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ORIGINAL ARTICLE

A place-based risk appraisal model for exploring residents' attitudes toward nature-based solutions to flood risks

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Abstract
Nature-based solutions (NBS) have gained popularity as a sustainable and effective way of dealing with increasing flood risks. One of the key factors that often hinders the successful implementation of NBS is residents' opposition to their implementation. In this study, we argue that the place where a hazard exists should be considered a critical contextual factor alongside flood risk appraisals and perceptions of NBS themselves. We have developed a theoretical framework—the "Place-based Risk Appraisal Model (PRAM)"—that draws on constructs inspired by theories of place and risk perception. A citizen survey ($n = 304$) was conducted in five municipalities in Saxony-Anhalt, Germany, where dike relocation and floodplain restoration projects have been conducted along the Elbe River. Structural equation modeling was adopted to test the PRAM. Attitudes toward the projects were assessed in terms of "perceived risk-reduction effectiveness" and "supportive attitude." With regard to risk-related constructs, well-communicated information and perceived co-benefits were consistently positive factors for both perceived risk-reduction effectiveness and supportive attitude. Trust in local flood risk management was a positive and threat appraisal a negative predictor of perceived risk-reduction effectiveness affecting "supportive attitude" only through "perceived risk-reduction effectiveness." Regarding place attachment constructs, place identity was a negative predictor of a supportive attitude. The study emphasizes that risk appraisal, pluralities of place contexts to each individual, and their relations are key for determining attitudes toward NBS. Understanding these influencing factors and their interrelationships enables us to provide theory- and evidence-based recommendations for the effective realization of NBS.

KEYWORDS
dike relocation, flood risk management, place attachment, risk perception, structural equation modeling

1 | INTRODUCTION

Recent evidence has revealed a rise in the frequency and intensity of flood risks globally (Alfieri, Feyen, Dottori, & Bianchi, 2015; Hirabayashi et al., 2013; Winsemius et al., 2016). Flooding has injured nearly 1.6 billion people globally in the previous two decades (2000–2019), accounting for 41% of all disaster types (CRED & UNDRR, 2020). In July 2021, More than 150 people lost their lives as a result of the severe floods in Western Germany. Although flood defense is still dominant as a technical or structural approach to prevent losses, an integrative perspective in flood risk management (FRM) that considers both natural and human systems has recently appeared on the scene (Bubeck et al., 2017). This perspective constitutes a response to the international call for nature-based solutions (NBS) as sustainable, future-proof means to manage flood risks (Browder, Ozment, Rehberger Bescos, Gartner, & Lange, 2019; European Commission, 2015; IUCN, 2016). While the goals of NBS span a wide range of societal concerns, this study focuses on NBS aimed at reducing flood risks. The salient characteristic of NBS as a means to manage flood risk is that they preserve the ecosystem's multi-functionality and contribute to nature conservation while also having the potential to reduce flood risks effectively (Kabisch et al., 2016; Pauleit, Zölch, Hansen, Randrup, & van den Bosch, 2017). The effectiveness of reducing flood risks of NBS was shown in a number of studies (e.g., S. C. Ferreira, Mourato, et al., 2020; Vermaat et al., 2016; Vojinovic et al., 2021). Kousky and Walls (2014) estimated the benefits and costs of levee setbacks in the Middle Mississippi River and concluded that setbacks would decrease expected annual damages by 55% in urban areas. In this regard, a shift in the way rivers themselves are framed goes hand in hand with the focus on NBS. In the past, rivers were regarded primarily as objects entailing hazards that needed to be better controlled by technical means such as flood defense systems. In the meantime, the meanings of rivers and floodplains have changed as they have come to also be considered an area in which diverse co-benefits (including ecological, aesthetic, and recreational benefits) can be achieved while simultaneously reducing the risk of flooding (Albert et al., 2021). As a result, the renaturalization of rivers and floodplains has come much more to the fore in a new FRM paradigm.

Along with this shift, greater emphasis has been placed on local participation in FRM. As in other European countries, a change from flood defense strategies to broader-based flood risk management has occurred in Germany since the European Floods Directive (2007/60/EC) came into force. The European Floods Directive thus became a basis for including participatory planning practices, regardless of European Union member states' differing adopting strategies (Newig, Challies, Jager, & Kochskämper, 2014). Debates about public participation in FRM tend to focus mainly on the need (or otherwise) for more intense, broader, and earlier participation in various controversies seeking distributive justice and procedural equity. At the same time, public participation per se, or whether it really promptly copes with the facing challenges in flood risk plans, has also been questioned in the narratives constructed, particularly after the severe flood events of 2013 in Germany (Otto, Hornberg, & Thieken, 2018). Kuhlicke, Callsen, and Begg (2016), among others, has documented the narratives that have arisen around highly politicized public participation in flood risk management in Germany. Similarly, others report that in some projects involving NBS, conflicts of interest and disagreements have frequently caused bottlenecks in project implementation (Bark, Martin-Ortega, & Waylen, 2021; V. Ferreira, Barreira, et al., 2020; Puskás, Abunnasr, & Naalbandian, 2021). Therefore, undertaking the public participation process in consideration of diverse public perspectives, which may trigger conflicts, should be taken into account in order to successfully implement NBS (Wamsler et al., 2020).

The reasons behind such conflicts and resistance include (but are not limited to) underestimating the potential of NBS (Gray, O'Neill, & Qiu, 2017) coupled with uncertainty around their effectiveness (Thorne, Lawson, Ozawa, Hamlin, & Smith, 2018; Wolf, Pham, Matthews, & Bubeck, 2021). An underlying explanation has been identified as a lack of long-term data to convince stakeholders, and unpredictability in nature as a baseline that interacts with physical, ecological, and socioeconomic aspects (Han & Kuhlicke, 2019). Furthermore, disputes over land acquisition from private landowners for the implementation of NBS projects can be a source of contention (Van Straalen, Hartmann, & Sheehan, 2018). For example, when a project requires a change in land use and, particularly, when stakeholder interests are involved, citizens' participation in decision-making may prevent conflicts (Begg, Callsen, Kuhlicke, & Kelman, 2018; Wamsler et al., 2020). How individual attitudes toward NBS projects are constructed and which factors affect public perceptions are, therefore, key issues in achieving successful outcomes.

So far, a small number of review articles have explored the factors shaping public perceptions and attitudes toward projects involving NBS (Anderson & Renaud, 2021; Garcia, Benages-Albert, Buchecker, & Vall-Casas, 2020; Han & Kuhlicke, 2019; Mallette, Smith, Elrick-Barr, Blythe, & Plummer, 2021; Venkataramanan et al., 2020). In their review of 102 articles, for example, Han and Kuhlicke (2019) identified six topics as being the most influential factors shaping attitudes toward NBS for flood risks, including, among others, the perceived co-benefits and risk reduction efficacy of NBS.

By way of summary, the current literature indicates that several factors are essential in shaping individuals' attitudes toward projects involving NBS.

First, risk perceptions were identified as a critical factor affecting people's attitudes toward NBS. The major underlying reason is that local people often perceive natural flood risk management measures as less effective than structural measures (e.g., Chou, 2012; Chou, 2013; Martinez-Juarez, Chiabai, Suarez, & Quiroga, 2019). Some studies pointed out that the immediate physical presence of structural measures gives the people affected a stronger sense of safety (Gray et al., 2017; Martinez-Juarez et al., 2019) and can be perceived as an expression of the (local) government's commitment to guarantee that safety (Ardaya, Evers, & Ribbe, 2017). Other studies have shown that policymakers as well as practitioners also tend to underestimate the efficacy of NBS. For example, policymakers and practitioners have more reliance on technical measures than nature-based solutions compared to the people in academia from their interviews (Han & Kuhlicke, 2021; Wolf et al., 2021). In cases where flood risks were considered to be high or where a locality has experienced severe flooding in the past, technical measures were preferred by the policymakers (Brillinger, Dehnhardt, Schwarze, & Albert, 2020). Furthermore, the reintroduction of natural elements might sometimes be interpreted as rather a trigger for increased flood risk (Gapinski, Hermes, & von Haaren, 2021).

Second, heterogeneous preferences and concerns of stakeholders need to be considered prior to project design and implementation. It is important to ensure greater effectiveness and less resistance during implementation (Alves, Gersonius, Kapelan, Vojinovic, & Sanchez, 2019). People's perceptions of the co-benefits of NBS, including the provision of ecosystem services, vary (Cinderby & Bagwell, 2018; Giordano, Pluchinotta, Pagano, Scrieciu, & Nanu, 2020; Hagedoorn et al., 2021; Spahr, Smith, McCray, & Hogue, 2021). How people perceive these co-benefits depends also on whether they consider themselves as beneficiaries (Jacobs et al., 2016; Sanon, Hein, Douven, & Winkler, 2012; Small, Munday, & Durance, 2017). Sometimes co-benefits of NBS are offset by uncertainty or negative externalities from NBS. When perceived risks and negative externalities are greater than the perceived present value of NBS, the project may generate conflicts (Howe, Suich, Vira, & Mace, 2014; Jacobs et al., 2016; Small et al., 2017). For example, when stakeholders place a high value on agricultural productivity, there is a greater likelihood of conflict over retention and wetland restorations between different stakeholder groups, which may result in lost farm income (Collentine & Futter, 2018; Giordano et al., 2020).

Third, place attachment is key to understanding people's attitudes toward measures aimed at reducing local flood risks. An increase in extreme weather events and subsequent significant environmental impacts cause changes in where people live. The changes involve not only climatic ones but also human modifications to the place for risk reduction (Devine-Wright & Quinn, 2020). Such local dynamics along with the changes bring alterations in people's attitudes and perception, interwoven with emotional attachment to the place (Devine-Wright & Quinn, 2020).

One of the shortcomings of existing studies on public perceptions and attitudes toward NBS is that only a few empirical studies grounded in an explicit theoretical framework have been conducted so far (e.g., Heldt et al., 2016). Theory-driven research is essential, as it makes the research reproducible and generalizable, allowing researchers to build up a body of knowledge on a particular subject (Kuhlicke et al., 2020).

In light of these introductory comments, we present a case study on dike relocation and floodplain restoration in Saxony-Anhalt, Germany, which reflects a paradigm shift from structural flood defenses to NBS in flood risk management. Floodplain restoration on the River Elbe has been ongoing since the beginning of the 1990s. The German federal state of Saxony-Anhalt provided funding for Elbe floodplain restoration initiatives and performed a feasibility study on 32 dike relocation projects (Puhlmann & Jährling, 2003). The first pilot study in Rosslau Oberluch was completed by the year 2005. The subsequent large-scale natural floodplain project in Lödderitzer Forst was implemented in 2006, as part of a nature conservation project (Monstadt, 2008). Another project that opened the traditional dike (Vasenwall) and relocated the dike to the motorway was implemented near the town of Vockerode starting in 2010 and completed in 2018. These three projects from a total of 15 dike relocation projects carried out along the Elbe River are to protect and renaturalize the floodplain forests from the river Mulde to the mouth of the river Saale with diverse animal and plant species that are typically found in floodplains. It is expected that reconnecting former floodplains directly to parts of the river often affected by flooding will facilitate the enactment of floodplain dynamics, including habitat dynamics and other functions of floodplains such as retention, sedimentation, and hydrodynamics (Scholten et al., 2005).

To advance our understanding of the factors that drive stakeholders' attitudes toward NBS, this study analyzes how different kinds of risk appraisal and place-based factors influence people's attitudes toward NBS. We, therefore, propose a theoretical framework, referred to as a Place-based Risk Appraisal Model and described in greater detail in Section 2, which allows us to analyze how risk perception and place attachment affect people's attitudes toward dike relocation. Structural equation modeling (SEM) was utilized to test the hypotheses based on theoretical underpinnings (Fan et al., 2016).

This article continues in Section 2 with a review of relevant theories and suggests a theoretical framework that links risk and place-related attributes to attitudes toward NBS. Section 3 describes the data collection and methodology. The results are presented in Section 4, followed by a discussion in Section 5. Finally, Section 6 concludes with suggestions for future study.

2 | THEORETICAL FRAMEWORK

Based on the assumption that attitudes toward NBS are shaped not just by individual psychological processes (and thus individual risk appraisal) but also by the specific place where NBS are realized and implemented, we based our framework on both place-oriented theories and risk perception-related theories.

2.1 | Place attachment focusing on place identity and nature bonding

Place attachment entails an emotional bond between people and their environment (Low & Altman, 1992; Manzo, 2005). It is a powerful predictor of attitude toward place-related changes, while attitudes can be both positive and negative (Bonaiuto, Carrus, Martorella, & Bonnes, 2002; Devine-Wright, 2009). It can play a role as a motivation for long-term stewardship (Chapin & Knapp, 2015, p. 38) and action supporting conservation initiatives, or pro-environmental behaviors (Larson, Stedman, Cooper, & Decker, 2015; Marr & Howley, 2019). In addition, place attachment can work as a catalyst for residents to acknowledge changes to the place in question (Chapin, Mark, Mitchell, & Dickinson, 2012). In this sense, place attachment can be helpful in better understanding preferences for place-based changes by providing cues for patterned attitudes and behaviors (Stedman, 2016). Conversely, place attachment can also often be an obstacle to transformative change when stakeholders perceive the change as disruptive (Adger, Barnett, Brown, Marshall, & O'brien, 2013; Marshall, Park, Adger, Brown, & Howden, 2012; Marshall & Stokes, 2014).

Place attachment can be operationalized differently depending on the context. In a given context, it is operationalized using the place identity construct (White, Virden, & Van Riper, 2008). Place identity refers to the symbolic meanings people ascribe to a specific place (Kyle, Graefe, & Manning, 2005), and it has been found to correlate significantly positively with pro-environmental behavior (Scannell & Gifford, 2010a; Vaske & Kobrin, 2001) as well as place-protective action (Devine-Wright & Howes, 2010).

Another dimension of place attachment studies emphasizes the relevance of people's ties to the natural world, referred to as nature bonding. Nature bonding portrays people's interactions with the environment as vital to their sense of self (Clayton, 2003). Terms such as environmental identity, emotional affinity to nature, and closeness to nature have all been used to define nature bonding (Raymond, Brown, & Weber, 2010). Several studies have demonstrated that people who have high nature bonding believe more in the effectiveness of natural risk-reduction measures (D'Souza, Johnson, & Ives, 2021; de Groot, 2012; Ferreira et al., 2020).

We argue that using a place attachment theory is appropriate for understanding place-related contextual attributes in people's attitudes toward NBS, particularly if the implementation of NBS is associated with profound physical changes to a place. It is crucial, therefore, to understand how people perceive a place and the changes it is undergoing and to unravel how they assign value and/or meaning to this change. In light of this, this study focuses on the two key constructs in place attachment: place identity and nature bonding.

2.2 | Theories of risk appraisal

Studies on risk perception refer to people's subjective judgments about the probability and severity of hazards, including the process of gathering, selecting, and analyzing signals concerning the unpredictable consequences of events, activities, or technologies (Renn, 1995; Slovic, 2000, 2016; Wachinger, Renn, Begg, & Kuhlicke, 2013). Risk perception can vary between individuals based on the information they have obtained, different levels of uncertainty, and other contextual interests (Slovic, 2000). In order to analyze risk adaptive attitudes, two prominent frameworks have been used in previous research—Protection Motivation Theory (PMT) and Protective Action Decision Model (PADM).

PMT, which was initially developed to describe health-related behavior (Rogers, 1975, 1983), has become prominent in flood risk management studies (e.g., Bubeck, Botzen, Kreibich, & Aerts, 2013; Bubeck, Wouter Botzen, Laudan, Aerts, & Thieken, 2018; Grothmann & Reusswig, 2006; Terpstra & Lindell, 2013). PMT captures the individual decision-making process as a response to risk by focusing on threat and coping appraisals (Maddux & Rogers, 1983; Rogers, 1975, 1983). Threat appraisal can also be rephrased as risk perception, meaning a person's acknowledgment of risks, including perceived probability and perceived severity (Grothmann & Reusswig, 2006). Coping appraisal captures the evaluation of possible responses to avoid or avert the perceived risk.

Complementing PMT, the PADM explains human responses to environmental hazards using a multistage model that involves a pre-decisional, perception, and protective action decision-making process (Lindell & Perry, 1992, 2012; Terpstra & Lindell, 2013). An important attribute of the PADM is that it emphasizes the perceived attributes of hazard adjustment as being important for understanding the perceived attributes of the hazard itself. According to the pathbreaking work of Lindell and Perry (2012), hazard adjustment has usually been demonstrated as a form of individual adaptive behavior that focuses on the modification of human behavior, but it also includes long-term hazard adjustment that enables people to live in a place. In addition, the scope of response efficacy in the PADM is broader than that of PMT, including not only the efficacy of protecting people and property but also its utility for other purposes (Lindell & Perry, 2012).

Although the focus of this study is on public protection and not on individual adaptive behaviors, we argue that some of the constructs underlying both PMT and the PADM are highly relevant in understanding people's attitudes toward NBS. One reason for this is that people's attitudes toward NBS can be seen as a result of the multidimensional individual-societal decision process in assessing risks. Second, we argue that the individual adaptive behavior primarily captured in PMT and PADM can be also reflected in a person's attitude or behavior toward a long-term public adaptive measure. Therefore, theories explaining individual adaptive behavior toward risk are also related to our research.

2.3 | Operationalization and hypotheses

Attitudes are defined as dispositions toward a specific issue (Ajzen, 2005). So far, studies with a focus on NBS for flood risk reduction have dealt with attitudinal and behavioral acceptance (Anderson et al., 2021), perceived utility and co-benefits (Kim & Petrolia, 2013; Venkataramanan et al., 2020), as well as the effectiveness of the measures (Santoro et al., 2019).

In this study, we understand "supportive attitude" toward NBS as an overarching variable for the degree of acceptance of a project. In addition, the perceived risk-reduction effectiveness of NBS is considered in the attitude as key among the diverse benefits NBS can bring. Therefore, we measure attitudes as a result of (a) supportive attitude toward a specific project involving NBS and (b) the perceived risk-reduction effectiveness of such a project.

Six hypotheses were formulated, inspired by the place attachment and risk appraisal theories (PMT and PADM). These hypotheses are summarized in the proposed "Place-based Risk Appraisal Model" or "PRAM" (Figure 1) presented here. Within this framework, our study seeks to answer two core research questions.

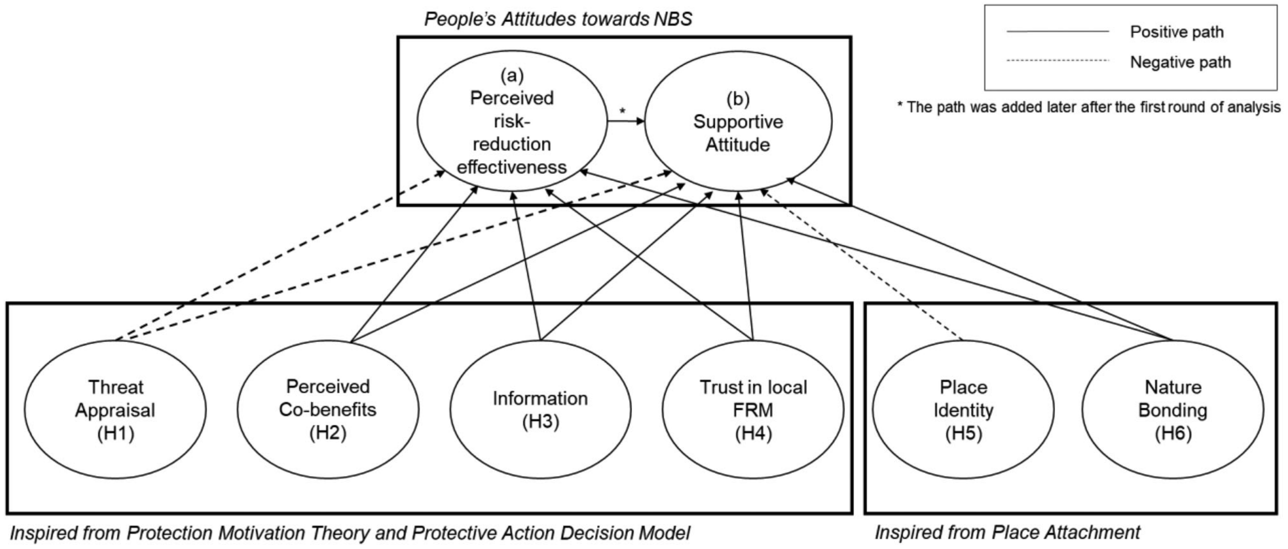

FIGURE 1 Hypotheses and constructs in the Place-based Risk Appraisal Model (PRAM) framework.

1. How do various risk appraisal factors influence individuals' attitudes (i.e., supportive attitude and perceived risk reduction effectiveness) toward NBS?
2. How do various place-based factors influence individuals' attitudes toward NBS?

First, risk perception is an essential determinant for decision-making relating to hazard adjustment (Lindell & Perry, 2012; Rogers, 1983). In previous empirical studies, a higher threat appraisal leads to a lower perceived risk reduction effectiveness of NBS and a preference for technical measures (e.g., Chou, 2013; Gray et al., 2017; Martinez-Juarez et al., 2019). Against this backdrop, we postulate the following hypothesis:

Hypothesis 1: Threat appraisal has a negative effect on the perceived risk-reduction effectiveness of (H1a) and a supportive attitude toward (H1b) NBS.

Second, when it comes to resource-related attributes, the perceived benefits of NBS for other purposes was previously assumed to be as influential in people's attitudes. Some empirical studies supported the idea of positive perceptions toward NBS when these demonstrate multiple benefits in addition to risk reduction (e.g., Kim & Petrolia, 2013; C. M. Raymond et al., 2017). These observations lead us to the following hypothesis:

Hypothesis 2: Perceived co-benefits have a positive effect on the perceived risk-reduction effectiveness of (H2a) and a supportive attitude toward (H2b) NBS.

Third, stakeholder perceptions include people's perceptions of the relevant authorities' expertise, trustworthiness, and responsibility to provide protection (Arlikatti, Lindell, & Prater, 2007; Siegrist & Gutscher, 2006). More specifically, the perceived trustworthiness of the information acquired from authorities and experts could significantly increase the effectiveness of risk communication (Slovic, 2000). Therefore, transparent and efficient communication of procedural information about a project is important in order to encourage a supportive attitude. Furthermore, the more information people receive, the more they may support and perceive the greater effectiveness of NBS. In this sense, positive attitudes toward NBS as a hazard adjustment measure can be motivated by effectively communicated information as well as by people's trust in local flood risk management. From this, we derive the following hypotheses:

Hypothesis 3: Well-communicated information on NBS has a positive effect on the perceived risk-reduction effectiveness of (H3a) and a supportive attitude toward (H3b) NBS.

Hypothesis 4: Trust in local FRM has a positive effect on the perceived risk-reduction effectiveness of (H4a) and a supportive attitude toward (H4b) NBS.

Fourth, we interpret the realization of a large-scale NBS as a disruptive change to a place, particularly if local residents have a strong place identity. Considering that we focus on large-scale NBS, we assume that there is a greater chance that people will perceive such transformative changes rather negatively (Adger et al., 2013; Marshall et al., 2012; Marshall & Stokes, 2014). On this basis, we propose the following hypothesis:

Hypothesis 5: Place identity does not affect the perceived risk-reduction effectiveness of NBS (H5a), but it does have a negative effect on a supportive attitude (H5b) toward them.

Finally, we focus on the relevance of stakeholders' ties to the natural world in the place attachment studies. Considering previous research on nature bonding which argues that it is linked with the perceived effectiveness of risk reduction of NBS (de Groot, 2012), we propose the following hypothesis:

Hypothesis 6: Nature bonding has a positive effect on the perceived risk-reduction effectiveness of (H6a) and a supportive attitude toward (H6b) NBS.

A summary of the above hypotheses is shown in Figure 1.

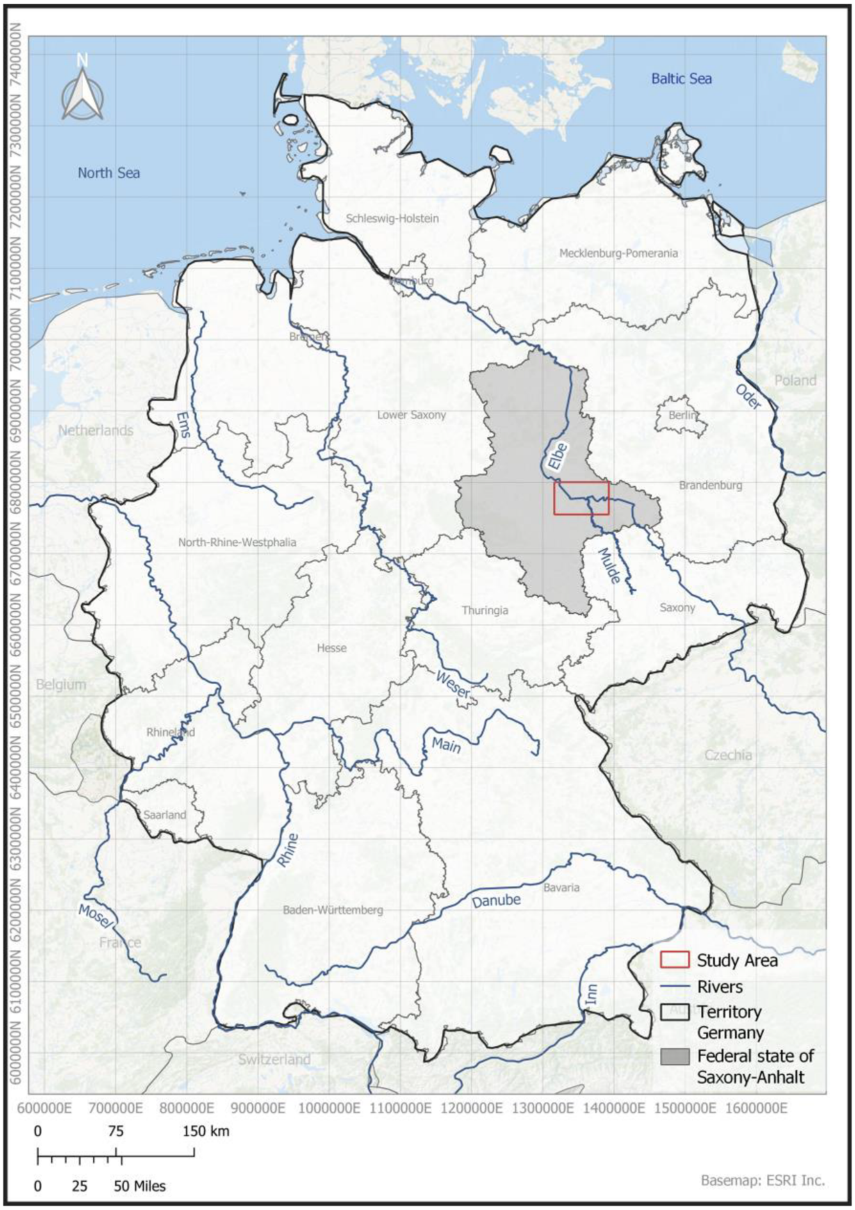

FIGURE 2 Study area and the federal state of Saxony-Anhalt in the map of Germany.

3 | METHODS

In the following subsections, we provide information on our case study areas, data collection, and analytical method. We also describe how we applied SEM to analyze the relationship between the constructs in the framework.

3.1 | Case study and data collection

This study uses the data collected in five towns, namely Lödderitz, Kühren, Aken, Rosslau, and Vockerode near Dessau-Rosslau in Saxony-Anhalt, where the dike relocation projects described in the introduction section were implemented (Figures 2 and 3). The towns were severely hit by the flood in Saxony in 2002 and 2013. The dike relocation was chosen to reduce flood risks after the disastrous events. The survey data were collected in July 2021. About three times as many flyers containing survey information as the planned distribution of the questionnaire were distributed in flood-prone areas in each town according to the 100- and 50-year flood hazard map. For instance, in Rosslau, we only surveyed the three horizontal alleys near the river, that is, higher risk areas. In total, 650 questionnaires were distributed, a week after putting information flyers into local citizens' postboxes. The survey campaigners visited the household door to door and asked people about their willingness to participate. If there was no one responding, we passed to the next household. The questionnaires could be returned in a dedicated return envelope free of postage, or to the survey campaigner during their visit a week later. Note that 304 questionnaires were answered; the response rate was very high, ranging from 41.5% to 56% in each location. Table 1 provides socio-demographic variables to

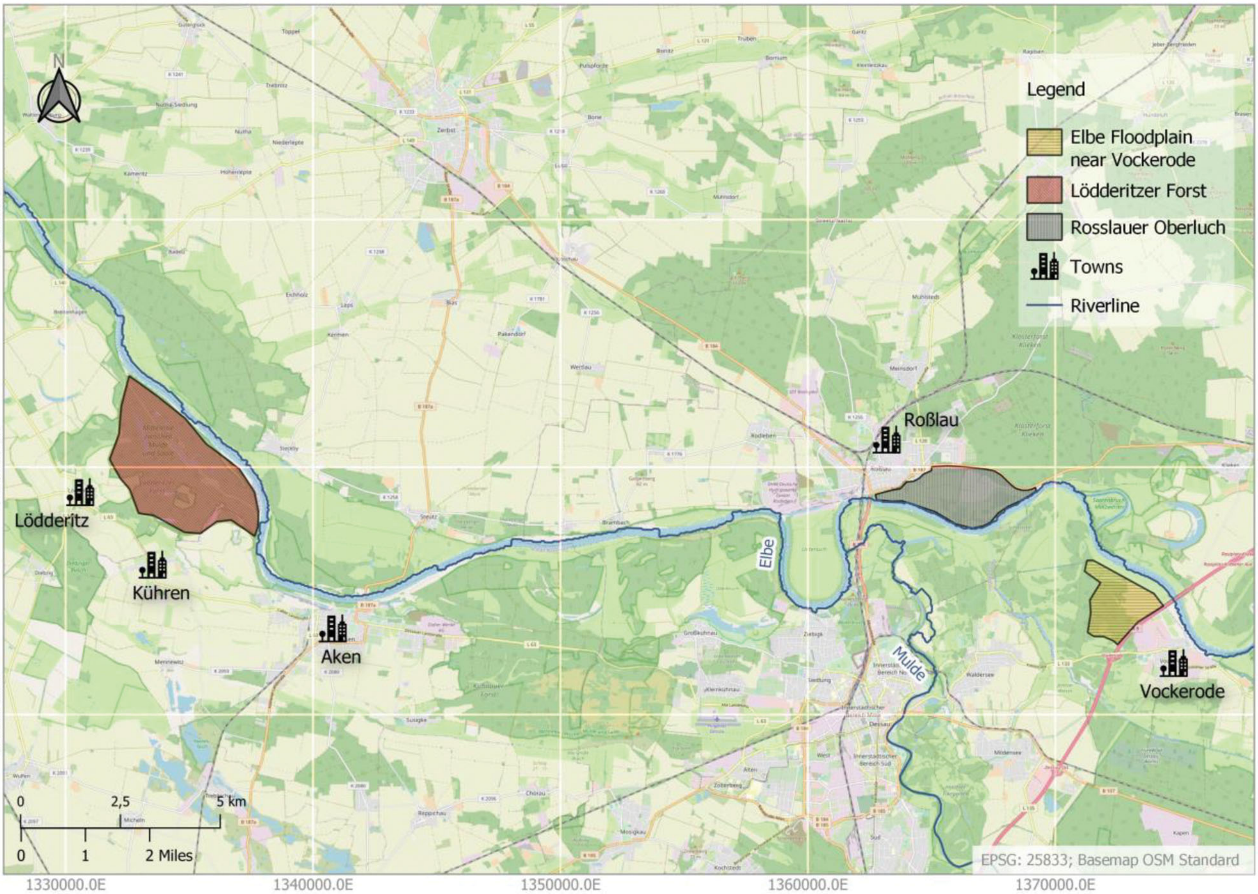

FIGURE 3 Map of the sites surveyed.

TABLE 1 Socio-demographic variables in five towns (pooled result)

Variables	Sample size	Average or percentage
Age	290	60.1 Years
Gender	294	
Female		41.8%
Male		57.1%
Diverse		1%
Number of household members	291	2.3
Education	280	
Elementary school diploma (8th/9th grade)		6.8%
Middle school diploma (10th grade)		51.8%
University/technical college entrance qualification		40%
Other college degrees		1.4%

obtain a better overview of the data. Overall, the sample represents the population characteristics of age and gender, but the education level in our sample is slightly higher than the average in the state of Saxony-Anhalt. The sample population is aged on average 60.1. Slightly more males than females answered the questionnaire. More than half of them possessed a middle school diploma (POS 10th grade), and 41.4% answered that they possessed university/technical college entrance quantification or other college degrees. Table 2 shows the characteristics of the towns surveyed. The whole questionnaire is attached in Appendix A in Supporting Information.

TABLE 2 Characteristics of the towns surveyed, and response statistics

Town	Lödderitz	Kühren	Aken	Rosslau	Vockerode
Geographical context	● A section of the town of Barby ● Approximately 3.8 km from the Elbe	● A district of town Aken ● Approximately 3 km from the Elbe	● A town in the district of Anhalt-Bitterfeld in Saxony-Anhalt ● Located on the left bank of the river Elbe ● Approximately 700 m from the Elbe	● A district of the town of Dessau-Roßlau ● Located on the right bank of the Elbe ● Approximately 1 km from the Elbe	● A district of the city Oranienbaum-Wörlitz ● Approximately 800 m from the Elbe
Estimated population	230	612	7,363	11,958	1,694
Project (construction year)	Mittlere Elbe—Large-scale nature conservation project (2006–2018)			Dike relocation and floodplain restoration of Rosslauer Oberluch (1996–2005)	Life + Nature Elbauen bei Vockerode (2010–2018)
Type of project	Dike relocation and floodplain restoration				
Number of responses/total distributed questionnaires (rate)	25/50 (50%)	28/50 (56%)	65/150 (43%)	83/200 (41.5%)	103/200 (51.5%)
Total number of responses (rate)	304 (46.7%)				

3.2 | Variables

In the questionnaire, the various variables used in the PRAM framework were specified as latent variables. Latent variables enable us to connect theory and data by measuring them at the construct level. The variables used in the survey were all measured on continuous seven-point Likert scales. The detailed scales are set out in Table 3.

Table 4 illustrates site-specific and NBS project-related variables in the towns. Most of the survey participants have lived in the town on average for more than 40 years and own their property. Almost 90% of the residents have visited the NBS sites at least once. Note that 36.4% of the respondents said that they visited the NBS sites several times a year, while 13.6% rarely visited the sites. The distance traveled to the NBS sites varies by town; people in Aken need more time to visit the sites (average 55.6 min) than the residents of the other towns. Approximately a quarter of people in Kühren and Lödderitz received compensation for land acquisition due to the project. People's attitudes toward the NBS project were either mixed (45%) or supportive (41%).

3.3 | Data pre-processing and analysis

SEM was conducted to test the hypotheses. SEM is a comprehensive statistical method that shows relationships between latent variables and their indicators (Hoyle, 1995). It tests the patterns of directional and non-directional relationships between the manifest (or observed) variables and unobserved latent variables (MacCallum & Austin, 2000). As SEM is a method based on covariance, having a sufficient sample size is important. Some studies noted that sample size needs to be decided dependent on the number of parameters, while the ratio of sample size and the number of parameters should be at least 5–1 (Bentler & Chou, 1987) or even 10–1 (Schreiber, Nora, Stage, Barlow, & King, 2006). Although there is no consistent rule of thumb for sample size in SEM, having a larger sample size is essential when the model is complex and the assumption of normality is violated. Without imputation, the full sample size of 304 observations is reduced to 260 observations with 53 parameters.

Overall, our data contains 2%–12% of missing values per variable of interest, missing at random. We used multiple imputations to make the best use of the data by including variables in the imputation model. Multiple imputation has been considered to improve the power of predictions and is more effective than listwise deletion (Collins, Schafer, & Kam, 2001; Raaijmakers, 1999). To reflect the contextual heterogeneity of towns and to increase statistical power, we adopted two-level imputation in this study. Ignoring the clusters and imputing the data by a single-level imputation method was not recommended unless the case has less than 5% of missing values, and the intra-class correlation is less than 0.1 (Grund, Lüdtke, & Robitzsch, 2018). For this reason, the package "miceadds" in R software (version 4.1.2) was used to include the contextual effects, meaning that an aggregated variable at a cluster level is included as a further covariate (Robitzsch, Grund, Henke, & Robitzsch, 2023). As a result, a full sample size of 304 households was gained as pooled data from three imputed data sets.

To check the reliability of the latent construct, we ran a confirmatory factor analysis model. Cronbach's α, composite reliability (CR), average variance extracted (AVE), and the correlation between latent constructs were checked (see Table 2). Cronbach's α and CR measure internal consistency, that is, they measure how closely a set of variables is related as a construct. The Cronbach's α and CR of each construct

TABLE 3 Latent constructs and manifest variables used in the survey

Construct	Item	Scale	Mean (SD)	Est.	Alpha	AVE	CR
Dependent variables/endogenous variables							
Perceived risk-reduction effectiveness (source: authors)	Because of the dike relocation, "Town" is better protected against floods.	Do not agree at all (1) to agree completely (7)	4.59 (1.82)	–	–	–	–
Supportive attitude (source: authors)	I support the dike relocation.	Do not agree at all (1) to agree completely (7)	4.21 (2.07)	–	–	–	–
Independent variables/exogenous variables							
Threat appraisal (source: authors)	How likely do you think it is that a severe flood will occur in your home within the next 5 years?	Very unlikely (1) to very likely (7)	3.10 (1.87)	1.68	0.81	0.60	0.81
	How big do you expect the damage to your home to be in such an event?	No damage (1) to very large damage (7)	3.69 (2.18)	1.63			
	The thought of future flooding in "Town" makes me …	Not afraid (1) to very much afraid (7)	4.00 (1.92)	1.24			
Perceived co-benefits (Based on: Verbrugge et al., 2019)	"NBS Site" is a good place to experience nature.	Do not agree at all (1) to agree completely (7)	5.65 (1.45)	1.16	0.85	0.59	0.85
	"NBS Site" is an ecologically valuable space.	Do not agree at all (1) to agree completely (7)	5.78 (1.41)	1.00			
	"NBS Site" is a place for rest and relaxation.	Do not agree at all (1) to agree completely (7)	5.89 (1.33)	1.15			
	"NBS Site" is an attractive landscape element.	Do not agree at all (1) to agree completely (7)	5.32 (1.72)	1.17			
Well-communicated information on NBS (source: authors)	I feel well informed about the dike relocation project.	Not informed at all (1) to very much informed (7)	3.34 (2.01)	–	–	–	–
Trust in local FRM (based on Babcicky & Seebauer, 2021)	Public flood protection gives me a sense of safety.	Do not agree at all (1) to agree completely (7)	4.44 (1.80)	1.72	0.94	0.89	0.94
	I trust that there is good public flood protection in my community.	Do not agree at all (1) to agree completely (7)	4.54 (1.81)	1.65			
Place identity (based on Williams & Miller, 2020)	"Town" means a lot to me.	Do not agree at all (1) to agree completely (7)	5.49 (1.65)	1.57	0.93	0.83	0.94
	I am very connected to "Town."	Do not agree at all (1) to agree completely (7)	5.40 (1.68)	1.62			
	I have many fond memories of "Town."	Do not agree at all (1) to agree completely (7)	5.57 (1.62)	1.27			
Nature bonding (based on Verbrugge et al., 2019)	The natural environment is important to me.	Do not agree at all (1) to agree completely (7)	6.273 (1.16)	1.01	0.91	0.78	0.91
	When I spend time in the natural environment, I feel at peace with myself.	Do not agree at all (1) to agree completely (7)	5.89 (1.35)	1.14			
	I am very attached to the natural environment.	Do not agree at all (1) to agree completely (7)	5.97 (1.31)	1.23			

Abbreviations: Alpha, Cronbach's α; AVE, average variance extracted; CR, composite reliability; Est., estimates; FRM, flood risk management; NBS, nature-based solutions.

are above 0.8, showing a good level of internal consistency. AVE, a measure of the amount of variance that is captured by a construct in relation to the amount of variance due to measurement error, is captured to assess discriminant validity. It can be seen from Table 5 that AVE is greater than the squared correlation coefficient with latent variables, meaning that it has sufficient discriminant validity for the SEM analysis.

For structural regression analysis, the packages "semTools" and "lavaan" in R were run with imputed pooled data using maximum likelihood estimation. The originally planned model considered only the residual covariance between the two endogenous variables (perceived-reduction effectiveness and supportive attitude). However, the residual covariance between these variables was significant, which indicates that these two variables could be causally related. To tackle this, we decided to establish a causal link between the two variables. Therefore, risk reduction effectiveness is considered one of the dimensions that

TABLE 4 Site-specific and nature-based solutions (NBS) project-related variables

Variables	Aken	Kühren	Lödderitz	Rosslau	Vockerode	Total
Duration of residence (years)/mean (SD)	48.3 (20.2)	40.9 (24.2)	42.2 (17.6)	45.0 (20.6)	40.6 (19.6)	43.5 (20.4)
Home ownership	96.8%	92.9%	92%	85%	85.1%	88.9%
Visit experience to NBS site	88.5%	92.6%	96%	79%	92.9%	88.4%
Distance to NBS site (average min)/mean (SD)	55.6 (37.6)	17.5 (8.5)	15.8 (11.3)	25.4 (17.2)	18.5 (18.5)	27 (26.3)
Duration of visits (av. min)/mean (SD)	68.6 (43.7)	82.9 (40.9)	81.5 (69.2)	68.6 (50.7)	62.6 (44.8)	69 (48.8)
Frequency of visits						
Every day	0%	3.8%	12.5%	0%	5.4%	3.5%
Several times a week	3.7%	7.7%	25%	0%	25%	12.8%
Once a week	3.7%	11.5%	8.3%	0%	9.8%	6.2%
Several times a month	13%	15.4%	12.5%	8.10%	22.8%	15.5%
Once a month	3.7%	3.8%	0%	12.9%	2.2%	5%
Several times a year	37%	42.3%	20.8%	48.4%	30.4%	36.4%
Once a year	14.8%	3.8%	4.2%	11.3%	1.1%	7%
Rare	24.1%	11.5%	16.7%	19.4%	3.3%	13.6%
Compensation	0%	28.6%	24%	0%	5.3%	6.9%
Attitude toward NBS project						
Indifferent	1.8%	11.5%	4%	18.2%	6.5%	9%
Mixed feelings	50%	42.3%	64%	29.9%	49.5%	44.8%
Rejection	7.1%	3.8%	12%	0%	6.5%	5.1%
Supportive	41.1%	42.3%	20%	51.9%	37.6%	41.2%

TABLE 5 Squared correlation coefficients of latent variables and average variance extracted (AVE)

	Threat appraisal	Perceived co-benefits	Trust	Place identity	Nature bonding	AVE
Threat appraisal	1.00	0.00	0.19	0.02	0.01	0.60
Perceived co-benefits	0.00	1.00	0.06	0.10	0.20	0.59
Trust	0.19	0.06	1.00	0.00	0.03	0.89
Place identity	0.02	0.10	0.00	1.00	0.10	0.83
Nature bonding	0.01	0.20	0.03	0.10	1.00	0.78

explain people's supportive attitude toward nature-based solutions.

Next, fit indices show the ability of a model to reproduce the data using a variance-covariance matrix. A good-fitting model is required before the model can be properly interpreted. This study employs four model fit indices: the comparative fit index (CFI), the Tucker–Lewis index (TLI), the root-mean-square error of approximation (RMSEA), and the sample standardized root mean squared residual (SRMR) (Table 4). The threshold value of CFI and TLI for a well-fitting model is 0.95 (Hu & Bentler, 1999) or even 0.90 (Marsh & Hocevar, 1985). RMSEA is considered to be good below 0.06, and SRMR below 0.08 (Browne & Cudeck, 1992; Hu & Bentler, 1999). All four indices are within the scope of the well-fitting model (goodness of fit: $X^2 = 133.252$ (110 d.f.), $p = 0.07$, CFI = 0.992, TLI = 0.989, RMSEA = 0.026, SRMR = 0.038).

4 | RESULTS

In this section, we discuss the regression and covariance coefficients that show the strength of relationships among variables for the research hypotheses.

The results mostly support our hypotheses from the PRAM framework except for H6 about the nature bonding

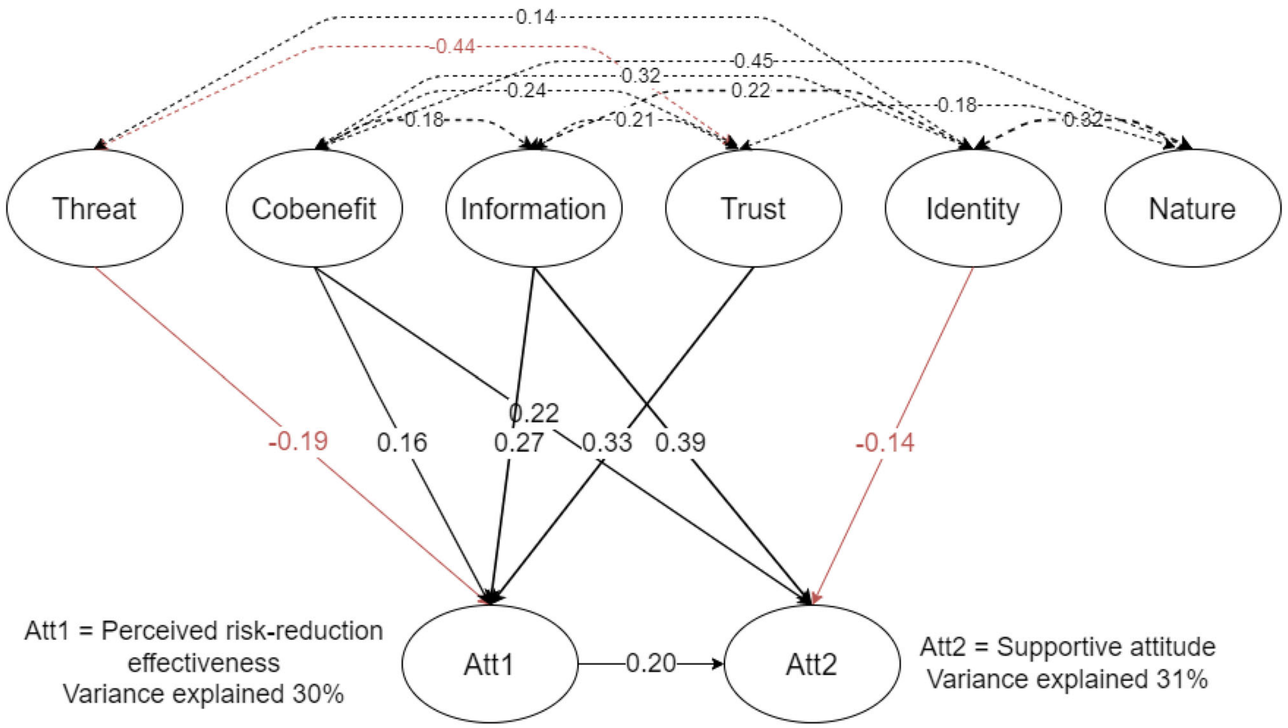

FIGURE 4 Structural equation model with the standardized regression (non-dotted arrow) and covariance coefficients (dotted arrow). *Note*: Only structural parts with significant paths are illustrated. Goodness of fit: $X^2 = 133.252$ (110 d.f.), $p = 0.07$, comparative fit index [CFI] = 0.99, Tucker–Lewis index [TLI] = 0.99, root mean square error of approximation [RMSEA] = 0.026, standardized root mean squared residual [SRMR] = 0.038).

construct (Figure 4, Tables 6 and 7). Figure 4 illustrates the structural equation model with standardized regression and covariance coefficients. Table 6 illustrates the standardized regression coefficient of each hypothesis (H1–H6) with the *p*-value marked with asterisks.

First, for the regression part, perceived risk-reduction effectiveness explains 30% of the variance, and the supportive attitude explains 31% of the variance. The regression of risk-reduction effectiveness on supportive attitude was additionally measured, and it was positively significant ($\beta = 0.20$, $p < 0.001$). It showed an indirect effect of the perceived risk-reduction effectiveness on the supportive attitude of the independent constructs (exogenous variables).

For the four risk-appraisal constructs, all the hypotheses are well supported for the perceived risk-reduction effectiveness, but the hypotheses of threat appraisal and trust in local FRM construct were not supported for the supportive attitude toward NBS. In detail, threat appraisal acts as a negative predictor for perceived risk-reduction effectiveness with the standardized coefficient of −0.16 ($p < 0.05$) (H1a); however, the regression of threat appraisal on supportive attitude was not significant (H1b). This means that if a person has a high threat appraisal, it is more likely that they will perceive lower risk-reduction effectiveness of NBS; however, it does not necessarily lead to a lower degree of support toward NBS. The regression of perceived co-benefit of NBS (H2a/b) was also positively significant for both NBS attitudinal variables. It was slightly more powerful for the supportive attitude ($\beta = 0.18$, $p < 0.01$) than perceived risk-reduction effectiveness ($\beta = 0.14$, $p < 0.05$). The information variable (H3a/b), which shows how well a person is informed about the NBS project, was strongly significant with a regression coefficient of 0.23 and 0.32 for each attitudinal variable, respectively ($p < 0.001$). The perceived level of information of each individual seems influential with regard to positive attitudes toward NBS. Trust in local FRM (H4a) shows a strong regression coefficient for perceived risk-reduction effectiveness ($\beta = 0.28$, $p < 0.001$), while for supportive attitude it was not significant (H1b). In other words, people's trust in local FRM influences their belief in the efficacy of NBS, but this would lead to a supportive attitude only indirectly through perceived risk-reduction effectiveness.

Regarding the place-based constructs, the results are mixed. The regression of place identity on risk-reduction effectiveness (H5a) was not significant, while it showed a negative regression coefficient for the supportive attitude (H5b) ($\beta = -0.11$, $p < 0.05$). The regression path of nature bonding was not significant at all for both perceived risk-reduction effectiveness and the supportive attitude (H6a/b). This explains that people do not show support for the project if they feel more attached to the place at a group or community level. It showed no explanatory power in terms of how supportive people are of NBS and how much they perceive NBS as safe.

Table 7 shows standardized covariance coefficients with the *p*-value denoted by asterisks. There was no strong correlation such that the coefficients are greater than 0.5. Taking only

TABLE 6 Regression part in structural equation model

Regression part	Coefficient estimate (SE)	Standardized Estimate	p (> |t|) Significance
Att1 (perceived risk reduction effectiveness)			
Threat appraisal (H1a)	−0.19 (0.08)	−0.16	0.02*
Perceived co-benefits (H2a)	0.16 (0.08)	0.14	0.04*
Well-communicated information (H3a)	0.27 (0.07)	0.23	0.00***
Trust in local FRM (H4a)	0.33 (0.08)	0.28	0.00***
Place identity (H5a)	−0.09 (0.07)	−0.08	0.18
Nature bonding (H6a)	0.13 (0.08)	0.11	0.10
Att2 (supportive attitude)			
Threat appraisal (H1b)	−0.10 (0.08)	−0.09	0.19
Perceived co-benefits (H2b)	0.22 (0.08)	0.18	0.01**
Well-communicated information (H3b)	0.39 (0.07)	0.32	0.00***
Trust in local FRM (H4b)	0.06 (0.08)	0.05	0.48
Place identity (H5b)	−0.14 (0.07)	−0.11	0.05*
Nature bonding (H6b)	0.04 (0.08)	0.03	0.64
Att1 (perceived risk reduction effectiveness)	0.20 (0.06)	0.20	0.00***

Note: If a *p*-value is less than 0.05, it is flagged with one asterisk. If a *p*-value is less than 0.01, it is marked with two asterisks. If a *p*-value is less than 0.001, it is flagged with three asterisks. Goodness of fit: $X^2 = 201.576$ (145 d.f.), $p = 0.001$, CFI = 0.98, TLI = 0.98, RMSEA = 0.04, SRMR = 0.04.
Abbreviation: FRM, flood risk management.

TABLE 7 Correlation between the constructs (standardized covariance coefficients)

	Threat	Co-benefit	Information	Trust	Identity	Nature
Threat	**1.00**					
Co-benefit	−0.03	1.00				
Information	−0.12	0.18**	1.00			
Trust	−0.44**	0.24**	0.21**	1.00		
Identity	0.14*	0.32**	0.22**	0.03	1.00	
Nature	0.12	0.45**	0.12	0.18**	0.32**	1.00

Note: Standardized paths coefficients and correlations.
$^*p < 0.05$; $^{**}p < 0.01$.

the significant correlation into account, first, it demonstrates that trust in local FRM is positively but weakly correlated with perceived co-benefits. Well-communicated information is negatively weakly correlated with threat appraisal, while it is positively weakly correlated with both perceived co-benefit and trust in FRM. Nature bonding is moderately positively correlated with perceived co-benefits and weakly positively with trust in FRM. Lastly, place identity is correlated with most of the other latent variables; it is moderately correlated with perceived co-benefits and nature bonding and weakly positively correlated with threat appraisal and well-communicated information.

5 | DISCUSSION

The PRAM framework is novel, as there have been no such studies that deal in an integrated way with the link between place attachment and risk appraisal in the context of NBS and floods or natural hazards. It establishes the link between place and risk, which goes beyond the traditional understanding of attitudes that are fragmented and does not fully consider the multidimensional aspects of attitude. Another novel aspect of this framework is that it provides ample evidence for each risk and place theory while also being benefited from standing on the solid foundations of each theory. The empirical findings of this study largely support the newly developed framework, while the relevance of nature bonding to a supportive attitude and perceived risk-reduction effectiveness toward NBS was not confirmed.

5.1 | Local perceptions of "natural" elements in NBS and the trade-offs

The results show that nature bonding is not a positive significant factor for both attitudinal variables of NBS, rejecting the hypotheses of H6a/b. Our hypotheses were designed to consider the previous studies using other related concepts with nature bonding, such as "environmental attitude" (de Groot, 2012), "self-transcendence value" (D'Souza et al., 2021), and "stewardship" (Ferreira et al., 2020), and empirical findings that people with higher levels of environmental awareness prefer "natural" measures over structural measures (Anderson, Renaud, Hanscomb, & Gonzalez-Ollauri, 2022). It has been commonly said that anthropogenic interventions that make more use of natural ecosystems enjoy greater approval compared to those driven by artificial and technology-based elements (Sjöberg, 2000). Such findings corroborate the positive connotation of "nature" provided in the NBS as an effective human intervention for dealing with risks. However, our analysis does not support nature bonding as a precursor of either supportive attitude or perceived risk reduction effectiveness.

So far, the eco-centric perspective, including beliefs expressing concern for the environment and positive consideration of the intrinsic value of nature, has been perceived as a powerful predictor for individual behavior directed toward supporting restoration activities (Connelly, Knuth, & Kay, 2002; House & Fordham, 1997; Schaich, 2009). One of the plausible reasons for this discrepancy may be whether or not the measures implemented in our case study were perceived as "restorative" or "natural" activities by the local people concerned. Nature's pure and pristine values are seen as one of the key characteristics around which NBS are founded (Osaka, Bellamy, & Castree, 2021); thus, the features of NBS were often regarded as a counterpart to traditional gray infrastructure measures (e.g., Gray et al., 2017; Onuma & Tsuge, 2018). However, a spectrum of NBS covers less engineered and closer to non-man-made/wild but also more engineered and hybrid measures (Eggermont et al., 2015). Likewise, a study by de Groot and de Groot (2009) showed a clear preference for options involving less human interference among diverse NBS options and a traditional structural option. In other words, when local stakeholders do not perceive the measure to be sufficiently "natural," there is a greater likelihood that the option will not be endorsed.

On the contrary, some have argued that "naturalness" actually hinders individuals' perceived risk-reduction effectiveness of NBS and therefore support for NBS. We could also question how nature bonding would influence people's attitudes in the case of more hybrid NBS, that is, involving more technical elements. In this regard, the "naturalness" of NBS becomes an obstacle to be dealt with, encouraging an integration of "green" and "gray" as a promising way forward (Anderson et al., 2022; Browder et al., 2019).

However, the discussion so far does not deliver a straightforward answer to the question of whether (perceived) naturalness brings more support for NBS. Rather, another element that has to be considered is the trade-offs (cost and co-benefit) people are exposed to alongside the primary objective of the project (i.e., reducing flood risks). In this case, individual appraisals of cost and benefit could affect the extent to which people support or do not support the project. On the one hand, the perceived co-benefits were positively significant for both perceived risk-reduction effectiveness and supportive attitudes, as stated in H2a and H2b. In line with this outcome, several restoration studies corroborated this argument that the other perceived utilities such as recreation and education opportunities (Kim & Petrolia, 2013), and aesthetic values (Buijs, 2009; Buijs, Elands, & Langers, 2009; Junker & Buchecker, 2008) besides risk mitigation benefit bring more positivity and endorsement to the project. On the other hand, the appraisal also needs to consider the diverse costs that the individual is being asked to bear. For example, issues of user convenience/inconvenience, such as road alterations that may be implemented as part of a project, may prove to be a hurdle to gaining more support for NBS. Thus, we can speculate that the power of nature bonding to generate more support for NBS may be offset by people's cost-benefit appraisal.

5.2 | Importance of communication in presenting NBS as an option for risk reduction

Our results regarding threat appraisal show that it affects the perceived risk-reduction effectiveness negatively as stated in H1a. H1b that threat appraisal affects supportive attitude was only supported through the mediation of perceived risk-reduction effectiveness. It means that people who have higher threat appraisal would have a higher possibility of not endorsing NBS as an ensuring measure against floods, and this indirectly affects the supportive attitude of NBS. The hypothesis confirms that the primary goal of safeguarding people and property from hazards should be understood as a non-negotiable criterion. It also confirms findings from previous empirical studies demonstrating that, for example, high perceived likelihood and severity of hazards were linked with more trust in technical solutions (Buchecker, Ogasa, & Maidl, 2016; Chou, 2012; D'Souza et al., 2021) and also with lower trust in the approach of dealing with hazards in a natural way (Kim & Petrolia, 2013). Uncertainty around the effectiveness of NBS was also considered by policymakers to be an obstacle to the implementation of NBS (Wolf et al., 2021). This poses a distinct challenge for risk management in many locations in which a purely technical approach such as dams, dykes, and retention basins, is no longer appurtenant to meet the demand for climate resilience (Browder et al., 2019).

In this context, establishing effective communication and providing high-quality information for residents is critical to change attitudes and behavioral change (Seebauer & Babcicky, 2018). On the one hand, risk communication should include the fact that technical flood defense infrastructure can also fail, and that residual risks can be very high (Di Baldassarre et al., 2018). On the other hand, information and knowledge about NBS should be communicated effectively to the stakeholders concerned. The significance of well-communicated information for both perceived risk-reduction effectiveness and supportive attitude, as shown in H3a and H3b, demonstrates the importance of conveying information clearly during the NBS process. Sharing knowledge about how NBS work to achieve specific purposes is particularly important in NBS projects as a way of improving people's assessments of the measures implemented (Chou, 2016). In addition, high uncertainty about the efficacy of NBS on the basis of a lack of technical components (Ardaya et al., 2017), and its non-market value (Czembrowski, Kronenberg, & Czepkiewicz, 2016; Mukherjee et al., 2014) justify the need for effective communication with residents. With effective communication regarding the project, it becomes possible to facilitate more participatory decision-making (Roca & Villares, 2012) and thus to enable a shared vision to be developed that delivers benefits for all (Schmidt, Gomes, Guerreiro, & O'Riordan, 2014).

5.3 | Role of trust when large-scale NBS are perceived as a disruptive change

Place identity was significant for negatively influencing supportive attitude, as stated in H5b and previous studies (Marshall et al., 2012). However, it was not significant for perceived risk-reduction effectiveness. This result suggests that dike relocation was considered a rather critical disruptive change to the integrity of a place and not primarily as a solution suited to reduce flood risks. The psychological distress due to such environmental change can be comparable with the concept of "solastalgia" coined in the seminal work of Albrecht (2005) (see also Albrecht et al., 2007). The concept received significant attention in the environmental change literature (e.g., natural hazards) but was not discussed well in the context of NBS or other restoration activities. This may also be attributed to the conflicting decision-making levels involved, powerful interest groups, and the landscape consequences of such interventions (Bonaiuto et al., 2002). From this finding, we can argue that a high degree of place identity can be a significant obstacle to consider when seeking to implement NBS. Considering heterogeneous civil groups within a community, the challenge is how to persuade individuals to recognize NBS as a positive transformative measure for their community. In this regard, values and meanings associated with a place need to be shared in order to generate agreement around collaborative action in favor of transformation (Chapin et al., 2012). Quinn, Bousquet, Guerbois, Heider, and Brown (2019), for example, argued that the meanings attached to a place impact people's preferences for local flood risk management. When a policy-oriented understanding of a place differs from that of local people, it may lead to additional opposition and disagreements over its significance. Therefore, the explicit purpose and process of NBS should be communicated to local residents as constituting a sustainable transformation in the place where they are emotionally attached and spend their lives.

In this context, the role of trust becomes essential. Trust in local FRM was strongly significant in perceived risk reduction effectiveness (H4a), and affected supportive attitude indirectly (H4b) through the perceived risk-reduction effectiveness. In other words, underlying trust in overall local flood risk management policy can be linked to support for non-conventional types of flood risk management. It aligns with the finding of Spaccatini et al. (2022) that distrust in science affects people's attitudes toward adaptive measures, including dislike and aversion. Trust in responsible governmental bodies helps to provide more familiarity with the project, and also offers an opportunity to share the values of NBS with citizens (Gordon, Brunson, & Shindler, 2014; Verbrugge & van den Born, 2018). Therefore, a large-scale NBS project that involves major landscape changes may necessitate additional actions to gain residents' trust in the institutions involved and to persuade them to accept the changes, for the sake of effective and beneficial improvements in FRM. Following the 2013 floods in Germany, it was demonstrated that previously implemented participation processes, such as public hearings, were not always an appropriate method, as they could exacerbate disputes and distrusts rather than allow for consensus (Kuhlicke et al., 2016; Renn, 2015). Further research is needed in order to have "intense, broader, earlier and continuous participation"; following other examples of already-ended controversies (e.g., renewable energy projects) can inspire the locally fitted strategy (Otto et al., 2018) to boost the trust.

5.4 | Limitations

Some limitations are acknowledged by the authors. First, although our study is novel and we believe our research contributes to advancing this line of research, there are still additional factors that could be taken into account in order to fully understand the unexplained dimension of the NBS's supportive attitude, such as cost-benefit appraisal or assigned meanings in places. Second, the construct of nature bonding does not focus on the place we investigated, but rather it points to the general natural environment (Martin et al., 2020; Scannell & Gifford, 2010b). Although previous research points out that emotional bonding to the general natural environment is important for their behavioral reaction, we bear in mind that it may not show the specific attachment of residents to the place. A more in-depth examination of place attachment needs to be further expanded.

6 | CONCLUSIONS

In this study, we have explored the factors shaping people's attitudes toward NBS using a framework inspired by theories of place and risk. We have shown that the elements which make NBS more "natural" do not guarantee either support or resistance and that there is no significant relationship between nature bonding and a supportive attitude toward NBS. Individual appraisal, as well as trade-offs, needs to be considered understanding attitudes toward NBS. Our analysis also suggested that high-threat appraisal could become a hindrance to gaining greater public support for NBS. This suggests the need for transparent and effective communication of the information needed by the public. The analysis also revealed the challenge arising from the fact that NBS are frequently perceived as a major disruptive change to a place from the perspective of local residents, making the role of trust more critical. We, therefore, recommend that stakeholders' attitudes need to be understood in relation to heterogeneous place contexts and each individual's risk appraisal. Often place-related attributes are neglected while the costs and benefits of NBS and their effectiveness in mitigating risk are emphasized. While we provide empirical evidence in favor of the newly developed PRAM, future research should investigate whether these findings can also be transferred to other geographical contexts and in relation to different environmental change processes. For example, blue-green infrastructure projects, other types of ecosystem-based adaptation measures, or even deep geothermal or offshore wind power projects whose aim is to cope with other environmental conditions and which, at the same time, bring changes to a place that can be considered within the PRAM framework.

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SUPPORTING INFORMATION

Additional supporting information can be found online in the Supporting Information section at the end of this article.

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