Evaluating Public Preferences for Sustainability with Choice Experiment Approach in Japan

1. Introduction

The coastal zone contains diverse and productive habitats important for human settlements, development, and local subsistence. More than half the world's population lives within 60 km of the shoreline, and this could rise to three quarters by the year 2020 (United Nations 1992). In the mean time, greatly increasing populations are leading to increased conflict between competing uses, such as fishery and tourism, in the coastal area. As a result, the coastal environment tends to deteriorate and the potential damage of coastal disasters like earthquakes, tsunamis, and floods increases. There is no simple, legislative solution to these complex problems to realize sustainable development in coastal areas. Given the diversity of physical, economic, cultural and institutional conditions, our actions must be flexible and focused on addressing the real problems on the ground. The integrated coastal zone management is considered to be a good tool (United Nations 1992, National Land Agency 2000, European Commission 2001). It is not just an environmental policy; while the need to protect the functioning of natural ecosystems is a core aim of the strategy, it also seeks to improve the economic and social well-being of coastal zones and help them develop their full potential as modern, vibrant communities. In the coastal zone, these environmental and socioeconomic goals are intrinsically interconnected (European Commission 2001).

On the other hand, public involvement is required in the coastal development. Without the full participation of local stakeholders, the management strategies will never succeed. In fact, local people are having more and more influence on the decision-making of coastal sustainable development and participatory coastal management has become a mainstream philosophy.

Unfortunately, there are few studies that quantitatively deal with local people's goals regarding coastal development, in particular, in Japan. As the New Coastline Law, revised in 1999, is implemented, public preference and involvement will play a more important role in decision-making processes for coastal zone management. However, much of the related research has focused on public preferences regarding specific issues, such as water quality, coastal landscapes, regional revitalization, and coastal disaster prevention except the research by Zhai *et al* (2007) focusing the important attributes of flood prevention measures and the effects of socio-economic factors on the public preferences. This body of research has not gone further by globally considering the relationships among the various goals/attributes of coastal zone management, like environmental protection, disaster countermeasures, and economic development, on the basis of total regional sustainability. One of the main reasons is due to Japan's strong sectoral management of the fisheries, regional development, energy, transport, environment, and military.

Therefore, this paper extends the scope of Zhai *et al* (2007) to water-related development and aims to evaluate the public preferences for coastal sustainability rather than for one or two sectors, through a random-utility-based choice experiment utilizing the results of a mail survey conducted in Yokohama, Japan in April 2006. We are not aware of any research applying this approach to evaluate public preferences for coastal sustainable development.

This paper consists of five sections as follows. Section II provides a method for multiple criteria evaluation of coastal sustainability through a choice experiment. Section III briefly describes the design and implementation process of the questionnarire survey. Section IV presents the main results of the survey and conjoint analysis. Section V provides concluding remarks.

2. Method

Choice modeling is based on the idea that any good 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, coastal management can be described in terms of natural disaster reduction such as earthquake, flood, high wave and tsunami, coastal uses like seaports, fishery, recreation, and concerns about coastal environmental protection. Choice modeling includes choice experiments, contingent ranking, contingent rating, and paired comparisons.

In 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 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:

$$U_i = V_i + \varepsilon_i , \qquad (1)$$

where U_i is the utility to choose the i^{th} scenario, 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 i^{th} scenario from the choice set Y follows a logistic distribution and leads to what is called the conditional logit model (Mcfadden 1973, Greene 2003):

$$P(i/Y) = \exp(\lambda V_i) \Big/ \sum_j \exp(\lambda V_i) . \qquad (2)$$

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

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

where A_i is an alternative-specific constant (ASC), β_j is the parameter of the j^{th} attribute of the i^{th} alternative represented by the variable x_{ij}, and α_h is the parameter of the h^{th} 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 follows:

$$MSR_i = -\frac{\partial V / \partial x_i}{\partial V / \partial price} . \qquad (4)$$

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 rate (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 follows:

$$MSR_{j->i} = -\frac{\partial V / \partial x_i}{\partial V / \partial x_j}. \qquad (5)$$

Choice experiment studies require much effort in their design, administration, especially the development of relevant scenarios and their attributes, and statistical methodology. We can already specify that coastal management must first be described by their main attributes and that different levels can be assigned to each attribute. The attributes and levels are then combined (using a orthogonal design) to create scenarios.

3. Data

Data is obtained by a survey. Kanazawa Ward of Yokohama City Kanagawa Prefecture in Japan is selected as a survey area because it can be regarded as a typical coastal zone located in Tokyo Bay and has developed to a residential, industrial, recreational and fishery area. Regional and coastal development brings with it coastal environmental problems and disaster risks.

To yield useful information, careful survey design is critical. The survey purpose determines the survey mode and the accuracy of the results. The ultimate implications of this survey include possibly helping to improve coastal management in Japan. Therefore, a mail survey is feasible (Desvousgaes et al 1998), and face-to-face interviews, as proposed by Arrow et al. (1993), are not necessarily required.

As a matter of common knowledge in Japan, coastal management has to consider three aspects: environment conservation, natural disaster countermeasures, and promotion of coastal area usage. Therefore, 14 criteria (attributes) comprising different public preferences for coastal management (**Table 1**) were utilized even if some are closely interrelated. Five levels were assigned to annual additional expense per capita, while seven levels were assigned to the other attributes.

To help individuals understand each attribute and to make the attributes meet the independence requirement of the model, brief and strict interpretations and definitions were provided in the survey questionnaires in accordance with the model's assumption on the independence of variables. Here, the levels for the attributes of environment conservation, natural disaster countermeasures and coastal area use promotion were defined with improvement/degradation rates of 10%, -10%, 20%, -20%, 50%, -50% and the status quo (0%).The signs of +/- are only used in survey design and data analysis. In the survey, they were replaced with the words like "improved" or "reduced" to make survey respondents more understandable. "-"signs for undesirable items like natural disasters, garbage and oil at sea surface and sand beach may increase people's utilities but for desirable ones like water quality improvement, ecosystem improvement, landscape improvement, and promoting coastal usage may reduce the utilities. The frequency of natural disasters occurrence itself cannot be reduced, but the frequency of the damages affected by natural disasters may be reduced by strengthening prevention measures. But the prevention measures need additional investment. The last attribute was the additional expense of coastal management, with levels

of 1,000 yen/year/person, 2,000 yen/year/person, 5,000 yen/year/person, 10,000 yen/year/person, and the status quo (0 yen/year/person).

Table 1 Attributes and levels in the choice experiment

Attributes		Attribute levels						
		Status quo	1	2	3	4	5	6
Improving environment quality	1. Water quality	0	-50%	-20%	-10%	10%	20%	50%
	2.Garbage and oil at sea surface and sand beach	0	-50%	-20%	-10%	10%	20%	50%
	3. Tree and grass at seaside	0	-50%	-20%	-10%	10%	20%	50%
	4. Coastal landscapes including revetment and block	0	-50%	-20%	-10%	10%	20%	50%
Reducing natural disaster risks	1. Earthquake	0	-50%	-20%	-10%	10%	20%	50%
	2. High wave and Tsunami	0	-50%	-20%	-10%	10%	20%	50%
	3. Flood	0	-50%	-20%	-10%	10%	20%	50%
	4. Typhoon	0	-50%	-20%	-10%	10%	20%	50%
Promoting coastal usage	1. Fishery	0	-50%	-20%	-10%	10%	20%	50%
	2. Industry	0	-50%	-20%	-10%	10%	20%	50%
	3. Port	0	-50%	-20%	-10%	10%	20%	50%
	4. Service sector like restaurant	0	-50%	-20%	-10%	10%	20%	50%
	5. Recreation facilities like parks and sports facilities	0	-50%	-20%	-10%	10%	20%	50%
Annual additional expense per capita (¥)		0	1,000	2,000	5,000	10,000	-	-

Based on the attributes and their levels, possible choice experiment options were created by using an orthogonal design approach using SPSS version 10.0J. After discarding some unreal options, we formed 16 choice cards (evaluation question cards) together with the status quo option from the 32 options that were left. The survey respondent is asked to make a choice decision based on all thirteen aspects with the ones not appeared regarded as no change (**Figure 1**). For each question, respondents were asked to choose the most desirable of three alternatives based on descriptions of coastal management at different additional expenses (options A and B), or to choose option C (the status quo). The valuation section of each questionnaire consisted of four separate choice cards. Therefore, there were four different versions with four valuation question cards.

The survey was conducted in April 2006. 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 used here has also been testified effective in Japan (Zhai *et al* 2007).

First, five people living in coastal area were asked to formally pre-test the questionnaires and returned their comments on the items of designed questionnaire survey such as spending time, difficulties in answering the questions. Based on returned information, the questionnaire was revised.

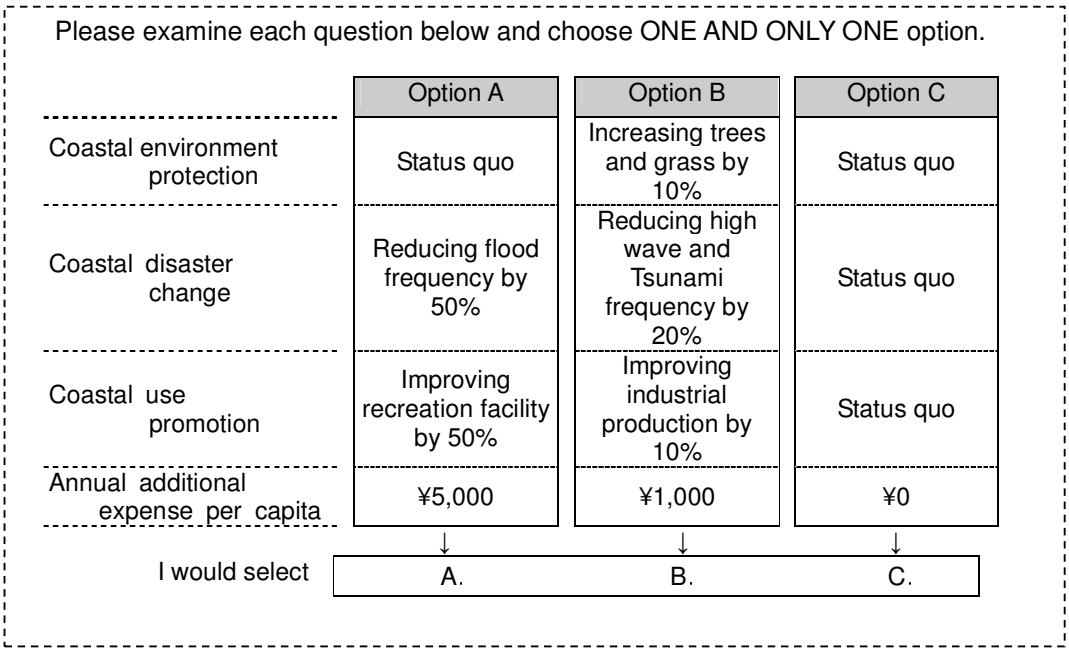

Figure 1 Valuation question card from the questionnaire

Second, 1,000 households were randomly selected from a commercial phone directory database: *Kurofune 2004* (Datascape & Communications Inc., 2004), in some areas of Kanazawa ward of Yokohama city, Kanakawa prefecture.

Third, the questionnaires were sent to the selected 1,000 households on April 14, 2006 by mail with a cover letter giving details of the institute and instructions for completing the survey; an addressed envelope for returning the survey and a postcard for informing the response of questionnaire were also enclosed. The respondents were asked to send their questionnaires and postcards separately to ensure that their replies to the surveys were anonymous.

Fourth and finally, a reminder postcard was sent on April 26, 2006 to the members whose confirmation postcards were not received approximately two weeks after the initial mailing. The postcard requested once again a response from those who had not yet responded.

As a result, of a total of 835 surveys that were validly distributed, questionnaires from 450 households were received by mail, for a response rate of 53.9%. The reasons why 16.5% people could not be reached are from two aspects. One is approximately 5% of annual immigration rate. And another is that database of *Kurofune 2004* is based on the year of 2003, not updated. Respondents have average age of 62.4 years, annual income of 6.42 million yen, household member of 3.02 persons, 79% of males, and 86.4% of privately owned houses, respectively.

4 Results

4.1 Results for multinomial logit model

Table 2 shows the results for a multinomial logit model, which was processed with LIMDEP Version 8.0 (Greene 2002). The model is a full model containing both the attributes and the socioeconomic factors. Those aspects that did not appear in a choice combination are coded as zero. The explanatory power of the model has an R-squared and an adjusted R-squared of 0.202 and 0.192, respectively.

Table 2 Results for two multinomial logit models with choice as a dependent variable

Independent variables		Coeff.	Std.Err.	t-ratio	P-value
Improving environment quality	1. **WATER** (Water quality)	0.001	0.006	0.233	0.816
	2. **GARBAGE_OIL** (Garbage and oil at sea surface and sand beach)	**-0.038**	**0.006**	**-5.990**	**<0.001**
	3. **ECOSYTEM** (Tree and grass at seaside)	**0.019**	**0.005**	**4.110**	**<0.001**
	4. **LANDSCAPE** (Coastal landscapes including revetment and block)	-0.029	0.048	-0.596	0.551
Reducing natural disaster risks	1. **EARTHQUAKE**	**-0.038**	**0.006**	**-6.195**	**<0.001**
	2. **WAVE** (High wave and Tsunami)	**-0.044**	**0.006**	**-7.263**	**<0.001**
	3. **FLOOD**	**-0.052**	**0.007**	**-7.174**	**<0.001**
	4. **TYPHOON**	0.006	0.009	0.738	0.460
Promoting coastal usage	1. **FISHERY**	0.001	0.004	0.316	0.752
	2. **INDUSTRY**	-0.002	0.006	-0.339	0.735
	3. **PORT**	**0.019**	**0.006**	**3.097**	**0.002**
	4. **SERVICE** (Service sector like restaurant)	**-0.064**	**0.023**	**-2.842**	**0.004**
	5. **RECREATION** (Recreation facilities like parks and sports facilities)	**-0.022**	**0.008**	**-2.614**	**0.009**
PAYMENT		**-0.00037**	**0.00005**	**-7.193**	**<0.001**
Interaction terms of respondents' characteristics with constants	ASCA	0.367	0.579	0.634	0.526
	ASCA x **SEX** (female =0, male=1)	**-0.403**	**0.226**	**-1.785**	**0.074**
	ASCA x **AGE** (year)	0.108	0.078	1.395	0.163
	ASCA x **INCOME** (less than ¥2 million =1, ¥2~4 million =2,…, more than ¥14 million =8)	**0.082**	**0.047**	**1.718**	**0.086**
	ASCA x **EDUCATION** (over high school=1,else=0)	-0.119	0.182	-0.656	0.512
	ASCA x **IMMIGRATION** (yes=1, no=0)	**-0.601**	**0.251**	**-2.392**	**0.017**
	ASCB	-0.690	0.600	-1.149	0.250
	ASCB x **SEX** (female =0, male=1)	**-0.456**	**0.229**	**-1.988**	**0.047**
	ASCB x **AGE** (year)	**0.250**	**0.081**	**3.073**	**0.002**
	ASCB x **INCOME** (less than ¥2 million =1, ¥2~4 million =2,…, more than ¥14 million =8)	0.040	0.049	0.808	0.419
	ASCB x **EDUCATION** (over high school=1,else=0)	-0.302	0.185	-1.627	0.104
	ASCB x **IMMIGRATION** (yes=1, no=0)	-0.221	0.267	-0.826	0.409
Number of observations = 1086		Log likelihood function = -952.56			
R-sqrd = 0.202		RsqAdj = 0.192			
Chi-squared[24] = 435.96		Prob [chi squared > value] = <0.00001			

Note: Variables in bold refer to having a statistical significance of 0.1 level.

Among four groups including 14 independent variables, nine attributes were statistically significant at the significance level of 0.01, and five (**WATER, LANDSCAPE, TYPHOON, FISHERY** and **INDUSTRY**) were not. Among the nine statistically significant variables, seven variables (**GARBAGE_OIL, EARTHQUAKE, WAVE, FLOOD, SERVICE, RECREATION,** and **PAYMENT**) were negative, while the other two (**ECOSYSTEM** and **PORT**) were positive. The findings show that what the respondents are most concerned about are the reduction of garbage and oil on the sea surface and beach, improvement of the seaside ecosystem such as by planting trees and grass, natural disaster countermeasures against earthquakes, high waves (tsunamis) and floods, promotion of port construction, and limitation of service and recreation facilities at the coastal area.

The effects of the socioeconomic factors can be discussed in terms of their interaction with the ASCs (Alternative Specific Constants), even though it is complicated to interpret. First, all interaction terms with **SEX** were statistically significant negative impacts on the utility at the 0.1 level. Second, although all interaction terms with **AGE, INCOME,** and **IMMIGRATION** were not statistically significant at the 0.1 level, their coefficients had the same signs. Third, no interaction terms with **EDUCATION** were statistically significant at the 0.1 level, but their coefficients were negative. The results imply that female, older, richer, and original inhabitants have a stronger desire for coastal management.

4.2 Implicit relationships between attributes from model results

Table 3 shows the matrix of marginal substitution rates (MSRs) obtained from the results in **Table 2**. The variables with statistical significance are marked in bold. To maintain the same utility if other conditions don't change, a 10% improvement in ecosystem should be proportional to a 5.1% decrease in garbage and oil on the sea surface and beach, to a 5.1% decrease in the earthquake risk, to a 4.3% decrease in high waves and tsunami risk, to a 3.7% decrease in the flood risk, or to 520 yen per capita of additional expense. In other words, it is proved that tradeoff relationships between different attributes exist.

The last column in **Table 3** lists point estimates of the marginal willingness to pay (MWTP) for each attribute. Specifically, respondents are willing to pay 1,020 yen for 10% reduction of garbage and oil pollution at the sea side, 520 yen for a 10% improvement in ecosystem, 1,010 yen, 1,190 yen and 1,390 yen for 10% risk reductions in earthquake, high wave and tsunami, and flood, respectively. Regarding coastal area usage, while rejecting the construction of services like restaurants and recreation facilities like park and sports facilities, respondents were willing to promote port construction. The economic value for the attribute can be estimated from the MWTP, and it may be taken into account in the cost-benefit analysis. In addition, MWTP for each attribute may be used as one of the most important quantity indicators when allocating social resources for coastal management.

5. Concluding Remarks

The multiple goal evaluation of public preferences for coastal sustainability yielded some interesting and important implications regarding future coastal management policy.

First, it is necessary for local and prefecture governments to re-allocate social resources to solve the problems that the public thinks is the most important to meet their requirements for coastal zone management. The findings show that the respondents are most concerned about reducing garbage and oil on the sea surface and beach, improving the ecosystem such as by planting trees and grass; reducing risks of earthquakes, high waves, tsunamis and floods; promoting port construction, and limiting service and recreational facilities on the area. Regarding coastal area usage, respondents rejected the construction of service facilities like restaurants and recreation facilities like parks and sports facilities, but were willing to promote the port construction. Respondents were willing to pay 1,020 yen for a 10% reduction of garbage and oil pollution of the sea side, 520 yen for a 10% improvement in the ecosystem, 520 yen for a 10% increase in seaport construction, 1,010 yen, 1,190 yen and 1,390 yen for 10% reductions in risks related to earthquakes, high waves and tsunamis, and floods, respectively. All these data provide a good reference standard for making decisions about coastal management. The marginal willingness-to-pay for each attribute may be used as an important quantity indicator when allocating social resources for coastal management.

Second, it is possible to implement a coastal management program with less cost for the same utility because of the tradeoff between the attributes/goals of coastal zone management. This research only clarified the MWTP for and the tradeoff between individual attributes. However, the effectiveness of implementing a coastal management program depends on other factors such as its efficiency. Given limited economic resources, a more efficient coastal management program must be preferred over other less efficient ones. In addition, respondents seemed to reject service and recreation facilities. This does not imply that respondents don't need such facilities, but that such facilities currently may be so superabundant that respondents consider them harmful to the coastal environment.

Table 3 Matrix of marginal rate of substitution among attributes

	WATER	GARBAGE_OIL	ECOSYTEM	LANDSCAPE	EARTHQUAKE	WAVE	FLOOD	TYPHOON	FISHERY	INDUSTRY	PORT	SERVICE	RECREATION	PAYMENT
WATER	-1.0	0.04	-0.07	0.05	0.04	0.03	0.03	-0.22	-1.01	0.63	-0.07	0.02	0.06	4
GARBAGE_OIL	27.3	-1.00	1.96	-1.32	-1.00	-0.85	-0.73	5.89	27.45	-17.23	1.95	-0.59	-1.71	-102
ECOSYTEM	-13.9	0.51	-1.00	0.67	0.51	0.43	0.37	-3.00	-14.00	8.79	-1.00	0.30	0.87	52
LANDSCAPE	20.6	-0.76	1.48	-1.00	-0.76	-0.64	-0.55	4.45	20.76	-13.04	1.48	-0.45	-1.29	-77
EARTHQUAKE	27.2	-1.00	1.95	-1.32	-1.00	-0.85	-0.73	5.86	27.35	-17.17	1.95	-0.59	-1.70	-101
WAVE	32.0	-1.17	2.30	-1.55	-1.18	-1.00	-0.86	6.90	32.20	-20.22	2.29	-0.69	-2.00	-119
FLOOD	37.4	-1.37	2.69	-1.81	-1.38	-1.17	-1.00	8.07	37.61	-23.62	2.68	-0.81	-2.34	-139
TYPHOON	-4.6	0.17	-0.33	0.22	0.17	0.14	0.12	-1.00	-4.66	2.93	-0.33	0.10	0.29	17
FISHERY	-1.0	0.04	-0.07	0.05	0.04	0.03	0.03	-0.21	-1.00	0.63	-0.07	0.02	0.06	4
INDUSTRY	1.6	-0.06	0.11	-0.08	-0.06	-0.05	-0.04	0.34	1.59	-1.00	0.11	-0.03	-0.10	-6
PORT	-14.0	0.51	-1.00	0.68	0.51	0.44	0.37	-3.01	-14.05	8.82	-1.00	0.30	0.87	52
SERVICE	46.1	-1.69	3.31	-2.23	-1.70	-1.44	-1.23	9.95	46.38	-29.12	3.30	-1.00	-2.89	-172
RECREATION	16.0	-0.59	1.15	-0.77	-0.59	-0.50	-0.43	3.44	16.06	-10.08	1.14	-0.35	-1.00	-59
PAYMENT	-1.0	-0.01	0.02	-0.01	-0.01	-0.01	-0.01	0.06	0.27	-0.17	0.02	-0.01	-0.02	-1

Third and finally, the representative participants must be carefully chosen when public involvement in coastal zone management is implemented, because different backgrounds like age, sex, education, and annual income may significantly affect their preferences. Furthermore, the stakeholders of coastal management must share information frankly and impartially, and faithfully communicate it to each other, rather than transmit it in one direction, say, from the government to the public.

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