QUANTITATIVE ANALYSIS OF TIDE EMBANKMENT CONSTRUCTION AND RESIDENT'S SELECTING ACTION

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1. INTRODUCTION

About three and a half years has passed since the Great East Japan earthquake in March, 2011. The damaged by Tsunami has still left in many disaster areas. In most of those areas, as one of the restoration, Plans of giant seawall (tide embankment) construction are pushed forward by governments and administrations. Based on the standards decided by government's Central Disaster Management Council, much higher seawalls are planned to be constructed than before collapsed. Movements against giant seawall construction, however, are slightly but surely gathering force among a part of residents in disaster areas. Some people point out landscape would have been destroyed by the construction, and others wonder if residents move to the high ground, nobody would be suffered from disasters. Over the issue of the construction, many conflicts are happened.

Kesennuma City, located in Miyagi prefecture, is no exception. In Kesennuma City, many districts near the coast suffered massive damages in the tsunami disaster. Plans of seawall construction are promoted regardless of cost benefit effects. Several studies on cost benefit analysis of the seawall construction have been conducted. Jun, K. et al[1)] studied that in Koizumi district, Kesennuma. In this district, in order to prevent tsunami, 14.7m (set with level1, L1[2)]), the heights of seawall are getting constructed. Regarding that, they concluded that costs, around 24.6 billion yen would be needed and in that case, the net benefit (benefit minus cost) would be negative (-20.75billion yen).

According to the review of the previous studies, found that construction a seawall with L1 is negative aspect of cost benefit. However, quantitative evaluation for cost benefit analysis under the consideration of environmental damages and residents selecting behavior has not yet been conducted enough in this district. Recently, the landscape and environmental issues are even more stirring up in those areas.

This study focuses on Koizumi district. Over the seawall construction, it clarifies what residents recognize, what they really interested in and what they wish to solve the problem. Firstly, by means of cost benefit analysis and multi standard analysis, suggests the preferable choice of the giant seawall construction and decision making, using outranking method. Secondly, by using covariance structure analysis shows a difference of resident's recognition structure to achieve agreement formation between Koizumi and total areas in Kesennuma.

2. Method

(1) Study contents

The period of survey is from 15 September to 18 September (in the case of 2014) in Koizumi and other district in Kesennuma. The survey was conducted household survey by using questionnaire consisting of 4 classifications; a basic attribute, a living condition, disaster prevention, the consciousness to a seawall. To compare more universally analysis to that of Koizumi, I also asked people all areas in Kesennuma.

(2)Analysis Method

As for cost benefit analysis, in this study, concordance matrix is applied[3]. It is explained as follows. It is a method of outranking analysis. Roy. B[4] developed it in 1960s, leading position in Europe.

It has a common characteristic to cost benefit analysis; it is started from a plan impact matrix to unify associated standard results of alternative plans. Conceder Concordance index C_{ij} and C_{ji}. Difference between C_{ij} and C_{ji} indicates superiority weighted plan i to weighted plan j

・Step1: Concordance Index

There assume two alternative plan u,v. First, a set, $\bar{C}_{uv}$ is defined as follows:

$$\bar{C}_{uv}=\{j/p_{ju}\geq p_{jv}\} \quad (i)$$

s.t. $\bar{C}$: set, j: evaluation item, p_{ju}, p_{jv} : effect of plan u, plan v

Then, c_{uv} is defined as follows:

$$c_{uv}=\sum_{j\in\bar{C}uv} w_j \quad (ii)$$

s.t. $w_j: (j \in \bar{C}uv)$

・Step2: Discordance Index

d_{uv} is the index that the degree of plan u inferior to plan$v$. There assume two alternative plan u,v. First, a set, $\bar{D}_{uv}$ is defined as follows:

$$\bar{D}_{uv}=\{j\,|\,p_{ju}\leq p_{jv}\} \quad (iii)$$

Then, d_{uv} is defined as follows:

$$d_{uv}=\max_{j\in\bar{D}_{uv}}\left(\frac{|Pju-Pjv|}{dj^{\max}}\right)$$

s.t. $dj^{\max}_{1\leq u,v\leq M}=\max\{j/p_{ju}-p_{jv}\}$ (iv)

・Step3 Solution

Based on c_{uv}, d_{uv} obtained by Step1 and Step2, determine the preference order as follows:

If $c_u>c_v$, then select plan u,

If $d_u<d_v$, then select plan v.

$$c_u=\sum_u Cuv-\sum_v Cvu, \quad (v)$$

$$d_u=\sum_u duv-\sum_v dvu \quad (vi)$$

Secondly, I conduct covariance structure analysis, using SPSS Amos ver. 22.0 IBM SPSS Final object on this survey is to examine find out the influence of what kinds of factor lead to agree or disagree to the sea wall construction. Finally, identify the resident's selection behavior. Based on collected data from questionnaire, two categories were made; Koizumi and Total districts in Kesennuma.

In order to specify the difference in affected factors each district, I use Mean Structure model[5]. By using this model, it is possible to estimate the average of latent variable. In this sense, we can regard the average as the difference between groups.

3. Results and Discussion

(1) Responder's Basic Data

The following fig.1 andfig.2 shows the collected data of responder's basic information. It can be seen obtained 106 responders. Regarding Fig.1 shows most responders are over 40s and ratio of 60s is the highest in this survey.

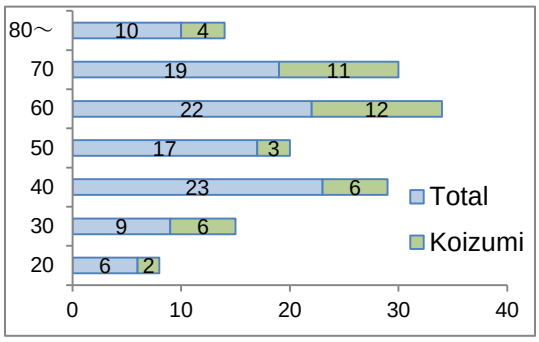

Fig. 1 Responder's Age distribution

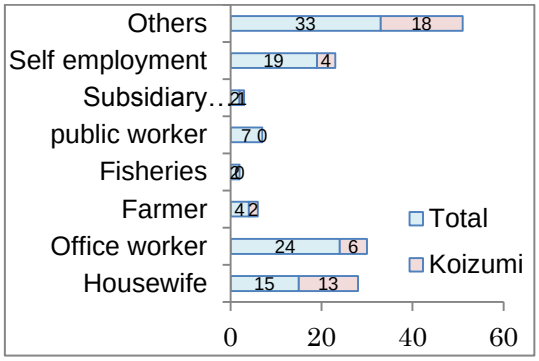

Fig.2 Distribution of Occupation

(master of house income)

Fig.2 shows occupation status of house income master. Most people belong to Office worker and others. Other represent ratio of older responders is much high and most of them retired and live on pension. Surprisingly in Koizumi, people who are gaged in Agriculture is only 2 in this survey.

Fig. 3 House Status information is as follows:

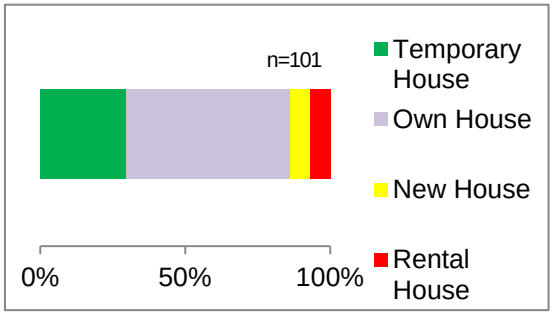

Fig.3 Current House situation

Fig.3 shows the responders current house status. From this figure, we can find most of people live in own house. I conducted interviews to some responders who live in Own house, they answered, most of their house are partially destroyed, or even take out a loan, they wish to buy a house or replace. Some people sold their own paddy field and allocate funds for housing.

n=237

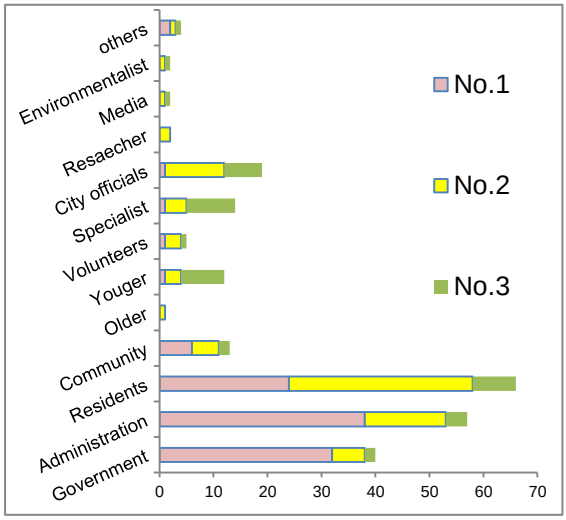

Fig.4 Top 3 Ranking of Key person

n=252(Multiple answered)

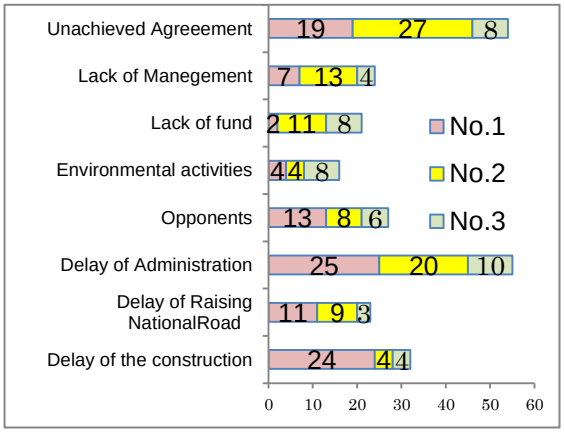

Fig.5 Top3 Ranking of Delayed Reconstruction

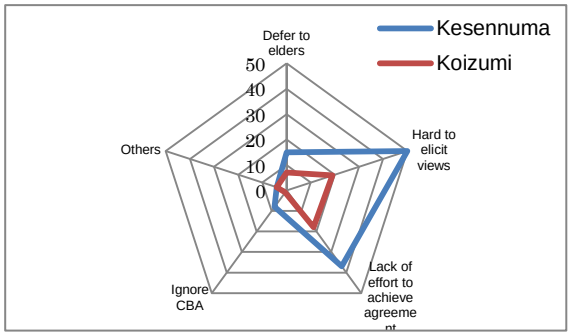

Fig.6 Not Favorable Custom in Community

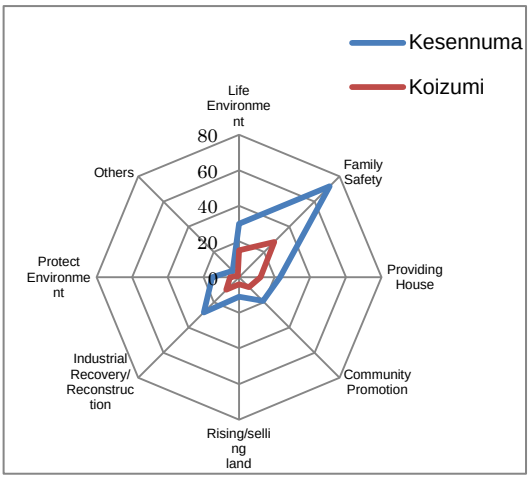

Fig. 7 Residents current interest

In the upper page, Fig 4 shows Top 3 ranked key person, who responders think could improve their current environment. From this figure, notice that each ranking occupies high percentages of Government, Administration, and Residents. However, Residents have the highest ratio as the total result. On the other hand, Fig. 5 shows that Top3 ranked causes of delaying Sea wall construction. As the results, we can notice responders think most causes of constructing delay are unachieved agreement and delay of administration. As the results, it seems to believe that Environmental activities are not so crucial cause of the delay.

Fig.6 shows not favorable customs of each responder's community. Comparing Koizumi with Kesennuma, we see that both districts have the same tangency. Hard to elicit views is the top ranked. Fig.7 shows higher ranked items are Family Safety and Industrial Recovery/Reconstruction.

(2) Results of Outranking Method

In this method, from the previous surveys and land scape designer's alternative plans[6] to the giant seawall, assumed three plans toward only Koizumi district. Then, analyzed cost benefit and ordered preferable ranking to each plan.

About Cost : Each plans costs are showed in the Fig. 7. Total cost of Current plan needs 23.6 billion yen[7]. Cost of Plan A is referenced the previous study by Jun, K. et al[1]. All plans are assumed they take maintenance costs in the next 50 years. Each year, it takes 0.05%[8] of total construction cost for each plan. About Alternative Plan B is designed to environmental-friendly. It was assumed to reduce 30% cost of Current plan. So the total cost is $236 \times 0.7 = 165.2$.

About Benefit: Benefit is assumed to prevent L1's tsunami wave and most of residents would be safe. So, damaged reduction rate is set for each plan in Fig.8.

Net benefit is calculated as follows:

B/C =Prevent L1 (%)/ Cost

About WTP: In this survey, I asked responders to answer the question how much you are willing to pay (WTP) for protecting the seaside environment. I collected data and obtained average of 1,944yen in Kesennuma and of 1,903yen in Koizumi. So, I set up WTP to Current plan is 1,944 per person and its plan B is 1903yen per person. Then 1,588[9] is applied to plan A. In Koizumi, as of 2014.8.31[10], there are 557 households. So total WTP of each plan is WTP*557. It is represented in Table.1

About Weight: Weight was decided by items of questionnaire. Responders felt most burden cost and not so much people are willing to pay. So, in this case, weight is regarded as exogenous variable.

Table.1 shows the final using matrix as follows.

Table.1 Effect of seawall construction (0.1billion)

	Cost	WTP	B/C
Current Plan	236	0.0108	1.61
Plan A	245	0.0088	1.63
Plan B	165.2	0.0106	1.94
weight	0.7	0.1	0.2

Table.2 Matrix of Concordance

	Current	Plan A	Plan B	Total
Current Plan		0.8	0.1	0.9
Plan A	0.2		0	0.2
Plan B	0.9	1		1.9
Total	1.1	1.8	0.1	

Table.3 Matrix of Dis-concordance

	Current	Plan A	Plan B	Total
Current Plan		0.06	1	1.06
Plan A	1		1	2
Plan B	0.12	0		0.12
Total	1.12	0.06	2	

Table.4 Results of Concordance matrix

	C_u	d_u	Total	Rank
Current Plan	-0.2	-0.06	-0.14	2
Plan A	-1.6	1.94	-3.54	3
Plan B	1.8	-1.88	3.68	1
Total	0	0		

In Table.3 and Table.4, each matrix shows concordance and dis-concordance matrix. From Table.4, the preference order is Plan B>Current Plan> Plan A.

It indicates even prevent L1 of Plan A is 80%, they should accept it and prepare for L1, which is assumed to happen once in 50 years.

(3) Results of covariance structure analysis

The following same typed models are assumed. It is investigated what current factors affect resident's behavior and what is different from districts. As a result, obtained some related factors in Fig.8 and Fig.9.

In those models, meanings of each model are as follows:

ART: Awareness of Risk of Tsunami,
APEnv: Awareness of Protection seaside Environment
ITGSW: Interesting Degree of GSW ,
SIM: simulation of evacuation ,

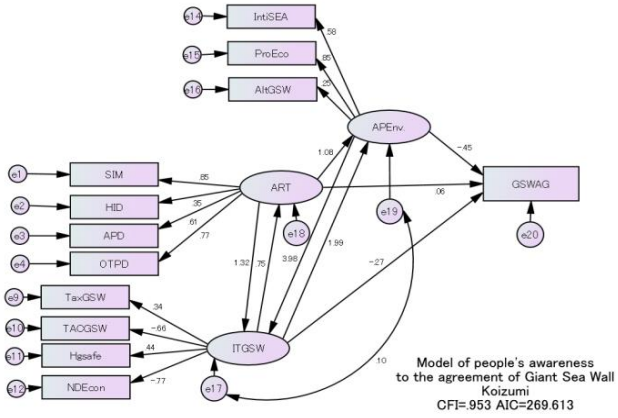

Fig.8 Awareness Model of Koizumi district

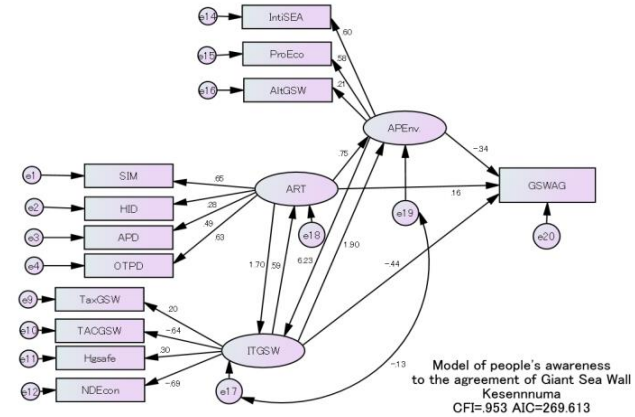

Fig.9 Awareness Model of Kesennuma

APD: Awareness of disaster prevention
OTPD: Opportunity to talk about disaster prevention
HID: Higher interest in Disaster
TaxGSW: knowing Giant Sea Wall construction is used national tax.
TACGSW: Trust to administrative project of Giant Sea Wall construction
Hgsafe : knowing if resident's moving to High ground, nobody will not be suffered
NDEcon: Need to construct Giant sea wall even if seaside ecosystem will be damaged
Intisea : Intimate to seaside
ProEco: will to protect ecosystem for the next generation
Alt Gsw: knowing Alternative Giant seawall
GSWAG: Agree to Giant seawall

As for results in Koizumi, it is illustrated in Fig.8, we can notice that APEnv→ProEco(0.85), ART→ SIM/OTPD(0.85) show high positive correlation.

On the other hand, the factor, having higher

interested in giant seawall affects negative influence the factor, not to need giant seawall (ITGSF→ NDEcon : -0.77). As for the influence of lateral variables, having awareness of protection Ecosystem and Interested in giant seawall affects negative decision to construction of current plan's seawall (APEnv →GSWAG:-0.45, ITGSW→GSWAG:-0.27). Compared with those factors in Kesennuma, it is obvious that the influence of APEnv to GSWAG is stronger than in Kesennuma (-0.44<-0.34). As for awareness of risk prevention, it affects positive decision to construct GSW. However, the influence is much weak(Koizumi:0.06, Kesennuma:0.16). Regarding Comparative fit index (CIF), which takes from 0-1, indicate consistency between model and data is 0.953. It shows good fitness of this model. In this study, CIF is applied to judge the degree of fitness.

4. Conclusions

The following conclusions can be derived from this survey.

(1) According to previous surveys and newspapers, in Kesennuma City, most of people accept administrative decisions even if they don't wish the project about seawall construction. However, from this survey, it is found that, in fact, people are not willing to accept it. Actually, they have higher reliability to Government and Administrative and believe they may improve their environment and community from results of collected data. Moreover, they also believe residents can improve their environment. In order to encourage their expectations, it is necessary to change the situation hard to tell their own mind more casually.

(2) In Koizumi, there is beautiful beach where filled with biological diversity. In this survey, I could get only 44 data sets in this district, However much more people seems to be interested in Environmental protection. If current giant seawall will be constructed, damages of sea ecosystem will not be inevitable. Administrations should listen to resident's opinion with flexibility.

(3) In this study, actual detailed data about cost and reduction rate of damages couldn't be got. In Kesennuma, there are some difficulties to use material with actual survey data and predict. As for cost benefit analysis, as the future challenges, analysis based on actual data should be conducted.

Furthermore, much amount of data couldn't be collected. So, in order to verify the universality of this survey, collecting much more data should be needed.

References

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