -50%, and the status quo (0%). Inundation depth reduction was defined as the decrease in the depth of inundation due to reduced sewage and pumping capacity during rains (i.e., an internal flood). The levels for this attribute were defined as -10, -20, -50 cm, and the status quo (0 cm). The fatality rate due to floods was defined as the number of deaths due to

Table 5. Attributes and levels in the choice experiment.

Attributes		Attribute levels: Status quo	1	2	3
Measures/ goals	Chance of reducing disastrous flood occurrence (%)	0	-10%	-20%	-50%
	Inundation depth decrease (cm)	0	-20	-50	-100
	Fatality rate due to floods	1 in 10,000	0.9 in 10,000	0.8 in 10,000	0.5 in 10,000
	Improvement rate for river environment	0	10%	20%	50%
Annual additional expense per capita		¥0	¥2,000	¥5,000	¥10,000

a flood over the total population affected by the flood. The current fatality rate due to floods is approximately 1 in 10,000 per flood event (Zhai *et al.*, 2006a). Here, the levels were specified as 0.9 in 10,000, 0.8 in 10,000, 0.5 in 10,000, and the status quo (1 in 10,000). Because the occurrence of fatalities largely depends on early warning and evacuation systems, the fatality rate reduction may be viewed as its representative index. The river environment refers to the natural environment, including the aquatic plants and animals in a river and in the waterfront ecosystem, and the living environment at the interface between the river and human beings, including the water quality, landscape, and river space. The levels for this attribute were defined as improvement rates of 10, 20, and 50%, and the status quo (0%). The last attribute was the additional expense of flood prevention measures, with levels of 2,000 yen/person/year, 5,000 yen/person/year, 10,000 yen/person/year, and the status quo (0 yen/person/year). Based on the attributes and their levels, 12 choice sets were created by an orthogonal design approach using SPSS version 10.0J (SPSS Inc., 1999a). The valuation section of the survey consisted of four separate questions. For each question, respondents were asked to choose the most desirable of three alternatives based on descriptions of flood prevention measures at different prices (options A, B, and C), or to choose option D (the status quo) (Fig. 9).

7.3 Main results

To find detailed relationships between the utility and the attributes or individual characteristics, the analysis results can be discussed in terms of four aspects. The first is to provide a statistical summary to help understand the results. The second is to evaluate the two types of model that we applied—one containing only attributes and the other containing both attributes and individual characteristics—to see whether they correctly describe the data and to determine which variables significantly affect each model. The third is to ob-

Please examine each question below and choose ONE AND ONLY ONE option

	Option A	Option B	Option C	Option D (status quo)
Chance of disaster occurrence	10% decrease	status quo	20% decrease	status quo
Inundation depth	status quo	20 cm decrease	100 cm decrease	status quo
Fatality rate due to floods	0.8 in 10,000	0.9 in 10,000	status quo	1 in 10,000
Improvement rate for river environment	status quo	50% improvement	status quo	status quo
Annual additional expense per capita	¥5,000	¥5,000	¥5,000	¥0
I would select	↓ A.	↓ B.	↓ C.	↓ D.

Fig. 9. Valuation question card from the questionnaire.

tain important information like the marginal substitution ratio (MSR) from the validated model or models. The fourth is to discuss whether there are regional differences in the model results.

Table 6 shows the results for two multinomial logit models, denoted as Model 1 and Model 2, which were both processed with LIMDEP Version 8.0 (Greene, 2002). Model 1 contained the attributes and constants, while Model 2 was a full model containing both the attributes and the socio-economic factors. To correctly draw inferences from the model results, it was important to validate the models. The validation included evaluating the goodness of fit and assessing each variable coefficient, including the alternative-specific constants (ASCs). The explanatory power of Model 2 was a little stronger, with an R-squared and an adjusted R-squared of 0.232 and 0.221, respectively.

The hypothesis that the socio-economic factors are not significant in explaining the respondents' choice preferences was strongly rejected by the likelihood ratio test (Eq. (6)): chi-squared $= 2[852.174 - 822.13] = 60.1$. The critical chi-squared value for 24 degrees of freedom is 36.42. This means that the socio-economic factors significantly affected an individual's decision-making, and thus, Model 2 was statistically proven to be stronger than Model 1 in terms of its explanatory power. The multinomial logit model necessarily involves strong assumptions about the independence of irrelevant alternatives (IIA). Hausman tests for IIA reject the null hypothesis.

$$\begin{aligned}\text{Chi-squared} &= 2(\ln L(\text{model with a factor}) \\ &\quad - \ln L(\text{model without a factor})) \\ &> \text{Chi-squared (degrees of freedom).}\end{aligned} \tag{6}$$

Four attributes (CHANCE, DEPTH, ENVIRONMENT, and EXPENSE) were statistically significant, and their coefficient signs were the same in both models, while the attribute of FATALITY was statistically insignificant in both models. The large p-values of the FATALITY variable in both models (0.97 and 0.88) imply that this attribute was almost totally ignored in decision-making on flood prevention measures when the ASCs and socio-economic factors were considered in the model.

All ASC coefficients were positive and statistically significant across all options in Model 1, but not in Model 2. ASCs can capture a mixture of status quo bias effects and the impacts of unobserved attributes in an attribute-only model (Bateman *et al.*, 2002). Thus, the different forms of the ASCs in Models 1 and 2 implied that the impact of unobserved attributes like the socio-economic factors was important, which is consistent with the model

Table 6. Results for two multinomial logit models with choice as a dependent variable.

	Model 1 (attributes and constants)	**Model 2** (full model)
CHANCE	**-0.997 (-3.52) ******	**-0.930 (-3.30)******
DEPTH	**-0.00632 (-3.37) ******	**-0.006 (-3.30)******
FATALITY	-0.00964 (-0.03)	0.044 (0.15)
ENVIRONMENT	**0.89 (3.06) *****	**0.910 (3.10)*****
EXPENSE	**-0.000215 (-8.37) ******	**-0.00022 (-8.40)******
ASCA	**1.82 (7.15) ******	-1.623 (-0.91)
ASCA x REGION		0.354 (0.83)
ASCA x INFOENV		-0.590 (-1.60)
ASCA x INFOBUDG		0.480 (1.30)
ASCA x EXPERIENCE		-0.540 (-1.30)
ASCA x SEX		**1.100 (2.0)***
ASCA x AGE		0.110 (0.65)
ASCA x INCOME		**0.330 (2.40)***
ASCA x EDUCATION		0.260 (1.20)
ASCA x DISTANCE		0.150 (1.30)
ASCB	**2.23 (8.92) ******	-0.2747 (-0.1617)
ASCB x REGION		0.172 (0.4176)
ASCB x INFOENV		-0.590 (-1.70)
ASCB x INFOBUDG		**0.720 (2.0)***
ASCB x EXPERIENCE		-0.620 (-1.60)
ASCB x SEX		**1.100 (2.10)***
ASCB x AGE		-0.096 (-0.58)
ASCB x INCOME		**0.270 (2.0)***
ASCB x EDUCATION		0.390 (1.80)
ASCB x DISTANCE		**0.300 (2.50)***
ASCC	**1.94 (6.39) ******	-1.4123 (-0.8007)
ASCC x REGION		0.266 (0.624)
ASCC x INFOENV		-0.560 (-1.50)
ASCC x INFOBUDG		0.430 (1.10)
ASCC x EXPERIENCE		**-0.980 (-2.40)***
ASCC x SEX		**1.300 (2.50)***
ASCC x AGE		0.087 (0.50)
ASCC x INCOME		**0.390 (2.90)*****
ASCC x EDUCATION		**0.430 (2.0)***
ASCC x DISTANCE		0.160 (1.30)
No. of observations	772	772
No. of choices	3088	3088
Log likelihood	-852.176	-821.59
R-sqrd	0.204	0.232
RsqAdj	0.201	0.221
Chi-squared	145.427	206.62
Prob[chi squared > value]	<0.00001	<0.00001

Note: 1) *t* value in parenthesis
2) *, **, ***, and **** refer to significance levels of 0.05, 0.01, 0.005, and 0.001, respectively.
3) ASCA, ASCB, and ASCC are the ASCs of Options A, B, and C with respect to Option D (status quo).

evaluation results mentioned above.

The effects of the socio-economic factors can be discussed in terms of their interaction with the ASCs, though the interpretation is complicated. First, the signs of all coefficients for the interaction terms with the socioeconomic variables, except for the AGE variable, were consistent with common knowledge. Second, the interaction terms with SEX and INCOME produced statistically significantly positive impacts on the utility, but the coefficients of the interaction terms with REGION, INFOENV, and AGE were statistically insignificant for all three non-status-quo options at the 0.05 level. Third, EXPERIENCE, INFOBUDG, EDUCATION, and DISTANCE were not significant for all three non-status-quo options at the 0.05 level. Here, we use the likelihood ratio test to discuss the effects of these variables on the models, based on the hypothesis that a certain factor is not significant in explaining the choice preferences for flood prevention measures. If the hypothesis is rejected by the likelihood ratio test (Eq. (6)), a factor's effect is significant. The chi-squared values and the probabilities given by the likelihood ratio test for certain factors listed in Table 7 show that EXPERIENCE and DISTANCE were statistically significant, while EDUCATION and IFORBUDG were not, at the 0.05 level.

7.4 Implicit relationships between attributes from model results

Table 8 shows the matrix of MSRs obtained from the results for Model 2 listed in Table 7. The variable FATALITY, which had little impact on decision-making (i.e., a high p-value), is marked with an asterisk. For Model 2, to maintain the same utility if other conditions do not change, a 10% improvement in the river ENVIRONMENT should be proportional to a 9.8% increase in the flood occurrence probability, to a 15.167 cm increase in the inundation depth, or to 413.6 yen per capita of additional annual expense. The last column in Table 8 lists point estimates of the marginal willingness to pay (MWTP) for each attribute.

Table 9 lists the implicit prices (MWTPs; in yen/person/year) and 95% confidence intervals for Models 1 and 2, as obtained by Monte-Carlo simulation with 1,000 iterations. The interval estimates show nearly the same values for each attribute, except for FATALITY, for both models. The similar results for MWTP imply that the choice experiment approach produced stable estimates that were nearly free of the socio-economic factors, but were affected by the ASCs. The fact that the confidence intervals for the attribute FATALITY crossed zero and had very small means in contrast to the deviations also implied that the MWTP for FATALITY may have been zero. Therefore, for Model 2, the MWTP values were 422.7 yen/person/year for a 10% decrease

Table 7. Chi-squared values from the likelihood ratio test for certain factors.

	Model 2
EXPERIENCE	8.24 (0.041)*
IFORBUDG	5.62 (0.132)
EDUCATION	5.60 (0.133)
DISTANCE	11.78 (0.008)**
REGION	1.1(0.777)

1) Probability in parentheses
2) *, **, ***, and **** refer to significance levels of 0.05, 0.01, 0.005, and 0.001, respectively.

Table 8. Marginal substitution ratios among the attributes in Model 2.

	CHANCE (100%)	DEPTH (cm)	FATALITY (/10,000 persons)*	ENVIRONMENT (100%)	EXPENSE (MWTP) (yen/person/year)
CHANCE (100%)	-1	-155	21.14	1.022	-4,227
DEPTH (cm)	-0.00645	-1	0.136	0.0066	-27
FATALITY (/10,000)*	0.04731	7.33	-1	-0.0484	200
ENVIRONMENT (100%)	0.97849	151.67	-20.68	-1	4,136
EXPENSE (yen/person/year)	-0.00024	-0.037	0.005	0.0002	-1

* Statistically insignificant at 0.1 level

Table 9. Implicit prices (MWTPs; yen/person/year) and 95% confidence intervals for each model by Monte-Carlo simulation with 1,000 iterations.

	Model 1	Model 2
CHANCE (100%)	-4,637 (-8,044 to -1,948)	-4,227 (-7,366 to -1,621)
DEPTH (cm)	-29 (-48 to -11)	-27 (-49 to -9)
FATALITY (/10,000)	-45 (-2,624 to 2,549)*	200 (-2,936 to 2,324)*
ENVIRONMENT (100%)	4,140 (1,387 to 7,098)	4,136 (1,458 to 7,157)

* Statistically insignificant at 0.1 level

in the flood occurrence probability, 270 yen/person/year for a 10 cm reduction in the inundation depth, and 422.7 yen/person/year for a 10% improvement in the river environment.

7.5 Result differences between regions

The fact that the variable REGION in the model proved insignificant according to the pooled (total) data implied that REGION statistically had no significant impact on the utility functions of Kita ward and Toki City. This does not necessarily mean, however, that the analysis results would have been the same in each region had we used regionally separated data. First, the discussion with regard to the likelihood ratio test concerns the involvement of the various socio-economic variables in the model and the results evaluated for different regions. In a manner similar to the above analysis, the former was discussed in terms of Eq. (6), while the latter was examined with Eq. (7) (Greene, 2003). This equation tests the alternative hypothesis that the constant term and the coefficients of the attribute variables were the same whether REGION equaled 1 (Toki City) or 2 (Kita ward). As a result, four cases were examined, and the results are listed in Table 10.

$$\begin{aligned}\text{Chi-squared} &= 2(-\ln L(\text{pooled}) + (\ln L(\text{model with a factor}) \\ &\quad + \ln L(\text{model without a factor}))) \\ &> \text{Chi-squared (degrees of freedom)}.\end{aligned} \tag{7}$$

The likelihood ratio tests on the model differences in the two regions showed that both models were significant at the 0.05 level. The tests on the differences in the two models, however, showed that the socio-economic factors were statistically significant in affecting the decision-making in Toki City (less than 0.0001), but not in Kita ward (0.1086), at the 0.05 level.

In addition, the differences were examined in terms of the coefficients of the attribute variables in the four models, as listed in Table 11. At least three things can be observed from the table. First, there were great differences not only in the coefficients, but also in the t-values of two variables, CHANCE and ENVIRONMENT, with respect to REGION. In the Toki City model, ENVIRONMENT was significant but CHANCE was not, while the opposite was true for Kita ward. Second, FATALITY was not statistically significant in any of the four models, which was consistent with the analysis results described above. Third, the coefficients for DEPTH and EXPENSE were nearly the same in all four models.

Finally, the degree of regional difference can be explained in terms of

Table 10. Significant probability for likelihood ratio tests between regions and models.

	Between regions	Toki city	Kita ward of Nagoya city
Between models 1 and 2		0.0001	0.1086
Model 1 (attributes and constants)	0.03373		
Model 2 (full model)	0.04449		

Table 11. Coefficients and t-values of the attribute variables in the four models.

	Kita ward of Nagoya city		Toki city	
	Model 1 (attributes and constants)	**Model 2** (full model)	**Model 1** (attributes and constants)	**Model 2** (full model)
CHANCE	-1.2753 (-3.121)	-1.15527 (-2.781)	-0.71314* (-1.809)	-0.65392* (-1.625)
DEPTH	-0.0061 (-2.255)	-0.00631 (-2.286)	-0.00626 (-2.395)	-0.00639 (-2.404)
FATALITY	0.4085* (0.992)	0.54369* (1.258)	-0.40976* (-1.058)	-0.42590* (-1.063)
ENVIRONMENT	0.4814* (1.139)	0.58882* (1.353)	1.25911 (3.112)	1.35282 (3.227)
EXPENSE	-0.00025 (-6.471)	-0.00026 (-6.476)	-0.00019 (-5.368)	-0.00020 (-5.444)

1) t-value in parentheses
2) * Statistically insignificant at 0.05 level

Table 12. Regional differences in MWTP (yen/person/year) for Models 1 and 2.

	Model 1 (attributes and constants)	**Model 2** (full model)
CHANCE (100%)	-1,197	-1,381
DEPTH (cm)	7.7	8.3
FATALITY (/10,000)	4,284	3,833
ENVIRONMENT (100%)	-4,560	-4,738

MWTP instead of MSR because of the complexities of the MSR matrices. Table 12 shows slight differences in the MWTPs between Toki City and Kita ward for both models. In the case of Model 2, as compared with those of Toki City, the MWTPs for Kita ward were 138.1 yen/person/year more for a 10% decrease in the flood occurrence probability, 83 yen/person/year less for a 10 cm reduction in the flood inundation depth, 383.3 yen/person/year less for a fatality reduction of 1/100,000, and 473.8 yen/person/year less for a 10% improvement in the river environment. Therefore, it seems that Nagoya City's Kita ward pays more attention to disastrous flood occurrences, while Toki City focuses more on environmental protection and fatality reduction measures.

8 Concluding Remarks

This study investigated public preferences regarding flood control measures, WTP, the main factors determining WTP, and the relationships among five attributes of flood risk reduction measured through a survey conducted in the Shonai-Toki River region of Japan from the end of March to the beginning of April, 2004. The main findings are summarized as follows.

- Most residents expect some flood control measures and have diverse interests in river management.
- Nearly half of the respondents accept no flood risk at all.
- The WTP levels for different measures range from ¥2,887 to ¥4,861 in terms of the mean and from ¥1,000 to ¥2,000 in terms of the median. It is likely that there is zero marginal WTP for flood risk reduction in both Toki City and Nagoya City. This is because WTP for flood risk reduction must be determined within a multi-risk context.
- Among the five attributes of the flood prevention measures, four attributes—specifically, the chance of reducing the number of disastrous flood occurrences, the reduction of inundation depth, the rate of improving the river environment, and the additional expense of new flood prevention measures—were statistically significant.
- There was a statistically significant difference in the model results between Toki City and Kita ward of Nagoya City.

How to apply CVM and the choice experiment approach the general cautions have been broadly discussed in environmental economics (e.g., Bateman, 2002, p. 74). However, when they are applied to flood risk reduction, additional cautions are necessary.

First, WTP for flood risk reduction should be considered together with the risk curve. That is, the "scope effect" in economics may not be detected at a statistically significant level due to its very small changes in WTP. Flood risk, particularly in terms of fatality, is very small, usually at a level of less than 10^{-6}. In the case of Japan, the number of annual fatalities due to floods is usually less than 100. People may not take it very seriously because they perceive that other risks, such as fire or earthquake risk, are more important than flood risk. This is reflected in the WTP where their marginal WTP may be close to zero. Actually, results for fatality reduction in both CVM and the choice experiment were statistically insignificant when socio-economic factors were included in the analyses. The value of statistical life (VOSL) obtained by other methods, such as a hedonic approach, should be used to calculate the benefit of fatality reduction due to flood risk reduction measures.

Second, the results for model analysis contain uncertainty. As in the analysis for the choice experiment, the fatality factor is statistically significant when only attributes are input in the model, but becomes non-significant when additional socio-economic factors are included. It is important to clarify information regarding how the WTP is produced; for example, by checking what kind of question was asked, what kind of model was used, and how well the model performed.

Third and finally, WTP for moral satisfaction may be induced when CVM is used. Because the marginal WTP for flood risk reduction is close to zero, it would be better to understand that the estimated WTP may be regarded as the one for moral satisfaction.

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