

# **Anxiety among Residents over Nuclear Plants in its Location Area after the Great East Japan Earthquake - A Case Study of Onagawa Town -**

**Takashi TSUJI / National Institute for Environmental Studies, Japan  
tsuji.takashi@nies.go.jp**

## **Introduction**

In Japan, the central government has promoted nuclear policies in a top-down manner. The March 2011 Fukushima nuclear disaster damaged the public's confidence in the central government. After the accident, many citizens have protested the government's nuclear policies in a bottom-up manner (Aldrich 2012; Hasegawa 2014).

The accident at Fukushima raised citizens' anxieties about the safety of nuclear energy. Citizens living in urban areas, that is, power-consuming areas, began to feel this kind of anxiety after the accident. On the other hand, little attention has been paid to residents' anxiety in areas, usually rural, near nuclear plants, even though if a severe accident occurs, these residents would face the greatest risk. A poll conducted after the Fukushima accident clarified that the residents of disaster-stricken prefectures—Iwate, Miyagi, and Fukushima prefectures—tended to feel more anxious about nuclear power as compared to residents living in other prefectures (Kono et al. 2016).

Regardless of the political conflict around the issue of nuclear energy, nuclear plants have continued to exist for several decades now. It is imperative to examine the anxiety of the residents living near nuclear plants to assess nuclear energy risks adequately.

## **Nuclear risk: Perception and Anxieties**

From among the various risks of nuclear power, citizens recognize 'unknown' and 'dreaded' risks (Slovic et al. 2000). It has been difficult to fully evaluate the effects of radiation on physical health from the viewpoint of science technology; evaluating mental and psychological health is even more difficult. Nuclear power increases 'risk anxiety' among citizens. Nakanishi points out that the 'risk anxiety' among citizens often influences national nuclear policy (Nakanishi 2004).

The Chernobyl nuclear power plant accident of 1986 drew people's attention to the serious impact of radioactive contamination on the environment and society as never before. Since the accident, many studies focusing on citizens' risk perception of nuclear power have been conducted.

This trend has been further promoted after the Fukushima accident. Some studies based on nationwide surveys have proved that trust in the nuclear governance institutions (Visschers & Siegrist 2013; Wachinger et al. 2013); and education, knowledge, and literacy about nuclear energy (Yim & Vaganov 2003; Kusumi et al. 2017) determine the citizen's risk perception of nuclear power. Studies based on community surveys have proved that a sense of place determine or alter residents risk perception (Vanables et al. 2012).

Other studies have suggested that it is important to focus on indigenous characteristics to evaluate residents' anxiety about nuclear plants. According to Lupton, social structures and power relationships determine personal risk behaviour (Lupton 2013). Notably, in a nuclear power plant location area, there are social relationships and social consciousness with delicate interests derived from the nuclear power plant, which have been historically and culturally formed (Yamamuro 1998). However, little attention has been given to indigenous social relationships and social consciousness in existing surveys.

Few studies have addressed the anxieties of residents with regard to nuclear power plants in their vicinity. One example is a study by a survey team of local Ibaraki University. Questionnaire surveys have been conducted by the team every year, from 2010 to 2017, in Tokai village and the area surrounding it, which is a location area of nuclear facilities. It is evident from the survey that the number of persons who feel anxiety with regard to nuclear facilities has increased after the Fukushima accident (Survey Team of 'local community and atomic energy' in Ibaraki University 2016). In Matsue City, which is the location of the Shimane nuclear power plant, a questionnaire survey revealed that women, senior residents, people who lived with families and residents who had lived in the city for a long time felt greater and more frequent anxiety over nuclear plants (Eguchi 2013). This study suggested that personal attributes affect a person's anxiety over nuclear plants.

### **Case study: Onagawa town**

In this study, the focus is on Onagawa town, which is the site for a nuclear facility. Based on a national census taken in 2010, the population of this town is 10,051 and

it has a total of 3,968 households. The percentage of people working in primary industries was 15.1%; secondary industries employ 32.3%; the tertiary industries employ 52.0%. Facing a long-term reduction, many residents are involved in fishery and marine product processing.

The Onagawa nuclear plant has been in the area since 1984. Since its opening, the residents have received several benefits, especially economic. As with the other nuclear sites, the town government collected nuclear energy-related taxes and subsidies from the central government. Using this income, the town government launched projects that would benefit the residents: construction of hospitals and industrial facilities. Figure 1 shows the Onagawa town hospital, which was built using these subsidies.



**Figure 1.** Onagawa town Hospital<sup>1</sup>

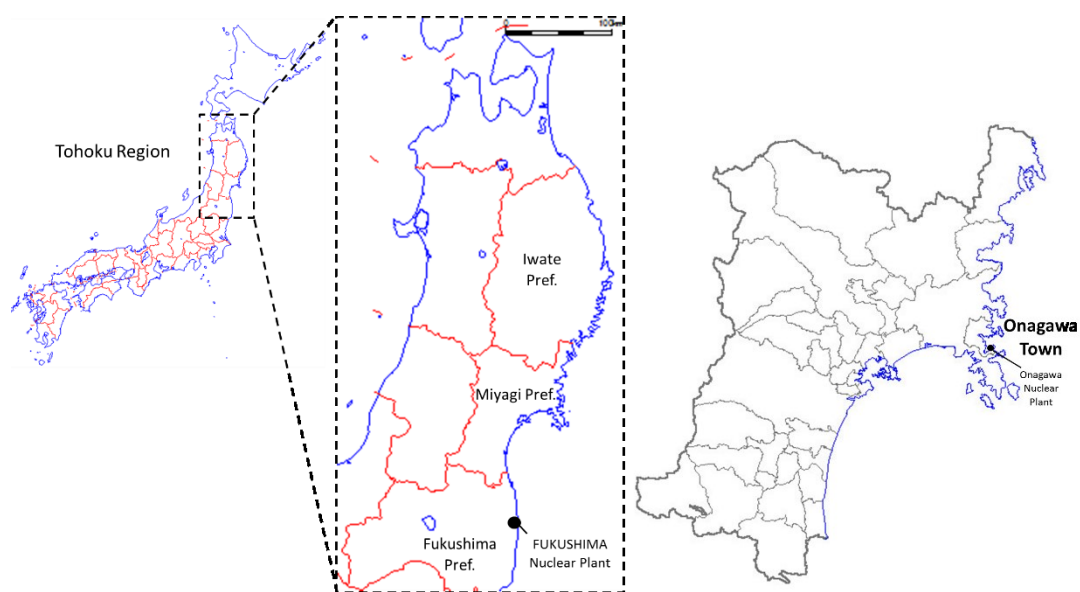
Source: *Koho Onagawa* [Onagawa-Town News], published on 15 May 1995.

This town suffered extensive damages because of the March 2011 tsunami. The death toll was 827 persons and 2924 houses, accounting for 66.3% of all houses in the town, were completely destroyed. Fortunately, the nuclear facility did not suffer any damages or leaks. After the tsunami, construction work to ensure the security and safety of the nuclear facility as well as of the residents was carried out. Discussions on resuming operations at the nuclear power plant were also started.

In Onagawa town, the town government and officials of the nuclear power plant operators (Tohoku Electric Power Co., Inc) implemented various promotional efforts

even before the 2011 tsunami, reaching out to residents to reduce their anxiety over the nuclear power plant. These activities include personal visits to all households in Onagawa, and have been conducted every year since 1994. These visits are known as ‘Hello visits’ and their purpose is to explain the status of the nuclear power plant and share operators’ efforts to ensure the safety of the residents.

The operators continued these efforts even after the Fukushima accident. They explain to residents safety measures against tsunamis, such as the construction of breakwaters at the nuclear plant site (*Ishinomaki kahoku* 2015.6.18).



**Figure 2.** The site of Onagawa town

Source: Author, using TEIKOKU-SHOIN Maps

## Methods

In this study, the residents’ risk perception was measured and their anxiety over nuclear plants was examined using a quantitative approach. A questionnaire survey was conducted in March 2015, 1545 samples were selected from among 6182 residents over the age of 20 using random systematic sampling.<sup>2</sup> The response rate was 49.6% (N = 731), after excluding non-delivered surveys and refusals. Slightly more than half of the participants (51.3%) were female, 61% were over 60 years old.

The dependent variable, the anxiety over nuclear facilities among residents, was measured both (A) before the disaster and (B) after the disaster (i.e., at the present time). A 4-point Likert scale was used for the two question groups (A and B)

as follows: (1) Feel anxiety, (2) Rather feel anxiety, (3) Rather do not feel anxiety, (4) Do not feel anxiety.

**Table 1.** The overview of the independent variables<sup>3</sup>

Variables	Range	Contents
Damage of the disaster		
House damage	1-5	Completely destroyed = 1, Half destroyed = 2, Partly destroyed = 3, Minor damage = 4, No damage = 5
Occupation change after the disaster	1-4	None = 1, Change of Occupation = 2, Retired = 3, No occupation = 4
Personal attributes		
Gender (female dummy)	0-1	Male = 0, Female = 1
Age	22-101	20s~30s = 1, 40s = 2, 50s = 3, 60s = 4, over70s = 5
Education	1-3	Primary education = 1, Secondary education = 2, Higher education = 3
Employment Status	1-5	White-collar = 1, Blue-collar = 2, Self-employed workers = 3, Non-regular employed workers = 4, Unemployed = 5
Child Status of household (children dummy)	0-1	Do not have any children = 0, Have children until college students = 1
Social relations		
Communication with neighbors [before the disaster / after the disaster (at the present time)] —Number of neighbors to greet —Number of neighbors enjoying small talk —Number of neighbors to talk about troubles ※Total 6 items	1-5	None = 1, 1~2 person = 2, 3~4 person = 3, 5~9 person = 4, More than 10 person = 5
Communication with local leaders —Leaders of neighborhood associations —Leaders of industrial associations —Officials of town hall (the rank higher than the section manager) —Town councilor —Prefectural assembly members and Member of the national diet ※Total 5 items	1-4	Have a close relationship = 1, Have a shallow relationship = 2, If you ask the acquaintance you can meet them = 3, No relationship = 4
Social consciousness		
Trust —General trust —Trust in relatives —Trust in neighbors —Trust in friends —Trust in experts (Ex. doctor, public health nurse) —Trust in onagawa town government ※Total 6 items	1-4	※Note
Awareness of benefits from Onagawa nuclear plant —Local employment —Local economy —Public services —Reconstruction from the disaster ※Total 4 items	1-4	Agree = 1, Agree somewhat = 2, Disagree somewhat = 3, Disagree = 4

The independent variables were grouped into four major factors: damage of the disaster, personal attributes, social relations and social consciousness (Table 1). Specific factors were examined—horizontal/vertical social relationships and social consciousness concerning nuclear power plants and disaster reconstruction—related to the nuclear plant's location.

It should be noted that employees of the nuclear power plant and the affiliated company (N = 102) were excluded from the survey to avoid bias.<sup>4</sup> There were two

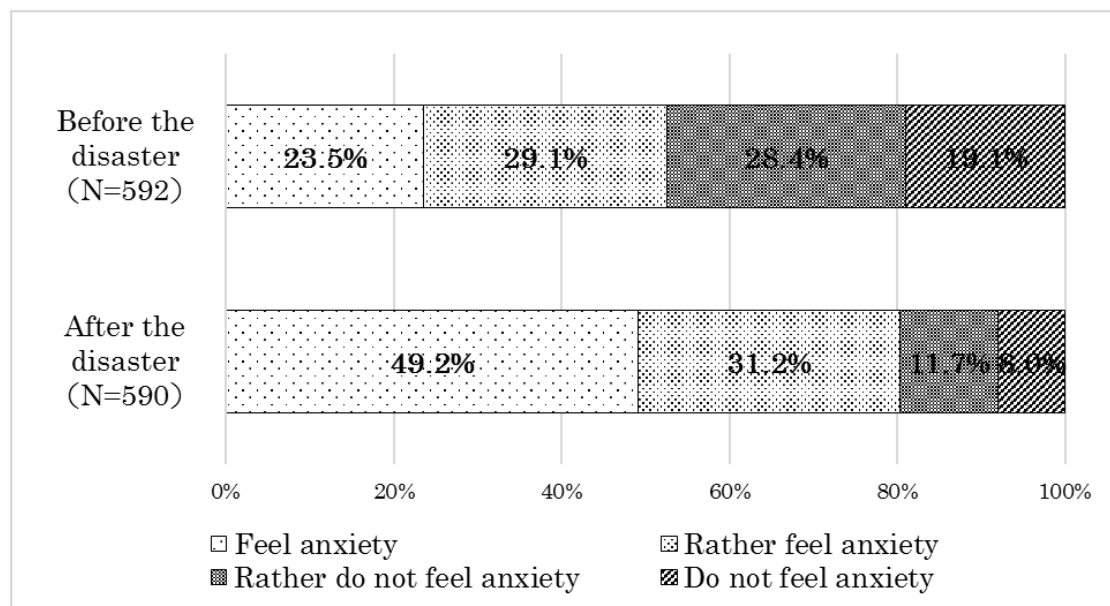
reasons for this. First, these workers cannot be considered representatives of local residents, as most moved to Onagawa town from other areas for work. Second, they are, in a sense, paid representatives, of nuclear power. Most of them share the value that ‘nuclear plants are safe’.

The statistical software utilized in this study was IBM SPSS Base and Regression (Ver23). A p-value less than 0.05 was considered statistically significant.

## Results

### *Description of the data/Relationship between category variables*

Figure 3 presents comparisons of anxiety over nuclear plants among the residents, (A) before the disaster and (B) after the disaster. The Wilcoxon signed rank sum test was used to test whether there was a difference between the two groups. The test results demonstrated that the two variables differed significantly ( $p < 0.001$ ). The percentage of residents who have anxiety over nuclear plants after the disaster was higher than the percentage of residents with anxiety before the disaster.

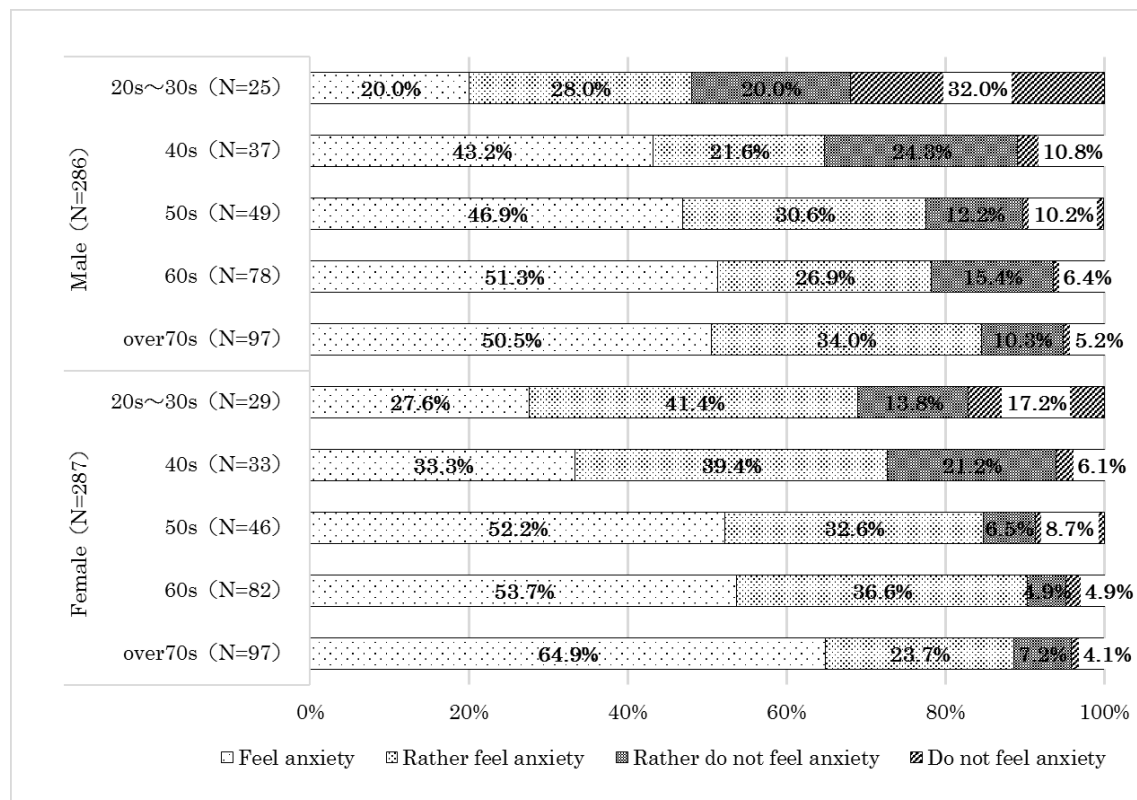


**Figure 3.** Comparison of anxieties over nuclear plants among residents: (A) Before the disaster, (B) After the disaster

Next, a cross-tabulation analysis was conducted to estimate the relationships between each of the independent variables and residents’ anxiety over nuclear plants. Residents’ anxiety over nuclear plants after the disaster was analysed.

First, the relationship between the damage caused by the disaster and residents' anxieties was analysed. Damage to houses did not differ significantly ( $\chi^2 = 6.726$ ,  $p = 0.347$ ).<sup>5</sup> Similarly, no significant differences could be found between occupation change after the disaster and residents' anxieties ( $\chi^2 = 15.898$ ,  $p = 0.069$ ).

Second, the relationship between personal attributes and residents' anxieties was analysed. With regard to gender, a significant interaction was found ( $\chi^2 = 7.942$ ,  $p = 0.047$ ). Similarly, a significant difference between age and residents' anxieties ( $\chi^2 = 44.630$ ,  $p = 0.000$ ) was found. Using Cramer's coefficient of association, it was found that age ( $V = 0.161$ ) was higher than gender ( $V = 0.117$ ). In addition, multiplex cross tabulations were conducted between gender, age, and anxiety. As shown in Figure 4, the more the age, the more likely are people to feel anxiety over nuclear plants. Moreover, elderly women are more likely to feel anxiety than males are.



**Figure 4.** Cross-tabulation of gender, age and anxiety over nuclear plants among residents<sup>6</sup>

The relationship between education (a personal attribute) and residents' anxiety was examined, and significant difference were found ( $\chi^2 = 14.326$ ,  $p = 0.026$ ,  $V = 0.112$ ). Residents with only primary education were more likely to feel anxiety

(59.5%) than residents with higher education were (44.9%). Additionally, the relationship between status, that is, employment status and child status of a household and residents' anxieties was checked. No significant difference was found between employment status and residents' anxiety ( $\chi^2 = 18.987$ ,  $p = 0.089$ ). Similarly, residents' anxiety did not differ significantly because of the presence (or absence) of children in the house ( $\chi^2 = 0.391$ ,  $p = 0.942$ ).

Third, the relationship between social relationships and residents' anxieties was analysed. Residents were asked about their horizontal/vertical relationships, including communication with neighbours and leaders in the local community. For communication with neighbours, no significant difference was found between all items of communication with neighbours and residents' anxieties. However, a significant interaction was found between communication with local leaders of neighbourhood associations and residents' anxieties ( $\chi^2 = 20.850$ ,  $p = 0.002$ ,  $\gamma = 0.209$ ).<sup>7</sup> Residents who had a relationship with leaders of neighbourhood associations were more likely to feel anxiety (54.1%) than residents who did not have a relationship with leaders of neighbourhood associations (44.2%). However, the other items did not show a significant interaction.

Finally, the relationship between social consciousness and residents' anxieties was analysed. Residents were asked about their trust (general trust/trust in various individuals and organizations) and awareness of the benefits received due to the existence of the Onagawa nuclear plant. A significant interaction was found between trust in relatives and residents' anxieties, although the coefficient was relatively low ( $\chi^2 = 17.192$ ,  $p = 0.046$ ,  $\gamma = 0.093$ ). Residents who did not trust their relatives were more likely to not feel anxiety (29.4%) than residents who did trust their relatives (6.1%). However, a significant difference could not be found between the other items and residents' anxieties. Significant interactions were found between all items of awareness in the benefits received due to the existence of the nuclear plant and residents' anxieties.<sup>8</sup> For instance, residents who were not aware of benefits that nuclear plants provide for public services were more likely to feel anxiety (82.4%) than residents who aware of the benefits (25.7%) ( $\chi^2 = 106.048$ ,  $p = 0.000$ ,  $\gamma = -0.496$ ).

### ***Multivariate logistic regression analysis***

Taking these analyses into account, it is reasonable to assume that several variables of (1) personal attributes, (2) communication with local leaders, (3) trust, and (4) awareness of benefits from the Onagawa nuclear plant affect the Onagawa residents' anxiety over nuclear plants. What kind of factors could be affecting it? A



multivariable logistic regression analysis was conducted to explore the effects of these independent variables.

To examine the scales reliability of (2)-(4), the Cronbach's coefficient alpha was calculated as follows: (2) communication with local leaders was 0.837, (3) trust was 0.711, (4) awareness of benefits from Onagawa nuclear plant was 0.870. Composite variables for these were generated using all items, and a multivariate logistic regression analysis was done.

The dependent variables were anxiety over nuclear plants among residents after the disaster: taking the distribution of data into account, four ranks were assigned (1) feel anxiety, (2) rather feel anxiety, (3) rather do not feel anxiety, (4) do not feel anxiety to two categorical ranks, (A) feel anxiety (B) do not feel anxiety.

**Table 2.** Summary of multivariate logistic regression analysis for variables predicting the residents' anxieties over nuclear plants after the disaster (N = 597)

Variable	Model 1				Model 2			
	B	se	exp(B)		B	se	exp(B)	
Gender (female dummy)	0.618	0.225	1.854	**	0.574	0.269	1.775	*
Age	0.332	0.089	1.393	**	0.384	0.112	1.469	**
Education	-0.264	0.212	0.768		0.083	0.262	1.086	
Communication with local leaders					-0.063	0.039	0.939	
Trust					0.061	0.041	1.063	
Awareness of benefits					-0.303	0.049	0.738	**
Nagelkerke R <sup>2</sup>	0.085				0.247			

\*\*p<0.01 \*p<0.05

Table 2 reports the results of a multivariate logistic regression analysis that explores the effects of anxiety over nuclear plants among the residents of Onagawa town after the disaster.

Model 1 shows the results of limiting independent variables to demographic variables. Gender and age were associated with anxiety. Female and senior residents were more likely to feel anxiety over the nuclear plant. This result matches Eguchi's argument from the questionnaire survey in Matsue city (Eguchi 2013). Education, against predictions, was not associated with anxiety.

Model 2 shows the results of the analysis, with social relationships and social consciousness added. Despite predictions, communication with local leaders and trust were not associated with anxiety. However, awareness of benefits from

Onagawa nuclear plant and anxiety were negatively related.

## **Conclusions and Discussion**

Based on the results of the questionnaire survey conducted in Onagawa town, several important conclusions have been derived.

First, even though residents who work for the power company were excluded from the sample, the percentage of residents who feel anxious over nuclear plants exceeds the percentage of people who do not feel anxious. Second, a significant interaction was found between variables related to personal attributes and the socio-political environment in the residential areas close to the nuclear plants and the resident's anxiety over nuclear plants. Third, even though the demographic variables were controlled for, residents' awareness of benefits from the construction of the nuclear plant affected the anxiety over nuclear plants.

In this study, the attempt was to examine predictors of residents' anxiety over nuclear plants in the vicinity of their towns. The most important finding of this study was that the various benefits received by the community from the construction of a nuclear plant, which the local government and residents received in exchange for accepting the nuclear plant, were inseparable from the residents' anxiety over nuclear plants.

The qualitative difference in the relationship between anxiety over nuclear plants and awareness of benefits for citizens living in power-consuming areas versus residents near nuclear power facilities needs to be further examined. It would appear that the findings of this current study could be applicable to future studies. However, these findings may not necessarily apply to studies in other parts of Japan or in other countries. Even so, it will be particularly meaningful to examine the questions raised in this study in future studies in other areas of the world.

There is a limitation to this study. As regards of independent variables, the use of simple measures—As regards of in Likert scale of 4 ranks. This study was not able to analyse residents' anxiety over nuclear plants in light of social problems such as unemployment and environmental pollution. To explore measures of residents' anxiety over nuclear plants, more qualitative investigations on various residents should be conducted in Onagawa town and other sites of nuclear facilities. Notwithstanding its limitations, this study does suggest the importance of focusing on the various benefits that towns derive from having nuclear facilities constructed close to the communities in advancing risk perception research.

## Notes

- <sup>1</sup> Onagawa town hospital was constructed in 1996. Approximately 15.5 hundred million yen out of the total construction cost of 35.5 hundred million yen was covered by subsidies from the government for the construction of the nuclear facility.
- <sup>2</sup> The sampling procedures were implemented using the Onagawa town voter lists (as of 2 December 2014).
- <sup>3</sup> Regarding general trust, a question was constructed using the SD method of four ranks: *Which option is closer to you on the following opinion?* (A) In most cases, people can be trusted; (B) In most cases, you should watch out for people. For trust in individuals and organizations, a question was constructed using a 4-point Likert scale: *Do you think that the following people can be trusted?*
- <sup>4</sup> The total samples without workers of nuclear power plant operators, workers of affiliated company (N=102) and were 597.
- <sup>5</sup> The five ranks were summarized into three ranks questions: Completely destroyed and half destroyed = 1; Partly destroyed and minor damage = 2; No damage = 3.
- <sup>6</sup> Males:  $\chi^2 = 26.791$ ,  $p = 0.008$ ,  $V = 0.177$ ; Females:  $\chi^2 = 27.793$ ,  $p = 0.006$ ,  $V = 0.180$ ; All:  $\chi^2 = 44.715$ ,  $p = 0.000$ ,  $V = 0.161$ .
- <sup>7</sup> In this analysis, the four levels were summarized into three questions: Have a close relationship and have a shallow relationship = 1; If you ask the acquaintance you can meet them = 2; No relationship = 3.
- <sup>8</sup> Regarding the awareness of benefits received from the construction of the Onagawa nuclear plant, a question was framed as follows: *What do you think about the following Onagawa nuclear power plants now?* (1) Nuclear plants contribute to job creation; (2) Nuclear plants have a positive impact on the development of local commerce and industry; (3) Thanks to the nuclear plant, we can receive substantial public services; (4) Nuclear plants have a positive impact on disaster reconstruction.

## Acknowledgement

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