Chapter 15
Assessing the Difficulty of Implementing Wildlife-Friendly Farming Practices by Using the Best–Worst Scaling Approach

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Abstract On Sado Island in central Japan, wildlife-friendly farming is widely practiced, using the crested ibis (*Nipponia nippon*) as an icon. On the basis of farmer preferences, we applied the best–worst scaling (BWS) approach to evaluate the difficulty of implementing seven representative wildlife-friendly farming practices on Sado Island. Typical wildlife-friendly farming practices include reduced inputs of agrochemicals (50 % or 80 % agrochemical reduction), organic (agrochemical-free) cultivation, winter flooding, installation of diversion ditches, installation of fishways, and installation of biotopes (fallow flooding). We conducted a questionnaire survey of 5,010 farmers on Sado Island who distributed rice to Japan Agricultural Cooperatives (JA) at the time of the survey. We employed two approaches to analyze the BWS data: counting analysis and econometric analysis. The results of both analyses showed that organic cultivation was the most difficult of all types of farming practices and that 50 % agrochemical reduction was the least difficult. As expected, the burden of implementing the various farming practices differed. When a farming practice can produce a certain amount of biodiversity with less burden, the practice is considered more efficient. The results of our analysis can be utilized to evaluate each farming practice by quantifying its cost-effectiveness. Our study approach may be an effective assessment tool for disseminating wildlife-friendly farming practices.

Keywords Best–worst scaling • Wildlife-friendly farming • Sado Island • Crested ibis • Farmer preferences

Introduction

Paddy fields are an important alternative wetland habitat for a range of aquatic and semi-aquatic wildlife (Lawler 2001; Bang et al. 2012; Miyashita et al. 2015). However, the dramatic decrease in the biodiversity of wetland habitats has shifted considerable focus to wildlife-friendly farming in Japan for conserving or restoring paddy field biodiversity (Natuhara 2013). Since wildlife-friendly farming is costlier and demands more effort, time, and skill and involves a greater risk of decreased yields than conventional farming (Pimentel et al. 2005), there is heavy burden on farmers practicing wildlife-friendly farming. Minimizing this burden is key to further disseminating wildlife-friendly farming practices.

Wildlife-friendly rice farming involves improving habitat quality for wildlife in and around paddy fields (Donald 2004; Natuhara 2013). Such practices include not only the reduced input of pesticides and chemical fertilizers (agrochemicals), but also the implementation of winter flooding, diversion ditches, fishways, and fallow flooding (hereafter termed *biotopes*). Although all these farming practices aim at conserving or restoring farmland biodiversity, the burden of implementing each farming practice may differ. When a farming practice can produce a certain amount of biodiversity with less burden, the practice is considered more efficient. Therefore, it is important to evaluate each farming practice by quantifying its cost-effectiveness, which involves evaluating the burden of implementing each farming practice and its effect on wildlife. Although ecologists have studied the effects of wildlife-friendly farming practices on paddy field biodiversity (Lane and Fujioka 1998; Amano et al. 2011; Usio et al. 2015), the burden of implementing each farming practice has rarely been investigated. Farmers consider the various burdens of implementing such farming practices and decide which farming practice to implement in their paddy fields. As is known, the difficulty experienced by farmers increases as they implement more burdensome practices. Therefore, for farmers, the difficulty of implementing each farming practice is a unidimensional index that reflects the various burdens of implementing each farming practice, and it can be interpreted as disutility (negative utility) as farmers obtain more negative utility from more burdensome farming practices. In this study, we have attempted to quantify the difficulty of implementing each farming practice based on farmer preferences.

On Sado Island in central Japan, wildlife-friendly farming is widely practiced using the crested ibis (*Nipponia nippon*) as an icon (Saito 2015; Usio et al. 2015). The crested ibis has been reintroduced to Sado Island from 2008 (Kato 2015) in an attempt to restore degraded secondary natural environments such as paddy fields and forests and to revitalize depopulated human communities. To improve food availability for the crested ibis and to enhance biodiversity in paddy fields, wildlife-friendly farming has become a common practice on Sado Island. To be approved by the rice certification initiative of Sado City, farmers must apply 50 % or less of the agrochemicals of conventional farming, and implement one of four biodiversity-enhancing practices (Usio et al. 2015). Biodiversity-enhancing practices include the implementation of winter flooding, diversion ditches (locally known by the name *e*), fishways, and biotopes.

We applied the best–worst scaling (hereafter termed *BWS*) approach (Finn and Louviere 1992) to evaluate the difficulty of implementing the wildlife-friendly farming practices used on Sado Island based on farmer preferences. To our knowledge, no study has quantified the difficulty of implementing various wildlife-friendly farming practices.

In the next section, we describe our questionnaire survey, the BWS approach, the design of the choice sets in our survey, and two approaches to analyze the BWS data used in this paper. Subsequently, we present the results of our analyses and discuss the implications of the results. Finally, we summarize the results and explore directions for future research.

Methods

Questionnaire Survey

From August through October 2011, a questionnaire survey was conducted with the farmers on Sado Island (Nakamura et al. 2014). Questionnaires were sent to all 5,010 farmers who distributed rice to Japan Agricultural Cooperatives (JA) at that time. At the time of the study, rice grown under conventional farming could no longer be legally distributed through the JA, and most farmers had reduced agrochemicals by at least 50 % relative to conventional farming. Therefore, we considered 50 % agrochemical reduction farming (compared to the amount of agrochemicals used in conventional farming) to be the base practice.

We attempted to quantify the difficulty of implementing the typical wildlife-friendly farming practices used on Sado Island, which include reduced inputs of agrochemicals (50 % or 80 % agrochemical reduction), organic (agrochemical-free) cultivation, and the aforementioned four types of biodiversity-enhancing practices (winter flooding, installation of diversion ditches, installation of fishways, and installation of biotopes) based on farmer preferences by using the BWS approach explained below.

Best–Worst Scaling Approach

BWS is a method for measuring individual preferences developed by Finn and Louviere (1992). It requires the respondent to choose one alternative that he/she thinks is the best or the most of a particular characteristic (e.g., *preferred*, *important*, *difficult*) and one that is the worst or least of that characteristic from a series of choice sets that contain different combinations of three or more alternatives. BWS is often referred to as *maximum difference scaling* because it assumes that respondents examine every possible pair of alternatives within each choice set and choose the maximally different pair based on an underlying latent scale such as utility, degree of importance, or degree of difficulty (Finn and Louviere 1992; Cohen 2003).

Considerable information can be obtained from the BWS questions (Cohen 2003; Marley and Louviere 2005). Consider a choice set of four alternatives from which a respondent chooses his/her most and least preferred alternatives. If the choice set consists of red, blue, yellow, and green and the respondent prefers red the most and green the least, we can obtain information about 5 of the 6 possible paired comparisons ($4 \times 3/2 = 6$ pairs): red > blue, red > yellow, red > green, blue > green, and yellow > green, where ">" means "is preferred more than." We can determine the location of each alternative on the underlying latent scale by using the extensive information obtained from BWS questions.

BWS is classified into three types—the object case (Case 1), the profile case (Case 2), and the multi-profile case (Case 3)—based on the type of alternative to be evaluated (Flynn 2010). The object case is appropriate when the purpose of the study is to examine the location of each object on an underlying latent scale. We employed the object case in our study because our purpose is to determine the relative difficulty of implementing the seven representative wildlife-friendly farming practices. Therefore, we focus primarily on the object case for our analysis. Refer to Flynn et al. (2007) for more details about profile case BWS and to Louviere et al. (2008) and Scarpa et al. (2011) for more details about multi-profile case BWS.

We employed BWS instead of a rating scale and ranking used for measuring individual preferences in various fields because BWS has certain advantages over these traditional methods (Cohen 2003, 2009; Auger et al. 2007; Lee et al. 2007; Lusk and Briggeman 2009; Flynn 2010). First, it is easier for respondents to complete BWS questions than a rating scale and ranking because the selection process is simple and involves choosing the extremes from among several alternatives. Unlike a rating scale and ranking, respondents are not asked either to rate their preference for each alternative or to rank them in order of preference. The relatively simple BWS questions are thus more suitable for surveys like ours that involve elderly respondents. Moreover, BWS is especially useful in cases involving the evaluation of many alternatives. Incorporating many alternatives in a rating scale and ranking will impose an additional burden on respondents, possibly reducing the reliability of response. In contrast, BWS can handle a relatively larger number of alternatives because respondents are expected to evaluate only several select alternatives out of all alternatives according to the experimental design in each question (Lee et al. 2007; Jaeger et al. 2008; Cohen 2009; Lusk and Briggeman 2009; Mueller and Rungie 2009; Mueller et al. 2009). Second, BWS overcomes the lack of discrimination among alternatives and scale use bias (or response style bias), which potentially exist in a rating scale. BWS is more discriminating since a rating scale allows respondents to equally rate all the alternatives, while BWS requires respondents to make trade-offs among alternatives to choose the maximally different pairs. Scale use bias may exist in a rating scale because respondents with different sociodemographic characteristics or cultural backgrounds may use the scale differently (Lee et al. 2007). In contrast, no bias caused by differences in response style exists in BWS because there is only one way to choose the best and worst alternatives (Auger et al. 2007; Cohen 2009; Lee et al. 2007; Lusk and Briggeman 2009). This implies that BWS is *scale free*. Because of this feature, BWS is more useful in cross-cultural and cross-national comparative studies (Finn and Louviere 1992; Auger et al. 2007; Cohen 2009; Goodman 2009). Finally, BWS is superior to ranking in terms of the extent of information obtained. While BWS tells us both the order and the strength of preference of all alternatives, ranking tells us only the order.

Because of these advantages, BWS has been widely applied in many academic fields. The object case BWS has been employed extensively to investigate consumers' food and beverage preferences (Finn and Louviere 1992; Hein et al. 2008; Jaeger et al. 2008; Louviere and Islam 2008; Lusk and Parker 2009; Casini et al. 2009; Cohen 2009; Goodman 2009; Jaeger and Cardello 2009; Lusk and Briggeman 2009; Mueller and Rungie 2009; Remaud and Lockshin 2009; Yu et al. 2009). In addition, the object case BWS has been used to investigate preferences on other goods and services (Cohen 2003; Chrzan and Golovashkina 2006; Garver 2009) and to examine people's decision making on business (Buckley et al. 2007) and attitudes on social and ethical issues (Auger et al. 2007). Moreover, the object case BWS has been employed in studies on values (Lee et al. 2007, 2008; Bardi et al. 2009) and conflict (Daly et al. 2010) in the psychology field. To the best of our knowledge, this is the first work that applies BWS to quantify the difficulty of implementing wildlife-friendly farming.

Questionnaire Design

The experimental design is used to construct choice sets in order to minimize the number of questions. Balanced incomplete block designs (BIBDs) are used in many empirical studies to ensure that each alternative appears an equal number of times and is equally paired with each of the other alternatives across all choice sets (Auger et al. 2007; Lee et al. 2007). We adopted the BIBD for this study (Table 15.1). We constructed seven choice sets by replacing each number in the BIBD with one of the seven aforementioned wildlife-friendly farming practices, and in this process, the BIBD table was converted to seven choice sets. Each farming practice appeared three times across all choice sets and each pair of farming practices appeared once. Each row corresponds to one choice set. Respondents were presented with all seven choice sets. Figure 15.1 illustrates a choice set. The respondents were required to choose from each choice set the farming practice that they considered the most difficult (best) and the least difficult (worst) to implement. In order to exclude the benefit of implementing each farming practice and evaluate only the difficulty of implementing each farming practice, we asked respondents to consider the amount of effort, time, and skill that each farming practice required and the associated risk of decreased yields, as well as to assume that there were no additional factors such as subsidies, relaxations of production adjustment, or purchasing at higher prices than conventional agriculture. Making these choices may not have been difficult for farmers since they often compare the difficulty of each farming practice, and this survey enabled them to make realistic decisions based on their farming practices.

Table 15.1 Conversion from BIBD to choice sets

BIBD

1	2	6	4
2	1	4	5
3	4	7	3
4	3	2	1
5	7	5	2
6	6	1	7
7	5	3	6

→

Choice sets

1	80 % agrochemical reduction	Installation of fishways	Winter flooding
2	50 % agrochemical reduction	Winter flooding	Installation of diversion ditches
3	Winter flooding	Installation of biotopes	Organic cultivation
4	Organic cultivation	80 % agrochemical reduction	50 % agrochemical reduction
5	Installation of biotopes	Installation of diversion ditches	80 % agrochemical reduction
6	Installation of fishways	50 % agrochemical reduction	Installation of biotopes
7	Installation of diversion ditches	Organic cultivation	Installation of fishways

From each set, please choose the farming practice most difficult to implement and the farming practice least difficult to implement in your paddy field[†].

*Please consider the effort, time, skill, and greater risk of decreased yields.

*Please assume that there are no additional factors such as subsidy, relaxation of production adjustment, or purchasing at a higher price than conventional agriculture.

The farming practice most difficult to implement		The farming practice least difficult to implement
☐	80% agrochemical reduction	☐
☐	Installation of fishways	☐
☐	Winter flooding	☐

[†] Three farming practices were presented in each set.

Fig. 15.1 Example of a choice set

Counting Analysis

Data obtained through BWS questions can be analyzed in a variety of ways. A detailed discussion of the theoretical foundation of each analysis is provided by Marley and Louviere (2005). We employed two approaches to analyze the BWS data: counting analysis and econometric analysis. Counting analysis involves simple calculations and is often used in the analysis of BWS data.

In counting analysis, we count the number of times each alternative was chosen as best and worst. These numbers are referred to as the *total best* and *total worst*, respectively. The *B–W score* for each alternative is calculated by subtracting the *total worst* of each alternative from the *total best* of each alternative. A higher B–W score implies that an alternative is evaluated relatively higher on the underlying latent scale. Marley and Louviere (2005) note that the B–W score is a close approximation of the maximum likelihood estimates of the conditional logit model. As can be observed, analyzing BWS data by the counting analysis method requires no special expertise, and this method is chosen because of its simplicity and ease.

Econometric Analysis

Econometric analysis was conducted for a more rigorous analysis and to check the validity of the counting analysis.

The Maximum difference (maxdiff) model introduced by Finn and Louviere (1992) is a fundamental econometric model for BWS data analysis. This model is a variant or a natural extension of the conventional conditional logit model derived from the random utility model (Thurstone 1927; McFadden 1974). The maxdiff model assumes that respondents examine the difference between every possible pair of alternatives in a choice set based on an underlying latent scale and that from among all possible pairs, they choose the pair that maximizes the difference between two alternatives.

If a choice set has J alternatives, there are $J(J-1)$ possible best–worst pairs a respondent can choose from. In our case, six ($3 \times 2 = 6$) such pairs exist since three of the seven farming practices are included in a choice set ($J = 3$). Let β_i represent the location of the alternative i on the underlying latent scale. Described as follows, $Difference_{ij}$ represents the difference between the locations on the underlying latent scale between alternatives i and j.

$$Difference_{ij} = \beta_i - \beta_j + \varepsilon_{ij} \tag{15.1}$$

where ε_{ij} is an associated error component. The probability that the respondent chooses alternatives i and j as the best and worst of the J alternatives in the choice set is equal to the probability that the difference between alternatives i and j is greater than all other possible (in this case, $6 - 1 = 5$) differences in the choice set. The conditional logit model developed by McFadden (1974) is derived by assuming that ε_{ij} is distributed independently and identically with a type-I extreme value distribution (Gumbel distribution). The probability that a respondent chooses alternatives i and j as the best and worst of the J alternatives in the choice set is described as follows (Lusk and Briggeman 2009):

$$\begin{aligned} &P(i\ is\ chosen\ as\ the\ best\ and\ j\ is\ chosen\ as\ the\ worst) \\ &= \frac{\exp(\beta_i - \beta_j)}{\sum_{k=1}^{J} \sum_{l=1}^{J} \exp(\beta_k - \beta_l) - J} \end{aligned} \tag{15.2}$$

In contrast to the conventional conditional logit model where the alternative chosen by the respondent is treated as choice outcome, each pair of alternatives chosen by the respondent as best and worst is treated as a choice outcome in this model. The dependent variable takes the value 1 for the pair of alternatives chosen by the respondent as best and worst and 0 for the remaining pairs of alternatives in the choice set that were not chosen as best and worst. The parameter β_i (in this case, the difficulty of implementing each farming practice) can be estimated by the maximum likelihood method (Train 2009).

Results and Discussions

Data Collection

Responses were obtained from 2,231 farmers, a response rate of 44.5 %. For analysis, we used the data from the 1,355 farmers who answered all seven BWS questions. Of these 1,355 respondents, 1,257 (92.8 %) were male and 97 (7.2 %) were female; 398 (29.4 %) were certified wildlife-friendly farmers and 957 (70.6 %) were uncertified. In terms of age, 17 (1.3 %) respondents were in their 20s–30s, 108 (8.0 %) were in their 40s, 349 (25.9 %) were in their 50s, 538 (39.9 %) were in their 60s, 277 (20.5 %) were in their 70s, and 61 (4.5 %) were in their 80s–90s. Since a significant proportion of the respondents were elderly, the relatively simple BWS questions were considered suitable for our survey.

Results of Counting Analysis

The results of the counting analysis are summarized in Table 15.2. The *total best* and *total worst* data compiled in Table 15.2 show the frequency of farming practices chosen by respondents as the most and least difficult from the set of farming practices. The most frequently chosen farming practice in the *total best* category was organic cultivation (chosen 2,955 times), followed by the installation of fishways (chosen 2,000 times) through to 50 % agrochemical reduction (chosen 127 times). The most frequently chosen farming practice in the *total worst* category was 50 % agrochemical reduction (chosen 3,380 times), followed by winter flooding (chosen 2,425 times) through to the installation of fishways (chosen 311 times). The B–W score presented in Table 15.2 is the difference between the *total best* and the *total worst* categories. The farming practice with the highest B–W score was organic cultivation, followed by the installation of fishways through to 50 % agrochemical reduction. This indicates that the organic cultivation

Table 15.2 Summary of counting analysis

Alternatives	Total best (Most difficult)	Total worst (Least difficult)	B–W score	Ranking
50 % agrochemical reduction	127	3,380	−3,253	7
80 % agrochemical reduction	1,310	653	657	4
Organic cultivation	2,955	466	2,489	1
Winter flooding	531	2,425	−1,894	6
Installation of diversion ditches	1,242	1,751	−509	5
Installation of fishways	2,000	311	1,689	2
Installation of biotopes	1,320	499	821	3

was identified as the most difficult farming practice, while 50 % agrochemical reduction was identified as the least difficult. Among the four types of biodiversity-enhancing practices, winter flooding was chosen as the least difficult, and the installation of fishways was identified as the most difficult. As expected, the burden of implementing each farming practice differed. The ranking of each of these farming practices is consistent with our expectations based on our prior conversations with the farmers.

Results of Econometric Analysis

Table 15.3 shows the estimation results for the maxdiff model (conditional logit model). We included a dummy variable for each farming practice. To estimate the relative difficulty of each farming practice as compared with 50 % agrochemical reduction, the coefficient of 50 % agrochemical reduction was set at zero (therefore, the term was not included in the estimation). All variables were found to be positively significant. The estimated parameter of the organic cultivation was the largest. These results indicate that the organic cultivation was the most difficult farming practice and that the 50 % agrochemical reduction was the least difficult. Among the four types of biodiversity-enhancing farming practices, winter flooding was the least difficult and the installation of fishways was the most difficult. These outcomes are the same as the results derived from the B–W score based on the counting analysis.

The probability that each farming practice is chosen as the most difficult farming practice (i.e., the share of each farming practice) can be calculated using estimated parameters. The probability that farming practice *i* is chosen as the most difficult

Table 15.3 Estimation results for the maxdiff model (conditional logit model)

Parameter	Estimate	*t*-value	*p*-value	ranking	share
50 % agrochemical reduction	0	–	–	7	0.019
80 % agrochemical reduction	2.006	46.95***	0.000	4	0.140
Organic cultivation	2.885	70.96***	0.000	1	0.336
Winter flooding	0.863	22.74***	0.000	6	0.045
Installation of diversion ditches	1.530	37.28***	0.000	5	0.087
Installation of fishways	2.478	58.77***	0.000	2	0.224
Installation of biotopes	2.079	49.49***	0.000	3	0.150
Number of observations	9,485				
AIC	12,279.0				
BIC	12,300.5				
Log likelihood	−12,273.0				

Note: *** $p < 0.01$. AIC and BIC refer to the Akaike information criterion and the Bayesian information criterion, respectively

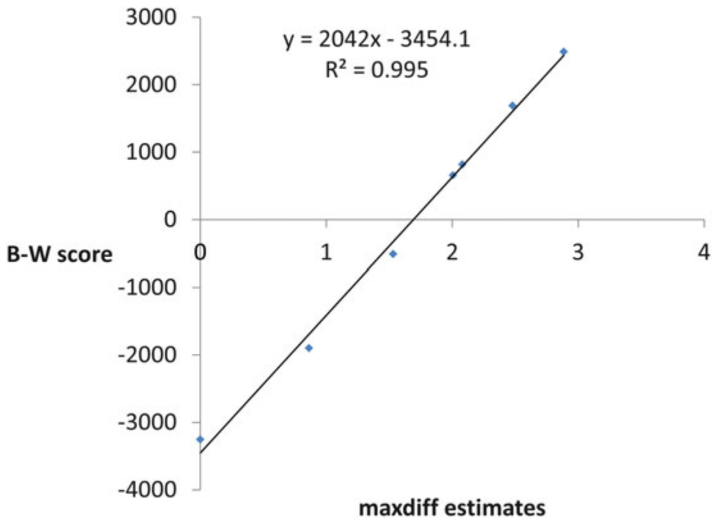

Fig. 15.2 Comparison between counting analysis and econometric analysis

farming practice is calculated by substituting the estimated parameters in the right-hand side of the following conditional logit model:

$$P(i\ \ is\ \ chosen\ \ as\ \ the\ \ most\ \ difficult) = \frac{\exp(\beta_i)}{\sum_{j=1}^{7} \exp(\beta_j)} \tag{15.3}$$

It can be observed from the calculated shares that 33.6 % of respondents find organic cultivation to be the most difficult farming practice.

As mentioned earlier, similar results were obtained from the counting analysis and the econometric analysis. Figure 15.2 shows a comparison between the two analyses. A strong linear relationship between the B–W score and the estimates of the maxdiff model can be observed. These results confirm the usefulness and validity of counting analysis as a simplified analytical method.

Conclusions

This study has successfully quantified the difficulty of implementing seven wildlife-friendly farming practices based on farmer preferences by applying the BWS approach. The results of counting analysis and econometric analysis showed that the organic cultivation was the most difficult farming practice and that 50 % agrochemical reduction was the least difficult. As expected, the burden of implementing each farming practice differed. When a farming practice can produce a certain amount of biodiversity with less burden, it is considered more efficient.

The result of our analysis is useful for evaluating each farming practice by quantifying its cost-effectiveness.

The promotion of wildlife-friendly farming practices is important not only in Japan, but also in many other parts of the world in which environmental deterioration is a serious concern. The results of this study make an important contribution to highlighting this issue, and the approach may provide an effective assessment tool for the dissemination of wildlife-friendly farming practices.

Several aspects remain to be addressed in future research. In our econometric analysis, parameters are assumed to be common among all respondents. However, this might be an unreasonable assumption. Since the individual attributes of farmers and farmland conditions vary, perceptions pertaining to farming practices might be heterogeneous. Analyzing the subject by incorporating these differences is an important research task. Moreover, analyzing the differences in the evaluation of each farming practice by certified and uncertified wildlife-friendly farmers is important to derive useful insights that may assist in the further dissemination of wildlife-friendly farming practices.

Conducting a cost-effectiveness analysis is also an important area for future research. The cost-effectiveness of wildlife-friendly farming practices for conserving or restoring farmland biodiversity could be calculated by using the ratio of effectiveness on paddy field biodiversity and difficulty. Moreover, the cost-effectiveness of wildlife-friendly farming practices on rice production can be calculated by using the ratio of the rice yield or consumption quality and difficulty. Data collection on the effectiveness of farming practices is key to any such analysis and could be considered as a subject for future research.

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