**Kubo, Takahiro, Tsuge, Takahiro, Abe, Hiroya and Yamano, Hiroya (2018) *Understanding island residents' anxiety about impacts caused by climate change using Best–Worst Scaling: a case study of Amami islands, Japan.* Sustainability Science, 14 . pp. 131-138. ISSN 1862-4065.**

Kubo, T., Tsuge, T., Abe, H., Yamano, H. (2019). Understanding island residents' anxiety about impacts caused by climate change using Best-Worst Scaling: A case study of Amami islands, Japan. *Sustainability Scien*ce 14, 131-138.
DOI: https://doi.org/10.1007/s11625-018-0640-8

**Title**

# Understanding island residents' anxiety about impacts caused by climate change using Best-Worst Scaling: A case study of Amami islands, Japan.

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**Acknowledgement**

We acknowledge financial support from the Japan Society for the Promotion of Science (No. 16K00697), and the Ministry of the Environmental, Japan (Economics and Policy Study; ERTDF (S-15: Predicting and Assessing Natural Capital and Ecosystem Services (PANCES)). We appreciate the Ministry of the Environment, the local governments and all respondents to the survey in the Amami Islands for their kind cooperation. We also thank Miyamoto, R., Mitsui, S., Mameno, K., and Uryu, S. for their support conducting the research.

**Understanding island residents' anxiety about impacts caused by climate change using Best-Worst Scaling: A case study of Amami islands, Japan**

**Abstract**

Climate change poses significant risk to island communities; however, there has been limited quantitative investigation into local people's perception toward the risk. This study applied Best-Worst Scaling (BWS) to understand residents' anxieties about potential incidents caused by climate change in Amami islands, Japan. Through an interview with stakeholders, we selected five potential incidents for our BWS attributes: damage caused by typhoon and heavy rain (Typhoon), damage caused by flood and a landslide (Flood), damage from a drought (Drought), damage from ciguatera fish poisoning (Ciguatera), and incident caused by jellyfish (Jellyfish). Changes in frequencies of the abovementioned incidents have already been observed in Japan. In 2016, we conducted a questionnaire survey of residents in Amami islands and received over 700 valid responses to BWS questions. Results showed that the average respondent was most anxious about the risk of Typhoon, followed by Flood, Drought, Ciguatera, and Jellyfish. Furthermore, a comparative analysis did not find large variations among the islands in the residents' anxiety ranking concerning the incidents, but the degrees of their anxieties were different. The Amami-Oshima residents, for example, had relatively higher anxieties about Flood, whereas the Okinoerabujima residents showed higher anxiety about Drought. These findings support that their risk perceptions are determined by their experience and surrounding environments. Understanding the sensitivity of residents to climate change risk will encourage stakeholders to communicate and enhance climate change adaptation in local communities.

**Key**

Amami islands, Best–Worst Scaling, Climate change adaptation, Climate change communication, Island resident

## 1. Introduction

Climate change has caused ecosystem changes and poses a significant threat to human's lives and well-being (Hoegh-Guldberg and Bruno, 2010; McMichael et al., 2006; Smith et al., 2009; Stevanović et al., 2016). In particular, coastal and island communities are highly vulnerable to climate change, because their livelihoods mostly rely on natural resources of the surrounding environment. Rise in sea-surface temperature, changes in precipitation and storm patterns, and rise in the sea level would drastically change their lives (Cinner et al., 2012; Lazrus, 2012). As many previous studies noted, incidents related to climate change have already occurred and have been identified as such (Albert et al., 2016). Jiang et al. (2015), for example, reported an increase in the risk of diseases associated with extreme weather events driven by climate change. Furthermore, the risks caused by climate change have continued and increased. Nerem et al. (2018), for instance, found that rise in the sea level has accelerated for a few decades, and the trend is consistent with the climate models created by the Intergovernmental Panel on Climate Change.

The vulnerability of coastal and island communities to climate change is determined by not only the natural environment but also social aspects such as stakeholders' acceptance toward the impacts and their preference for relevant management options (Adger, 2006; Cinner et al., 2012). Adaptation to climate change involves behavior, decisions, and attitudes to reduce the adverse impacts of the change and utilize new opportunities driven by the change (Neil Adger et al., 2005; Smit et al., 2000). Thus, it is essential to understand the social aspects alongside the natural environment, while enhancing climate change adaptations. The growing recent literature investigated people's perceptions and attitudes toward climate change impacts and climate change adaptation (Brulle et al., 2012; Buckley et al., 2017; Kahan et al., 2012; Lee et al., 2015). Findings of these intense work on public perception and attitudes toward climate change would help to strengthen communities' capacities and public support for the adaptation strategies. Despite high vulnerability, however, there has been limited quantitative investigation into the perceptions of local people, especially in island communities, concerning climate change risk.

To uncover the residents' anxieties about climate change risk in Amami islands, Japan, the present study applied Best-Worst Scaling (BWS). The Amami islands provide good examples of people's anxieties about climate change based on the variety of risks they face, and decision makers have been requested to develop a climate change adaptation plan by IUCN through the World Heritage Site designation process (IUCN, 2018). The BWS provides an advantage over other methodologies, such as Likert-scale questions, for understanding the relative importance and the priorities in decision making. Since the BWS is a relatively new approach (Finn and Louviere, 1992; Louviere et al., 2015), the applications has been limited. In the context of climate change, Rudd and Lawton (2013) presented one of the most relevant topics of this study. They used the BWS to elicit research priorities for coastal conservation and management based on coastal scientists' preference. They ranked the 20 research questions and found that integrated upland and coastal management was the top priorities. Interestingly, they also found significant preference heterogeneity, which caused by disciplinary training. It pointed that even science advice can cause conflicts among stakeholders including researchers. Rudd and his colleagues also conducted the BWS to know the research priorities within the context of marine and broader environment and natural resource management (Rudd, 2014; Rudd et al., 2014; Rudd and Fleishman, 2014). Other relevant BWS research was conducted in agriculture. Jones et al. (2013) evaluated farmers' preference for the greenhouse gas mitigation practices and then ranked them from the perspective of both effectiveness and practicality. They found promoting practices for policy makers and heterogeneity in farmers' opinion. Glenk et al. (2014) combined BWS with the information concerning the current adoption measures of farmers to enhance the mitigation policies.

As described above, the previous literatures using BWS have examined the relative importance of policy measures and noted potential conflicts over stakeholders in this context; however, few studies have evaluated the priorities based on perceptions of coastal/island residents. This is a good example to which to apply the BWS because the Amami islands are expected to face a variety of risks caused by climate change, and it is necessary to understand residents' anxieties about the risks and how they prioritize risk management to enhance risk communications.

## 2. Materials and Methods

### 2.1. Amami islands

Our research site, Amami islands, are located in southwest of Japan (Figure 1). The islands are composed of eight populated islands: Amami-Oshima, Kakeromajima, Yorojima, Ukejima, Kikaijima, Tokunoshima, Okinoerabujima, and Yoronjima. Here, administratively, Kakeromajima, Yorojima, Ukejima are considered as Amami-Oshima.

**Figure 1.** Map of research site. The filled circle shows AMeDAS (Automated Meteorological Data Acquisition System) station operated by JMA (Japan Meteorological Agency) for precipitation data comparison.

The islands have been recognized as areas vulnerable to climate change (Ministry of the Environment et al., 2018). Through interviews with stakeholders including officials from local municipalities on the islands (Amami-Oshima, Kikaijima, Tokunoshima, Okinoerabujima, Yoronjima), park rangers in the Ministry of the Environment, and local residents working on environmental conservation on the islands, we focused on five attributes: 1) Damage caused by typhoon and heavy rain (hereafter, Typhoon), 2) Damage caused by flood and a landslide (hereafter, Flood), 3) Damage from a drought (hereafter, Drought), 4) Damage from ciguatera fish poisoning (hereafter, Ciguatera), and 5) Incident caused by jellyfish (hereafter, Jellyfish). Although there has been little information concerning weather/climate in the regional scale and the incidents, we note the relevant information concerning the five attributes as follows.

First, the area faces the annual risk of Typhoon, Flood, and Drought; however, there have been few drastic changes in the number of typhoons appearing in Amami islands over the past 60 years[1], which is similar to the national trends in Japan[2]. Most typhoons approach all the islands when they move into the area, and thus there is little difference in the number of typhoons among the islands. According to the prediction models based on climate change scenarios, the number of intense cyclones would increase in the southern sea of Japan in the future, while the number of total cyclones would decrease (Mizuta et al., 2011; Yoshida et al.,

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[1] The Mann-Kendall tests were performed using XLSTAT 2018 software; the results showed that no significant trends were detected.

[2] http://www.data.jma.go.jp/cpdinfo/climate_change/

2017). The amount of rainfall in the Amami islands was reported by JMA[3]. Figure 3 shows the amount of the heavy (daily precipitation > 200 mm) and light (< 1 mm) rainfall at AMeDAS station in Amami islands (Amami-Oshima, Kikaijima, Tokunoshima, Okinoerabujima, and Yoronjima) from 1979 to 2017. Similar to typhoons, drastic changes in the number of days with heavy and light rain have not been observed in the past few decades.

**Figure 2.** Annual frequencies trends of the typhoon. Annual frequencies trends of the typhoon approaching Amami islands from 1951 to 2017. The solid line shows the five-year running mean. The data were obtained from JMA (http://www.data.jma.go.jp/fcd/yoho/typhoon/statistics/accession/amami.html).

**Figure 3.** The amount of (a) heavy (daily precipitation > 200 mm) and (b) light (< 1 mm) rainfall at AMeDAS station in Amami islands (Amami-Oshima, Kikaijima, Tokunoshima, Okinoerabujima, and Yoronjima) from 1979 to 2017.
The solid line shows the five-year running mean. The data were obtained from JMA (http://www.data.jma.go.jp/gmd/risk/obsdl/index.php).

On the other hand, there have been few reports concerning Ciguatera caused by toxic benthic dinoflagellates *Gambierdiscus* spp. in the Amami islands so far; however, their distribution has expanded in recent years. The incidents mainly occurred in the southern areas including the Southwest Islands of Japan (Fukuyo, 1981; Koike et al., 1991); recently, *Gambierdiscus* spp. were observed in the Pacific Ocean and Japan Sea (Nishimura et al., 2013). Since sea temperature increase has a positive influence on the *Gambierdiscus* spp. (Chateau-Degat et al., 2005), the risk for coastal communities across Japan is likely to increase as the temperature rises (Hatayama et al., 2011).
Finally, the risk of Jellyfish is demonstrated by incidents involving *Chironex yamaguchii* and *Physalia physalis*. Although the highly toxic *C. yamaguchii* has been observed in Amami islands, to our knowledge, there have been few incidents. However, the risk will increase with climate warming, since many incidents have been reported in Okinawa prefecture, which is located in southern areas adjacent to the Amami islands (Lewis and Bentlage, 2009). The above information concerning the five attributes are summarized in Table 1.

[3] http://www.data.jma.go.jp/gmd/risk/obsdl/index.php

***Table 1.*** *Characteristics of the Amami islands. The number indicates the references. The future trends of damage from ciguatera fish poisoning and incident caused by jellyfish are presumed on the warming trend of sea surface temperature, although there are no specific references.*

### 2.2. Best-Worst Scaling (BWS) and survey design

The present study applied the objective case (Case 1) of BWS, which is one of the simplest and most practical approaches among the three approaches of BWS: the object case, the profile case, and the multi-profile case (Louviere et al., 2015). To construct choice sets with the attributes, the Balanced Incomplete Block Design (BIBD) was used in this study, followed by many empirical studies (Glenk et al., 2014; Louviere et al., 2013; Mori and Tsuge, 2017). The BIBD ensure that each alternative appears equal number of times and is equally paired with each of the other alternatives across all choice sets. After the application, five choice sets composed of four attributes were constructed in this study. That is, each risk attribute appeared four times across all choice sets and each pair appeared once. The respondents were asked to choose from each choice set that they were anxious about the most and least. Based on their choices, the counting analysis was conducted. Although there are many advanced econometrics models (e.g., maxdiff), the counting analysis has a significant practical advantage in that researchers are able to know individual priorities even with a limited sample size and most findings are consistent with the econometric models (see Louviere et al. (2015) and Marley and Louviere (2005) for detail).

### 2.3. Analysis

Based on the above, two types of score were reported here: the simple average score (B-W score) and the standardized B-W score. The former score of each attribute was calculated by subtracting the number of times each choice was chosen as the least anxiety from the number of times each choice was chosen as the most anxiety in each choice set. The latter score was calculated by dividing the B-W score by the number of the respondents to compare the B-W score within the islands. That is, the standardized B-W score here was from -4 to +4. To uncover differences in the B-W of each attribute within the islands, One-way ANOVAs with

Tukey's HSD were implemented. The analyses were carried out using R (Version 3.4.4 and the standard equipment packages therein;(R Core Team, 2018).

### 2.4. Sampling and data

In 2016, our survey was conducted using the Basic Resident Register of the islands, in cooperation with the Ministry of the Environment and local governments. Questionnaire surveys, including the choice sets, were distributed to 7,430 residents in the Amami islands, and we received 765 valid responses to the BWS questions. The characteristics of respondents are summarized in Table 2. Because the response rate to the series of BWS questions was not high, the present study does not discuss the heterogeneity of anxieties based on individual characteristics (e.g., age) and is limited to the applications of counting models.

***Table 2*** Respondents' characteristics concerning Gender, Age, and Residential areas.

## 3. Results

The results of the counting analysis are summarized in Table 3. With the simple calculation, Typhoon had the highest Best-Worst (B-W) and Standardized B-W score (2,334 and 3.05, respectively), followed by Flood (1,039 and 1.36), Drought (-158 and -0.21), Ciguatera (-1,415 and -1.85), and Jellyfish (-1,800 and -2.35), based on the residents' average preference.

**Table 3** Summary of Best-Worst (B-W) scores

To compare residents' risk preferences between the islands, the standardized B-W scores of each island's residents were calculated (Figure 4). The rankings of the B-W scores were the same for all of the islands, except for the second and third ranks. That is, Typhoon had the highest B-W scores on all islands (2.82, 3.58, 3.16, 3.35, and 3.85, in the order of Amami-Oshima, Kikaijima, Tokunoshia, Okinoerabujima, and Yoronjima). Likewise, Ciguatera ranked fourth (-1.89, -1.74, -1.70, -2.13, and -1.52, respectively), and Jellyfish ranked fifth (-2.20, -2.51, -2.67, -2.24, and -2.81, respectively). In terms of the second and third ranks, Flood had the second highest score for residents in Amami-Oshima (1.83), Kikaijima (0.56), and Tokunoshima (1.16), and the third highest score for residents in Okinoshima (0.38) and Yoronjima (0.10). On the other hand, Drought had the third highest score for residents in Amami-Oshima (-0.56), Kikaijima (0.11), and Tokunoshima (0.05), and the second highest score for residents in Okinoshima (0.64) and Yoronjima (0.38). Figure 4 describes the results of the one-way analysis of variance (ANOVA); the letters indicate differences in the standardized B-W scores of each attribute within islands ($P < 0.05$). In other words, B-W scores that do not share the letters differ at $p < 0.05$. There were significant differences in the scores of each attribute except for Ciguatera: Typhoon ($F = 11.37$, df =4, $p < .001$), Flood ($F = 43.29$, df =4, $p < .001$), Drought ($F = 17.89$, df =4, $p < .001$), Ciguatera ($F = 1.55$, df =4, $p < .187$), and Jellyfish ($F = 3.31$, df = 4, $p < .011$).

**Figure 4** Comparisons of Best-Worst (B-W) scores among the Amami islands. In each attribute, the alphabets (a–c) indicate statistical differences in the scores among the islands based on the results of a one-way analysis of variance with Tukey's honest significant difference test.

## 4. Discussion

### 4.1. Climate change communication based on stakeholders' risk perception

Communication with stakeholders is an essential aspect throughout the process of adaptation to climate change (Cinner et al., 2018), because the successful of adaptation is determined by people's subjective values, perception, knowledge, intention and culture (Adger et al., 2009). Thus, a lack of understanding of stakeholders' attitudes concerning climate change impacts hinders their responses to the issues. The present study elicited the anxieties of island residents about climate change impacts using BWS. Due to the constraints of a variety of resources (e.g., funding), understanding the relative importance of these issues for local residents will help the decision making concerning the implementation of adaptation policies. The results based on residents' average perception showed that the risks of Typhoon and Flood were perceived as higher, whereas the risks of Ciguatera and Jellyfish were perceived as lower for local residents. The findings imply that decision makers and managers need to give priority to communication Typhoon and Flood for the majority of the residents. As discussed by previous studies (Adger, 2006; Neil Adger et al., 2005), alleviating the stakeholders' anxieties could be an important strategy to enhance climate adaptation. There are several possible factors causing their anxieties. First, their experiences with weather events are most reasonable factors (Dai et al., 2015; Zaalberg et al., 2009). In the Amami islands, as described in Figure 2 and 3, typhoons and heavy rain occur annually, causing flood and landslides. Although the number of associated injuries has been very limited, the residents experienced and observed some impacts. Many similar correlations concerning natural hazards have been reported in Europe (Frondel et al., 2017; Keller et al., 2006; Thieken et al., 2007; Weber, 2006). Through this study, we have contributed by adding an Asian example to the literature. Moreover, the findings concerning relatively minor risk (Ciguatera and Jellyfish) would support the findings of the correlations between residents' experiences with natural hazards and their attitudes since there have been few reports concerning incidents in Amami islands. On the other hand, there is a possibility that the attributes of incidents affect residents' perceptions (Rachman, 1990; Slovic, 1987). Although investigating how their perception depends on the attributes is beyond our scope, the residents may have prioritized Typhoon and Flood higher as they consider them as being relatively uncontrollable. Further work with integration of psychological approach (Fischhoff, 2006; Sjöberg, 2000; Slovic, 1987) is therefore suggested.

### 4.2. Necessity of island-specific tailored adaptation measures

The findings by comparing the residents' anxieties among islands would ensure the ranking of the priorities because we did not find large variations in the anxiety ranking concerning the climate change incidents; thus, we suggest that providing exchange of information especially about Typhoon is given priorities over the others even in island scale. The findings also suggest that sharing the anxieties among stakeholders could be a better first step toward effective communication compared with sharing the relevant opinions and preferences (Jones et al., 2013; Rudd and Lawton, 2013). Whereas, the differences in their B-W scores provided deeper insights into the cause of their anxieties. In particular, residents in Amami-Oshima showed relatively higher anxieties about Flood, whereas residents in Okinoerabujima showed higher anxiety about Drought. This implies that the differences in the rank about Flood and Drought would be explained by the differences in the amount of both heavy and light rainfall, and the number of typhoons, which support previous findings (Dai et al., 2015; Frondel et al., 2017). Suppose their anxieties are triggered by their experience, their ranking would change drastically. As described in Table 1, the future scenarios predicted the climate change will increase risk of the relevant events and incidents except for the number of typhoons. To predict the change in their anxieties about the climate change and understand the priority, research on regional-scale resolution climate change projections is needed.

## 5. Conclusions

In conclusion, public engagement is essential to enhance climate change adaptation. Communication concerning Typhoon and Flood is an important first step of climate change communication in islands. Although climate change impacts remain highly uncertain, it is important to know whether people accept the change driven by climate change. Such acceptance will lead people to migrate and resettle and drastically change the communities. The present study shows BWS can help identify the relative importance of the issues for people; however, our insights have been limited to heterogeneity of anxieties among islands; thus, further analysis, such as latent class model, can provide deeper knowledge to enhance tailor-mode strategies. Understanding the sensitivity of residents to climate change risk will encourage stakeholders to communicate and enhance climate change adaptation in local communities.

## 6. Figures

### 6.1. Figure 1

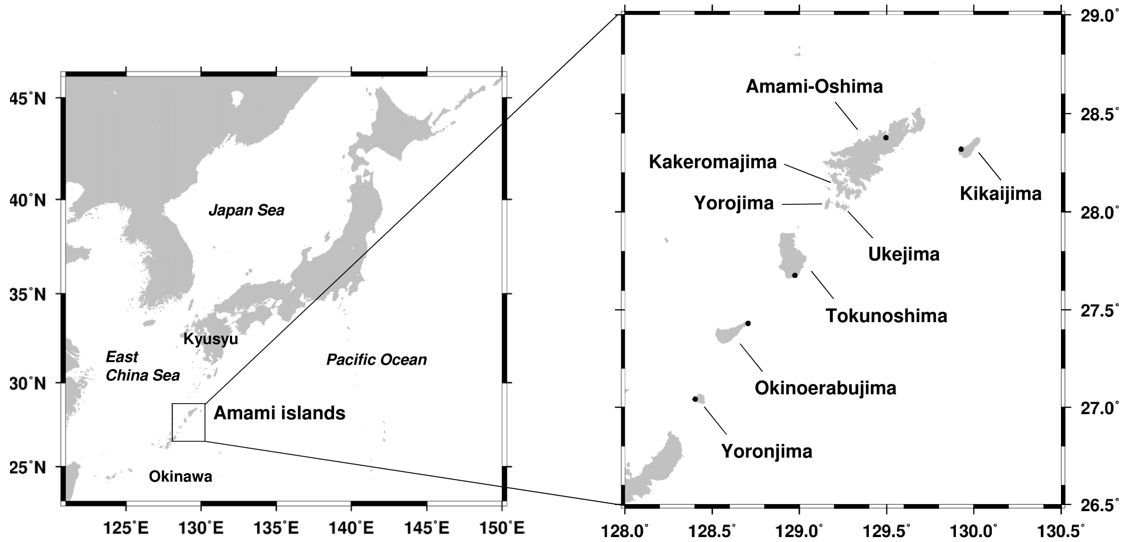


Figure 1 Map of research site. The filled circle shows AMeDAS (Automated Meteorological Data Acquisition System) station operated by JMA (Japan Meteorological Agency) for precipitation data comparison.

### 6.2. Figure 2

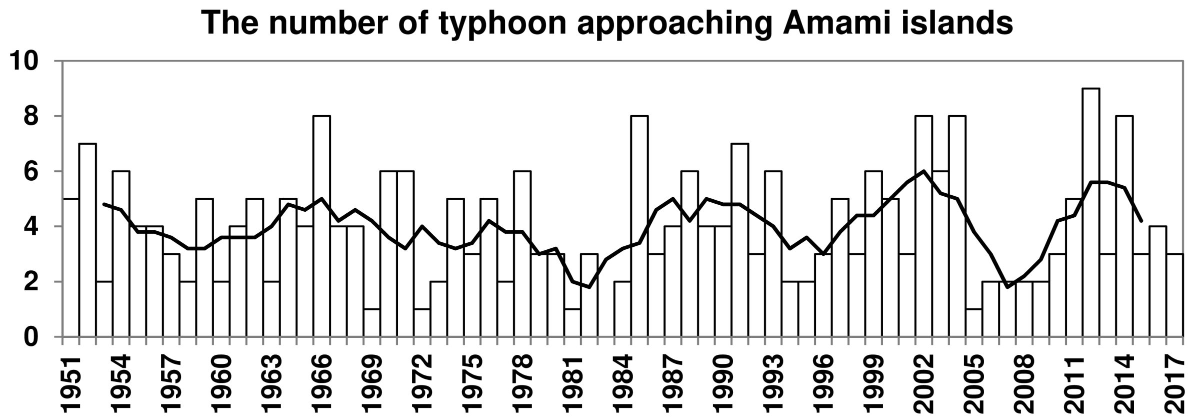


Figure 2 Annual frequencies trends of the typhoon. Annual frequencies trends of the typhoon approaching Amami islands from 1951 to 2017. The solid line shows the five-year running mean. The data were obtained from JMA (http://www.data.jma.go.jp/fcd/yoho/typhoon/statistics/accession/amami.html).

## 6.3. Figure 3

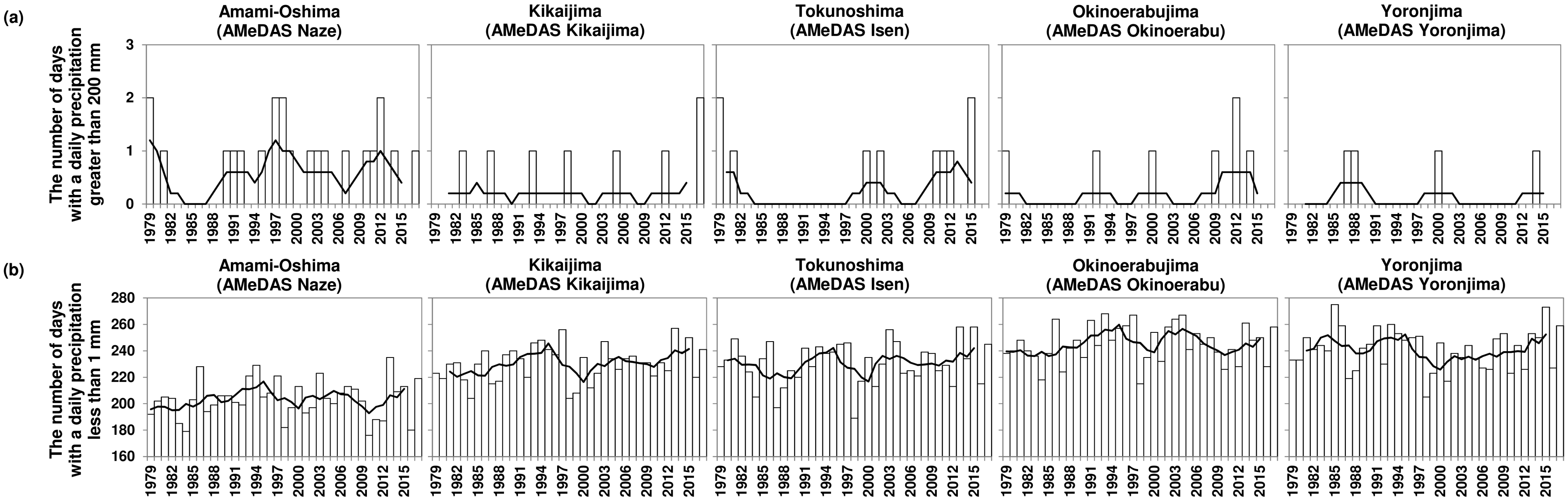


Figure 3 The amount of (a) heavy (daily precipitation > 200 mm) and (b) light (< 1 mm) rainfall at AMeDAS station in Amami islands (Amami-Oshima, Kikaijima, Tokunoshima, Okinoerabujima, and Yoronjima) from 1979 to 2017. The solid line shows the five-year running mean. The data were obtained from JMA (http://www.data.jma.go.jp/gmd/risk/obsdl/index.php).

### 6.4. Figure 4

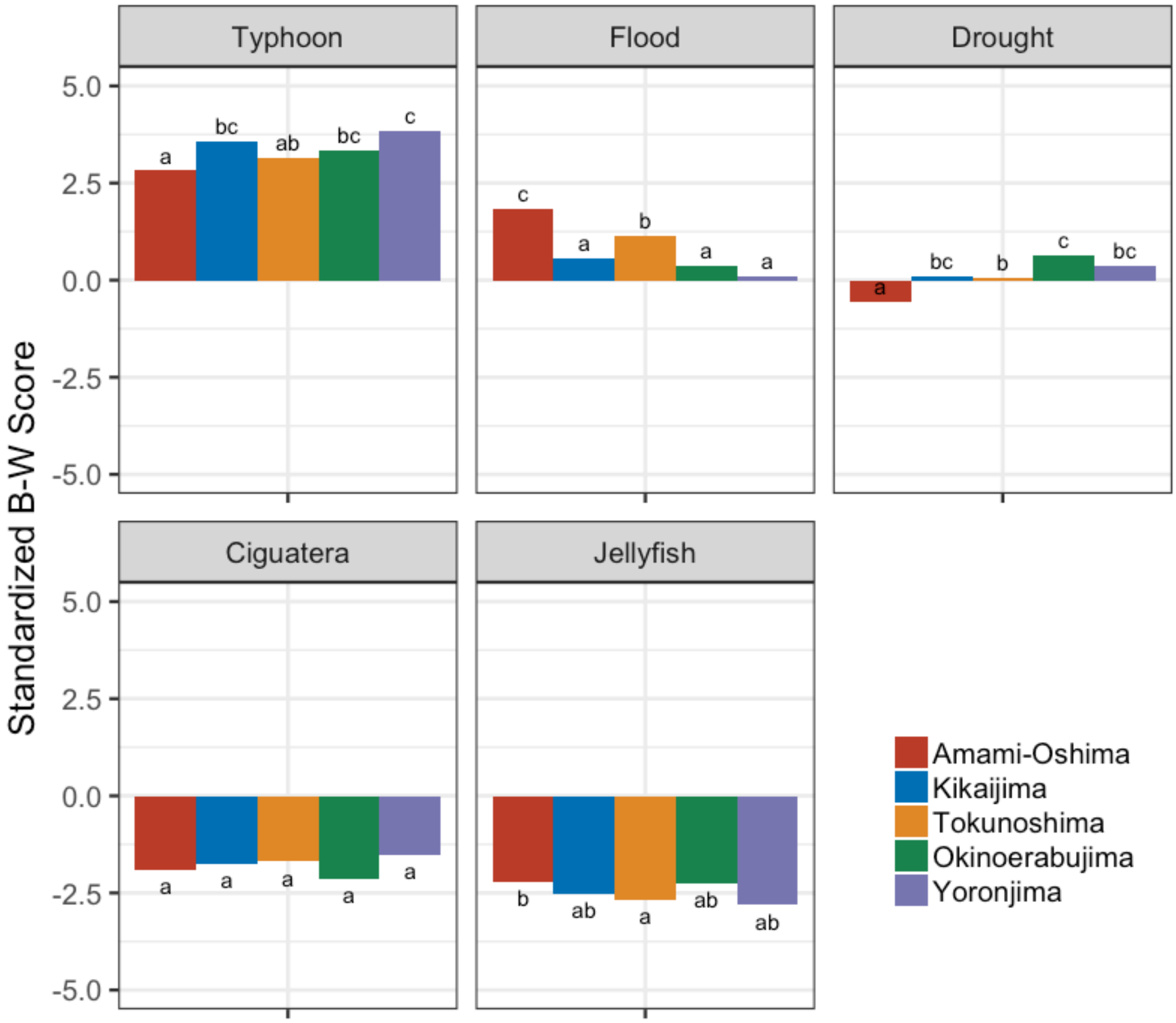


Figure 4 Comparisons of Best-Worst (B-W) scores among the Amami islands. In each attribute, the letters (a–c) indicate statistical differences in the standardized B-W scores within islands based on the results of a one-way analysis of variance with Tukey's honest significant difference test.

# 7. Tables

## 7.1. Table 1

Table 1 Characteristics of the Amami islands. The number indicates the references. The future trends of damage from ciguatera fish poisoning and incident caused by jellyfish are presumed on the warming trend of sea surface temperature, although there are no specific references.

| | Reported trends | (spatial scale) | Predicted trends | (spatial scale) |
|---|---|---|---|---|
| Number of typhoons | No-trend | Amami islands [1] | Decrease | south of Japan [2] |
| Occurrences of very intense typhoons | Unknown | — | Increase | south of Japan [2] |
| Occurrences of heavy rain | No-trend | Each island among Amami islands [3] | Increase | Okinawa-Amami area/ Kyusyu-Okinawa area [4] |
| Occurrences of light rain | No-trend | Each island among Amami islands [3] | Increase | Okinawa-Amami area/ Kyusyu-Okinawa area [4] |
| Sea surface temperature | Increase | Okinawa-Amami area/ Kyusyu-Okinawa area [5] | Increase | Okinawa-Amami area/ Kyusyu-Okinawa area [6] |
| Damage from ciguatera fish poisoning | Unknown | — | Increase | Okinawa-Amami area/ Kyusyu-Okinawa area |
| Incidents caused by jellyfish | Unknown | — | Increase | Okinawa-Amami area/ Kyusyu-Okinawa area |

[1] http://www.data.jma.go.jp/fcd/yoho/typhoon/statistics/accession/amami.html
[2] Yoshida et al. (2017)
[3] http://www.data.jma.go.jp/gmd/risk/obsdl/index.php

[4] http://www.data.jma.go.jp/cpdinfo/GWP/index.html
[5] http://www.data.jma.go.jp/kaiyou/data/shindan/a_1/japan_warm/japan_warm.html
[6] http://www.data.jma.go.jp/cpdinfo/GWP/Vol7/index.html

**7.2. Table 2.**

Table 2. Respondents' characteristics concerning gender, age, and residential areas.

| Attributes | Characteristics (Number) |
|---|---|
| Gender | Male (368), Female (367), Unknown (30) |
| Age | 20s (51), 30s (122), 40s (151), 50s (170), 60s (181), 70s (69), Unknown (21) |
| Residential areas | Amami-Oshima (438), Kikaijima (57), Tokunoshima (115), Okinoerabujima (86), Yoronjima (48), Unkown (21) |

### 7.3. Table 3

Table 3 Summary of Best-Worst (B-W) scores

| Attributes | Best | Worst | B-W Score | Standardized B-W Score | Rank |
|---|---|---|---|---|---|
| Typhoon | 2,351 | 17 | 2,334 | 3.05 | 1 |
| Flood | 1,095 | 56 | 1,039 | 1.36 | 2 |
| Drought | 273 | 431 | -158 | -0.21 | 3 |
| Ciguatera | 59 | 1,474 | -1,415 | -1.85 | 4 |
| Jellyfish | 47 | 1,847 | -1,800 | -2.35 | 5 |

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