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Opinion changes among participants in citizen participation workshops: a case study on the final disposal of removed soil outside Fukushima Prefecture

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Existing studies on risk perception have identified key factors influencing policymaking and its support; however, their effects in practical situations remain unclear. While research on science and technology communication has explored various case studies, the measurement of changes in participants' opinions regarding risk perception and its related factors has been rare. This study seeks to integrate these two research areas by examining participants' opinion changes during a practical setting—workshops on the final disposal of removed soil outside Fukushima Prefecture. Specifically, the study investigates changes in psychological variables, such as policy acceptance and risk perception. To achieve this, pre- and post-workshop questionnaire surveys were issued to 47 participants to assess identify the factors expected to correlate with acceptance and risk perception. The results revealed significant differences in participants' interest, sense of involvement, knowledge, risk perception, and certain acceptance aspects before and after the workshops. Furthermore, significant correlations were found between acceptance, risk perception, interest, and trust. Notably, participants' interests and perceptions of their involvement were significantly correlated only after the workshops. Therefore, this study contributes to the literature by presenting a concrete yet nuanced case in environmental risk psychology, thus helping integrate studies on citizen participation with science and technology communication.

KEYWORDS

citizen participation, removed soil, risk perception, science and technology communication, acceptance

1 Introduction

Studies on risk perception have investigated various factors such as knowledge, trust, and public acceptance (cf. Flynn et al., 1992; Qi et al., 2020; Rowe et al., 2008; Sjöberg, 2008; Visschers and Siegrist, 2013). However, most of these studies are based on laboratory experiments or surveys that ask participants to respond to hypothetical scenarios, resulting in a diminished sense of participant involvement in real-world contexts. Only a few studies have focused on practical situations (Zoellner et al., 2008). By contrast, research on citizen participation in science and technology communication has examined the interactions between participants and experts in practical settings (Devine-Wright and Howes, 2010; Ohnuma et al., 2022; Pellizzone et al., 2015; Pellizzone et al., 2017; Rennie and Williams, 2002). However, substantial quantitative analyses of changes in risk perception and related factors remain scarce. This study seeks to bridge these topics by combining research on risk perception with science and technology communication. Specifically, we examine the factors already identified in risk perception studies within a practical setting. In other words, this study addresses the subject of citizen participation workshops in an actual setting—the case of the final disposal of removed soil outside Fukushima Prefecture as a concrete implementation of science and technology communication. It also explores the effect of participation in workshops and their design on psychological variables, including acceptance and trust, by analyzing changes in participants' opinions. Based on this analysis, implications for the unique aspects of the issue and its applicability to other issues are discussed.

2 Literature review

Studies on risk perception have explored the relationship between risk-management policies and various influencing factors. Risk perception, trust, policy acceptance, and other elements are intricately interconnected, making it crucial to understand these factors when addressing contemporary issues (Siegrist, 2000). Previous study findings have been useful in identifying the factors that shape public opinions on policies, such as site selection for the geological disposal of high-level radioactive waste (Slovic et al., 2000; Tanaka, 2004). These key factors can be summarized as follows.

The first factor is risk perception, which is closely linked to public acceptance. For instance, if a policy is perceived as risky, it is often deemed unacceptable (Flynn et al., 1992; Siegrist, 2000). Trust is another critical factor, often studied in relation to both risk perception and public acceptance (Kim et al., 2014; Shirai et al., 2023; Sjöberg, 2004). Trust influences the acceptance of policies and associated factors (Earle et al., 2007; Siegrist et al., 2003). Moreover, Flynn et al. (1992), Siegrist (2000), and Earle and Cvetkovich (1995) demonstrated that trust affects acceptance through its impact on risk perception. In summary, previous research indicated that trust and risk perception are both linked to the acceptance of risk-related policies (Shirai et al., 2023; Yokoyama et al., 2021). Additionally, trust in information sources shapes risk perception, highlighting the importance of those delivering the information (McComas and Trumbo, 2001; Trumbo and McComas, 2003).

Knowledge of this issue is also relevant to risk perception and trust. The literature on risk perception suggests that individuals with greater knowledge tend to have lower risk perceptions (Sjöberg and Drottz-Sjöberg, 1991). Additionally, those with more knowledge are more likely to accept risky technologies (Kim et al., 2014). However, Coussi and Siegrist (2011) found that people with greater knowledge may have higher risk perceptions. Therefore, the relationship between knowledge and risk perception appears inconsistent in previous studies. Moreover, Siegrist and Cvetkovich (2000) noted that the correlation between knowledge and risk perception varies by topic. In other words, the relationship is not straightforward; rather, it depends on the background and characteristics of the issue in question.

Interest in the issue and the perception of involvement are indispensable when considering the acceptance of a risk management policy. Before discussing these factors, it is important to distinguish between the acceptance of a general policy and its implementation in nearby residential areas, which is sometimes referred to as "Not In My Back Yard" (NIMBY: Burningham et al., 2006). This distinction significantly affects public attitudes (Yokoyama et al., 2023). Even if individuals generally agree with a policy, they may oppose its implementation in their local area, particularly when it involves risk-related facilities. In such a situation, place attachment is relevant to acceptance, as it is a matter of place-related process, involving emotions and community ties (Devine-Wright, 2009). In this study, we focus on the issue of the removed soil outside Fukushima Prefecture. An opinion poll indicated that opposition in nearby residential areas was double that on the general policy (Ministry of the Environment, 2023b). Interest in the issue and the sense of involvement are likely relevant, although the reasons for opposition may differ.

3 Case overview

The issue of removed soil is the focus of the citizen participation workshops discussed in this study.

The accident at the Fukushima Daiichi Nuclear Power Station occurred in March 2011, releasing radioactive material into the environment. As a response, the government conducted decontamination across approximately 15,600 ha in Fukushima Prefecture (Ministry of the Environment, 2020). The removed soil is currently stored at an interim storage facility located in Okuma and Futaba Towns in Fukushima Prefecture, covering an area of approximately 1,600 ha (Ministry of the Environment, 2019). These areas were once residential villages, encompassing rice fields, schools, shrines, and cemeteries. Some residents still hope to return to their hometowns even today. As a result, the interim storage facility was constructed under the condition that the final disposal of the removed soil outside Fukushima Prefecture would occur by 2045, as required by law (Ministry of the Environment, 2021).

The total amount of removed soil is estimated to be approximately 22 million m^3, making it impractical to dispose of all of it. Therefore, the government plans to use soil with relatively low radiation levels, less than 8,000 Bq/kg, as recycled material for public works, such as embankments, road foundations, green spaces, and farmland (Ministry of the Environment, 2016; Ministry of the

Environment, 2019). A standard of 8,000 Bq/kg was established to ensure that the annual additional exposure dose to workers handling the recycled soil does not exceed the international limit of 1 mSv (ICRP, 2007; Ministry of the Environment, 2019). It is estimated that approximately 80% of the removed soil contains cesium radioactivity below 8,000 Bq/kg (Ministry of the Environment, 2021). Demonstration tests on the recycling of the removed soil were conducted in Iitate and Minamisoma, Fukushima Prefecture, with no observed changes in radiation levels in either case. Furthermore, for agricultural land in Iitate, the concentration of radioactive cesium in crops was two orders of magnitude lower than the standard limits for radioactive substances (Baba, 2022; Hasegawa, 2021; Ministry of the Environment, 2023a). Nevertheless, the specific locations for recycling the removed soil and its final disposal, as well as the process for selecting these sites, are still to be finalized.

In principle, the final disposal and recycling of the removed soil can take place anywhere in Japan. As a result, anyone living in Japan could potentially be affected. However, people outside Fukushima showed less interest in the removed soil compared to Fukushima residents. According to a survey, over 50% of the respondents within Fukushima Prefecture were aware of the legislation regarding the removed soil, while only around 25% of respondents outside Fukushima Prefecture had knowledge of it (Ministry of the Environment, 2023b).

Against this background, the government called for a national discourse on the final disposal of removed soil outside Fukushima (Ministry of the Environment, 2016). However, as it is unclear how to conduct such a nationwide public discourse, a social experiment on citizen participation is necessary. As a result, citizen participation workshops were held in September 2023 in Tokyo and Osaka. As concrete treatment measures and candidate sites for final disposal and recycling were yet to be proposed, these workshops were held in the early stages of the process.

The workshops were designed to meet the general requirements for science and technology communication, offering opportunities for interaction between the public and experts (Office of Science and Technology and the Wellcome Trust, 2001; Burns et al., 2003).

Citizens unfamiliar with the topic were recruited through a research company at each venue. Specifically, 23 individuals participated in Tokyo and 25 in Osaka, for a total of 48 participants (M = 48.73 years old, SD = 16.92). At each venue, participants were divided into four groups with approximately equal age and gender distributions. Each group consisted of six or seven individuals. The workshops were facilitated by a general facilitator who managed the program, four group facilitators, and four assistants. Additionally, an organizer provided an overall explanation, and three experts (government officials, lawyers, and geological specialists) attended to share information.

The first half of the workshop followed a science and technology communication format, where participants were provided with information presented by experts, including basic knowledge, the history of decontamination efforts, and the current state of interim storage. Science and technology communication aims to deepen participants' understanding of an issue by providing knowledge and information, thereby generating new insights. To achieve this, moderate and unbiased information should be transparently shared from various perspectives. For this reason, participants received information from multiple viewpoints, including those critical of the final disposal process. First, a comprehensive overview was presented, followed by explanations from a government official, a lawyer critical of the final disposal, and a geological expert. In a subsequent question-and-answer session, participants posed questions, which the experts addressed.

The participants then conducted a preliminary evaluation of the removed soil. They recorded their thoughts and reasons on a sheet of paper and presented them to the group.

In the latter half of the workshop, the participants discussed the issue within their groups. All participants were asked to express their opinions. Before doing so, they wrote down positive, negative, and uncertain points regarding the agenda on sticky notes and presented them.

Subsequently, the group facilitators organized the opinion sharing and discussions within their groups and shared them with the other groups. Participants then shared their impressions and questions about the content. Finally, they were asked to evaluate the removed soil issue in the same way as during the preliminary evaluation, but present their opinions to the entire venue this time.

As the purpose of this study was to examine the changes in participants' perceptions of the removed soil and their interest in the issue, integrating studies on risk perception with those on science and technology communication would be beneficial. We selected knowledge, interest in the issue, sense of involvement, risk perception, trust, and acceptance as the psychological variables of focus.

Knowledge about the removed soil was expected to increase through participation in the workshop, aligning with the primary aim of science and technology communication. Participants may also develop a greater interest in the issue and a stronger sense of involvement, as they had the opportunity to express their opinions and increase their commitment to the issue.

Changes in risk perception, particularly regarding final disposal and recycling, were explored in the workshops. However, contradictory hypotheses suggest that risk perception may either increase or decrease. This study seeks to determine the pattern observed.

Additionally, trust in the government and experts is expected to increase. Participants received information from experts and engaged with one another by asking questions during the workshops. In science and technology communication, it is important to deepen mutual understanding through interactions between experts and the public. Therefore, participants are likely to increase their trust in both the government and experts involved.

Finally, we do not propose a hypothesis for changes in the acceptance of the removed soil policy because it is difficult to predict. Acceptance may remain unchanged since the workshops were not designed to persuade participants to accept the policy, and both positive and negative opinions were discussed. However, acceptance may increase if risk perception and trust shift as a result of the workshops, as these factors are often associated with acceptance. Therefore, it is worth considering.

Furthermore, acceptance differs depending on the policy, whether it refers to recycling or final disposal. If participants understood the knowledge presented during the workshops, they would recognize the difference between recycling soil with relatively

low radiation levels and the final disposal of landfill soil with higher radiation levels. For this reason, there may be differences in risk perceptions and opinions, leading to decisions to accept recycling but reject final disposal. Therefore, the acceptance of recycling and final disposal policies are measured separately, as are their risk perceptions. Additionally, this study distinguishes between the acceptance of general policy and its implementation in nearby residential areas. Even if recycling or final disposal policies are generally accepted, their implementation in residential areas may not be acceptable.

This study also examines the relationships between variables and how changes in these correlational patterns occurred. Knowledge is correlated with risk perception (Coussi and Siegrist, 2011; Siegrist and Cvetkovich, 2000), which is in turn related to acceptance (Flynn et al., 1992). Moreover, trust in authority and experts is also linked to acceptance (Flynn et al., 1992).

We analyze whether interest in, and sense of the involved party correlates with acceptance. However, it is difficult to predict whether increasing interest and the sense of involvement will lead to increased or decreased acceptance. On the one hand, as participants gain a deeper understanding of the removed soil issue, they may find it more acceptable, realizing that it affects areas beyond Fukushima. On the other hand, if they perceive the issue as more immediate and realistic, their acceptance might decrease, potentially increasing aversion.

In summary, this study investigates whether participating in the workshops altered the psychological variables related to the removed soil and explored changes in the correlational patterns between these variables.

4 Methods

An online questionnaire survey was conducted before and after the workshops in September 2023. The respondents were workshop participants from Tokyo and Osaka, Japan. We obtained 47 responses from 48 participants (23 from Tokyo and 25 from Osaka; 23 men and 25 women), as one female participant from the Tokyo workshop did not respond to the post-questionnaire. The sample size was determined based on the design limitations of the workshops, not on power analysis. The average age of participants was 48.73 years (SD = 16.92). This study was approved by the research ethics committee of the authors' institution (receipt number R04-05).

In the pre-questionnaire, participants provided demographic details, such as gender and age. They were then asked to read a short three-page explanation of the removed soil (Supplementary Appendix SA). After reading each page, participants completed a two-choice validity check to ensure they understood the information correctly. They could proceed to the next section only if all questions were answered correctly. If the participants answered incorrectly, the explanation was presented again. Participants were unable to respond to the validity checks until 15 s after the page was displayed. After reading all information, they answered the questions listed below it.

Participants were asked about their interest, sense of involvement, knowledge of the removed soil, risk perception regarding final disposal and recycling, trust in the government and experts, and acceptance of the removed soil. Regarding acceptance, participants were asked whether they generally accepted the final disposal and recycling of the removed soil and whether they accepted it in their residential area. The specific questions are listed in Supplementary Appendix SB.

Responses were recorded on a scale of 1–5 (1 = agree, 5 = disagree), except for the questions on interest and knowledge. Interest was rated from 1 (interested) to 4 (not interested), while knowledge was assessed based on the number of correct answers to five questions. For analysis, all items were reverse-scored, so a higher score indicated a more positive response.

The post-questionnaire was identical to the pre-questionnaire, except that the information on the removed soil was omitted. Each participant was assigned an ID number, enabling matching of pre- and post-questionnaire responses without revealing personal information.

All analyses were conducted using R version 4.1.3.

5 Results

Table 1 provides the average and standard deviation for each question, and Table 2 the number of correct knowledge-related answers.

The internal consistencies of the items used to measure each variable were examined. The results confirmed that Cronbach's alpha for each variable was 0.80 or higher, both pre- and post-questionnaire. Therefore, all variables demonstrated adequate internal consistency, and the average of each variable was used as the score in the subsequent analysis. Table 3 provides the descriptive statistics for each variable.

First, paired t-tests were performed for each variable to examine the effects of workshop participation on each variable (Table 3).

The results showed that interest and the sense of involvement were significantly higher in the post-questionnaire than in the pre-questionnaire. After the workshop, participants became more interested and felt a stronger sense of involvement regarding the removed soil issue.

Moreover, the knowledge of soil removal in the post-questionnaire was significantly higher than in the pre-questionnaire. While risk perception related to recycling was significantly higher in the post-questionnaire, there was no significant change in risk perception regarding final disposal. Additionally, respondents' trust in government officials and experts did not significantly differ between the pre- and post-workshop surveys. Therefore, workshop participation increased participants' knowledge and lowered their risk perception related to recycling, but it did not alter their risk perception regarding final disposal or their trust in officials and experts.

A significant difference in the acceptance of the removed soil was found only in the acceptance of recycling in residential areas. No significant differences were observed in the general acceptance of final disposal, recycling, or the acceptance of final disposal in residential areas. Therefore, participants became more accepting of recycling in their residential areas after the workshops, while their acceptance of other aspects did not change.

Correlation analysis was conducted to examine the relationships between variables (Table 4). The results revealed significant negative relationships between the four types of acceptance (recycling and

TABLE 1 Summary statistics by item.

Interest	Before	After
(pre-questionnaire) Before answering this question, how interested are you in the issue of soil removal?	2.02 (0.76)	3.49 (0.66)
(post-questionnaire) How interested are you in the issue of soil removal?		
Sense of the involved party		
(1) Do you feel that the issue of soil removal concerns you?	3.62 (1.11)	3.92 (1.06)
(2) Do you feel involved in soil removal?	3.19 (1.06)	3.81 (1.10)
Risk perception regarding the recycling		
(1) Recycling the removed soil is frustrating	2.96 (1.04)	2.51 (1.12)
(2) Recycling removed soil can cause life-threatening damage	2.26 (0.94)	2.06 (0.92)
(3) Recycling the removed soil can cause many victims at once	2.13 (0.92)	1.83 (0.84)
(4) Damage may occur due to the recycling of the removed soil	3.04 (1.08)	2.75 (1.09)
(5) It is possible that radioactive materials leak during recycling the removed soil	2.98 (1.05)	2.72 (1.14)
Risk perception regarding the final disposal		
(1) The final disposal of the removed soil is frustrating	2.92 (0.97)	2.75 (1.22)
(2) The final disposal of the removed soil can cause life-threatening damage	2.47 (0.97)	2.19 (0.99)
(3) The final disposal of the removed soil may cause many victims	2.26 (0.90)	1.94 (0.87)
(4) Damage may occur due to the final disposal of the removed soil	2.94 (1.05)	2.75 (1.17)
(5) Radioactive materials may leak during the final disposal of the removed soil	2.89 (1.05)	2.77 (1.15)
Trust		
(1) Government can make appropriate decisions	3.32 (1.04)	3.11 (1.24)
(2) The government should make decisions considering the public	3.13 (1.19)	3.28 (1.26)
(3) Government can be trusted	2.70 (1.20)	2.87 (1.15)
(4) Researchers and engineers involved in the treatment of removed soils can make appropriate decisions	3.96 (0.91)	3.85 (0.88)
(5) Researchers and engineers involved in the treatment of removed soils should make public decisions	3.70 (0.98)	3.87 (0.92)
(6) The researchers and engineers involved in the treatment of the removed soil can be trusted	3.83 (0.84)	3.89 (0.96)
Acceptance of removed soil		
(1) The recycling policy is accepted	3.64 (1.05)	3.77 (1.00)
(2) The final disposal policy outside Fukushima Prefecture is accepted	3.26 (1.03)	3.11 (1.07)
(3) If it was decided to recycle in the area where I live, I would be able to accept it	2.87 (1.28)	3.23 (1.09)
(4) The final disposal of removed soil in the area where I lived would be acceptable	2.87 (1.28)	2.89 (1.22)

Note: Values within parentheses are standard deviations. Responses were recorded on a scale of 1–5 (1 = agree, 5 = disagree), except for questions on interest. Interest was recorded on a scale of 1–4 (1 = interested, 4 = not interested). All items were reverse-scored, so a higher score indicated a more positive response.

final disposal × general policy and residential area) and the two risk perceptions, both before and after the workshop. The only exception was that the general acceptance of final disposal was not significantly correlated with the two risk perceptions after the workshops. These findings suggest that participants with higher risk perceptions were less likely to accept the removed soil, both before and after the workshop.

Interest and all four types of acceptance were significantly negatively correlated before the workshops. By contrast, interest and the sense of involvement were significantly positively correlated only after the workshops. Risk perception was significantly negatively correlated with trust in the government and experts both before and after the workshops.

6 Discussion

6.1 Interpretation of the results and future research directions

The results showed that participants' interest and sense of involvement in the issue increased after the workshop. This

TABLE 2 Number of people who answered correctly the questions about the removed soil.

	Before	After
(1) The effects of radiation can be prevented by covering the building with soil	36 (76.6%)	41 (87.2%)
(2) Because radioactive cesium is strongly adsorbed by soil, it has little impact on groundwater	13 (27.7%)	42 (89.4%)
(3) Exposure to radioactive materials on the ground surface is called internal exposure	18 (38.3%)	33 (70.2%)
(4) Evacuation orders are still issued for the entire areas of Okuma and Futaba, where interim storage facilities are located, and no single resident can return home	26 (55.3%)	34 (72.3%)
(5) The final disposal of the removed soil outside Fukushima Prefecture was decided by the cabinet	17 (36.2%)	30 (63.8%)

Note: Knowledge of the removed soil was assessed by the number of correct answers to five questions. Participants responded to the questions by selecting "true," "false," or "I do not know." the correct answers to the first, second, and fifth questions are correct answers to five questions. Participants responded to the questions. The numbers in brackets indicate the percentage of people who answered correctly.

TABLE 3 Summary statistics and t-test results.

	Before	After	*t*	*p*	
Interest	2.02 (0.77)	3.49 (0.66)	−10.83	<0.001	**
Sense of the involved party	3.40 (1.03)	3.86 (1.05)	−3.41	0.001	**
Knowledge	2.34 (1.42)	3.83 (1.27)	−6.73	<0.001	**
Risk perception regarding recycling	2.67 (0.82)	2.37 (0.86)	2.76	0.008	**
Risk perception regarding final disposal	2.69 (0.85)	2.48 (0.88)	1.85	0.071	
Trust in government	3.05 (1.01)	3.09 (1.09)	−0.26	0.799	
Trust in experts	3.83 (0.85)	3.87 (0.81)	−0.39	0.697	
General acceptance of recycling	3.64 (1.05)	3.77 (1.00)	−0.80	0.429	
General acceptance of final disporsal	3.26 (1.03)	3.11 (1.07)	0.91	0.368	
Acceptance of recycling in their residential area	2.87 (1.28)	3.23 (1.09)	−2.46	0.018	*
Acceptance of final disposal in their residential area	2.87 (1.28)	2.89 (1.22)	−0.15	0.878	

Note: Values within parentheses are standard deviations. **p < .01, *p < .05.

suggests that participating in the workshops gave participants an opportunity to better understand the removed soil issue. Additionally, participants gained knowledge and reduced their risk perception of recycling. This indicates that many of them understood correctly the information provided during the workshops and grasped the safety measures for recycling. These findings demonstrate that the workshops achieved the goal of engaging participants' interest, sense of involvement, and knowledge through dialogue.

Trust in the government and experts responsible for the removed soil did not change significantly. One possible explanation is that while participants positively evaluated the individual government officials and experts who participated in the workshops, they did not generalize this evaluation to the entire government or all experts. Alternatively, participants' political views might have influenced trust. Trust in government, policies, and science varies depending on political views (Gauchat, 2012; Rudolph, 2009), and this may have been the case in these workshops. Future research should consider participants' political views. However, studies targeting Japanese demonstrated that the differences between conservatives and liberals are unclear, unlike for Westerners (Aoyama, 2019; Murayama and Miura, 2019).

However, the correlation between acceptance and trust in the government shifted after the workshops. Considering these findings, although the workshops did not increase participants' overall trust in the government and experts, they may have influenced participants' subsequent perceptions of trust and acceptance. Furthermore, trust in the government and experts was significantly correlated with risk perception, suggesting that participants with lower trust levels tended to have higher risk perceptions. Trust may affect acceptance by mediating risk perceptions (Flynn et al., 1992; Siegrist, 2000). However, the results of this study alone cannot establish a causal relationship or mediation effect among these variables.

Additionally, participants became more positive only about the acceptance of recycling in their residential areas. There are three possible explanations for these differences.

First, participants may have become more positive about the acceptance of recycling in nearby residential areas due to a decrease in their risk perceptions. In fact, participants' risk perception of recycling decreased, and this was negatively correlated with acceptance. It is possible that acceptance increases as risk perception decreases (Flynn et al., 1992; Siegrist, 2000). By contrast, the acceptance of final disposal may not have changed

TABLE 4 Correlation of variables before and after the workshops.

	1		2		3		4		5		6		7		8		9		10		11	
1. Interest			0.542	**	0.102		−0.172		−0.116		0.327	*	0.243		0.211		−0.014		0.070		0.012	
2. Sense of the involved party	0.017				−0.100		−0.056		−0.076		0.175		0.072		0.020		0.091		0.133		0.056	
3. Knowledge	−0.147		0.045				−0.259		−0.333	*	0.094		0.364	*	0.512	**	0.078		0.233		0.086	
4. Risk perception regarding final disposal	0.343	*	−0.188		−0.225				0.892	**	−0.323		−0.378	*	−0.578	**	−0.267		−0.599	**	−0.501	**
5. Risk perception regarding recycling	0.387	**	−0.121		−0.146		0.858	**			−0.260		−0.369	**	−0.610	**	−0.200		−0.536	**	−0.300	**
6. Trust in government	−0.086		0.023		−0.068		−0.295	*	−0.353	*			0.522	**	0.450	**	0.048		0.338	*	0.346	*
7. Trust in experts	−0.151		0.110		0.007		−0.382	**	−0.369	**	0.459	**			0.513	**	0.183		0.190		0.169	
8. General acceptance of recycling	−0.476	**	−0.013		0.288	*	−0.539	**	−0.653	**	0.290	*	0.206				0.328	*	0.549	**	0.387	**
9. General acceptance of final disporsal	−0.310	*	−0.028		0.236		−0.666	**	−0.570	**	0.182		0.250		0.708	**			0.446	**	0.526	**
10. Acceptance of recycling in their residential area	−0.330	*	−0.117		0.204		−0.675	**	−0.640	**	0.117		0.240		0.692	**	0.849	**			0.756	**
11. Acceptance of final disposal in their residential area	−0.308	*	0.065		0.240		−0.603	**	−0.516	**	0.072		0.173		0.612	**	0.701	**	0.867	**		

The left and downward side of the matrix presents the correlation coefficients of before workshops, and the right and upper side present those of after the workshops. **p < .01, *p < .05.

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because its risk perception did not change. However, this explanation does not account for why only the acceptance of recycling in residential areas increased, while the acceptance of the overall recycling policy remained unchanged. If risk perception is closely linked to acceptance, acceptance should increase regardless of where the recycling takes place.

Second, while the participants became more positive about recycling through the workshops, their general acceptance did not change because they were unable to judge others' thoughts. However, this study did not measure participants' speculations about others' thoughts about the removed soil and cannot determine the validity of this possibility. Further investigations should be conducted on this topic.

Third, participants may have increased their acceptance of recycling in their residential areas due to their heightened interest and sense of involvement in the issue. While a negative correlation between interest and acceptance of recycling in residential areas was observed before the workshops, this correlation was no longer significant after the workshops. These findings suggest that the participants who were initially negative about the acceptance of final disposal and recycling were still interested in the issue before the workshops, but this trend subsequently disappeared. However, this interpretation has a limitation, as the correlation between the sense of involvement and acceptance was not significant. More data are needed to further explore the relationships between variables, but the fact that the degree of acceptance and the associated factors vary between recycling and final disposal raises questions about the results of previous studies on risk perception, trust, and acceptance.

6.2 Limitations

This study has several limitations. First, examining the relationships between variables was challenging due to the small number of workshop participants. The small sample size also limited our ability to conduct causal and mediation analyses of how trust and risk perception influence acceptance.

Second, although participants were recruited to represent the population by gender and age, the sample was skewed toward residents from the Tokyo and Osaka metropolitan areas. Different reactions were expected between residents of large cities and those from the depopulated areas, particularly among Fukushima residents. However, this assumption was not tested in this study. To examine regional differences, future research should conduct workshops across multiple regions.

Moreover, this study could not determine whether the changes in variables before and after the workshops were directly caused by participation, as there was no control group to measure the attitudes of non-participants. Future studies should use an experimental design that includes control conditions to address this limitation.

This study analyzed data from a questionnaire survey; however, participants' comments during the workshops were not analyzed. For instance, while the results indicated an increase in the acceptance of recycling in residential areas, it remains unclear what reasons contributed to this attitude based solely on the questionnaire responses. Future research should analyze the data alongside participants' comments.

Additionally, whether the changes in participants' opinions were sustained over time should be examined. If participants revert to their pre-workshop views shortly afterward, the significance of the workshop is diminished. Conversely, if participants retain the knowledge provided during the workshops over time, the workshop's impact is meaningful for science and technology communication. Future studies should include follow-up surveys to assess this issue.

6.3 Conclusion

This study analyzed the case of workshops on the issue of removed soil in Fukushima. Opinion changes were examined before and after the workshops, focusing on risk perceptions and their associated factors. The results indicated that workshop participants did not increase their trust in the government and experts, but did increase their knowledge and interest. Some positive changes in acceptance and risk perception were also found, while other factors showed no changes. Notably, no negative changes occurred despite participants being provided with unbiased information and discussing both positive and negative points.

This study makes a valuable contribution to the upcoming national discourse on the removed soil issue, which is essential for the long-term revitalization of Fukushima, by examining changes in participants' opinions. This experience could also help bridge the gap between the studies on environmental risk psychology and science and technology communication.

Science and technology communication is indispensable for the nationwide public discourse on the removed soil issue caused by the Fukushima Daiichi Nuclear Power Station accident. The opportunity for such communication does not merely consist of imparting correct knowledge. The public discourse is for neither putting policymakers in a favorable light nor for opposition. Instead, the public is expected to deliberate on both the positive and negative sides. Therefore, such science and technology communication should be evaluated regarding its effects on participants. Identifying the changes in participants' perceptions, such as risk perception, trust, and acceptance, is essential in examining the potential and implications of the discourse. Combining the practice of science and technology communication with the findings of risk perception studies will help expand the scope of environmental psychology research.

Data availability statement

The original contributions presented in the study are included in the article/Supplementary Material, further inquiries can be directed to the corresponding author.

Ethics statement

The studies involving humans were approved by the research ethics committee of Hokkaido University. The studies were conducted in accordance with the local legislation and

institutional requirements. The approval number is R4-05. The participants provided their written informed consent to participate in this study.

Author contributions

YkS: Data curation, Formal Analysis, Investigation, Methodology, Writing–original draft, Writing–review and editing. QC: Investigation, Methodology, Writing–review and editing. YmS: Investigation, Methodology, Writing–review and editing. MiT: Investigation, Methodology, Writing–review and editing. HU: Investigation, Writing–review and editing. NK: Data curation, Investigation, Writing–review and editing. MaT: Investigation, Writing–review and editing. TY: Funding acquisition, Project administration, Supervision, Writing–review and editing. SO: Funding acquisition, Investigation, Methodology, Project administration, Supervision, Writing–review and editing.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Generative AI statement

The author(s) declare that no Generative AI was used in the creation of this manuscript.

Publisher's note

Supplementary material

The Supplementary Material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/fenvs.2025.1507210/full#supplementary-material

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