Model Analysis of Residents’ Consciousness Regarding Seawall Construction: Case Study of Kesennuma City in Miyagi Prefecture

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Abstract

Kesennuma City, located in Miyagi Prefecture, area affected by the Great East Japan earthquake and tsunami (2011), have developed construction plans to build giant seawall barriers for protection. The majority of the residents in Kesennuma City have accepted the current construction plans. However, in the Koizumi District, some residents are against the construction of the walls and have proposed alternate plans to protect the landscape and ecosystem of the seaside. This has subsequently caused conflicts between the local government and residents.

In this study, household surveys were conducted in Kesennuma in 2014 (N=150). Using a cost-benefit analysis and employing a mean-structure model, we identified factors that lead residents to agree or disagree with the construction of seawalls. The results showed residents in Koizumi District have a keen ‘awareness of risk prevention’ the walls can provide, while residents in Kesennuma City do not share the same consciousness (Kesennuma: mean = 0, Koizumi: mean = .23, p < .001). Consciousness of environmental preservation negatively affect decisions to construct the current seawall plan (Kesennuma: r = −.47, Koizumi: r = −.87, p < .001). These factors may negatively affect the ability to create community consensus for higher seawall construction. Koizumi District showed significantly stronger disagreement than Kesennuma.

In conclusion, this study identified that residents have a keen awareness of environmental conservation and aspire to incorporate an eco-friendly construction plan for the seawalls. However, there also exists an unfavorable community environment in which residents feel it is difficult to express their opinions. Enhancing consciousness of environmental preservation, may make it possible to achieve community consensus and choose an alternative eco-friendly plan.

JEL Classifications: C3, D1, R2, Q5
Keywords: Seawall Construction Project, Seaside Environment Preservation, Residents’ Consciousness, Mean Structure Model, Great East Japan Earthquake And Tsunami In Kesennuma, Miyagi

1. Introduction

Approximately four years has passed since the Great East Japan earthquake in March 2011. The damage from this event and its related tsunami is still evident in many disaster areas. In most of those areas, as part of restoration, governments and administrations are planning to construct giant seawalls. Kesennuma, a city of 334 km², located in Miyagi prefecture, was no exception. In Kesennuma, many districts near the coast suffered serious damage in the 2011 tsunami disaster. Regardless of cost-benefit effects, plans for giant concrete seawalls that may protect residents in the future were proposed. Some researchers have conducted cost-benefit analysis for seawall construction. In Japan, a cost benefit analysis is required for the investment
in public works project such as the seawall construction. However, in fact, some cases are reported that resident’s action against the intention of the government policy lets business fail (Kono [14]). Jun, K. et al. ([3]) studied cost–benefit effects of seawall construction in Koizumi district, Kesennuma. In this district, to prevent tsunamis, a seawall with a height of 14.7 m (set with level 1 : L11 (Miyagi prefectural Government ([8]))) was being constructed. Regarding this construction, Jun, K. et al. concluded that funds of around 24.5 billion yen would be needed. The net benefit (benefit minus cost) would be negative (−20.75 billion yen) (Miyagi prefectural Government ([8])). People of most districts in Kesennuma agreed with the government’s proposed seawall construction. However, residents of the Koizumi area were still against the current plan. The massive tsunami more than 10 meters attacked Koizumi district which is adjacent in Minamisanriku-cho in the Great East Japan Earthquake on March 11. 266 in 518 households of the district were flowed out and destroyed completely. Nonetheless, the toll of dead and missing was only 43 among 1,810 at that time2. Because residents had an argument at a disaster drill one week before the earthquake and that result they changed the evacuation area (Mori [13]).

Environmentalists proposed an alternative plan that could preserve the coastal environment of the Miyagi prefectural government. The Miyagi prefectural and municipal governments set up a meeting to exchange public views (Miyagi prefectural government ([9])). Owing to local traditional customs, however, residents regarded that governments should have taken the initiative in development. In this environment, residents, especially in Koizumi, were unwilling to express their honest opinions. In general, the North-Easterners are patient, and tend to regard a knit unity of cooperation in their community and neighborhood as more important than their own opinions. Consequently, little agreement had been reached regarding the current construction plan. Few have yet studied what residents’ concerns really are in regard to seawall construction.

We sought to verify which seawall construction plan would be preferable and to describe the structure of residents’ awareness of seawall construction and the environment.

2. Overview of the seawall construction

Based on the standards of the government’s Central Disaster Management Council, Miyagi prefectural government wishes to construct much higher seawalls than those destroyed by the tsunami. The walls will be 400 km long, up to 90 m wide, and the highest wall will be 15.5 m high (equivalent to a five-story building). The government planned to allocate approximately 1 trillion yen (10 billion dollars) for the construction of these gigantic walls for the next three to five years, as part of their 200 trillion yen (2 trillion dollar) ‘Resilient Japan’ public/commercial developments, which are intended to surround most of Japan’s 35,000-kilometer coast with gigantic concrete walls (Change.org ([2])).

In Kesennuma, movements against giant seawall construction, however, were small but consolidated, gathering pace among a proportion of residents in affected areas. Some people claimed that the current construction plan would destroy the area’s precious ecosystems on which the residents’ traditional fishery, aquaculture and tourism industries depend3. Despite their gigantic size, their heights only equate to one-half to two-thirds of the height of the 2011 tsunami. Others have argued that if residents were to move to higher ground, nobody would suffer from these kinds of disasters4.

This previous study suggested that construction of a seawall to protect against an L1 tsunami indicated negative aspects of cost–benefit effectiveness (Jun, K. et al. ([3])). However, a quantitative evaluation for

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1 L1 indicates a tsunami of a scale that occurs once a decade to once in 100 years.
2 In Kesennuma, 9,500 in 26,601 households was damaged.
The toll of dead and missing was 1,438 among 73,494 as of 2015/03/09.
3 Tanigawa et al., “Proper of seawall construction — considering acceptable alternative plan for residents —,” ISFJ Policy forum, 2013, pp. 10–12.
cost–benefit analysis on the consideration of environmental damages is still not complete.

In Minami Sanriku, the seawater close against a direct vertical plane is apt to be stagnant. When a seawall is built, it has clearly influence on the environment. If it is restored in the place where a coast line moves back to the offing, it is in same things as what builds the reclamation dike, and it may cause the environmental problem such as the case of the Gulf of Isahaya. Moreover, in current plan, blocking up beaches of the Rias coast in consecutive underground wall, it is worried by division of the groundwater that it causes deterioration of the coast environment. Research on this point has not been done sufficiently. Therefore, it is necessary for quantitatively evaluation of the groundwater and reflects it in the construction environment (Yokoyama [5]). Residents appealed for concern to water environment by the construction in talks with government. However, such opinions were not reflected in the plan (Yokoyama [5]). There is only one seawall construction plan. This means it does not let residents reach the agreement. Therefore, no system which obtains residents’ opinion and reflects in the plan causes dissatisfaction and the reconciliation of residents.

The objectives of our study were as follows:
1. Investigate the preferred choice of seawall construction, using a ranking method of cost–benefit analysis and multi standard analysis.
2. Identify the differences between the Koizumi area and all other areas in Kesennuma, using covariance structure analysis and obtaining the differences of the structure of residents’ awareness.
3. Measure how district level (Kesennuma and Koizumi) might affect individuals’ community participation.
4. Clarify what kinds of factors might lead to agreement or disagreement of the residents with the seawall construction

3. Methods

3.1.

3.1.1. Study design: field-based cross-sectional study.
Study participants: Residents in Koizumi and other districts in Kesennuma, Miyagi, Japan.

3.1.2. Questionnaire survey
The survey was conducted as a household survey with a structured questionnaire consisting of 5 sections socio demographic characteristics of the respondents including personality, living conditions, attitude, behaviors on disaster prevention and awareness of the seawall.

3.1.3. Survey Items
[I. Personality]
Age and occupation of head of household.

[II. Living condition]
Current house status, opinions of the causes of reconstruction delay, key person responsible for improving current community environment, current interests to measure the awareness model for agreement to the seawall construction, we used a Likert scale.

The following items in III, IV, V were evaluated on a Likert scale. It has five Likert items with response levels ranging from ‘strongly disagree ( = 1)’ to ‘strongly agree ( = 5).’ In detail: Strongly agree: 5, Agree: 4, Neither: 3, Disagree: 2, and Strongly disagree: 1.

It indicates each variable defined in the mean-structure method model.

[III. Awareness of Protection of the Seaside Environment]
Regarding respondents’ awareness, they are defined as follows;
1. I feel an intimacy with the seaside (intimate with the seaside)
2. I would like to protect the ecosystem for the next generation (protect seaside ecosystem)
3. I know a lot about the construction of an alternative giant seawall (know well alternative GSW)
[IV. Awareness 1 of Tsunami Risk]

4. I can imagine a simulation of tsunami evacuation (imagine tsunami simulation)
5. I am highly interested in disaster (high interest in disaster)
6. I am aware of disaster prevention (awareness of disaster prevention)
7. I get more opportunity to talk about disaster prevention than ever before 3/11 (opportunity to talk about disaster prevention)

[V. Interest Degree in GSW (Interest in GSW)]

8. I know the giant seawall construction needs to be funded by a national tax (GSW needs national tax)
9. I trust the administrative project of giant seawall construction (trust administrative project for GSW)
10. I believe that if residents move to high ground, nobody will suffer (high ground move nobody suffers)
11. I will not need a giant seawall if the seaside ecosystem would be damaged (no need for GSW if it damages ecosystem)
12. I agree with the construction of a current giant seawall (agreement with current GSW plan)

3.1.4. Sampling

In the Koizumi area, we employed convenience sampling. We visited 50 houses located around Koizumi junior high school and asked residents to reply to the survey. In the case of resident absence, we distributed the survey by mail, and visited to collect it on the due date. The response rate was 88% (44/50).

3.1.5. Survey period

We collected data from September 15 to 18, 2014.

3.2. Data Analysis

As for the cost-benefit analysis, we applied a concordance matrix (Hagihara ([15])). The concordance method generates a preference ranking which best satisfies a given concordance measure. Roy ([11]) developed this method in the 1960s and it is widely recognized as a leading method in Europe. It has a common characteristic with cost-benefit analysis; it began from a planned 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 of weighted plan $i$ to weighted plan $j$.

3.2.1. Ranking Method

1) Step 1: Concordance Index

Table 1 shows plans for seawall construction in Koizumi district. Table 2 shows the effect of seawall construction in this district.

<table>
<thead>
<tr>
<th>Alternative plan</th>
<th>Item</th>
<th>Total Cost</th>
<th>Cost</th>
<th>WTP</th>
<th>Prevent L1 (%)</th>
<th>Benefit</th>
</tr>
</thead>
<tbody>
<tr>
<td>(1) Current plan</td>
<td></td>
<td>236.00</td>
<td>59.0</td>
<td>0.0108</td>
<td>95.00</td>
<td>1.61</td>
</tr>
<tr>
<td>(2) Plan A</td>
<td></td>
<td>245.00</td>
<td>61.30</td>
<td>0.0088</td>
<td>100.00</td>
<td>1.63</td>
</tr>
<tr>
<td>(3) Plan B</td>
<td></td>
<td>165.20</td>
<td>41.30</td>
<td>0.0106</td>
<td>80.00</td>
<td>1.94</td>
</tr>
</tbody>
</table>

Table 2. Effect of seawall construction (0.1 billion yen)

<table>
<thead>
<tr>
<th></th>
<th>(X) Total Cost</th>
<th>(Y) WTP</th>
<th>(Z) Benefit</th>
</tr>
</thead>
<tbody>
<tr>
<td>(1) Current plan</td>
<td>236.00</td>
<td>0.0108</td>
<td>1.61</td>
</tr>
<tr>
<td>(2) Plan A</td>
<td>245.00</td>
<td>0.0088</td>
<td>1.63</td>
</tr>
<tr>
<td>(3) Plan B</td>
<td>165.20</td>
<td>0.0106</td>
<td>1.94</td>
</tr>
</tbody>
</table>

Weight

0.70

0.10

0.20
Model Analysis of Residents’ Consciousness Regarding Seawall Construction

There are assumed to be two alternative plans \( u \) and \( v \). First, a set \( C_{uv} \) is defined as follows:

\[
C_{uv} = \{ j \mid P_{ju} \geq P_{jv} \}
\]

(i)

Here, \( C \) : set, \( j \) : evaluation item, \( P_{ju}, P_{jv} \) : effect of plan \( u \), plan \( v \). For example, in Table 2, if we set \( u = (1) \) Current plan, \( v = (2) \) Plan A, then \( C_{uv} \) is as follows:

\[
C_{12} = \{ j \mid P_{j1} \geq P_{j2} \} = \{ X, Y \}
\]

(ii)

The concordance index \( c_{uv} \) is a total sum of evaluation items included in \( C_{uv} \). Hence, \( c_{uv} \) is defined as follows:

\[
c_{uv} = \sum_{j \in C_{uv}} W_j = c_{12} = \sum_{j \in C_{12}} W_j = 0.8
\]

(iii)

Such procedures are conducted for all plans, then a matrix of concordance is made in Table 2.

2) Step 2: Discordance Index

There are assumed to be two alternative plans, \( u \) and \( v \). \( d_{uv} \) is the index that the degree of \( u \) is inferior to \( v \). First, the set \( D_{uv} \) is defined as follows:

\[
D_{uv} = \{ j \mid P_{ju} < P_{jv} \}
\]

(iv)

In (iv), if we also set \( u = (1) \) Current plan, \( v = (2) \) Plan A, then \( D_{12} \) is as follows:

\[
D_{12} = \{ j \mid P_{j1} < P_{j2} \} = \{ Z \}
\]

(v)

Then, \( d_{uv} \), which is the index that alternative \( u \) is inferior to \( v \) is defined as follows:

\[
d_{uv} = \max_{j \in D_{uv}} \{ |P_{ju} - P_{jv}| \cdot d_{j}^{\max} \}
\]

(vi)

When there are \( M \) alternative plans, \( d_{j}^{\max} \) is defined as follows:

\[
d_{j}^{\max} = \max_{1 \leq u, v \leq M} \{ |P_{ju} - P_{jv}| \}
\]

(vii)

\( 0 \leq d_{uv} \leq 1 \). If differences between plan \( u \) and plan \( v \) are maximum, then \( d_{uv} = 1 \), and if those are minimum, then \( d_{uv} = 0 \). For example, if we set \( u = (1) \) Current plan, \( v = (2) \) Plan A, then \( d_{12}^{\max} \) is as follows:

\[
d_{12}^{\max} = \max_{1 \leq u, v \leq 3} \{ |P_{1u} - P_{1v}| \} = P_{1a} - P_{1c} = 0.33
\]

(viii)

Hence, \( d_{12} \) is as follows:

\[
d_{12} = \max \{ 0.02/0.33 \} = 0.06
\]

(ix)

Such procedures are conducted for all plans, a matrix of discordance is showed in Table 3.

3) Step 3: Solutions

Based on \( c_{uv} \) and \( d_{uv} \) obtained by Step 1 and Step 2, the preference order are determined, superiority indexes \( c_u \) and \( d_u \) are defined as follows:

\[
\begin{align*}
\mbox{cu} & = \sum_{v} c_{uv} - \sum_{v} c_{uv} \\
\mbox{du} & = \sum_{v} d_{uv} - \sum_{v} d_{uv}
\end{align*}
\]

(x)

(xi)

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Table 3. Matrix of Concordance and Discordance

<table>
<thead>
<tr>
<th>Alternative plans</th>
<th>Current plan</th>
<th>Plan A</th>
<th>Plan B</th>
<th>Total</th>
<th>Current plan</th>
<th>Plan A</th>
<th>Plan B</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Current plan</td>
<td>–</td>
<td>0.80</td>
<td>0.10</td>
<td>0.90</td>
<td>–</td>
<td>0.06</td>
<td>1</td>
<td>1.06</td>
</tr>
<tr>
<td>Plan A</td>
<td>0.20</td>
<td>–</td>
<td>0.00</td>
<td>0.20</td>
<td>1.00</td>
<td>–</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Plan B</td>
<td>0.90</td>
<td>1.00</td>
<td>–</td>
<td>1.90</td>
<td>0.12</td>
<td>0.00</td>
<td>–</td>
<td>0.12</td>
</tr>
<tr>
<td>Total</td>
<td>1.10</td>
<td>1.80</td>
<td>0.10</td>
<td>2</td>
<td>1.12</td>
<td>0.06</td>
<td>2</td>
<td>3</td>
</tr>
</tbody>
</table>

---
In (x), if $c_u > c_v$, then $u$ is selected, and in (xi), if $d_u < d_v$, then $v$ is selected.

From the above steps, the most preferable criterion for selecting a plan is to choose the plan that has the 1st rank of the mean in the superiority index between concordance and discordance.

3.2.2. **Mean Structure Model (MSM)**

This study applied covariance structure analysis, using SPSS Amos 22.0 IBM (Oishi and Tsuduku ([10])). MSM is a method of Structural Equation Modeling. In MSM, when we estimate pass coefficients, estimated errors of variation and covariance are minimized. Therefore, by testing the mean of lateral variables, MSM can specify differences among the model of groups. By setting the following two required limitations, we measured the related size of lateral variables. All of these estimations are significant at $p < .001$.

1) **Limitation 1**: fix a mean of the lateral variables that have the same meaning to a standard value such as 0 or 1.
2) **Limitation 2**: impose an equality constraint on the intercept of the observation variable that has the common means, composing a lateral variable.

Based on the collected data from questionnaires (III-V), we made two models divided into two groups: Koizumi and other all districts in Kesennuma.

In a covariance structure model, in general, good fit of index (GFI) or adjusted goodness of fit of index (AGFI) are applied. However, in MSM, the comparative fit index (CFI) is often applied as a replacement for GFI or AGFI. CFI is used as well as the Akaike information criterion (AIC) in a model that estimates mean and intercept. CFI ranges from 0 to 1. It is determined from the following formula:

$$ CFI = 1 - \frac{\max((N-1)d_f - df, 0)}{\max((N-1)d_f - df, 0)} $$

4. **Results**

4.1. **Respondents’ socio demographic characteristics**

The following Table 4 shows the baseline characteristics of respondents. We obtained data from 150 respondents: 44 from Koizumi and 106 respondents who lived in other districts in Kesennuma. Regarding Table 4, the age distribution of respondents in Kesennuma was mean = 52.9, SD = 1.6. In Koizumi, mean = 55.0, SD = 17.3. Table 4 indicated that the proportions of over 50s were high in this survey. As for the occupations of the heads of the household, the most common occupations were office worker and others. In Koizumi, people who were engaged in agriculture represented only 4.5% (2/44). About the respondent’s current housing status, this table shows over half (59.5%) of the people lived in their own house in Kesennuma. On the other hand, 52.3% people in Koizumi lived in temporary houses. The respondents answered that most of their house were partially destroyed, or that they took out a loan. They planned to purchase a new house or replace the existing one. Some people sold their own paddy fields and allocated funds for housing.

Fig. 1 shows the Top 3 ranking of the key actors who respondents thought were able improve their current environment. We observed each ranking was occupied with high percentages of Government Administration, and Residents (total = 69%). The ratio of residents was 28%. On the other hand, Fig. 2 shows that in the Top 3 ranked causes for the delay in seawall construction, respondents argued that the greatest causes of delays to construction delay were incomplete agreement (Kesennuma = 20%, Koizumi = 28%) and delayed decisions from the administration (Kesennuma = 20%, Koizumi = 20%).

Fig. 3 shows unfavorable customs of each community. Comparing Koizumi with Kesennuma, we noticed that both communities had similar opinions. Hard to elicit views was the 1 top-ranked. However, the dif-

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5. An equality constraint tells the SEM computer program that, in reaching its solution, it must provide the identical unstandardized coefficient for all parameters within a set that has been designated for equality (even when equality constraints have been imposed, standardized coefficients are not be exactly the same within the constrained set).

Table 4. Socio demographic characteristics of the respondents

<table>
<thead>
<tr>
<th>Studied variables</th>
<th>Other areas in Kesennuma</th>
<th>Koizumi area</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>n</td>
<td>%</td>
</tr>
<tr>
<td><strong>Age</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>20-29</td>
<td>6</td>
<td>5.70</td>
</tr>
<tr>
<td>30-39</td>
<td>9</td>
<td>8.50</td>
</tr>
<tr>
<td>40-49</td>
<td>23</td>
<td>21.70</td>
</tr>
<tr>
<td>50-59</td>
<td>17</td>
<td>16.00</td>
</tr>
<tr>
<td>60-69</td>
<td>22</td>
<td>20.80</td>
</tr>
<tr>
<td>70-79</td>
<td>19</td>
<td>17.90</td>
</tr>
<tr>
<td>80≤</td>
<td>10</td>
<td>9.40</td>
</tr>
<tr>
<td>Total</td>
<td>106</td>
<td>100.00</td>
</tr>
<tr>
<td><strong>Occupation (Head of Household)</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Housewife</td>
<td>15</td>
<td>14.20</td>
</tr>
<tr>
<td>Office worker</td>
<td>24</td>
<td>22.60</td>
</tr>
<tr>
<td>Farm household</td>
<td>4</td>
<td>3.80</td>
</tr>
<tr>
<td>Fishery (fish-raising, coastal industry)</td>
<td>2</td>
<td>1.90</td>
</tr>
<tr>
<td>Government worker of nearby cities, towns, and villages</td>
<td>7</td>
<td>6.60</td>
</tr>
<tr>
<td>Farmer with side job in which the main source of income comes not from farming, but from other jobs</td>
<td>2</td>
<td>1.90</td>
</tr>
<tr>
<td>Family-operated business</td>
<td>19</td>
<td>17.90</td>
</tr>
<tr>
<td>Others</td>
<td>33</td>
<td>31.10</td>
</tr>
<tr>
<td>Total</td>
<td>106</td>
<td>100.00</td>
</tr>
<tr>
<td><strong>Current House Style</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Temporary House (sufferers living in makeshift housing after the disaster)</td>
<td>31</td>
<td>29.20</td>
</tr>
<tr>
<td>Own House which escaped the disaster</td>
<td>57</td>
<td>53.80</td>
</tr>
<tr>
<td>New Own House (sufferers built their new house after the disaster)</td>
<td>6</td>
<td>5.70</td>
</tr>
<tr>
<td>Apartment House</td>
<td>7</td>
<td>6.60</td>
</tr>
<tr>
<td>Unanswered</td>
<td>5</td>
<td>4.70</td>
</tr>
<tr>
<td>Total</td>
<td>106</td>
<td>100.00</td>
</tr>
</tbody>
</table>
Fig. 1. Top 3 Ranking of Key Person

Fig. 2. Top 3 Ranking of Delayed Reconstruction
ference was 8% in Kesennuma, and 2% in Koizumi. Fig. 4 shows that respondents ranked current interest items more highly; Family Safety and Industrial Recovery/Reconstruction were emphasized (Kesennuma=35%, Koizumi=34%).

4.2. Results of Outranking Method

From the previous surveys and the landscape designer’s alternative plans (Hirose ([12])) for a giant seawall, three plans were proposed for Koizumi: Current Plan, Plan A and Plan B (see Table 1). The current plan was proposed by the Miyagi prefectural government ([7]). The estimated cost was 23.6 billion yen, and the height of the seawall in Koizumi was 14.7 m. Plan A was a simulated plan on the study by Jun, K. et al. ([3]). Plan B was an alternative plan proposed by Hirose7. He proposed an eco-friendly and cost-cutting plan. From these plans, we set up the following three comparative contents.

1) Total Cost: Each plan’s costs are shown in Fig. 7. The total cost of the current plan was 23.6 billion yen (Miyagi prefectural government ([7])). The cost of Plan A was 24.5 billion yen (Jun, K. et al. ([3])). The cost of alternative Plan B was assumed to be a 30% reduction of the current plan’s cost (23.6×0.7=16.52 billion yen). We assumed that each of the three plans would generate maintenance costs over the next 50 years. Each year, this might amount to 0.05% (Aomori prefectural government ([1])) of the total construction cost for each plan.

2) Benefit: Benefit was assumed in a ratio of preventing an L1 tsunami wave and keeping most residents safe. A damage reduction rate was set for each plan, as shown in Table 1.

Net benefit is calculated as follows:

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3) Willingness to Pay (WTP): We also asked how much each respondent was willing to pay (WTP) for protecting the seaside environment. According to previous studies, plan A was estimated to be 1,588 yen (Kasai ([4])). We collected data and obtained an average of WTP 1,944 yen in Kesennuma, and 1,903 yen in Koizumi. In Koizumi, there were 557 households (as of August 31, 2014) (Kesennuma ([6])). Total WTP of each plan was WTP×557 (see Table 2).

4) Weighting: We analyzed data using a weighting coefficient for all items in the questionnaire.

Concerning a question on seawall construction, “Regarding the seawall construction plan, please prioritize the top three items about which you are most concerned.” Item: ① Total Construction Cost, ② WTP, and ③ Benefit (Safety/Cost). Then, according to this collected data, the voting ratio of the three items was obtained. We applied the relative ratio to weight each item. Hence, weight was regarded as an exogenous variable. In this survey, 70% respondents ranked construction cost as the most concerning issue. 10% respondents ranked Willingness to pay (WTP) and 20% respondents ranked Safety/cost as the most concerning issue.

In Table 3, each matrix shows a concordance and discordance matrix. From Table 5, the result of preference order was Plan B > Current Plan > Plan A.

This indicated that even Plan B for prevention L1 might be beyond 80%⁸. They might accept it and prepare for an L1, which is assumed to happen once in almost every 50 years.

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Fig. 4. Respondents’ Current Interest

Benefit = Prevent L1 (%) / Cost

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4.3. Results of covariance structure analysis (Figure 5, 6, 7 and Table 6 and 7)

We imposed equality constrains on Models (see Fig. 5). Figs. 6 and 7 show the same type of model between Kesennuma and Koizumi. Equality constraints involve comparative model-testing and chi-square tests. In those model, chi square = 117.654, degree of freedom (df) = 118 and significance probability = .024. The comparative fit index (CFI, range from 0 to 1) indicated a consistency between model and data at 0.964, AIC = 241.654. This indicates the good fitness of this model. We applied CFI to the fitness index of this model. Table 6 shows results of estimates of path-coefficient (standardized and unstandardized), intercepts and the mean value of lateral variable (‘awareness of tsunami risk’). We put standard value 0 in Kesennuma on the mean value of it. As the results, in Koizumi, estimated mean value of ‘awareness of tsunami risk’ was .23.

As shown in the results in Fig. 6 and Fig. 7, the following factors were significant in both areas: regarding unstandardized coefficients from each lateral variable, first, ‘Awareness of protection of the seaside environment’ affected positive influence on ‘Intimate with the seaside’ (Kesennuma: $r = 2.14$, Koizumi: $r = 2.58$, $p < .001$) and on ‘Protect seaside ecosystem’ (Kesennuma: $r = 2.45$, Koizumi: $r = 3.69$, $p < .001$). Second, as for ‘Awareness of risk of tsunami,’ it affected positive influence on ‘Imagine tsunami simulation’ (Kesennuma: $r = .61$, Koizumi: $r = .80$, $p < .001$). Table 7 shows the results of measured Mean Structure Models. In Table 7, we found mean differences of latent variables. Especially, as for ‘Awareness of risk of tsunami’, it was higher in Koizumi (Kesennuma: $r = 0$, Koizumi: $r = 0.23$, $p < .001$). Moreover, in Table 6, it also affected positive influence on ‘Awareness of disaster prevention’ in (both areas $r = .69$, $p < .001$). Third, as for ‘Interest in GSW,’ which indicated the highest interest in giant seawall construction, it affected negative influence on ‘No need for GSW if it damages ecosystem’ (Kesennuma: $r = -1.95$, Koizumi: $r = -1.83$, $p < .001$). Also, it affected positive influence on ‘High ground move & Nobody suffers’ (both areas: $r = .95$, $p < .001$).

As for influences on ‘Agreement with current GSW plan,’ ‘Awareness of protection of the seaside environment’ affected a negative decision to construct the current plan’s seawall (Kesennuma: $r = - .47$, Koizumi: $r = - .87$, $p < .001$). ‘Interest in GSW’ also negatively affected on ‘Agreement with current GSW plan.’ However, the influence was significantly weak (Kesennuma: $r = - .58$, $p < .05$, Koizumi: $r = - .36$, $p < .1$).

5. Discussion

From our results, we summarized as follows:

The primary concern of respondents was not the community environment but the safety of their family (see Fig. 4). We found that many people obviously recognized that it was difficult to express what they essentially wanted to do in their community. This current situation seemed to create difficulties among residents in reaching consensus (see Fig. 3).

However, residents actually noticed the lack of efforts to obtain agreement (see Fig. 2), and they grasped the key to improve their environment (see Fig. 1).

Although they did not declare what they really wanted to do, from the results of MSM, we found that they
have strong awareness of seaside environmental protection and expect an eco-friendly alternative plan (see Fig. 6 and Fig. 7). In addition, they also had a strong awareness of tsunami disaster leading to the simulation of evacuation. In Koizumi this awareness was significantly higher than in Kesennuma (see Fig. 6, Fig. 7, and Table 6). This is in accordance with the fact that most sufferers in Koizumi were able to evacuate. In addition, this indicated that the reason why they were saved was high risk awareness of disaster prevention and residents’ appropriate action rather than the grace of the seawall. In the northeastern tsunami area, people have learned grapevine, education and drill concerning the disaster prevention. From this point, it was not a world’s best huge seawall, but cultural climate was more likely to relieve their lives. Most residents did not deny the ineffectiveness of the seawall because residents think that some people need it. It occurred discrepancy between residents. It seems to cause the phenomenon that sets up a seawall as necessary thing, though it was actually unneeded. Mean value differences of ‘Awareness of tsunami risk’ were higher in Koizumi (see Table 7). Residents in Koizumi might have a strong awareness of the requirements of evacuation. A strong awareness of seaside environmental conservation and interests in seawall construction might cause a negative influence on gigantic seawall construction. From this, the possibility that the seawall construction lets refuge awareness of inhabitants rather degenerate is thought about. It seems that the seawall construction degenerates risk awareness of residents. It may deprive the sense scene such as landscape of the seaside and the salt tang of the sea, a sign and inference power of the surge, past memory about the sea and tradition concerning the sea. In that sense, it seems to not be necessary to construct a concrete seawall tolerating an L1 tsunami (Miyagi prefectural government ([8])).

Based on our present study results, it is significant to reconsider the current seawall construction plan.

Fig. 5. Equality constraints of Models
Note 1: The authors calculated the average of Koizumi, which assumed a mean of estimates of latent variable (Awareness of tsunami risk) in Kesennuma is standard value 0. Equality constraints are as follows:
Note 2: Residual errors of observed variables: v1 ~ v2, f1, f2.
Note 3: Residual errors of latent variables: vvv2, vvv3.
Note 4: Variance of latent variable: vvv1.
Note 5: Interceptions of observed variables: i1 ~ i12.
Note 6: Path-coefficient: a1, a2, a3, b1, b2.
Note 7: Means determination of path-coefficient: Kesennuma = .50, Koizumi = 1.00.
Fig. 6. Model of different awareness for the Seawall agreement formation in Kesennuma.

Note 1: ** * * p < 0.001
Note 2: A mean of latent variable (Awareness of tsunami risk) in Kesennuma to be standard value 0.
Note 3: Path-coefficients are unstandardized.

Fig. 7. Model of different awareness for the Seawall agreement formation in Koizumi.

Note 1: ** * * * p < 0.001.
Note 2: The authors calculated the mean of Koizumi, which assumed a mean of latent variable (Awareness of tsunami risk) in Kesennuma to be standard value 0. A mean of latent variable of Koizumi = 0.23.
Note 3: Path-coefficients are unstandardized.
Table 6. Mean Structure Models: Results of Estimates of standardized and unstandardized regression weights

<table>
<thead>
<tr>
<th>path</th>
<th>Latent Variables</th>
<th>Kes ennuma</th>
<th>Koizumi</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Estimates of unstandardized regression weights (r)</td>
<td>S.E.</td>
<td>t-value</td>
</tr>
<tr>
<td>Intimate with the seaside</td>
<td>Awareness of Protection of the Seaside Environment</td>
<td>2.14</td>
<td>0.17</td>
</tr>
<tr>
<td>Protect seaside ecosystem</td>
<td>Awareness of Protection of the Seaside Environment</td>
<td>2.45</td>
<td>0.08</td>
</tr>
<tr>
<td>Know well alternative GSW plan</td>
<td>Awareness of Protection of the Seaside Environment</td>
<td>0.50</td>
<td>1.00</td>
</tr>
<tr>
<td>Interest in GSW</td>
<td>Awareness of Protection of the Seaside Environment</td>
<td>0.18</td>
<td>1.23</td>
</tr>
<tr>
<td>Agreement with current GSW plan</td>
<td>Awareness of Protection of the Seaside Environment</td>
<td>−0.47</td>
<td>0.45</td>
</tr>
<tr>
<td>Imagine tsunami simulation</td>
<td>Awareness of tsunami risk</td>
<td>0.61</td>
<td>0.12</td>
</tr>
<tr>
<td>High interest in tsunami disaster</td>
<td>Awareness of tsunami risk</td>
<td>0.71</td>
<td>0.09</td>
</tr>
<tr>
<td>Awareness of disaster prevention</td>
<td>Awareness of tsunami risk</td>
<td>0.69</td>
<td>0.11</td>
</tr>
<tr>
<td>Opportunity to talk about disaster prevention</td>
<td>Awareness of tsunami risk</td>
<td>1.00</td>
<td>1.00</td>
</tr>
<tr>
<td>Agreement with current GSW plan</td>
<td>Awareness of tsunami risk</td>
<td>0.15</td>
<td>0.06</td>
</tr>
<tr>
<td>GSW needs national tax</td>
<td>Interest in GSW</td>
<td>1.00</td>
<td>1.00</td>
</tr>
<tr>
<td>Trust the administrative project for GSW</td>
<td>Interest in GSW</td>
<td>−1.71</td>
<td>0.61</td>
</tr>
<tr>
<td>High ground move &amp; Nobody suffers</td>
<td>Interest in GSW</td>
<td>0.95</td>
<td>0.40</td>
</tr>
<tr>
<td>No need for GSW if it damages ecosystem</td>
<td>Interest in GSW</td>
<td>−1.95</td>
<td>0.75</td>
</tr>
<tr>
<td>Agreement with current GSW plan</td>
<td>Interest in GSW</td>
<td>−0.58</td>
<td>0.28</td>
</tr>
<tr>
<td>Awareness of Protection of the Seaside Environment</td>
<td>Interest in GSW</td>
<td>0.26</td>
<td>0.38</td>
</tr>
</tbody>
</table>

Intercepts in the equation of observation variables

| Estimates of means of exogenous variables (means of it in Kes ennuma = 0) | S.E. | t-value | p-value | Label |
|-----------------|------------------|------------|---------|
| Intimate with the seaside | 3.95 | 0.11 | 37.587*** | i1 |
| Protect seaside ecosystem | 4.30 | 0.08 | 52.743*** | i2 |
| Know well alternative GSW plan | − | − | − | |
| Imagine tsunami simulation | 4.39 | 0.08 | 52.236*** | i4 |
| High interest in tsunami disaster | 4.35 | 0.08 | 52.165*** | i5 |
| Awareness of disaster prevention | 4.06 | 0.10 | 40.065*** | i6 |
| Opportunity to talk about disaster prevention | − | − | − | |
| Agreement with current GSW plan | 0.55 | 0.06 | 9.92*** | i8 |
| GSW needs national tax | − | − | − | |
| Trust the administrative project for GSW | 2.58 | 0.10 | 26.132*** | i10 |
| High ground move & nobody suffers | 4.25 | 0.11 | 39.911*** | i11 |
| No need for GSW if it damages ecosystem | 2.18 | 0.11 | 19.413*** | i12 |

Note 1: Path coefficients are normalized.
Note 2: GSW = Giant seawall
and adopt an alternative plan such as plan B, considering its ability to ensure a better environment.

Moreover, our study emphasized that many residents had strong awareness of seaside environmental conservation, and were conscious of the necessity of passing the ecosystem on for the next generation.

6. Conclusion

In the survey area of this study, it was discovered that a strong consciousness of environment preservation and disaster prevention is extant. On this point, we suggest that residents may avoid the risks of a tsunami without a gigantic concrete seawall. In fact, our study demonstrated that residents recognized a lack of community consensus to create an unexpectedly giant seawall. They need the ability to express an independence of will in their community. From those factors, we concluded that enhancing a community environment that can easily reflect their opinions and consciousness of environment preservation could constitute a preferable alternative to seawall construction for residents.

7. Limitations

Our study identified several new findings with regard to detailed facts of a preferred plan and resident consciousness. However, we have to take into account several study limitations. First, as for cost–benefit analysis, we applied data based on previous studies. In fact, we might have needed more actual data. Second, the total amount of collected data was limited due to the study period and budget. Our evidence was, therefore, not enough to generalize for all tsunami–affected areas in Japan. However, we have demonstrated a certain level of the current hidden situation of our study area.

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References


[2] Change.org, NOGIANTR CONCRETE WALLS! Bou-cho tei yori fukko shien, https://www.change.org/p/save-coasts-and-tsunami-victims-%E9%98%B2%E6%BD%AE%E5%A0%A4%E3%82%88%E3%82%8A%
Ai Tashiro and Kayako Sakisaka

E5%BE%A9%E8%88%88%E6%94%AF%E6%8F%B4, accessed Sep 22, 2014.


