Finanziato dall'Unione europea NextGenerationEU | Ministero dell'Università e della Ricerca | Italiadomani PIANO NAZIONALE DI RIPRESA E RESILIENZA | SAPIENZA UNIVERSITÀ DI ROMA

multi-Risk sciEnce for resilienT commUnities undeR a changiNgclimate

Codice progetto MUR: **PE00000005** – B53C22004020002

Deliverable title: Report on variables, processes and biases

Deliverable ID: 5.1

Due date: 30 November 2023

Submission date: 30 November 2023

AUTHORS

Marino Bonaiuto, Annalisa Theodorou, Alessandro Milani, Federica Dessi, Silvia Cataldi, and Alessandra Talamo
UNIROMA1

Luca Cetara, Tommaso Bastiani, Veronica Castiglione, and Pasquale La Malva
EURAC

Emilia Corradi, Camillo Frattari, and Francesca Vigotti
POLIMI

Anna Rinaldi and Ettore Gallo
UNIBA

Adriano Schimmenti, Rubinia Celeste Bonfanti, and Giovambattista M. L. Presti
UNIKORE

Francesca Comunello[*], Alessandra Massa[*], and Stefano Scippo[**]
[*]UNIROMA [**]UNIFI

1. Technical references

Project Acronym	RETURN
Project Title	multi-Risk sciEnce for resilienT commUnities undeR a changiNg climate
Project Coordinator	Domenico Calcaterra UNIVERSITA DEGLI STUDI DI NAPOLI FEDERICO II domcalca@unina.it
Project Duration	December 2022 – November 2025 (36 months)

Deliverable No.	DV5.1
Dissemination level*	PU
Work Package	WP5 - WP Psychological, sociological and behavioral aspects in decision making
Task	T5.1 - Measurement of the gap between objective risk and perceived risk, analyzing existing evidence on relevant variables affecting people's choices.
Lead beneficiary	UNIROMA1
Contributing beneficiary/ies	EURAC, POLIMI, UNIBA, UNIKORE, UNIROMA1, UNIFI

* PU = Public

PP = Restricted to other programme participants (including the Ministry Services)

RE = Restricted to a group specified by the consortium (including the Ministry Services)

CO = Confidential, only for members of the consortium (including the Ministry Services)

1.1 Document history

Version	Date	Lead contributor	Description
0.1	20.11.2023	Annalisa Theodorou, Alessandro Milani, Federica Dessi (UNIROMA 1)	First draft
0.2	23.11.2023	Marino Bonaiuto, Silvia Cataldi, Alessandra Talamo (UNIROMA 1)	Critical review and proofreading
0.3	29.11.2023	All participants to TK 5.1	Integrations and edits for approval
1.0	30.11.2023	All participants to TK 5.1	Final version

2. Abstract

Managing the risk of natural hazards entails risk assessment by experts and the consequent participation of populations for engagement in protection behaviour. Nevertheless, lay people's risk perceptions do not always follow statistical previsions or probability calculations to evaluate risk. Thus, to understand how to better motivate individuals to perceive risk and to act basing on it, it is crucial to find the antecedents of risk perception. The literature investigating the predictors of risk perception is flourishing; nevertheless, a summary of the state of the art is still lacking, apart from a few outdated and unsystematic reviews. Especially, a quantitative summary based on a meta-analysis may provide specific effects for each antecedent as well as the identification of moderators of the relationship between each predictor and risk perception. Thus, the aim here is then twofold: identifying effect sizes and finding possible moderators. Results for the first aim showed that several antecedents resulting from the literature search were found significant and that they could be classified as: 1) factors related to the relationship between the individual and the risk; 2) factors related to the relationship between the individual and the community, and 3) individual factors (i.e., sociodemographic and dispositional factors). All in all, the first cluster concerning factors related to the relationship between the individual and the risk shows the highest number of significant variables with strong effects. Regarding moderators, the type of natural hazard considered, and the level of risk area of the sample result relevant in same cases. Implications and future research directions are discussed.

3. Table of Contents

1. TECHNICAL REFERENCES 2

1.1 DOCUMENT HISTORY 3

2. ABSTRACT 4

3. TABLE OF CONTENTS 5

3.1 LIST OF TABLES 6
3.2 LIST OF FIGURE 7

4. INTRODUCTION 8

5. MATERIALS AND METHODS 11

5.1 SEARCH STRATEGIES 11
5.2 INCLUSION AND EXCLUSION CRITERIA 12
5.3 ANALYSIS STRATEGY 17
5.4 HETEROGENEITY ANALYSIS 19
5.5 VARIABLES MERGE 19
5.6 TIMELINE OF TASK ACTIVITIES 23

6. RESULTS 24

6.1 PRELIMINARY ANALYSES: NORMALITY OF DISTRIBUTION 24
6.2 MAIN RESULTS 24
6.2.1 Aim 1: Effect Sizes Analysis 24
6.2.1.1 Publication Bias 30
6.2.2 Aim 2: Moderation analysis 30
6.3 ANCILLARY ANALYSES: DETECTION OF OUTLIERS 34

7. DISCUSSION 37

7.1 DISCUSSION OF THE FINDINGS 37
7.2 RESEARCH IMPLICATIONS 40
7.3 APPLIED IMPLICATIONS 41
7.4 TAKE HOME MESSAGE 42
7.5 PROJECT'S INTERNAL IMPLICATIONS 43
7.5.1 Community and policy maker awareness (T 5.3) 43
7.5.2 Risk elicitation methods (T 5.2) 45
7.5.3 New approach in integrated planning based on co-design processes for DRR e CCA policies (T 4.4) 46
7.5.4 Nudging the uncertainty (T 5.4) 48
7.5.5 New models of education and communication for resilience to risks (WP6) 50

8. REFERENCES 54

APPENDIX A 62

APPENDIX B 70

3.1 List of Tables

Table 1. Search queries used for systematic search of the antecedents of risk perception of natural hazards on Scopus, Web of Science, and PsycINFO…….. 13

Table 2. Detailed information about the merged variables and codification..…….. 20

Table 3. Skewness and kurtosis of the predictor variables.…… 25

Table 4. Results of the random effect meta-analyses, showing estimated effects for each antecedent of risk perception. Variables are sorted in ascending order of effect size.…….…….…… 26

Table 5. Results of the analysis for the assessment of publication bias, sorted by effect size……. 31

Table 6. Results of the moderation analyses conducted on the relationships between different antecedents of risk perception and risk perception…… 35

3.2 List of Figure

Figure 1. Flow diagram, drawn up according to the PRISMA statement, graphically presenting details of the literature search and the number of records screened, assessed, and include……..……..……..……..……... 15

Figure 2. A graphical representation of the timeline followed for the completion of the meta-analyses.…… 23

Figure 3. Graphical representation of mean estimated effects for the antecedents of risk perception…… 28

Figure 4. Contingency table showing the frequencies of the type of risk assessed per antecedent considered…… 29

4. Introduction

Natural hazards can be very destructive, and lead to devastation, both in terms of human lives loss and enormous economic damage. "*It is far from easy to determine whether Nature has proved to man a kind parent or a merciless stepmother*," Pliny the Elder stated in his famous encyclopaedia, the Naturalis Historia (Pliny the Elder, 78 C.E.). According to the Hyogo Framework for Action held in 2005, an hazard is defined as "a potentially damaging physical event, phenomenon or human activity that may cause the loss of life or injury, property damage, social and economic disruption or environmental degradation" (UNDRR, 2005). Here the term natural hazards is referred as hazards caused by natural processes (UNDRR, 2016). According to a recent study (Ritchie et al., 2022), over the past century, the number of deaths imputable to natural hazards was subjected to a large decline due to earlier prediction, better preparedness for people and infrastructure, as well as a more coordinated response. In this scenario, involving people in the preparedness and response to such events is becoming more and more crucial, also considering that many natural hazards are dramatically exacerbated by climate change (UNDRR, 2015).

Among the determinants of individuals' action to protect themselves - both before and after a natural hazard- one important aspect is the perceived risk associated to the event (Slovic, 1987; van Valkengoed & Steg, 2019a). Risk may be defined as the likelihood of experiencing negative consequences of a specific hazard (Short, 1984). Perceived risk is strongly related to the concept of uncertainty, in the sense that something of human value (including human life) is at stake, and the outcome is uncertain (Rosa, 2003). Other conceptualizations include different aspects that together define risk perception, namely the perceived likelihood of the event to occur, the expected negative consequences, and the perceived vulnerability (Wilson et al., 2019). Interestingly, it has been highlighted that a specific domain of risk perception provides useful insights into demand for risk reduction, namely the perceived consequences of a hazard (Sjöberg et al., 2004). Scholars generally agree that the likelihood of experiencing negative consequences to be at the core of risk perception (Lindell & Prater, 2000; Sjöberg, 1998; Wachinger et al., 2013).

Risky circumstances demand appropriate evaluations to lead to successful protective actions. However, risk assessment by the population is hardly based on objective risk (Slovic, 1987; Slovic et al., 1979). In fact, what has been found is that the risk as perceived by people is not a mere probability calculus, and thus, differ from what policy makers may consider (Sjöberg et al., 2004). This bias occurs because people are different, and individual differences, and social and cultural differences too, may determine a variation in how they experience risk (Barnett & Breakwell, 2001; Brun, 1994; Gierlach et al., 2010; Siegrist & Árvai, 2020). Since individuals infer risks most commonly without referring to statistics, it may also be biased in the way they calculate risks due to heuristics (Siegrist & Árvai, 2020; Slovic et al., 1980). These aspects urge experts

and policymakers to identify possible determinants and sources of bias when referring to individual risk perception.

To understand the state of art on the antecedents of risk perception, it would be useful to refer to specific reviews on the topic analysing the interdisciplinary work available. One of the most recent review available (Wachinger et al., 2013), classified the antecedents of risk perception in four clusters: 1) factors associated with the scientific aspect of risk, such as the perceived likelihood of the event occurring; 2) informational factors, such as media coverage and informational sources; 3) personal factors, meaning the individual characteristics involved in the assessment of risk, such as age, gender, knowledge, prior experience of the hazard, trust in authorities, and religiousness; and 4) contextual factors, for instance home ownership, household characteristics, and objective risk (e.g., distance from the river in the case of flood).

Since risk perception can be considered to boost protective and coping behaviour, it may be relevant to report also the results of a review (Bonaiuto & Ariccio, 2020) on the antecedents of resilient behaviour, namely before (preparedness), during (response), and after (recovery) the event. Interestingly, in their work, the authors provided a different classification than that of Wachinger et al. (2013). In particular, they conceptualized three clusters: 1) factors concerning the relationship between the individual and the risk, namely how the individual relate with the risk in their area of living, e.g., risk perception, objective and subjective knowledge, and prior experience of the hazard; 2) factors concerning the relationship between the individual and the community, namely how the individual relate to the place and the community in which they live, e.g., sense of community, place attachment, social norms, social identity, and trust in authorities; and 3) individual factors, less likely to be modified, namely a) sociodemographic (e.g., educational qualification, home ownership, residential tenure, having or not children, household size) and b) dispositional factors (e.g., self-efficacy and fatalism). Each cluster can be more or less relevant, depending on the phase (i.e., preparedness, response, and recovery) of resilience (Bonaiuto & Ariccio, 2020).

All in all, it seems that reviews converge on some of the most important variables emerging from the literature. Among the abovementioned variables, Wachinger et al. (2013) found prior experience and trust in authorities as the two most important determinants of risk perception. However, the direction of their effects was not straightforward. Regarding prior experience, the review showed how some studies reported positive effects, highlighting how having experienced the event enhanced the perceived probability of its occurrence, thus, increasing risk perception. Others found negative effects, suggesting that having experienced the disaster and coped with it gave the illusion that future similar event could be simpler to overcome. Thus, the authors hypothesized that the severity of prior disaster can be the most important aspect of experience, namely the extent of the perceived negative impacts of the event that can heighten risk perception (Wachinger et al., 2013). Regarding trust in authorities, some studies showed a negative effect, presumably because people with high trust are relieved from the burden of responsibility of taking actions for protecting themselves and see future disasters as less probable and less severe. Other important antecedents highlighted in the literature for which

research is still ongoing are knowledge, values, personality traits, and optimistic bias (Boholm, 1998; Siegrist & Árvai, 2020).

All in all, despite risk perception being an important factor in risk management, studied by a variety of disciplines (Yu et al., 2021), important questions are yet to be answered. To draw conclusions regarding the direction of the effects of antecedent variables across the available studies, and to find specific conditions that can alter these effects (i.e., moderators), a meta-analysis seems essential. A meta-analysis is a statistical technique for combining the findings from independent studies addressing the same question (Moher et al., 2010; Page et al., 2021). According to the psychometric paradigm, which aims at studying perceived risk perception through questionnaires and quantitative analysis (Fischhoff et al., 1978; Slovic et al., 1984), the main focus of this deliverable is to describe methods and results of different meta-analyses on the antecedents of risk perception in the context of natural hazards. Findings will be discussed considering the available literature and theory and will be used as a starting point for delineating practical and future research implications.

A recent meta-analysis (van Valkengoed & Steg, 2019a) focused on a related topic, namely the antecedents of climate change adaptation behaviour. They found important significant effects for a variety of variables that already emerged from the abovementioned reviews, including social norms, self-efficacy, knowledge, prior experience, place attachment, and trust in authorities. Nevertheless, this meta-analysis did not specifically focus on risk perception. Thus, there is a need for meta-analyses that can identify key predictors of risk perception of natural hazards to further develop and complete these findings. Therefore, the aim of this work is twofold:

- Aim 1: to estimate effect sizes of different potential antecedents of risk perception in the domain of natural hazards, providing a quantitative summary of research available (Page et al., 2021);
- Aim 2: to investigate the effect of possible moderators of such relationships.

5. Materials and Methods

The methodology adopted for the meta-analyses followed the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) statement (Moher et al., 2010; Page et al., 2021). The aim of the meta-analyses is twofold: first, to estimate effect sizes of different potential antecedents of risk perception in the domain of natural hazards, providing a quantitative summary of research available (Page et al., 2021); second, to investigate the effect of possible moderators of such relationships. On thirty-five possible antecedents detected, after preliminary analyses, thirty-two meta-analyses are conducted in total (for more information on the selection of variables for meta-analyses, see below the paragraph "Preliminary Analyses: Normality of Distribution" in the Results section).

5.1 Search Strategies

The literature search is aimed at identifying the studies that focused on the antecedents of risk perception in the domain of natural hazards. To build the query string, the focus is on defining the research topic (e.g., natural hazards), define the dependent variable (i.e., risk perception), and provide keywords for a set of independent variables identified in the literature. Regarding this latter point, such an approach serves to broaden and better direct the search; however, it is also possible to consider additional independent variables from the resulting records which are not originally included in the query string. In this way, an attempt is made to include as much as independent variables as possible.

In order to define which natural hazards have to be considered, by following the United Nations definitions (UNDRR, 2015; United Nations, 2023) the search includes:

1. geological or geophysical hazards, originating from internal earth processes (e.g., earthquakes, volcanic activity, landslides; UNDRR, 2015);
2. hydrometeorological hazards, of atmospheric, hydrological, or oceanographic origin (e.g., cyclones, floods; UNDRR, 2015);
3. natural hazards considered as effects of climate change (e.g., sea level rise, loss of biodiversity; United Nations, 2023).

In order to better define the dependent variable and all possible independent variables by using pertinent keywords, one available review on the antecedents of risk perception of various natural hazards (Wachinger et al., 2013), another review on the determinants of risk perception limited to floods (Lechowska,

2018), and a more recent review which comprises risk perception in different domains, also outside natural hazards (Siegrist & Árvai, 2020) are consulted. A more general search on the strings used in the literature on the topic is also conducted (e.g., van Valkengoed & Steg, 2019).

The query string is then composed of keywords organized into three interdependent levels:

1. keywords that defined the research topic (i.e., natural hazards);
2. keywords that defined the dependent variable (i.e., perceived risk);
3. keywords that defined a set of independent variables retrieved from the available literature (e.g., knowledge, trust in authorities, norms).

The bibliographic search is carried out through three of the most important databases for the psychological literature, namely Scopus, Web of Science, and PsycINFO, on June 13th, 2023. The search results in a total of 3,926 records (in detail: Scopus: 1,977; Web of Science: 1,442; PsycInfo: 507).

5.2 Inclusion and Exclusion Criteria

The initial pool of records identified by the query string is screened through automatic search tools, provided by the databases Scopus and Web of Science, by:

1. subject area, mostly excluding disciplines which do not involve studies on human participants (e.g., physical sciences, veterinary) and risk perception of natural hazards (i.e., pharmacology);
2. document type, excluding records which do not present data (i.e., reviews and notes);
3. language, excluding records not written in English.

After this preliminary screening, duplicates are also excluded using the platform EndNote (The EndNote Team, 2013). At this point, three researchers (AT, AM, MX) independently review a total of 2,572 records by title, abstract, and keywords, resulting in 806 selected records. Then, three researchers (AT, AM, FD), after having filtered further and independently the records by full text, arrive at the final number of 127 records selected. Search queries are presented in Table 1. In Figure 1, a flow diagram describing the selection process of the articles is presented.

Finanziato dall'Unione europea NextGenerationEU | Ministero dell'Università e della Ricerca | Italiadomani PIANO NAZIONALE DI RIPRESA E RESILIENZA | SAPIENZA UNIVERSITÀ DI ROMA

Table 1 - Search queries used for systematic search of the antecedents of risk perception of natural hazards on Scopus, Web of Science, and PsycINFO.

Database	Search queries	N
Scopus	(TITLE-ABS-KEY ("natural hazard" OR "environmental hazard" OR "hazardous event" OR "multi-risk" OR "multi-hazard" OR "natural risk" OR "environmental risk" OR "climate change" OR "extreme event" OR "natural threat" OR "environmental threat" OR disaster OR flood OR avalanche OR earthquake OR seismic AND risk OR storm OR volcan* OR *tsunami OR cyclone OR *fire OR hurricane OR landslide OR "land slide" OR mudslide OR tornado OR storm OR typhoon OR flooding OR "cold wave" OR drought OR "sea level rise" OR thunder OR lightning OR "heat wave" OR "strong wind" OR "winter weather" OR biodiversity OR "loss of species" OR "ocean acidification") AND TITLE-ABS-KEY ("risk perception" OR "risk appraisal" OR "perceived risk" OR "perceived susceptibility" OR "risk judg*" OR "perceived threat" OR "subjective risk" OR "subjective assessment" OR "subjective perception" OR "personal risk" OR "personal assessment" OR "personal perception") AND TITLE-ABS-KEY ("risk communication" OR "*bjective knowledge" OR "risk awareness" OR "hazard awareness" OR "objective risk" OR closeness OR "past experience" OR "perceived severity" OR "perceived likelihood" OR "perceived frequency" OR "perceived vulnerability" OR "personal vulnerability" OR "subjective vulnerability" OR "psychological distance" OR "psychological harm" OR "trust in the institution*" OR "trust in expert*" OR "trust in authorit*" OR "trust in government" OR religio* OR optimis* OR "place attachment" OR "negative affect" OR "positive affect" OR norm* OR "information seeking" OR "technology us*" OR "technology adoption" OR "support for technology" OR "climate change belief" OR "climate change concern" OR "self-efficacy" OR "outcome efficacy" OR "personal responsibility" OR "personal value*" OR "world view" OR "personality" OR "personality trait*" OR "individual difference*" OR disposition* OR "risk attitude*" OR "environmental attitude*")) AND (EXCLUDE (SUBJAREA , "COMP") OR EXCLUDE (SUBJAREA , "BIOC") OR EXCLUDE (SUBJAREA , "ARTS") OR EXCLUDE (SUBJAREA , "MATH") OR EXCLUDE (SUBJAREA , "CENG") OR EXCLUDE (SUBJAREA , "MATE") OR EXCLUDE (SUBJAREA , "PHYS") OR EXCLUDE (SUBJAREA , "CHEM") OR EXCLUDE (SUBJAREA , "IMMU") OR EXCLUDE (SUBJAREA , "PHAR") OR EXCLUDE (SUBJAREA , "VETE") OR EXCLUDE (SUBJAREA , "DENT")) AND (EXCLUDE (DOCTYPE , "re") OR EXCLUDE (DOCTYPE , "no")) AND (LIMIT-TO (LANGUAGE , "English")))	1,977
Web of Science	“natural hazard” OR “environmental hazard” OR “hazardous event” OR “multi-risk” OR “multi-hazard” OR “natural risk” OR “environmental risk” OR “climate change” OR “extreme event” OR “natural threat” OR “environmental threat” OR disaster OR flood OR avalanche OR earthquake OR seismic risk OR storm OR volcan* OR *tsunami OR cyclone OR *fire OR hurricane OR landslide OR “land slide” OR mudslide OR tornado OR storm OR typhoon OR flooding OR “cold wave” OR drought OR “sea level rise” OR thunder OR lightning OR “heat wave” OR “strong wind” OR “winter weather” OR biodiversity OR “loss of species” OR “ocean acidification” (Topic) and “risk perception” OR “risk appraisal” OR “perceived risk” OR “perceived susceptibility” OR “risk judg*” OR “perceived threat” OR “subjective risk” OR “subjective assessment” OR “subjective perception” OR “personal risk” OR “personal assessment” OR “personal perception” (Topic) and “risk communication” OR “*bjective knowledge” OR “risk awareness” OR “hazard awareness” OR “objective risk” OR closeness OR “past experience” OR “perceived severity” OR “perceived likelihood” OR “perceived frequency” OR “perceived vulnerability” OR “personal vulnerability” OR “subjective vulnerability” OR	1,442

	"psychological distance" OR "psychological harm" OR "trust in the institution*" OR "trust in expert*" OR "trust in authorit*" OR "trust in government" OR religio* OR optimis* OR "place attachment" OR "negative affect" OR "positive affect" OR norm* OR "information seeking" OR "technology us*" OR "technology adoption" OR "support for technology" OR "climate change belief" OR "climate change concern" OR "self-efficacy" OR "outcome efficacy" OR "personal responsibility" OR "personal value*" OR "world view" OR "personality" OR "personality trait*" OR "individual difference*" OR disposition* OR "risk attitude*" OR "environmental attitude*" (Topic) and Meteorology Atmospheric Sciences or Mathematics Interdisciplinary Applications or Geography or Computer Science Information Systems or Engineering Chemical or Nuclear Science Technology or Materials Science Multidisciplinary or Computer Science Theory Methods or History Philosophy Of Science or Physiology or Chemistry Multidisciplinary or Linguistics or Physics Applied or Statistics Probability or Automation Control Systems or Biotechnology Applied Microbiology or Chemistry Physical or Computer Science Interdisciplinary Applications or Pharmacology Pharmacy or Veterinary Sciences or Zoology (Exclude – Web of Science Categories) and Review Article (Exclude – Document Types) and English (Languages)	
PsycInfo	Level 1: "natural hazard" OR "environmental hazard" OR "hazardous event" OR "multi-risk" OR "multi-hazard" OR "natural risk" OR "environmental risk" OR "climate change" OR "extreme event" OR "natural threat" OR "environmental threat" OR disaster OR flood OR avalanche OR earthquake OR seismic risk OR storm OR volcan* OR *tsunami OR cyclone OR *fire OR hurricane OR landslide OR "land slide" OR mudslide OR tornado OR storm OR typhoon OR flooding OR "cold wave" OR drought OR "sea level rise" OR thunder OR lightning OR "heat wave" OR "strong wind" OR "winter weather" OR biodiversity OR "loss of species" OR "ocean acidification" Level 2: "risk perception" OR "risk appraisal" OR "perceived risk" OR "perceived susceptibility" OR "risk judg*" OR "perceived threat" OR "subjective risk" OR "subjective assessment" OR "subjective perception" OR "personal risk" OR "personal assessment" OR "personal perception" Level 3: "risk communication" OR "*bjective knowledge" OR "risk awareness" OR "hazard awareness" OR "objective risk" OR closeness OR "past experience" OR "perceived severity" OR "perceived likelihood" OR "perceived frequency" OR "perceived vulnerability" OR "personal vulnerability" OR "subjective vulnerability" OR "psychological distance" OR "psychological harm" OR "trust in the institution*" OR "trust in expert*" OR "trust in authorit*" OR "trust in government" OR religio* OR optimis* OR "place attachment" OR "negative affect" OR "positive affect" OR norm* OR "information seeking" OR "technology us*" OR "technology adoption" OR "support for technology" OR "climate change belief" OR "climate change concern" OR "self-efficacy" OR "outcome efficacy" OR "personal responsibility" OR "personal value*" OR "world view" OR "personality" OR "personality trait*" OR "individual difference*" OR disposition* OR "risk attitude*" OR "environmental attitude*"	507

Note: PsycINFO does not provide an advance search query.

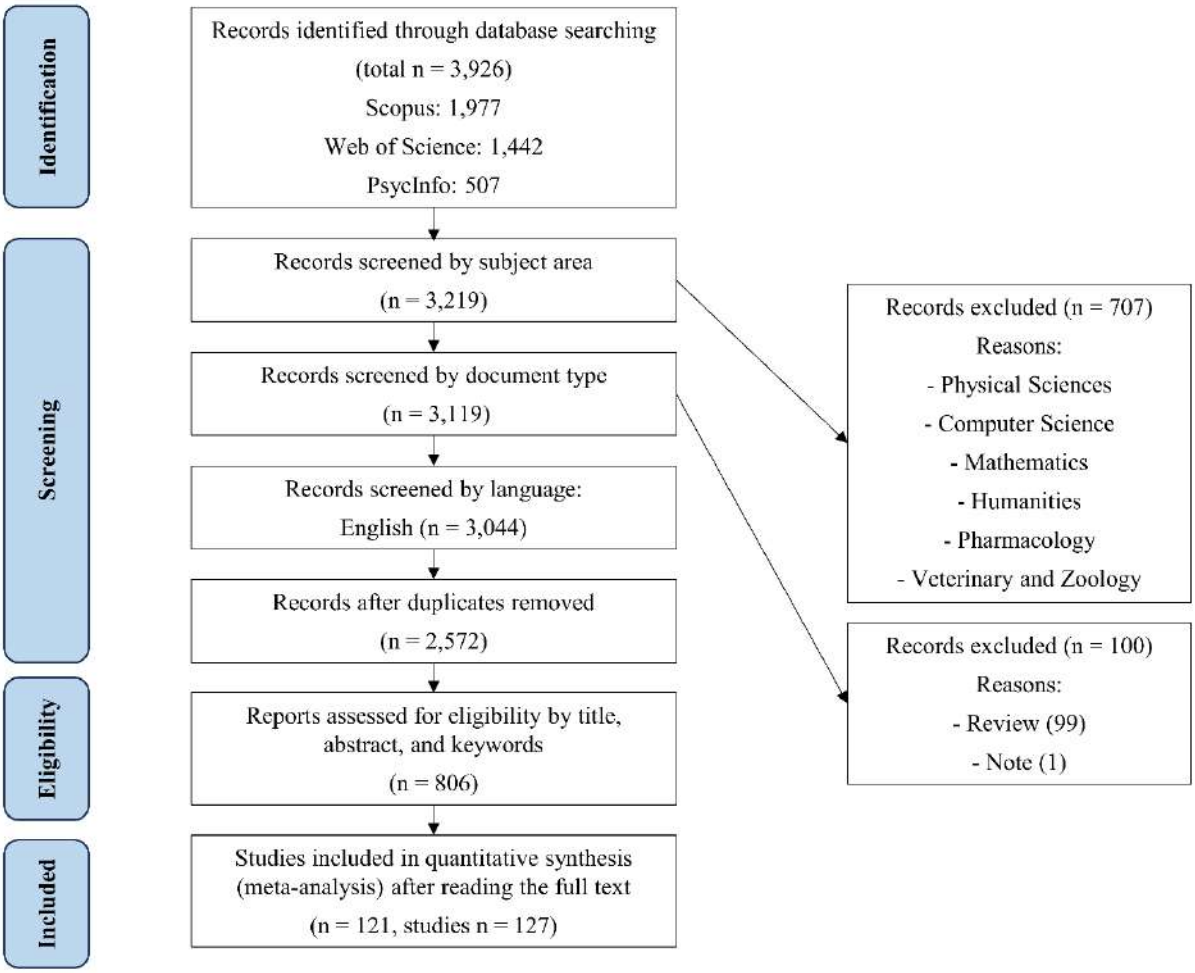

Figure 1 - Flow diagram, drawn up according to the PRISMA statement, graphically presenting details of the literature search and the number of records screened, assessed, and included.

The intent of this work is to include as much antecedents as possible. Thus, the aim is explorative and not driven by specific theory. According to that principle, in the definition of risk perception, the query string is built to be as general as possible to include the largest number of studies. In filtering the records to be included though, researchers have been forced to select studies that used similar measures of risk perception. The initial pool of records comprised studies which used very different, and mostly mixed, measures of risk perception. Thus, during the full-text selection phase, a procedure that retained studies measuring risk perception using a general measure is employed. This involves directly inquiring about the perceived risk associated with the specific hazard (e.g., *At what degree of flood risk is your area or neighbourhood exposed?*). Since selecting only these studies would have meant excluding more than half of the records, measures focused on the expected consequences of the natural hazard have been included too. The expected consequences are considered for two reasons. First, in the selected studies, this is the most recurrent measure, common to most studies. Second, it has been argued that this aspect of risk perception provides useful insights for risk reduction (Sjöberg et al., 2004), while scholars pointed to this aspect of risk perception to be at the core of risk perception (Lindell & Prater, 2000; Sjöberg, 1998; Wachinger et al., 2013).

Inclusion criteria consider also full texts located online and accessible in scientific databases. Non-accessible full texts are personally asked to the corresponding author(s). In particular, 9 full texts are received out of 27 requested (response rate: 33.33%). Included studies have also to present quantitative analysis and, specifically, to investigate the association between a certain antecedent of risk perception (i.e., a specific predictor) and the risk perception measurement (i.e., the dependent variable). Moreover, to be included, they have to report specific statistical coefficients (i.e., effect sizes) to express the association between an independent variable and the dependent variable (e.g., Pearson's *r*, standardized correlation coefficients, Odds Ratio). When the considered effect sizes are correlations, if theoretical reasons apply, variables are considered as antecedents of risk perception, also in cases in which the original study do not view them as such.

Corresponding authors are contacted to request specific statistics when studies presented appropriate data without providing the necessary coefficients. In particular, since standardized coefficients from regression models with multiple predictors differ from correlations, especially when there are high correlations among them, caution should be taken when including such regression coefficients in meta-analyses (Aloe, 2015). For this reason, in such cases, authors are contacted directly to request Pearson's *r* coefficients to avoid using coefficients from multiple regression analysis as much as possible. In total, in 172 cases, authors were contacted personally and 25 provided the requested statistics (response rate: 14.53%), therefore only these are included if other statistics were not available (e.g., standardized regression coefficients). For longitudinal studies, associations between variables measured at baseline (first data collection before the intervention) are considered. For experimental studies, only those presenting associations between variables measured in the control group are included.

5.3 Analysis Strategy

Effect sizes are grouped and meta-analysis are conducted if a minimum of five studies is achieved (Hornsey et al., 2016). To establish if a certain study would qualify to describe the relationship between a certain independent variable and risk perception, items and response scales of the independent variable are also examined. If the items do not match the specific independent variable of interest (e.g., items asking about self-efficacy associated with a variable label "social vulnerability"), the study is excluded from that specific meta-analysis (e.g., vulnerability and risk perception) and, possibly, collocated in a different one (e.g., self-efficacy and risk perception).

In some cases, multiple effects sizes are collected for each sample between a specific antecedent and the dependent variable risk perception. This happens when, for instance, multiple risk perceptions are measured in the same study (e.g., relationship between the same antecedent, self-efficacy, and personal and global risk perceptions). Including both correlations separately would have violated the meta-analytical assumption of independent data. Therefore, in these cases, before proceeding with the meta-analysis, effect sizes from the same study are averaged. This strategy has been employed in previous meta-analysis when dealing with multiple effect sizes from the same sample (e.g., van Valkengoed & Steg, 2019). Whenever effect sizes are coming from studies that used reverse-coded items (e.g., response inefficacy) as compared to other studies (e.g., response efficacy), the effect is reversed (i.e., from negative to positive or vice versa) in order to include the study together with the other ones.

All the collected effects sizes are transformed into Pearson's *r* before conducting each meta-analysis. Spearman's rho (ρ_s) is converted using the formula by Rupinski and Dunlap (1996). Standardized coefficients (β) are transformed in Pearson's *r* using the formula by Peterson and Brown (2005). Lastly, odds ratio (*OR*) and log odds ratio (L_{OR}) are converted using the formulae by Sánchez-Meca et al. (2003). Finally, a transformation (and back transformation) to Fisher's *z* (r_z) (and back to Pearson's *r*) is applied to correlation coefficients to stabilize the variance. To do so, it is used respectively the Fisher's *z* formula (Borenstein et al., 2021) and the inverse of the Fisher's *z* formula. Analyses are performed using the "metafor" package (Viechtbauer, 2010), version 4.4.0 for RStudio, version 4.2.2. Random-effects meta-analysis models are applied for each factor.

In total, thirty-five possible predictors are identified:

1. Age
2. Altruistic Values
3. Biospheric Values
4. Children
5. Climate Change Awareness

6. Conservative
7. Education
8. Egoistic Values
9. Event Perceived Likelihood
10. Expected Response Efficacy
11. Fatalism
12. Woman
13. Home Ownership
14. Household Size
15. Income
16. Knowledge
17. Married
18. Media Use
19. Negative Emotions
20. Objective Risk
21. Place Attachment
22. Preparedness
23. Prior Experience
24. Prior Experience Severity
25. Pro-Environmental Orientation (this variable was measured in all studies with the New Environmental Paradigm (NEP, Dunlap et al., 2000) scale)
26. Psychological Distance
27. Religiosity
28. Residential Tenure
29. Self-efficacy in Response
30. Sense of Community
31. Social Norms
32. Social Support
33. Trust in Authorities
34. Trust in Community
35. Vulnerability

Moreover, fourteen variables are omitted because they do not reach the minimum of five studies required for conducting a meta-analysis:

1. Attribution of Responsibility;

2. Big Five Personality Traits;
3. Community Participation;
4. Connectedness with Nature;
5. Employment;
6. Environmental Attitudes;
7. Frequency of Information Exchange in the Social Network;
8. Future Migration Probability;
9. Locus of Control;
10. Perceived Behavioural Control;
11. Risk Salience;
12. Risk Seeking;
13. Rural or Urban Residential Location;
14. Worldviews.

5.4 Heterogeneity Analysis

Heterogeneity among studies is assessed using different statistics, namely Cochran's Q, τ^2, and I^2. Cochran's Q is a test that provides statistical significance of observed heterogeneity following a chi-square distribution (Ioannidis et al., 2007). This test is dependent on the number of studies, thus, it could not be employed to compare different meta-analyses (Ioannidis et al., 2007). Moreover, when the number of studies is low, this statistic may not have an adequate power (Borenstein et al., 2021). Thus, two additional statistics were employed, namely τ^2, which estimates the standard deviation of true effects across studies, and the I^2, which represent the percentage of total variation in the observed effects that can be attributed to heterogeneity among studies (Higgins & Thompson, 2002).

5.5 Variables Merge

Variables coming from different studies have been merged, with the aim to collect as many predictors of risk perception as possible. In several cases, variables exhibit a similar meaning (especially when looking at the items and instrument used) although they had been named differently. Thus, these variables are grouped (or averaged, in the case of more variables coming from the same study) considering the similar meaning shared. This practice increased the accuracy of the meta-analyses. More information about the merged variables is reported in Table 2.

Table 2 - Detailed information about the merged variables and codification.

Original Variable Name	Merged/modified Variable Name
Age, Year of Birth	Age
Altruistic Values	Altruistic Values
Biospheric Values	Biospheric Values
Number of children, Children in home, Children in the household, Child, Children under the age of 14 years	Children
Climate Change Belief, Perceived susceptibility to CC, Awareness about climate change, Belief in Climate Change, Knowledge about the causes of climate change, Belief about anthropogenic climate change, Scientific consensus on anthropogenic climate change, Cause knowledge	Climate Change Awareness
Communist Party of China membership, Political affiliation, Political orientation, Ideology, Democrat, Party affiliation, Political ideology, Republican	Conservative
Education, Years of education, Educational level	Education
Egoistic Values	Egoistic Values
Likelihood of threats, Likelihood Occurrence, Likelihood of event of similar magnitude, Likelihood flood, Risk Perception Probability, Perceived probability of tsunami in the next 50 years, Perceived probability of droughts, Perceived probability of floods and dry spells, Perceived probability of increased temperature, Perceived probability of worsening harmattan, Perceived probability of reduction plant and animals, Perceived probability of decrease forest, Perception of location flooding possibility, Perceived susceptibility	Event Perceived Likelihood
Response efficacy, Response efficacy beliefs, Outcome Expectations, Effectiveness of protective behaviors, Intervention efficacy, Mitigation Response Efficacy	Expected Response Efficacy
Fatalism, Fatalism belief	Fatalism
Gender	Woman
Home ownership, Ownership, Housing, Home owner, Tenants, House	Home Ownership
Household size, Number of households members, Number of residents	Household Size
Income, Household income, Annual household income, Family income	Income
Knowledge, Actual knowledge, Individual knowledge, Hazard knowledge, Objective Knowledge, Subjective Knowledge, Knowledge about heat risks, Knowledge perception, Knowledge Correct intended action during an earthquake, Knowledge about contributors of Climate Change, Knowledge of Health Effects of Climate Change, Cause of climate change knowledge,	Knowledge

Impact of climate change knowledge, Response to mitigate climate change knowledge, Knowledge of natural hazards, No knowledge of the causes of flooding, Knowledge about the occurrence of landslides in the community, Risk awareness, Awareness of flood risk, Response knowledge, Scientific knowledge, Cause Knowledge, Impact Knowledge, Response Knowledge, Knowledge and reported skills, Knowledge climate change, Self-Reported Knowledge, Costal risk awareness, Need for information for a safe environment	
Married, Marriage, Marital status	Married
Media use, Media Sources, Science media use - Newspapers, Science media use - Television news, Science media use - Online newspapers, Science media use - Online bulletin boards and blogs, Media exposure, Social media use, Newspapers in assessing their own risk from hurricanes, Radio in assessing their own risk from hurricanes, Television in assessing their own risk from hurricanes, Web sites in assessing their own risk from hurricanes, Perceived information searched for earthquake risk information across sources	Media Use
Negative emotions, Dread, Environmental concern, Anxiety, Feelings, Worry flood risk, Concern, Worry, Negative affect, Anger, Perceived threat based on flood early warnings, Affect, Emotional threat, Fears associated to the risk, Severe-weather Worry, Negative Affect associated with possible future flooding scenarios, Fear, Depression, State Anxiety	Negative Emotions
Geographical proximity, Distance level, Wave arrival time, objective risk in severe earthquake shaking zone, Liquefaction zone, Distance to coast, Geographic vulnerability, Risk zone, Distance to rivers, Proximity of home to the coast, Proximity - Distance to coast, Distance to main river, Distance, Distance from the sea	Objective Risk
Home Place Attachment, Neighborhood attachment, Dependence, Place dependency, Sense of place, Home Attachment	Place Attachment
Preparedness, Personal preparedness, Preparedness Behaviors, Have flood cover, Home insurance cover, Current preparedness, Flood protective behaviors, Protective behaviors, Physical preparedness, Informational preparedness, Adaptation behavior, Past behavior, Disaster Risk Reduction Behaviors, Registered for SMS info services, Personal precautions taken, Protective behaviors Hazard adjustments adopted at time of survey	Preparedness
Past experience with glacial lake outburst flood, Disaster experience, Previous flood experience, Prior exposure to wildfire lasting more than 1 week, Experience of flood and evacuation, Experienced floods, Experienced landslides, Experience, Affected by landslide, Past flood experience, Hazard Experience, Experience with flash floods, Prior experience with Extreme Weather, Previous experience, Previous hurricane experience, Direct experience, Experienced Hugo, Past tsunami, Personal Experience, Exposure	Prior Experience
Flood impacts in the past, Past experience, Extent of damage to home, Extent of damage to community, Damage from another tornado, Societal impact of recent earthquake, Disaster Impact, Impact, Hurricane experience, Past exposure to extreme	Prior Experience Severity

weather situations, Experienced earthquake impacts, Experience severity, Earthquake property damage experience in Oklahoma	
New Ecological Paradigm, New Ecological Values, Environmental attitudes	Pro-Environmental Orientation
Psychological distance, Psychological distance - social, Psychological distance - geographic, Psychological distance - temporal, Psychological distance - uncertainty, Psychological distance - hypotheticality, Psychological distance related to flooding, Psychological distance related to climate change	Psychological Distance
Religiosity, Religion, Religious, No religion, Importance of religion	Religiosity
Residing in community, Years living in the area, Community tenure, Number of years in New Orleans, Number of years in current home, Tenure, Duration community, Duration home, Residential time, Length of residence, Community tenure, Duration of residence in their town, Years living in the same place, Years living in the same house, Residence, Duration in neighborhood	Residential Tenure
Self-efficacy, Efficacy beliefs, Self-confidence, Perceived efficacy, Self-efficacy protect themselves, Self-efficacy climate change, Self-efficacy regarding ability to protect oneself and/or their family in the event of an eruption, Self-efficacy regarding hazards, Preparedness, Perceived effectiveness, Preparedness	Self-Efficacy in Response
Sense of Community, Place identity, Social cohesion, Psychological Sense of Community, Cognitive social capital, Social norms	Sense of Community
Social norms, Subjective norm, Descriptive norm, Injunctive norm, Normative concern, Family/friends want me to insure, Other people would buy too, Community norms	Social Norms
Social support, Social capital, Informal support	Social Support
Trust in authorities, Trust in government, Trust of government and information, Trust in government agencies, Trust in corporations, Trust in authorities and local authorities, Trust in High-level Government, Trust in local Government, Trust, Confidence, Government trust, Trust in scientists' knowledge, Social trust of Florida government officials, Trust in agency competency	Trust in Authorities
Social trust, Trust in Helpers, Family trust, General trust, Specific trust, Trust, Trust in general public knowledge	Trust in Community
Perceived vulnerability, Vulnerability awareness, Perceived Susceptibility, Perceived earthquake risk zone, Location perception	Vulnerability

5.6 Timeline of Task Activities

The task methodological activities started in December 2022. From December 2022 to January 2023, a literature review was conducted. From February to March 2023, theoretical elaboration has been carried out. In the next two months (April-May 2023), the definition of the query string and the search in the relevant databases proceeded, together with the consequent screening of the resulting bibliographic records by subject area, type of document, and language. Lastly, the removal of duplicates between databases have been carried out. The activities of June and July 2023 involved the screening of the bibliographic records resulting from the process by title, abstract, and keywords. During August and September 2023, the activities focused on screening the articles by full text and the consequent extraction of the effect sizes. In the last two months (October and November 2023), the data extraction and organization in datasets were concluded, the analyses were performed, and the deliverable prepared. A graphical representation of the timeline is shown in Figure 2.

Figure 2 - A graphical representation of the timeline followed for the completion of the meta-analyses

6. Results

6.1 Preliminary Analyses: Normality of Distribution

A complete list of the final studies included and a classification of studies for each antecedent are presented in Appendix A and B, respectively. Before conducting each meta-analysis, the normality of the distribution of the effects sizes for each predictor variables is assessed. Values of skewness and kurtosis between −2.5 and +2.5 are considered acceptable (Field, 2013). Table 3 presents the values of skewness and kurtosis for each predictor identified. For three predictors, skewness and kurtosis show a non-normality distribution of effects, namely Age, Education, and Income. Values remain unacceptable also after removing outliers. Thus, a violation of the assumption of normality of the distribution of the effects size for the meta-analysis is detected (Kontopantelis & Reeves, 2012) and these three variables are omitted from further analysis.

6.2 Main Results

Results are presented according to the two aims, namely:

- Aim 1: to estimate effect sizes of different potential antecedents of risk perception in the domain of natural hazards (Effect-sizes analysis);
- Aim 2: to investigate the effect of possible moderators of such relationships (Moderation analysis).

6.2.1 Aim 1: Effect Sizes Analysis

Overall, 127 studies (121 records) are considered. Results of the random-effect meta-analyses for each antecedent are shown in Table 4 and are ordered by effect size resulted. Figure 3 shows a graphical representation of the effects ordered by size.

Table 3 - Skewness and kurtosis of the predictor variables.

Factor	Skewness	Kurtosis
Age	**−1.72**	**9.98**
Altruistic Values	−0.72	0.89
Biospheric Values	−0.93	−0.49
Children	−1.51	0.56
Climate Change Awareness	1.23	0.7
Conservative	0.48	−0.35
Education	**1.45**	**7.22**
Egoistic Values	0.32	1.96
Event Perceived Likelihood	0.88	−0.3
Expected Response Efficacy	0.37	−1.29
Fatalism	−0.41	−1.52
Woman	0.01	1.01
Home Ownership	0.76	−1.28
Household Size	−0.08	−1.81
Income	**−1.24**	**5.44**
Knowledge	0.37	0.1
Married	−0.14	−1.55
Media Use	0.76	−0.86
Negative Emotions	0.13	−1.01
Objective Risk	−0.29	−0.88
Place Attachment	0.35	−1.01
Preparedness	0.69	−1.2
Prior Experience	0.1	−0.48
Prior Experience Severity	1.02	−0.56
Pro-Environmental Orientation	0.19	−2.21
Psychological Distance	0.44	−1.78
Religiosity	−0.47	−1.55
Residential Tenure	0.64	−0.15
Self-efficacy in Response	0.09	−1.11
Sense of Community	0.19	−1.98
Social Norms	−0.47	−1.29
Social Support	−0.18	−1.79
Trust in Authorities	0.98	0.34
Trust in Community	0.52	−1.74
Vulnerability	0.65	−1.03

Note. Variables for which the distribution of effects sizes resulted non-normal are highlighted in bold.

Table 4 - Results of the random effect meta-analyses, showing estimated effects for each antecedent of risk perception. Variables are sorted in ascending order of effect size.

Variable	*r*	*95% CI*	*k*	*n*	I^2	*Q*	τ^2	*p*
Social Support	-0.18	-0.40-0.07	5	4961	98.51	226.05	0.08	0.158
Conservative	*-0.16*	*-0.26- -0.06*	*15*	*13404*	*97.20*	*483.41*	*0.04*	***0.002***
Psychological Distance	-0.14	-0.52-0.29	5	1240	98.26	160.47	0.24	0.534
Place Attachment	-0.11	-0.39-0.20	7	3858	98.76	180.07	0.17	0.498
Children	*-0.09*	*-0.24-0.06*	*7*	*4674*	*96.12*	*112.87*	*0.04*	*0.239*
Fatalism	-0.07	-0.15-0.01	5	3260	77.34	15.69	0.01	0.069
Sense of Community	-0.05	-0.20-0.11	6	2821	93.51	59.80	0.03	0.551
Religiosity	*-0.03*	*-0.14-0.08*	*9*	*34549*	*98.04*	*435.07*	*0.03*	*0.542*
Married	*-0.01*	*-0.12-0.10*	*5*	*2258*	*82.70*	*20.20*	*0.01*	*0.877*
Residential Tenure	*0.01*	*-0.06-0.07*	*14*	*8193*	*87.37*	*101.56*	*0.01*	*0.905*
Self-efficacy in Response	0.05	-0.11-0.20	14	9364	98.18	679.04	0.09	0.541
Household Size	*0.06*	*0.01-0.10*	*8*	*5053*	*47.46*	*12.41*	*0.01*	***0.012***
Home Ownership	*0.08*	*-0.01-0.16*	*8*	*3272*	*82.49*	*38.79*	*0.01*	*0.074*
Trust in Community	0.09	-0.08-0.24	6	3894	95.86	137.30	0.04	0.296
Woman	*0.09*	*0.05-0.13*	*54*	*64943*	*95.21*	*839.64*	*0.02*	***<.0001***
Objective Risk	*0.1*	*0.02-0.17*	*12*	*6117*	*88.58*	*114.22*	*0.02*	***0.011***
Media Use	0.12	0.01-0.22	8	31878	97.15	169.45	0.02	**0.031**
Egoistic Values	0.16	0.08-0.24	7	4280	86.32	45.58	0.01	**0.001**
Prior Experience	*0.18*	*0.11-0.24*	*32*	*22459*	*95.92*	*696.85*	*0.03*	***<.0001***
Prior Experience Severity	*0.18*	*0.07-0.28*	*10*	*8268*	*94.68*	*67.64*	*0.03*	***0.001***
Preparedness	0.18	0.12-0.25	16	9870	89.36	187.90	0.01	**<.0001**
Trust in Authorities	0.19	0.03-0.34	15	13885	98.92	1333.14	0.10	**0.021**
Knowledge	0.19	0.13-0.25	33	24012	95.82	1316.13	0.03	**<.0001**
Vulnerability	*0.22*	*0.13-0.31*	*6*	*5684*	*90.15*	*78.46*	*0.01*	***<.0001***
Expected Response Efficacy	0.3	0.05-0.51	7	4359	98.48	402.59	0.12	**0.020**

Social Norms	0.35	0.25-0.45	13	10897	97.24	470.52	0.04	**<.0001**
Event Perceived Likelihood	*0.36*	*0.12-0.55*	*10*	*5510*	*98.81*	*1222.12*	*0.16*	***0.004***
Altruistic Values	0.4	0.32-0.47	7	4280	87.94	50.35	0.01	**<.0001**
Negative Emotions	*0.46*	*0.37-0.54*	*27*	*27722*	*98.73*	*1850.75*	*0.08*	***<.0001***
Biospheric Values	0.48	0.39-0.56	7	4280	91.46	80.76	0.02	**<.0001**
Climate Change Awareness	0.5	0.32-0.65	14	12236	99.27	2073.55	0.18	**<.0001**
Pro-Environmental Orientation	0.53	0.33-0.69	5	2661	97.38	85.77	0.08	**<.0001**

Note.

k = number of studies included in the meta-analysis

n = total number of participants across all the studies included in each meta-analysis

I^2 = proportion of heterogeneity attributed to differences between studies

Q = total heterogeneity observed in the analysis

τ^2 = absolute heterogeneity between studies

The sum of the total number of studies per meta-analysis is not equal to the total sample considered, since some studies are included in more than one meta-analysis.

As can been seen in Table 4, the effects of ten variables does not result significant, namely those of Social support, Psychological Distance, Place Attachment, Children, Sense of Community, Religiosity, Married, Residential Tenure, Self-efficacy in Response, and Trust in Community. There are the effects of two variables, namely Fatalism (negative effect) and Home Ownership (positive effect), which show a tendency to significance. Significant mean correlation effect sizes are then interpreted following Cohen's recommendations (Cohen, 1992): r =.10 represents a small, r =.30 a medium, and r =.50 a large effect. Twelve variables result in small effect sizes, namely Conservative, Household size, Woman, Objective Risk, Media Use, Egoistic Values, Prior Experience, Prior Experience Severity, Preparedness, Knowledge, Trust in Authorities, and Vulnerability. Six variables show medium effect sizes, namely Expected Response Efficacy, Social norms, Event Perceived Likelihood, Altruistic Values, Negative Emotions, and Biospheric Values. Lastly, two variables show large effect sizes, namely Climate Change Awareness and Pro-Environmental Orientation.

Figure 4 presents, for each antecedent, the number of studies that assesses risk perception for each type of natural hazard. Overall, in the included studies, perceived risk is assessed regarding twelve natural hazards and multi-risk hazards. Figure 4 shows how the literature on the topic focuses mainly on some specific natural hazards, while others are underrepresented. Specifically, the risk perception of earthquakes, floods, cyclones, and climate change seems overrepresented, while on the other hand, other natural hazards, such as landslides, drought, heat waves, or biodiversity loss turn out to be poorly investigated in the literature.

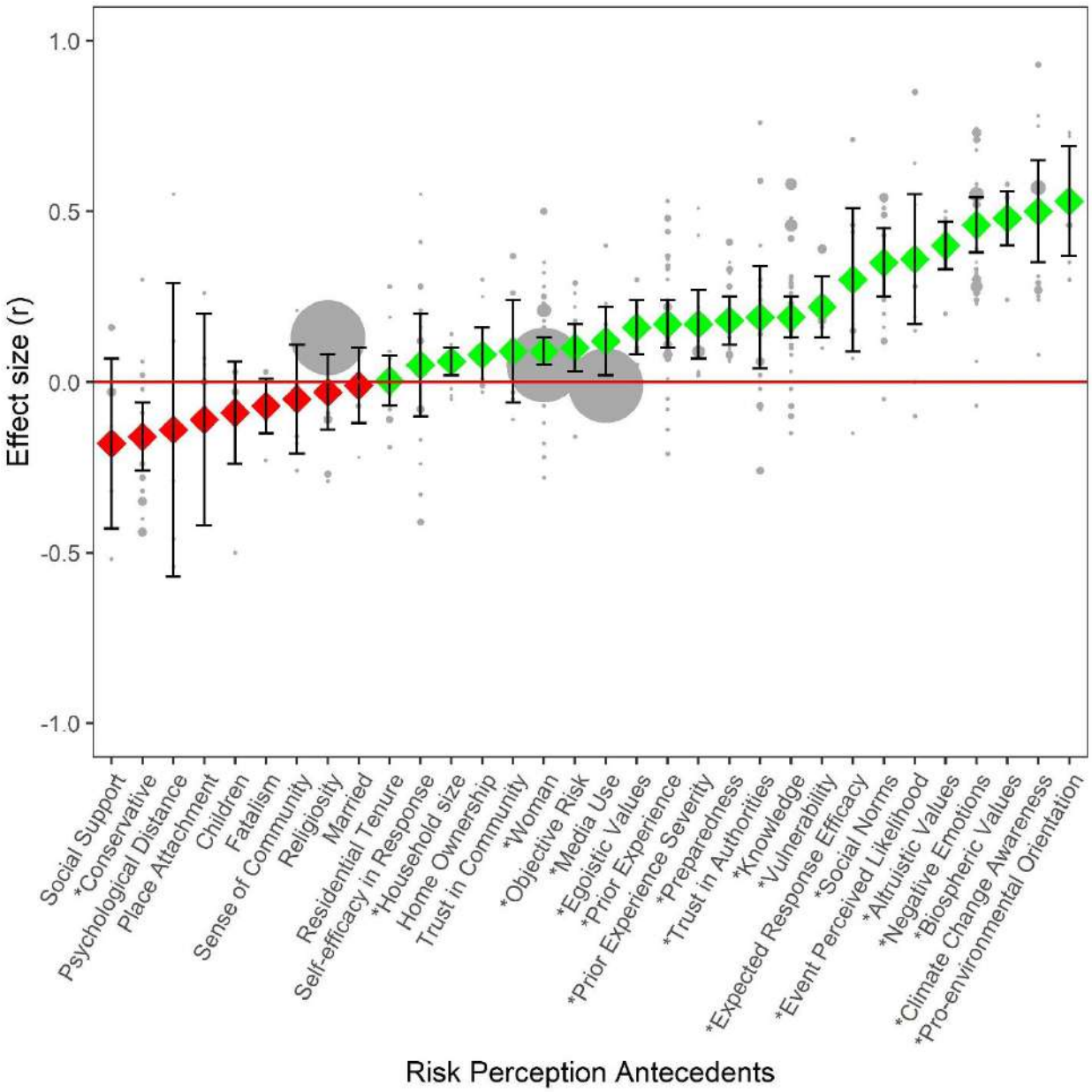

Figure 3 - Graphical representation of mean estimated effects for the antecedents of risk perception.

Note.

Red diamonds indicate negative meta-analytical effect sizes (*r*) for each specific variable.

Green diamonds indicate positive meta-analytical effect sizes (*r*) for each specific variable.

Error bars represent 95% confidence intervals (CI). Confidence intervals that include the zero (error bars that crosses the red line) indicate non-significant effect sizes (i.e., Social Support, Psychological Distance, Place Attachment, Children, Fatalism, Sense of Community, Religiosity, Married, Residential Tenure, Self-efficacy in Response, Home Ownership, and Trust in Community).

Variables names marked with an asterisk indicate significant effect sizes for that antecedent.

Each grey circle represents the single effect size observed in each individual study included in each meta-analysis, while the size of each circle represents the sample size of the respective study.

	Earthquake	Vulcanic activity	Landslide	Flood	Tsunami	Cyclone	Wildfire	Drought	Sea level rise	Heat wave	Biodiversity loss	Climate change	Multi-risk	Total
Social Support	1	0	0	2	0	0	0	0	0	0	0	1	1	5
Conservative	1	0	0	0	0	0	0	0	1	0	0	12	1	15
Psychological Distance	0	0	0	1	0	0	0	1	0	0	0	2	1	5
Place Attachment	0	0	0	3	1	1	1	0	0	0	0	0	1	7
Children	2	0	0	2	0	2	0	0	1	0	0	0	0	7
Fatalism	2	0	0	3	0	0	0	0	0	0	0	0	0	5
Sense of Community	0	1	0	3	0	1	0	0	0	0	0	0	1	6
Religiosity	1	0	0	0	0	0	0	0	0	0	0	6	2	9
Married	2	0	0	2	0	0	0	0	0	0	0	1	0	5
Residential Tenure	3	0	0	4	2	1	0	0	0	0	0	1	3	14
Self-efficacy in Response	1	2	0	1	1	0	2	0	0	0	0	4	3	14
Household size	0	2	0	3	2	0	0	0	0	0	0	1	0	8
Home Ownership	4	0	0	2	1	0	0	0	1	0	0	0	0	8
Trust in Community	3	0	0	1	0	0	0	0	0	0	0	1	1	6
Woman	7	2	0	9	2	5	0	0	1	1	0	22	5	54
Objective Risk	2	1	0	4	2	0	0	0	1	0	0	2	0	12
Media Use	1	0	0	0	0	1	0	0	1	0	0	4	1	8
Egoistic Values	0	0	0	0	0	0	0	0	0	0	0	7	0	7
Prior Experience	2	1	1	11	2	3	1	0	0	0	0	8	3	32
Prior Experience Severity	4	0	0	2	0	2	0	0	0	0	0	1	1	10
Preparedness	3	1	1	4	1	1	1	0	0	0	0	1	3	16
Trust in Authorities	1	1	0	2	0	1	1	0	0	0	1	5	3	15
Knowledge	5	1	1	4	3	0	0	0	0	2	1	13	3	33
Vulnerability	1	2	0	1	1	1	0	0	0	0	0	0	0	6
Expected Response Efficacy	1	1	0	0	0	1	0	0	0	0	0	3	1	7
Social Norms	2	0	0	1	0	0	0	0	0	0	0	9	1	13
Event Perceived Likelihood	2	0	0	2	1	1	1	0	0	0	0	2	1	10
Altruistic Values	0	0	0	0	0	0	0	0	0	0	0	7	0	7
Negative Emotions	2	1	0	7	0	1	0	0	0	0	1	12	3	27
Biospheric Values	0	0	0	0	0	0	0	0	0	0	0	7	0	7
Climate Change Awareness	0	0	0	0	0	2	0	0	0	0	0	11	1	14
Pro-environmental Orientation	0	0	0	0	0	0	0	0	0	0	0	4	1	5

Figure 4 - Contingency table showing the frequencies of the type of risk assessed per antecedent considered.

Note.

The column "Cyclone" includes hurricane, tornado, and typhoon.
The columns of other three expected types of natural hazards (namely, storm, thunder lightening, and ocean acidification) were removed since no studies were found for them.
The red colour highlights zero studies in that specific variable for that specific natural hazard.
The yellow colour emphasizes one to four studies in that specific variable for that specific natural hazard.
The green colour indicates at least five studies in that specific variable for that specific natural hazard. The green colour also shows that an adequate number of studies is available to conduct a specific meta-analysis in that specific variable for that specific natural hazard.

6.2.1.1 Publication Bias

Publication bias occurs whenever published research is systematically unrepresentative of the population of studies done in a specific topic (Rothstein et al., 2005). This may take place due to the tendency to publish statistically significant results more than non-significant ones, leading to biased meta-analysis and inflated estimates (Card, 2015). To evaluate the presence of publication bias, the distribution of effect sizes and standard errors around the pooled estimated effects are plotted to assess asymmetry. Moreover, the failsafe N test (Rosenthal, 1979), the trim-and-fill method (Duval & Tweedie, 2000) and Egger's regression test of funnel plot asymmetry (B. Egger et al., 2011; M. Egger et al., 1997) are considered. See Table 5 for results of the analysis for the assessment of publication bias.

As can been seen in Table 5, the funnel plot asymmetry test is significant for five predictors, namely Prior Experience Severity, Fatalism, Psychological Distance, Trust in Community, and Pro-Environmental Orientation. The trim-and-fill method indicate the addition of data points for elven predictors (see Table 6). One study is imputed for altruistic values, with the effect remaining the same, and for Pro-Environmental Orientation, for which the resulted effect would have been weaker. Two studies are imputed for Household Size, Children, Vulnerability, Event Perceived Likelihood, Negative Emotions, Climate Change Awareness, and Biospheric Values. The effects would have been non-significant for household size, would have remained non-significant for Children, slightly stronger for Vulnerability, the same for Event Perceived Likelihood and Biospheric Values, almost the same for Negative Emotions, and stronger for Climate Change Awareness. Three studies are imputed for Prior Experience, indicating that the effect would have been stronger. Lastly, nine studies are imputed for Knowledge, suggesting that the effect would have been stronger.

Failsafe *N* tests indicate that, except for Household Size, a considerable number of effects lacking statistical significance would be required to make the overall effect non-significant. This means that, except for Household Size, meta-analyses conducted can be considered stable, with a very low risk that emerged results could be imputable to case and, thus, be considered significant when in fact they are non-significant. All in all, there is some evidence that publication bias affects the effects sizes resulted from the analyses.

6.2.2 Aim 2: Moderation analysis

Moderation analyses are generally conducted in meta-analyses to interpret heterogeneity across studies (Lipsey, 2003). In our case, results of most of the meta-analyses conducted showed considerable heterogeneity among effect sizes reported by each individual study included (see Table 4, indices I^2, Q, and τ^2). To detect possible sources of heterogeneity, different moderator variables are hypothesized.

Table 5 - Results of the analysis for the assessment of publication bias, sorted by effect size.

Antecedent	Asymmetry	Trim and fill	Adjusted effect	Failsafe N
Social Support	|Z|=-0,96; P=0,34	No data points imputed	NA	NA (overall effect was already nonsignificant)
Conservative	|Z|=1,55; P=0,12	No data points imputed	NA	2554
Psychological Distance	**|Z|=2,05; P=0,04**	No data points imputed	NA	NA (overall effect was already nonsignificant)
Place Attachment	|Z|=0,38; P=0,70	No data points imputed	NA	NA (overall effect was already nonsignificant)
Children	|Z|=-0,49; P=0,62	No data points imputed	NA	NA (overall effect was already nonsignificant)
Fatalism	**|Z|=-3,04; P=0,002**	No data points imputed	NA	NA (overall effect was already nonsignificant)
Sense of Community	|Z|=1,08; P=0,28	No data points imputed	NA	NA (overall effect was already nonsignificant)
Religiosity	|Z|=-0,66; P=0,51	No data points imputed	NA	NA (overall effect was already nonsignificant)
Married	|Z|=-1,12; P=0,26	No data points imputed	NA	NA (overall effect was already nonsignificant)
Residential Tenure	|Z|=0,94; P=0,34	No data points imputed	NA	NA (overall effect was already nonsignificant)
Self-efficacy in Response	|Z|=0,82; P=0,41	No data points imputed	NA	NA (overall effect was already nonsignificant)
Household Size	|Z|=-0,93; P=0,35	**2 studies imputed**	**r=-0,08; 95%CI[-0,03;0,12]**	**27**
Home Ownership	|Z|=0,89; P=0,38	No data points imputed	NA	NA (overall effect was already nonsignificant)
Trust in Community	**|Z|=-2,79; P=0,005**	No data points imputed	NA	NA (overall effect was already nonsignificant)
Woman	|Z|=-0,83; P=0,41	No data points imputed	NA	7625

Objective Risk	|Z|=0,98; P=0,33	No data points imputed	NA	222
Media Use	|Z|=0,88; P=0,38	No data points imputed	NA	190
Egoistic Values	|Z|=0,76; P=0,45	No data points imputed	NA	260
Prior Experience	|Z|=-1,09; P=0,28	**3 studies imputed**	**r=0,21; 95%CI[0,14;0,28]**	7694
Prior Experience Severity	**|Z|=3,16; P=0,002**	No data points imputed	NA	438
Preparedness	|Z|=-1,55; P=0,12	No data points imputed	NA	2008
Trust in Authorities	|Z|=0,68; P=0,49	No data points imputed	NA	1875
Knowledge	|Z|=-1,94; P=0,052	**9 studies imputed**	**r=0,27; 95%CI[0,20;0,34]**	12370
Vulnerability	|Z|=-0,78; P=0,43	**2 studies imputed**	**r=0,27; 95%CI[0,18;0,36]**	626
Expected Response Efficacy	|Z|=-1,29; P=0,19	No data points imputed	NA	1291
Social Norms	|Z|=-0,36; P=0,72	No data points imputed	NA	6782
Event Perceived Likelihood	|Z|=-0,31; P=0,75	**2 studies imputed**	**r=0,48; 95%CI[0,23;0,73]**	2972
Altruistic Values	|Z|=0,95; P=0,34	**1 study imputed**	**r=0,40; 95%CI[0,32;0,49]**	1826
Negative Emotions	|Z|=-0,88; P=0,38	**2 studies imputed**	**r=0,54; 95%CI[0,43;0,65]**	61809
Biospheric Values	|Z|=0,27; P=0,79	**2 studies imputed**	**r=0,48; 95%CI[0,38;0,58]**	2836
Climate Change Awareness	|Z|=-0,04; P=0,97	**2 studies imputed**	**r=0,62; 95%CI[0,41;0,83]**	15801
Pro-Environmental Orientation	**|Z|=2,24; P=0,03**	**1 study imputed**	**r=0,40; 95%CI[0,32;0,49]**	1156

Such moderators have been picked up because they vary across the included studies and/or because they do not reach the threshold to be included as predictors ($k \geq 5$) and/or because they represent inter-study methodological differences theoretically bearing potential effects. Some moderators are considered across all variables, while others are hypothesized only for specific variables.

Specifically, the moderators hypothesized for all variables are:

- Case study (n/y);
- Type of natural hazard (Climate Change/Other);
- Rural/urban sample;
- Low/high risk area sample;
- Age;
- Gender.

Moderators hypothesized for specific variables are:

- Residential tenure referring to Area/Home (variable: Residential tenure);
- Measurement referring to having or not experienced/Frequency of experience of a specific natural hazard (variable: Prior Experience);
- Type of Knowledge (i.e., Objective knowledge/Subjective knowledge; variable: Knowledge);
- Type of Social Norms (i.e., Descriptive/Injunctive; variable: Social norms).

Hypothesized moderators are tested only on significant effect-size meta-analyses.

Despite the hypotheses, in practice, it is not always possible to test the identified moderators since not for every antecedent variable the minimum number of studies required for moderation analyses is reached. Indeed, studies reporting information on the moderator variables needs to be a minimum of 6 studies for each continuous moderator (in our case, Age), and a minimum of 4 studies for each level of a categorical moderator (Fu et al., 2011). Some moderators are never tested since they never reach the above-mentioned thresholds:

- Gray Literature (n/y);
- Type of Risk (health, economic);
- Risk Attribution (to self/others);
- Education.
-

All moderation analyses are reported in Table 6.

6.3 Ancillary Analyses: Detection of Outliers

Outlier analyses are performed to assess meta-analyses sensitivity to single studies influencing the results, as recommended by Viechtbauer and Cheung (2010). To this aim, two different methods are employed, namely the "leave one out" through sensitivity analysis (Cooper et al., 2009; Sahebkar, 2013a, 2013b) and the Cook's distances (Läuter, 1985). Outliers are removed only when the normality of the distribution of the effect sizes is violated and/or its removal affects significance of the effect. In such cases, the meta-analysis is launched again without the outlier (Viechtbauer & Cheung, 2010). Following these considerations, outliers are detected and removed from final analysis in four cases, namely for the variables: Objective Risk, Prior Experience Severity, Knowledge, and Trust in Authorities.

Regarding the predictor Objective Risk, the study by Babcicky and Seebauer (2017) is considered an outlier because it is the study reporting the greater Cook distance and the higher impact on heterogeneity, according to the sensitivity analysis (Cooper et al., 2009; Läuter, 1985). Indeed, it reports stronger than average negative correlation ($r = -.39$). Its removal makes the non-significant meta-analysis significant. Before the removal, the effect is non-significant ($r = .07$; $p = .183$), while, after the removal, it becomes significant ($r = .10$; $p = .011$), also reducing heterogeneity among the effects of the studies (from $I^2 = 93.16$ to $I^2 = 88.58$). The removal is not affecting normality of the distribution since skewness and kurtosis presents acceptable values both before ($S = -1.02$; $K = .44$) and after ($S = -.29$; $K = -.88$) the outlier removal.

Regarding the predictor Prior Experience Severity, the study by Han et al. (2021) is excluded from further analysis. The study is considered an outlier because it is the one reporting the greater Cook distance and the higher impact on heterogeneity (Cooper et al., 2009; Läuter, 1985). Indeed, it is the only study reporting a negative (and strong) effect ($r = -.43$). Before the removal, the meta-analysis results non-significant ($r = .12$; $p = .110$) and becomes significant after the outlier removal ($r = .18$; $p = .001$). Heterogeneity is only slightly affected (from $I^2 = 97.66$ to $I^2 = 94.68$). The effects are normally distributed both before ($S = -.44$; $K = .29$) and after ($S = 1.02$; $K = -.57$) Han and colleagues' study removal.

Regarding Knowledge, the study by Lowe et al. (2022) is removed. It is the study reporting the greater Cook distance and the higher impact on heterogeneity (Cooper et al., 2009; Läuter, 1985). Indeed, the study presents a stronger than average positive correlation ($r = .77$). Significance of the meta-analysis is not affected since the effect is significant ($r = .21$; $p < .001$) and remains such ($r = .19$; $p < .001$) after the outlier removal. Heterogeneity decreases only slightly (from $I^2 = 97.22$ to $I^2 = 95.82$). Nevertheless, the distribution of the effects is affected significantly by the outlier removal since values of kurtosis indicates non-normality before removal ($S = 1.27$; $K = 2.68$), while becomes acceptable after removal ($S = .37$; $K = .10$).

Table 6 - Results of the moderation analyses conducted on the relationships between different antecedents of risk perception and risk perception.

Antecedents of risk perception	*r*	*p*	R^2
Conservative			
Moderator: Age		0.406	0.00%
Woman			
Moderator: Case study		0.273	1.14%
Moderator: Type of natural hazard		0.093	4.95%
Moderator: Rural/urban sample		0.613	0.00%
Moderator: Low/high risk area sample		**0.001**	17.11%
Low risk area sample	0.17	**<.0001**	
High risk area sample	0.03	0.342	
Moderator: Age		0.782	0.00%
Objective Risk			
Moderator: Case study		0.871	0.00%
Egoistic Values			
Moderator: Age		0.703	0.00%
Prior Experience			
Moderator: Y/N, Frequency		0.350	0.00%
Moderator: Case study		0.462	0.00%
Moderator: Type of natural hazard		0.653	0.00%
Moderator: Rural/urban sample		0.710	0.00%
Moderator: Woman		0.336	0.65%
Prior Experience Severity			
Moderator: Case study		0.888	0.00%
Moderator: Age		0.176	15.98%
Preparedness			
Moderator: Case study		0.164	6.80%
Moderator: Woman		0.810	0.00%
Moderator: Age		0.752	0.00%
Trust in Authorities			
Moderator: Case study		0.971	0.00%
Moderator: Type of natural hazard		0.189	7.02%

Knowledge			
Moderator: Type of Knowledge		**0.028**	13.53%
Objective knowledge	0.13	**0.005**	
Subjective knowledge	0.28	**<.0001**	
Moderator: Case study		0.984	0.00%
Moderator: Type of natural hazard		0.924	0.00%
Moderator: Rural/urban sample		0.270	2.50%
Moderator: Low/high risk area sample		0.698	0.00%
Moderator: Woman		0.984	0.00%
Social Norms			
Moderator: Descriptive/Injunctive		0.485	0.00%
Moderator: Low/high risk area sample		0.917	0.00%
Moderator: Age		0.787	0.00%
Altruistic Values			
Moderator: Age		0.316	0.00%
Negative Emotions			
Moderator: Type of natural hazard		**0.036**	13.35%
Climate change	0.54	**<.0001**	
Other natural hazard	0.36	**<.0001**	
Moderator: Case study		0.277	1.10%
Moderator: Low/high risk area sample		**0.041**	21.58%
Low risk area sample	0.54	**<.0001**	
High risk area sample	0.31	**0.001**	
Moderator: Woman		0.235	2.85%
Biospheric Values			
Moderator: Age		0.791	0.00%
Climate Change Awareness			
Moderator: Low/high risk area sample		0.990	0.00%
Moderator: Age		0.644	0.00%

Lastly, regarding the variable Trust in Authorities, again the study by Han et al. (2021) is removed considering the Cook distance and the impact on heterogeneity (Cooper et al., 2009; Läuter, 1985). Indeed, it reports a stronger than average negative correlation ($r = -.50$). The removal influences the significance of the results: when analysis comprised the outlier, the effect is non-significant ($r = .15$; $p = .110$), while after removal it becomes significant ($r = .19$; $p = .021$). Heterogeneity is reduced only slightly (from $I^2 = 99.11$ to $I^2 = 98.92$). The removal is not affecting the normality of the distribution (before: $S = .47$; $K = .21$; after: $S = .98$; $K = .34$).

7. Discussion

First, results discussion is presented; then, some tentative implications are advanced for both scientific research and applied purposes; finally, the take home message summarizes key findings.

7.1 Discussion of the Findings

The aim of the current work is twofold. The first aim is to identify the antecedents of risk perception, while the second is to find moderators of the resulting relationships. Regarding the first aim, a series of thirty-two meta-analyses show significant relationships with most of the predictors emerged from the literature. In particular, resulted antecedents tap the clusters identified by Bonaiuto and Ariccio (2020), namely:

1. factors related to the relationship between the individual and the risk: Objective Risk, Prior Experience, Prior Experience Severity, Preparedness, Knowledge, Vulnerability, Expected Response Efficacy, Event Perceived Likelihood, Negative Emotions, Climate Change Awareness;
2. factors related to the relationship between the individual and the community: Media Use (namely how individuals gather relevant socially shared information available for the community), Trust in Authorities, Social Norms;
3. individual factors:
    a. sociodemographic factors: Conservative, Household Size, Woman;
    b. dispositional factors: Egoistic Values, Altruistic Values, Biospheric Values, Pro-Environmental Orientation.

Other two individual factors, namely Home Ownership and Fatalism, show effects that are only marginally significant ($.05 < p < .10$). Findings are generally in line with previous review on the topic (Boholm, 1998; Wachinger et al., 2013), with the difference that the current work gives also back a quantitative summary of the effects reported in the literature. Moreover, these results answer important questions raised by these reviews. For instance, it emerges that Prior Experience and Prior Experience Severity exhibit the same positive effect, contrary to what hypothesized by Wachinger et al. (2013). Indeed, they expected that it is the severity of the experience to affect risk perception, more than experience itself. These meta-analyses show that both aspects of experience play a similar role.

In particular, the strongest effects (above .30, i.e., medium to large effect sizes) regarding the first cluster, namely the factors concerning the relationship between the individual and the risk, emerge for the variables Climate Change Awareness, Negative Emotions, Event Perceived Likelihood, and Expected Response Efficacy. The strongest effects regarding the second cluster, namely the variables related to the relationship between the individual and the community, are observed for Social Norms. Lastly, the largest effects for the third cluster, namely individual factors, are observed for Pro-Environmental Orientation and individual values (i.e., Biospheric and Altruistic). All in all, it seems that the cluster with the majority of variables showing strong effects is the first one (factors concerning the relationship between the individual and the risk). Regarding individual factors, only dispositional factors exhibit strong effect; in fact, regarding the other factors included in this cluster, namely the sociodemographic factors, no variable exhibited medium to large effects and, thus, this suggests that they are less important antecedents. Overall, the findings are partly in line with the recent meta-analysis by van Valkengoed and Steg (2019) on predicting adaptation behaviours to climate changes, especially regarding medium effects observed for Expected Response Efficacy, Negative Emotions, and Social Norms, and the significant role (although with different magnitudes) of Climate Change Awareness, Knowledge, Prior Experience, and Trust in Authorities.

What emerges from these findings is that, for the first cluster's factors, higher risk perception is predicted by: higher objective risk associated with the area of living, having had prior experience with the natural hazard, higher severity from this previous experience, higher engagement with preparative behaviours, as well as higher awareness related to the risk, specifically higher knowledge of the natural hazard, higher perceived vulnerability to the natural hazards, higher expectation that one's response to the specific natural hazard can be effective, higher perceived likelihood that the natural hazard can occur, more heightened negative emotions experienced concerning the specific natural hazard, and higher perception that climate change is happening.

Moreover, regarding the second cluster's factors, higher frequency of media uses for information seeking regarding the natural hazard, higher trust in authorities (e.g., local, government), and greater attention and perception of what others in the community do and believe, namely higher social norms related to the natural hazard, are also associated with stronger risk perception.

Finally, for the third cluster's factors, some individual factors seem to facilitate risk perception. In detail, some sociodemographic factors increase risk perception: having a greater household size, being a woman, and being liberal. Similarly, some personal dispositions heighten an individual's risk perception too: higher importance given to maximizing individual outcomes, the welfare of others, and the environment and the biosphere (i.e., egoistic, altruistic, and biospheric values), and having a pro-environmental orientation, thus believing that humans are dependent on nature and need to protect it.

Although the findings are rich and deserve attention, it is important to highlight that several meta-analyses point to a certain degree of publication bias across different antecedents. This means that results regarding these variables (i.e., Psychological distance, Fatalism, Household Size, Trust in Community, Prior Experience, Prior Experience Severity, Knowledge, Vulnerability, Event Perceived Likelihood, Altruistic Values, Negative Emotions, Biospheric Values, Climate Change Awareness, and Pro-Environmental Orientation) should be interpreted with caution. Lastly, almost all meta-analyses show a high degree of heterogeneity among study conducted. This points to a high dispersion of effect sizes among studies considered for each meta-analysis. One way to explain this heterogeneity is through the identification of moderators.

Thus, the second aim of this work is to find possible moderators of the identified relationship of each predictor with risk perception. The conducted moderation analyses showed important moderators as well as non-significant moderators. Regarding the former, Low or high-risk area sample is moderating the relationship between Woman and Risk perception, in a way that the effect is positive and significant only when the risk area of the sample is low. This can mean that women may better foresee risk when not immediately salient, while, when the risk is high, there is not such difference between genders. Moreover, the Type of Knowledge moderates the relationship between Knowledge and Risk perception. It results that both Objective and Subjective Knowledge are positively associated with Risk Perception, but the effect is stronger for Subjective Knowledge. This points to the importance of acquired knowledge, and awareness of knowledge, more than just knowing per se. Lastly, two moderators are significant in the relationship between Negative Emotions and Risk Perception, namely the Type of Natural Hazard considered and the Low or High Risk Area of the Sample. It emerges that Climate change and Low risk area sample had higher effect as compared to Other types of natural hazard and High risk area sample. This result should be investigated further, since there could be an overlap between the two moderators; indeed, samples interviewed regarding climate change are almost always coded as in a low-risk area (i.e., not immediate risk).

Of note are also the non-significant effect of the moderators Case study, Rural/urban sample, Age, and Gender, which strengthen the importance of the relationship observed. Moreover, the moderation analysis also shows that the Measurement of Prior Experience (i.e., having or not experienced vs. frequency of experience) does not affect the relationship between this antecedent and risk perception in line with the result of the meta-analysis by van Valkengoed and Steg (2019). Similarly, for Social Norms, the Type of Norm (i.e., injunctive or disjunctive) does not affect the relationship between the antecedent Social Norm and Risk Perception (i.e., both norms equally work).

All in all, this contribution represents a novel attempt to quantitatively summarize the available literature on the topic of the determinants of risk perception. Some strengths of the work lie in the broad inclusivity of records that allowed to consider interdisciplinary studies, including also grey literature, and with no limits in terms of authors' countries (contrary to the review by Wachinger et al., which focused only on European research). This research is not free of limitations too. One of the most important is the choice

regarding the measurement of risk perception for a study to be included in the meta-analyses, with the consequence of having excluded different conceptualizations of risk perception. This may have also reflected in the results. As reported elsewhere (Wilson et al., 2019), risk perception has been measured in different ways. Meta-analyses considering the antecedents of different, more specific, aspects of risk perception, such as event perceived likelihood and risk salience, may give somewhat different results.

7.2 Research Implications

Although the results of the meta-analyses presented here help answering questions raised in the literature, at the same time, they open new research pathways. More specifically, the relationships between some antecedents and risk perception deserve further investigation. For instance, the results highlight how higher frequency of exposure to media that deal with the specific natural hazard is associated with greater risk perception. Future studies may delve into this relationship, by investigating which type of communication has proved to be more effective, as well as the preferable media source. This research may provide important guidelines for policy makers interested in enhancing awareness regarding specific risks associated to natural hazards.

Moreover, as mentioned in the Materials and Methods section, the literature search highlights that the findings on the topic should be broaden. First, fourteen variables (i.e., Attribution of Responsibility, Big Five Personality Traits, Community Participation, Connectedness with Nature, Employment, Environmental Attitudes, Frequency of Information Exchange in the Social Network, Future Migration Probability, Locus of Control, Perceived Behavioural Control, Risk Salience, Risk Seeking, Rural or Urban Residential Location, Worldviews) are found not reaching the minimum of five studies required for conducting a meta-analysis. Thus, to allow a quantitative summary of results available including such variables too, more research is needed. Moreover, as mentioned in the Results section (see Figure 4), research is scanty regarding some types of natural hazards (e.g., landslides, drought, heat waves, biodiversity loss) across all the variables here considered. Therefore, broader research is needed to collect more data and to deepen the investigation of the antecedents of risk perception regarding these specific natural hazards. This would be even more important considering that moderation analysis showed how the type of natural hazards may intervene in altering the relationship between the antecedent and risk perception.

7.3 Applied Implications

The findings reported here may guide decision and policy makers in enhancing awareness on risk especially, but not limited to, high risk populations. In particular, risk management should consider the three clusters of antecedents and intervene accordingly to the specific phase in which risk perception proved essential, namely preparedness and response.

Regarding the factors concerning the relationship between the individual and the risk, knowledge may be favoured through media and education. Moreover, personal prior experience may be prompt through simulations that may show to participants the possible risk through direct training (Bonaiuto & Ariccio, 2020). Required timeframe could be estimated as short-medium time, under appropriate circumstances, with the necessity of a long-term frame for more stable and durable effects.

Implications at societal level are envisaged in the second cluster, namely the factors concerning the relationship between the individual and the social community. Importantly, community interventions may consider the power of descriptive and injunctive norms in sustaining risk perception, that is, evidence from consensual behaviours respectively suggested (injunctive norms) as well as adopted (descriptive norms) by significant others. This may be used, for example, in advertisement as well as on social media and media in general. Trust in authorities may be favoured through direct dialogue with institutions, and leaders more attentive to the need of population. Required timeframe could be estimated at least as short-medium time, under appropriate circumstances, with the necessity of a long-term frame to enable stability and durability.

Lastly, as highlighted also by Bonaiuto and Ariccio (2020), individual factors may be more difficulty addressed because they are less easy to change. Fortunately, regarding socio-demographic factors, what emerged is also that these variables are not so important as compared to the other clusters. Both socio-demographic and dispositional factors resulted from the meta-analyses may be taken into consideration when designing educational, informational, and community interventions, to tailor specific actions for different individuals. Interestingly, it seems that, among the most important dispositional determinants, there are people's values, which are relatively stable individual dispositions. It seems that all values (whether biospheric and altruistic ones as expected, or egoistic ones too) can play an important positive role here, in the sense that any target (either the environment, or other persons, or the person's interests), which is endowed with subjective importance, can work as a trigger for enhancing risk perceptions (and consequently protection behaviours) from people who assign importance to that target. This may entail considering the importance given to different targets by different cultures and micro-cultures. Interventions should be fuelled by continuous research and vice versa, to more deeply understand how to encourage protective actions by specific populations and constantly ameliorate field interventions.

7.4 Take Home Message

In conclusion, why is it important to study the antecedents of risk perception? High risk perception has been found to be an important motivational factor for individuals in taking action to protect themselves from a natural hazard (van Valkengoed & Steg, 2019a). Nevertheless, the relationship between risk perception and behaviour is not straightforward. In fact, scholars has been referring to a "risk perception paradox" for which high perceived risk is often not associated, or even negatively associated, with protective behaviour, both before, during and after the event (Wachinger et al., 2013). It could also be that the relationship between risk perception and protective behaviours is nonlinear: too low or too high-risk perceptions may lead to freezing, while a good amount of it may be more constructive. Studying the antecedents of risk perceptions is important to shed light on the mechanisms underlying it and to intervene in altering risk perceptions to favour protective behaviour. The take home message of the present meta-analysis is that risk perception, being a potential precursor of adaptation to environmental hazards at least if it is not too high nor too low, can be adequately boosted by the following factors (ordered by Effect Size, ES).

1) Factors related to the relationship between the individual and the risk are taken into consideration, namely from the weaker ones with white dots (ES < .30) to the stronger ones with black dots (ES > .30):
    - higher objective risk,
    - presence of prior experience with the natural hazard,
    - higher severity of this previous experience,
    - higher engagement with preparative behaviours,
    - higher knowledge of the natural hazard,
    - higher perceived vulnerability to the natural hazard,
    - higher expectation that one's response to the specific natural hazard could be effective (i.e., Expected Response Efficacy)
    - higher perceived likelihood that the natural hazard can occur,
    - higher negative emotions experienced concerning the specific natural hazard,
    - higher perception that climate change is happening.

2) Factors related to the relationship between the individual and the community are considered, namely from the weaker ones with white dots (ES < .30) to the stronger ones with black dots (ES > .30):
    - higher frequency of media uses for information seeking regarding the natural hazard,
    - higher trust in authorities (e.g., local, government),
    - higher social norms (both injunctive and descriptive ones) related to the natural hazard.

3) Factors pertaining the individual's sociodemographic and dispositions from the weaker ones with white dots (ES < .30) to the stronger ones with black dots (ES > .30):
    - having a greater household size,
    - being a woman,
    - being liberal,
    - stronger importance given to maximizing individual outcomes (i.e., Egoistic Values),
    - stronger importance given to the welfare of others (i.e., Altruistic Values),
    - stronger importance given to the environment and the biosphere (i.e., Biospheric Values),
    - a greater pro-environmental orientation (measured with NEP).

7.5 Project's internal implications

This section aims to transfer the above reported outcomes into the various WPs and Tasks featuring internal partners in Task 5.1 (listed according to the Gantt diagram). Paragraphs are assigned to a specific Task or WP, being written by each responsible unit as follows:

1. the paragraph "Community and policy maker awareness (T 5.3)" is written by Adriano Schimmenti, Rubinia Celeste Bonfanti, and Giovambattista M. L. Presti (UNIKORE);
2. the paragraph "Risk elicitation methods (T 5.2)" is written by Anna Rinaldi and Ettore Gallo (UNIBA);
3. the paragraph "New approach in integrated planning based on co-design processes for DRR e CCA policies (T 4.4)" is written by Emilia Corradi, Camillo Frattari, and Francesca Vigotti (POLIMI);
4. the paragraph "Nudging the uncertainty (T 5.4)" is written by Luca Cetara, Tommaso Bastiani, Veronica Castiglione, and Pasquale La Malva (EURAC);
5. the paragraph "New models of education and communication for resilience to risks (WP6)" is written by Francesca Comunello and Alessandra Massa (UNIROMA1), and Stefano Scippo (UNIFI)

7.5.1 Community and policy maker awareness (T 5.3)

The public's perception of risk is fundamental in the processes of preventing, responding to, and recovering from risks (Alegria et al., 2021). This systematic review and meta-analysis has demonstrated the importance of recognizing the antecedents of risk perception, given their significance for individuals in taking action to globally protect themselves from natural hazards (van Valkengoed & Steg, 2019b). Simultaneously, these meta-analytic findings are crucial for the implementation of risk intervention policies.

The majority of the predictors that emerged for risk perception concern the relationship between the individual and the risk (e.g., Prior Experience or Knowledge). This finding underscores the significance of integrating individual and local knowledge as valuable information sources for disaster experts and scientists. Engaging with the local community and considering people's knowledge and prior experiences can help implement intervention policies in a functional manner, and it also fosters community trust among stakeholders involved in disaster risk reduction efforts (Marín et al., 2020). From this vantage point, policymaking ought to prioritize the establishment of collaborative and participatory bonds between disaster experts and local communities. This approach not only diminishes the adverse effects of a lack of risk awareness and uncertainty, but it also fosters heightened levels of trust within both the community and its institutions. Also, factors concerning the relationship between the individual and the community (e.g., Media use or Trust in Authorities) were found to be significant antecedents of risk perception. Focusing on these variables during risk management policies is thus crucial. Through effective utilization of communication channels (e.g., mass media or social media), disaster experts can facilitate the dissemination of emergency information and the development of trust. In turn, trust contributes to enhancing community awareness, fostering a deeper understanding of hazard processes, therefore playing a fundamental role in increasing community preparedness (Zander et al., 2022). Trust in Authorities, in addition to resulting a predictor variable of risk perception, should be interpreted as a fundamental variable throughout the disaster management cycle. In this cycle, individuals can cultivate trust in their community (e.g., relatives, neighbours, coworkers) and institutions (e.g., agencies, authorities, government). Building trust can significantly enhance the capacity for disaster risk prevention, management, and resilience in communities.

Finally, some individual factors seem to facilitate risk perception (e.g., being liberal or having a greater household size). These findings could be useful with respect to communication strategies to be implemented in intervention policies. Having a specific target profile (i.e., specific group of individuals; Jansen et al., 2020) facilitates the development of appropriate messages and their dissemination for disaster risk reduction and climate change adaptation.

Considering the findings of this study, it is worth noting that increased frequency of exposure to media dealing with the specific natural hazard is connected with greater risk perception. For this reason, it is crucial to emphasize the importance of risk communication, with their related policies and practices. Essentially, irrespective of the specific motivation behind communication before, during, and after risks, any methodologies devised for public risk communication should be grounded in a comprehensive understanding of the precursors of risk perceptions and subsequent expected behaviours. This is particularly crucial given the public's expectations of effective communication in high-impact risk situations.

Primarily, it is imperative to grasp that the accurate reception of messages by the public can delineate the divergence between a successful and unsuccessful response. The quality of risk communications significantly shapes both risk perceptions and subsequent behaviors, consequently impacting the probability

of encountering diseases, injuries, survival, or fatalities. Acknowledging that public responses to critical events often mirror the quality and accessibility of knowledge and information, alongside the degree of trust toward institutions, stands as a pivotal stride in governments' strategic communication efforts.

Indeed, an effective communication strategy holds the potential to cultivate heightened trust, facilitating a stronger linkage between individual responses, risk awareness, and actions taken to mitigate or address disasters. It is noteworthy that endeavors aimed at nurturing trust within institutions and enhancing community resilience should commence well in advance of the initial phases of risk management. As all facets of disaster risk reduction—comprising prevention, preparedness, response, and recovery—are interlinked and frequently intersect (Bullock et al., 2013), successful disaster risk reduction strategies necessitate the early cultivation of trust in authorities and the broadening of knowledge. This might also involve tailoring messages to suit specific target groups and diversifying them as needed, as this meta-analysis suggests: indeed, establishing a robust sense of trust is paramount for limiting damage and expediting recovery, as shown by research indicating that communities characterized by strong trust, solidarity, and active participation exhibit more efficient responses to natural disasters.

7.5.2 Risk elicitation methods (T 5.2)

The investigation of how individuals perceive objective risk, that is subjective risk, is deeply intertwined with the way preferences are formed in different contexts. In this respect, the investigation of individual preferences under conditions of risk and uncertainty is fundamental to understanding decision-making processes across numerous sectors and domains, which is the topic of task 5.2.

From the behavioural economics perspective, the ability to elicit and measure individuals' preferences provides valuable insights into their willingness to take risks and informs crucial choices and strategies. However, the diversity of available methods for eliciting preferences presents a challenge for researchers seeking to select the most appropriate approach for their specific research question and study population.

To examine different individual perceptions under different scenarios, the focus is on the difference between elicitation techniques under conditions of risk and uncertainty, moving beyond the traditional boundaries of normative theory à la Savage (Savage, 1954). In doing so, the canonical distinction of Knight (1921), according to which risk refers to scenarios where probabilities of certain outcomes can be objectively determined or estimated based on available data and statistical analysis, is followed. This is not the case in situations of uncertainty, where individuals at most have knowledge of the probability distribution.

Under conditions of risk, decision-makers can employ quantitative models and techniques to assess and effectively manage risky outcomes. On the other hand, uncertainty pertains to situations characterized by

a lack of reliable data or an inability to assign probabilities to potential outcomes. Knight (1921) argued that uncertainty is inherently subjective and cannot be reduced to measurable probabilities. Decision-making under uncertainty requires more qualitative and intuitive approaches, as decision-makers must rely on their judgment, experience, and qualitative analysis to navigate through the complexities of uncertain environments.

By delineating risk and uncertainty, Knight's distinction provides a theoretical foundation for understanding decision-making processes in different contexts and underscores the need for nuanced strategies to address these distinct phenomena.

Building upon this distinction, the literature on the methods available for eliciting individual preferences under conditions of risk (among others, Crosetto & Filippin, 2013; Eckel & Grossman, 2002; Gneezy & Potters, 1997; Holt & Laury, 2002) and uncertainty (Ellsberg, 1961; Lejuez et al., 2003) will be review. The review of available methods to elicit individual preferences under conditions of risk and uncertainty will be complemented by a quantitative literature review, conducting a systematic web scraping of papers indexed in Google Scholar.

Among all elicitation methods employed in experimental and behavioural economics, only the DOSPERT psychometric test (Blais & Weber, 2006; Weber et al., 2002) investigates individual risk perception. This method includes three separate response scales and considers 'Risk-Taking' as the dependent variable of 'Risk-Perceptions' and 'Expected Benefits,' revealing individual risk attitude. It is worth noting that the method should differ based on the scope of the research. Since decision-making under conditions of risk and uncertainty relies on distinct cognitive mechanisms, methods to elicit preferences should also vary in motivation and experimental procedures. Each method has its own strengths and weaknesses, and researchers must carefully evaluate which method is most appropriate for their research question and study population, considering factors such as the level of realism desired, the target population's characteristics, the available resources, and the specific research goals when choosing a particular elicitation method. Additionally, it is important to find the potential biases and limitations associated with each method and to carefully interpret the obtained results.

7.5.3 New approach in integrated planning based on co-design processes for DRR e CCA policies (T 4.4)

The main objective of the task is the definition of an approach that allows public entities and decision-makers to structure plans and policies combining the objectives of disaster risk reduction, mitigation, and climate change adaptation. Such an approach should include also participatory processes.

As defined in the literature in DDR (Disaster Risk Reduction) and CCA (Climate Change Adaptation) frameworks there are overlapping and divergent aspects. Such a situation occurs when dealing with the timing of mitigation alternatives.

The task will activate participatory co-design processes. By actuating these practices, it is intended to pursue the identification of criteria useful to individuate spatial models, which will allow the activation of strategies concerning the following aims:

- Analyse the context of risk from a spatial and physical perspective;
- Individuate communities' characteristics in respect with the different contexts of risk (Norberg Schulz, 1979);
- Investigate and evaluate the impact of risk elements over communities' conservation and maintenance of their cultural, built, and environmental heritage;
- Analyse the level of risk perception of communities', and their involvement in existing policies and plans to counteract risks;
- Identify the ethnographic dimension (Bilò, 2019) of risk through a multidisciplinary mapping approach;
- Develop and structure a "memory of risk" as a tool to foster cohesion and the activation of solidarity processes in communities, in the perspective to structure preventive education actions with respect to different risks (Bauman, 2011).

The guidelines will allow public bodies and decision-makers to structure strategic planning. At the same time, the guidelines will enhance aspects already developed within the framework of DDR, considering the perspective of climate change adaptation.

The conceptual framework for DRR approaches based on community involvement requires education in risk perception (Lari, 2013) that increases community motivation to address the imperative of adaptation to climate change and disaster risk reduction.

The risk perception affects the engagement of the individuals and the community in a participatory process, especially when the level of involvement requires the highest degree of participation as in co-design processes.

The guidelines will be structured considering the following aspects:

A. Implications of risk perception, including planning and organizational strategies aimed to act on prevention.
B. Acceptation of risk and prevention: definition of strategies and policies structured with communities and relevant stakeholders, considering factors related to the relationship between the individual and

the risk, the individuals and the community, and individual factors (i.e., sociodemographic and dispositional).

C. Definition of best and bad strategies and practices of intervention, maintenance and planning in respect of urban and architectural design, and heritage conservation; definition of a toolkit dedicated to inhabitants and technicians.

7.5.4 Nudging the uncertainty (T 5.4)

A nudge is a behavioural economics tool that can be adopted to affect the behaviour of individuals: it consists of any aspect of the choice architecture that alters behaviour in a predictable way, without prohibiting any option or significantly modifying the economic incentives associated with alternative options. Generally, it is considered a soft policy tool aimed at protecting people from making choice errors that could negatively impact their well-being (Thaler & Sunstein, 2008).

Among the errors and biases of judgment that lead to inaccurate choices affecting an agent's well-being, the most recurrent ones, in relation to which the application of a nudge can be effective, include: lack of information, making choices based on erroneous evaluation of experiences already lived or the "focusing illusions" (Sunstein, 2020), and the presence of choice heuristics. In the case of natural risks, the "availability heuristic" is worth mentioning. Following the occurrence of a natural event, such as an earthquake, people will be significantly interested in taking out an insurance policy that protects them from this possible event, but their interest in this regard will progressively decrease as the memory of the natural event fades (Cheung & Yiu, 2022; Lin, 2020; Pitterle, 2022; Yin et al., 2016).

When this "availability bias" occurs (Angner, 2012), if assessments are aligned with the probability of an event through the adoption of nudging strategies that allow an improved risk perception, it is possible to make more accurate both public and private decisions, and choices can be oriented towards objectives of adaptation to natural and climate risks.

In the context of risk perception, it is crucial to consider the influence of individual knowledge and subjective factors. Research has shown that risk perception is a subjective judgment influenced by cognitive, emotional, social, and cultural factors (M. F. Y. Han et al., 2021). Studies have stressed that subjective factors, such as perceived level of exposure, can have a stronger influence on risk perception than objective knowledge, highlighting the importance of addressing subjective perceptions in the design of nudges (Seo et al., 2020).

Moreover, psychological and socio-cultural factors have been identified as significant determinants of psychological disorders during crisis events, highlighting the complex interplay of various influences on risk

perception (Dong et al., 2021). The use of nudges to influence behaviour and decision-making has been extensively studied in many fields, including the one of natural events and disasters (Fujimi & Tatano, 2013).

By considering the cognitive, emotional, and social influences on risk perception, as well as the effectiveness of nudges in shaping behaviour, it is thus possible to design targeted interventions that address the diverse factors influencing risk perception.

The examination of the factors emerged from the meta-analysis assumes crucial relevance for the development of nudging strategies to facilitate the adoption of natural risk mitigation behaviours. To develop effective nudges that mitigate natural risk, the range of antecedent variables that influence risk perception are worth to consider. As the meta-analysis has shown, these antecedent variables play a crucial role in shaping individuals' perceptions of natural risk and can be leveraged to design effective nudges, as literature already suggests (Huang et al., 2019; Seo et al., 2020).

The identification of determinants such as a balanced risk perception, an active involvement in preparatory behaviours, together with a solid trust in the authorities, provide a robust conceptual substrate for the development of persuasive interventions. Furthermore, adherence to social norms, including the promotion of collective norms to support protective behaviours, could be a cornerstone for nudging techniques (Sunstein, 2020).

Trust in local and governmental authorities, together with social norms related to natural risks, consistently with findings of research in behavioural economics, can act as a lever to motivate protective behaviours on a collective scale (Lim et al., 2022; Mol et al., 2021; Robinson & Botzen, 2022). Even behavioural policies based on the introduction of nudges such as using media to convey information on risk management together with persuasive messages, can contribute to shaping risk perceptions on a social or community scale (Fan et al., 2023; Mirbabaie et al., 2021; Robinson et al., 2021).

Furthermore, the meta-analysis clearly identified several critical aspects, including the importance of a balanced risk perception, which avoids excesses in both directions (too high or too low) and the so-called "risk perception paradox" (Wachinger et al., 2013). The resulting preference for a balanced approach calls not only for a diffused awareness of the severity of the risk, but also for a realistic recognition of one's own vulnerability, and of the probability associated to an event.

Adopting a tailored approach, which takes into account individual factors such as sociodemographic characteristics and personal dispositions, is crucial to effectively adapt nudging strategies to the geographical and social context in which they are expected to be introduced. For example, recognizing differences in risk perceptions between demographic groups may allow to design specific messages that resonate more effectively with certain categories of individuals.

Overall, the adoption of an approach aware of risk perception dynamics and consistently using the results of the meta-analysis when designing nudging interventions appears to be a substantial contribution to broadening the awareness and propensity of communities towards environmental risks.

In conclusion, the development of nudging techniques based on the results of the meta-analysis represents a step forward in promoting behaviours oriented to environmental protection, safety and mitigation of environmental risk. More generally, a multidimensional approach to nudge design that considers both individual and social elements in shaping context-specific measures is likely to increase the effectiveness of such interventions, thus contributing to mitigating environmental risks, promoting greater community resilience, and increasing the interest of public and private decision-makers for nudge-based policy interventions.

7.5.5 New models of education and communication for resilience to risks (WP6)

WP6 focuses on designing effective tools for communicating and educating on natural, environmental, and climate change-related hazards. The final project outputs include drafting guidelines for proper risk communication and developing and applying innovative and immersive educational tools for risk education. The WP5's literature review's findings significantly impact future project tasks concerning environmental, natural, and climate-risk communication activities. The "Risk Communication Tools and Strategies Design" task (Task 6.2) includes an analysis of audiences and stakeholders and scenarios in which risk communication can take place. Risk communication models and prototypes will be created, considering diverse objectives and audiences. The project examines risk communication efforts advanced by public sector actors and institutions while considering other significant stakeholders by activating bottom-up processes. The WP5's literature review findings outlined herein can be incorporated into the preparatory efforts for designing the communication campaign as follows. Regarding factors pertaining to the *relationship between the individual and risk*, pertinent solutions may incorporate certain elements delineated in the literature review.

- Designing campaigns that target and are linked to local risks (with *higher objective risk*) is recommended.
- To promote risk prevention and resilience messages, intensification is required after direct or media-mediated risk exposure experiences by providing flexible and stratified media planning. For instance, the frequency of messages can be amplified by combining the proximity of experience with agenda setting effects (*prior experience and severity*) when a natural hazard affects a specific and nearby region or receives significant media coverage, even if the incident is geographically distant.

- Hypothesize interactive platforms (e.g., for monitoring river status and drought) based on user-generated content to incentivize *engagement with preparatory behaviours*. Collaborative and cooperative communication forms may facilitate this process.
- Hypothesize information sources and products that offer different levels of risk analysis, utilizing scientifically precise information with clear and comprehensible language. This information can be shared via mainstream media, such as collaborating with scientists or scientific popularisers in information spaces. Proprietary platforms or sites, such as the INGV earthquake site and social media accounts, in the Italian case, can also disseminate the information. Additionally, *knowledge of natural hazards* can be distributed through support from social network sites or online platforms.
- It is recommended to translate hazard-related statistical data into easily understandable formats. Consider the graphic representation of alerts, such as yellow, orange, and green, and how the public may perceive these regarding risk possibility and severity. This is especially relevant in the case of yellow alerts, which signify *the likelihood of a natural hazard* occurring, which, in turn, could influence the *event perceived likelihood*.
- Provide content illustrating the concrete effects of climate change on natural environments, such as comparing the size of glacier areas, riverbeds, and lakes before and after fluctuations due to climate change. Additionally, the impact climate change has on daily life should be explored, including the growing recognition of its reality and how it affects people's lives to enhance the *perception that climate change is happening*.

The influences impacting the *relationship between individuals and society* are undoubtedly pertinent and align with the content of Deliverable 6.1. This report concentrated on an exploratory, scoping review of risk communication campaigns, tools, and practical implementations. To clarify, the connections between the factors are as follows:

- Consider the type and frequency of people's media consumption habits and develop multi-format and multichannel advertising campaigns that connect with various viewing and consumption patterns and pathways. These potential differences in exposure must also be considered when designing campaign storytelling. This can be achieved by offering content that is independently easily comprehensible and enjoyable, as well as horizontal storylines and narratives that apply to various media contexts, as implied by *the frequency of media usage for seeking information about natural hazards*.
- Focusing on assessing the trustworthiness of messages based on their source and the testimonials endorsing them, including government officials, experts, the scientific community, and local municipalities and governments, taking advantage of *trust in authorities*.

- Propose proactive and community-oriented models for risk education, mitigation, and adoption of protective measures. Emphasize the cost-benefit value of such actions for the community, emphasizing *social norms related to natural disasters*.

Individual factors will be considered when designing the campaigns. Messages and pathways for dissemination will be tailored to individuals' characteristics, such as gender, risk and pro-environmental behaviour socialization, physical disabilities, and others. These factors are significant for the "Risk Communication Tools Testing and Validation" task (Task 6.3). The task entails testing and validating the communication campaigns designed in the prior task action. The campaigns will undergo testing in various contexts, considering different risks and audiences. The meta-analysis results advocate incorporating knowledge of audiences by planning to include tools in the evaluation sessions that can capture individuals' sociocultural positioning. Surveys and in-depth interviews could investigate various aspects such as *liberal beliefs, egoistic values, altruistic values, biospheric values, and pro-environmental orientation* among the target audience. This action would help establish a qualitative relationship between campaign exposure and perceived effectiveness.

From a more strictly educational standpoint, the outcomes of this meta-analysis carry two potential implications for completing task 6.4, titled "Innovative tools and strategies for risk education: design".

In the short term, the first implication pertains to the ongoing literature review, forming part of deliverable 6.4, due by 31/12/2023 (D6.6). The second implication, more towards the medium term, concerns the development of pilot activities for risk education, outlined in deliverable D6.9 titled "Executive planning of piloting activities based on the developed tools and technologies", to be submitted by 30/09/2024.

Starting with the short-term implications, it is essential to highlight that D6.6 is titled "Report on innovative methodologies based on immersive digital environments for vicarious experiences in protected environments, to develop a better knowledge of the risks and effects associated with dangerous events in a diachronic and spatial perspective". This deliverable focuses on a literature review concerning the use of extended reality for risk education. The results of this meta-analysis provide new analytical perspectives on the identified papers in this field. Specifically, the meta-analysis has pinpointed the factors influencing risk perception and quantified their respective influences. These factors have been grouped into three clusters, using Bonaiuto and Ariccio's categorization (2020). The first cluster relates to the individual's relationship with risk, the second to the individual's relationship with the community, and the third encompasses individual factors.

Within the discussions of these findings, it is specified that educational interventions could prove beneficial concerning factors in the first cluster, namely those pertaining to the individual's relationship with risk. Among these factors, the most significant influencers on risk perception include: 1) climate change awareness, and awareness of climate change, 2) experiencing negative emotions (such as environmental

concern, worry about the risk of floods or adverse weather conditions, anxiety, anger, fear, depression), and 3) the perceived likelihood of the event (such as floods, tsunamis, droughts, deforestation). Therefore, in the ongoing literature review concerning the use of extended reality for risk education, attention can be directed towards studies that include these three variables among their learning objectives, as indicated by this meta-analysis.

This focus could prove valuable for the future design of pilot activities to be tested and validated in subsequent tasks related to risk education. Identifying methodologies or educational practices that effectively alter these three variables using extended reality will aid in designing an intervention to achieve the same results. Moreover, it is important to consider the "risk perception paradox", where a high perceived risk often is not associated, or even negatively associated, with protective behaviours (Wachinger et al., 2013). To address this, it would be beneficial to measure the risk perception of each individual within a targeted educational intervention group. This ensures adjusting the intervention only for those with low risk perception to avoid heightening the risk perception for those who already possess an adequate (or excessive) level, potentially leading to reduced inclination towards adopting protective behaviours.

Hence, this meta-analysis could have a medium-term implication on educational tasks by guiding the design of extended reality-based educational interventions for risk education, to be tested and validated in the coming months.

8. References

Alegria, K. E., Fleszar-Pavlović, S. E., Ngo, D. D., Beam, A., Halliday, D. M., Hinojosa, B. M., Hua, J., Johnson, A. E., McAnally, K., McKinley, L. E., Temourian, A. A., & Song, A. V. (2021). The Role of Risk Perceptions and Affective Consequences in COVID-19 Protective Behaviors. *International Journal of Behavioral Medicine*, *28*(6), 801–807. https://doi.org/10.1007/s12529-021-09970-4

Aloe, A. M. (2015). Inaccuracy of regression results in replacing bivariate correlations. *Research Synthesis Methods*, *6*(1), 21–27. https://doi.org/10.1002/jrsm.1126

Angner, E. (2012). *A Course in Behavioral Economics*. Bloomsbury Publishing.

Babcicky, P., & Seebauer, S. (2017). The two faces of social capital in private flood mitigation: opposing effects on risk perception, self-efficacy and coping capacity. *Journal of Risk Research*, *20*(8), 1017–1037. https://doi.org/10.1080/13669877.2016.1147489

Barnett, J., & Breakwell, G. M. (2001). Risk Perception and Experience: Hazard Personality Profiles and Individual Differences. *Risk Analysis*, *21*(1), 171–178. https://doi.org/10.1111/0272-4332.211099

Bauman, Z. (2011). *Community. Seeking safety in an Insecure World*. Polity Press.

Bilò, F. (2019). *Le Indagini Etnografiche di Pagano*. Letetra22.

Blais, A.-R., & Weber, E. U. (2006). A Domain-Specific Risk-Taking (DOSPERT) scale for adult populations. *Judgment and Decision Making*, *1*(1), 33–47. https://doi.org/10.1017/S1930297500000334

Boholm, A. (1998). Comparative studies of risk perception: A review of twenty years of research. *Journal of Risk Research*, *1*(2), 135–163. https://doi.org/10.1080/136698798377231

Bonaiuto, M., & Ariccio, S. (2020). La resilienza comunitaria: Cornice concettuale e strumenti di misura. In L. Caravaggi (Ed.), *Progetto SISMI-DTC Lazio Conoscenze e Innovazioni per la Rcostruzione e il Miglioramento Sismico dei Centri Storici del Lazio* (pp. 78–85). Quodlibet.

Borenstein, M., Hedges, L. V., Higgins, J. P. T., & Rothstein, H. R. (2021). *Introduction to Meta-Analysis*. John Wiley & Sons.

Brun, W. (1994). Risk perception: Main issues, approaches and findings. In G. Wright & P. Ayton (Eds.), *Subjective probability* (pp. 295–320). John Wiley & Sons.

Bullock, J. A., Haddow, G. D., & Coppola, D. P. (2013). Mitigation, Prevention, and Preparedness. In G. Haddow, J. Bullock, & D. Coppola (Eds.), *Introduction to Homeland Security* (pp. 435–494). Elsevier. https://doi.org/10.1016/B978-0-12-415802-3.00010-5

Card, N. A. (2015). *Applied Meta-Analysis for Social Science Research*. Guilford Publications.

Cheung, K. S., & Yiu, C. Y. (2022). Public perception of flood hazards in the housing market: A revealed preference study of affect heuristics and availability heuristics. *International Journal of Disaster Risk Reduction*, *75*, 102977. https://doi.org/10.1016/j.ijdrr.2022.102977

Cohen, J. (1992). A power primer. *Psychological Bulletin*, *112*(1), 155–159. https://doi.org/10.1037/0033-2909.112.1.155

Cooper, H., Hedges, L. V., & Valentine, J. C. (2009). *The Handbook of Research Synthesis and Meta-Analysis*. Russel Sage Foundation.

Crosetto, P., & Filippin, A. (2013). The "bomb" risk elicitation task. *Journal of Risk and Uncertainty*, *47*(1), 31–65. https://doi.org/10.1007/s11166-013-9170-z

Dong, D., Chen, Z., Zong, M., Zhang, P., Gu, W., Feng, Y., & Qiao, Z. (2021). What protects us against the COVID-19 threat? Cultural tightness matters. *BMC Public Health*, *21*(1), 2139. https://doi.org/10.1186/s12889-021-12161-1

Dunlap, R. E., Van Liere, K. D., Mertig, A. G., & Jones, R. E. (2000). New Trends in Measuring Environmental Attitudes: Measuring Endorsement of the New Ecological Paradigm: A Revised NEP Scale. *Journal of Social Issues*, *56*(3), 425–442. https://doi.org/10.1111/0022-4537.00176

Duval, S., & Tweedie, R. (2000). A Nonparametric "Trim and Fill" Method of Accounting for Publication Bias in Meta-Analysis. *Journal of the American Statistical Association*, *95*(449), 89–98. https://doi.org/10.1080/01621459.2000.10473905

Eckel, C. C., & Grossman, P. J. (2002). Sex differences and statistical stereotyping in attitudes toward financial risk. *Evolution and Human Behavior*, *23*(4), 281–295. https://doi.org/10.1016/S1090-5138(02)00097-1

Egger, B., Klaefiger, Y., Theis, A., & Salzburger, W. (2011). A Sensory Bias Has Triggered the Evolution of Egg-Spots in Cichlid Fishes. *PLoS ONE*, *6*(10), e25601. https://doi.org/10.1371/journal.pone.0025601

Egger, M., Smith, G. D., Schneider, M., & Minder, C. (1997). Bias in meta-analysis detected by a simple, graphical test. *BMJ*, *315*(7109), 629–634. https://doi.org/10.1136/bmj.315.7109.629

Ellsberg, D. (1961). Risk, Ambiguity, and the Savage Axioms. *The Quarterly Journal of Economics*, *75*(4), 643. https://doi.org/10.2307/1884324

Fan, Y., Gao, Q., Sitoh, Y. E., & Wan, W. X. (2023). Gone with the Flood: Natural Disaster, Population Replacement, and Information Nudge. *SSRN Electronic Journal*. https://doi.org/10.2139/ssrn.4343838

Field, A. (2013). *Discovering Statistics Using IBM SPSS Statistics: And Sex and Drugs and Rock "N" Roll,*

4th Edition. Sage.

Fischhoff, B., Slovic, P., Lichtenstein, S., Read, S., & Combs, B. (1978). How safe is safe enough? A psychometric study of attitudes towards technological risks and benefits. *Policy Sciences*, *9*(2), 127–152. https://doi.org/10.1007/BF00143739

Fu, R., Gartlehner, G., Grant, M., Shamliyan, T., Sedrakyan, A., Wilt, T. J., Griffith, L., Oremus, M., Raina, P., Ismaila, A., Santaguida, P., Lau, J., & Trikalinos, T. A. (2011). Conducting quantitative synthesis when comparing medical interventions: AHRQ and the Effective Health Care Program. *Journal of Clinical Epidemiology*, *64*(11), 1187–1197. https://doi.org/10.1016/j.jclinepi.2010.08.010

Fujimi, T., & Tatano, H. (2013). Promoting Seismic Retrofit Implementation Through "Nudge": Using Warranty as a Driver. *Risk Analysis*, *33*(10), 1858–1883. https://doi.org/10.1111/risa.12086

Gierlach, E., Belsher, B. E., & Beutler, L. E. (2010). Cross-Cultural Differences in Risk Perceptions of Disasters. *Risk Analysis*, *30*(10), 1539–1549. https://doi.org/10.1111/j.1539-6924.2010.01451.x

Gneezy, U., & Potters, J. (1997). An Experiment on Risk Taking and Evaluation Periods. *The Quarterly Journal of Economics*, *112*(2), 631–645. https://doi.org/10.1162/003355397555217

Han, M. F. Y., Mahendran, R., & Yu, J. (2021). Associations Between Fear of COVID-19, Affective Symptoms and Risk Perception Among Community-Dwelling Older Adults During a COVID-19 Lockdown. *Frontiers in Psychology*, *12*. https://doi.org/10.3389/fpsyg.2021.638831

Han, Z., Wang, L., & Cui, K. (2021). Trust in stakeholders and social support: risk perception and preparedness by the Wenchuan earthquake survivors. *Environmental Hazards*, *20*(2), 132–145. https://doi.org/10.1080/17477891.2020.1725410

Higgins, J. P. T., & Thompson, S. G. (2002). Quantifying heterogeneity in a meta-analysis. *Statistics in Medicine*, *21*(11), 1539–1558. https://doi.org/10.1002/sim.1186

Holt, C. A., & Laury, S. K. (2002). Risk Aversion and Incentive Effects. *American Economic Review*, *92*(5), 1644–1655. https://doi.org/10.1257/000282802762024700

Hornsey, M. J., Harris, E. A., Bain, P. G., & Fielding, K. S. (2016). Meta-analyses of the determinants and outcomes of belief in climate change. *Nature Climate Change*, *6*(6), 622–626. https://doi.org/10.1038/nclimate2943

Huang, L., Wu, C., Wang, B., Ouyang, Q., & Lin, H. (2019). An unsafe behaviour formation mechanism based on risk perception. *Human Factors and Ergonomics in Manufacturing & Service Industries*, *29*(2), 109–117. https://doi.org/10.1002/hfm.20762

Ioannidis, J. P. A., Patsopoulos, N. A., & Evangelou, E. (2007). Uncertainty in heterogeneity estimates in meta-analyses. *BMJ*, *335*(7626), 914–916. https://doi.org/10.1136/bmj.39343.408449.80

Jansen, B. J., Salminen, J. O., & Jung, S.-G. (2020). Data-Driven Personas for Enhanced User Understanding: Combining Empathy with Rationality for Better Insights to Analytics. *Data and Information Management*, *4*(1), 1–17. https://doi.org/10.2478/dim-2020-0005

Knight, F. H. (1921). *Risk, Uncertainty and Profit, Vol. 31*. Houghton Mifflin.

Kontopantelis, E., & Reeves, D. (2012). Performance of statistical methods for meta-analysis when true study effects are non-normally distributed: A simulation study. *Statistical Methods in Medical Research*, *21*(4), 409–426. https://doi.org/10.1177/0962280210392008

Lari, Y. (2013). *Disaster Preparedness Manual*. Heritage Foundation of Pakistan Ed.

Läuter, H. (1985). Cook, R. D., S. Weisberg: Residuals and influence in regression. Chapman and Hall, New York — London 1982. VIII, 229 pp., £ 12,-. *Biometrical Journal*, *27*(1), 80–80. https://doi.org/10.1002/bimj.4710270110

Lechowska, E. (2018). What determines flood risk perception? A review of factors of flood risk perception and relations between its basic elements. *Natural Hazards*, *94*(3), 1341–1366. https://doi.org/10.1007/s11069-018-3480-z

Lejuez, C. W., Aklin, W. M., Zvolensky, M. J., & Pedulla, C. M. (2003). Evaluation of the Balloon Analogue Risk Task (BART) as a predictor of adolescent real-world risk-taking behaviours. *Journal of Adolescence*, *26*(4), 475–479. https://doi.org/10.1016/S0140-1971(03)00036-8

Lim, J. R., Liu, B. F., & Atwell Seate, A. (2022). Are you prepared for the next storm? Developing social norms messages to motivate community members to perform disaster risk mitigation behaviors. *Risk Analysis*, *42*(11), 2550–2568. https://doi.org/10.1111/risa.13957

Lin, X. (2020). Feeling Is Believing? Evidence From Earthquake Shaking Experience and Insurance Demand. *Journal of Risk and Insurance*, *87*(2), 351–380. https://doi.org/10.1111/jori.12291

Lindell, M. K., & Prater, C. S. (2000). Household Adoption of Seismic Hazard Adjustments: A Comparison of Residents in Two States. *International Journal of Mass Emergencies & Disasters*, *18*(2), 317–338. https://doi.org/10.1177/028072700001800203

Lipsey, M. W. (2003). Those Confounded Moderators in Meta-Analysis: Good, Bad, and Ugly. *The ANNALS of the American Academy of Political and Social Science*, *587*(1), 69–81. https://doi.org/10.1177/0002716202250791

Lowe, B. S., Israel, G. D., Paudyal, R., & Wallen, K. E. (2022). The Influence of Evangelical and Political Identity on Climate Change Views. *Society & Natural Resources*, *35*(12), 1372–1389. https://doi.org/10.1080/08941920.2022.2113486

Marín, A., Vergara-Pinto, F., Prado, F., & Farías, C. (2020). Living near volcanoes: Scoping the gaps

between the local community and volcanic experts in southern Chile. *Journal of Volcanology and Geothermal Research*, *398*, 106903. https://doi.org/10.1016/j.jvolgeores.2020.106903

Mirbabaie, M., Ehnis, C., Stieglitz, S., Bunker, D., & Rose, T. (2021). Digital Nudging in Social Media Disaster Communication. *Information Systems Frontiers*, *23*(5), 1097–1113. https://doi.org/10.1007/s10796-020-10062-z

Moher, D., Liberati, A., Tetzlaff, J., & Altman, D. G. (2010). Preferred reporting items for systematic reviews and meta-analyses: The PRISMA statement. *International Journal of Surgery*, *8*(5), 336–341. https://doi.org/10.1016/j.ijsu.2010.02.007

Mol, J. M., Botzen, W. J. W., Blasch, J. E., Kranzler, E. C., & Kunreuther, H. C. (2021). All by myself? Testing descriptive social norm-nudges to increase flood preparedness among homeowners. *Behavioural Public Policy*, 1–33. https://doi.org/10.1017/bpp.2021.17

Norberg Schulz, C. (1979). Genius loci: towards a phenomenology of architecture. In J. Cody & F. Siravo (Eds.), *Historic Cities: Issues in Urban Conservation* (pp. 31–45). Getty Conservation Institute.

Page, M. J., Moher, D., Bossuyt, P. M., Boutron, I., Hoffmann, T. C., Mulrow, C. D., Shamseer, L., Tetzlaff, J. M., Akl, E. A., Brennan, S. E., Chou, R., Glanville, J., Grimshaw, J. M., Hróbjartsson, A., Lalu, M. M., Li, T., Loder, E. W., Mayo-Wilson, E., McDonald, S., … McKenzie, J. E. (2021). PRISMA 2020 explanation and elaboration: updated guidance and exemplars for reporting systematic reviews. *BMJ*, n160. https://doi.org/10.1136/bmj.n160

Peterson, R. A., & Brown, S. P. (2005). On the Use of Beta Coefficients in Meta-Analysis. *Journal of Applied Psychology*, *90*(1), 175–181. https://doi.org/10.1037/0021-9010.90.1.175

Pitterle, C. (2022). Climate change, natural disasters 2021 and the impact on insurance demand! A look at Germany from the perspective of Behavioral Economics. *International Business Information Management Association*, 354–358.

Pliny the Elder. (78 C.E.). *Historia Naturalis*. Venice, Johannes de Spira, 1469.

Ritchie, H., Rosado, P., & Roser, M. (2022). *Natural Disasters*. https://ourworldindata.org/natural-disasters

Robinson, P. J., & Botzen, W. J. W. (2022). Setting descriptive norm nudges to promote demand for insurance against increasing climate change risk. *The Geneva Papers on Risk and Insurance - Issues and Practice*, *47*(1), 27–49. https://doi.org/10.1057/s41288-021-00248-0

Robinson, P. J., Botzen, W. J. W., Duijndam, S., & Molenaar, A. (2021). Risk communication nudges and flood insurance demand. *Climate Risk Management*, *34*, 100366. https://doi.org/10.1016/j.crm.2021.100366

Rosa, E. A. (2003). The logical structure of the social amplification of risk framework (SARF):

Metatheoretical foundation and policy implications. In N. K. Pidgeon & P. Slovic (Eds.), *The Social Amplification of Risk* (pp. 47–49). Cambridge University Press.

Rosenthal, R. (1979). The file drawer problem and tolerance for null results. *Psychological Bulletin*, *86*(3), 638–641. https://doi.org/10.1037/0033-2909.86.3.638

Rothstein, H. R., Sutton, A. J., & Borenstein, M. (2005). Publication Bias in Meta-Analysis. In *Publication Bias in Meta-Analysis* (pp. 1–7). Wiley. https://doi.org/10.1002/0470870168.ch1

Rupinski, M. T., & Dunlap, W. P. (1996). Approximating Pearson Product-Moment Correlations from Kendall's Tau and Spearman's Rho. *Educational and Psychological Measurement*, *56*(3), 419–429. https://doi.org/10.1177/0013164496056003004

Sahebkar, A. (2013a). Why it is necessary to translate curcumin into clinical practice for the prevention and treatment of metabolic syndrome? *BioFactors*, *39*(2), 197–208. https://doi.org/10.1002/biof.1062

Sahebkar, A. (2013b). Does PPARγ 2 Gene Pro12Ala Polymorphism Affect Nonalcoholic Fatty Liver Disease Risk? Evidence from a Meta-Analysis. *DNA and Cell Biology*, *32*(4), 188–198. https://doi.org/10.1089/dna.2012.1947

Sánchez-Meca, J., Marín-Martínez, F., & Chacón-Moscoso, S. (2003). Effect-Size Indices for Dichotomized Outcomes in Meta-Analysis. *Psychological Methods*, *8*(4), 448–467. https://doi.org/10.1037/1082-989X.8.4.448

Savage, L. J. (1954). *The Foundations of Statistics*. John Wiley & Sons.

Seo, M.-S., Choi, J.-W., Kim, K.-H., & Choi, H.-D. (2020). The Relationship between Risk Perception of Cell Phones and Objective Knowledge of EMF in Korea. *International Journal of Environmental Research and Public Health*, *17*(19), 7207. https://doi.org/10.3390/ijerph17197207

Short, J. F. (1984). The Social Fabric at Risk: Toward the Social Transformation of Risk Analysis. *American Sociological Review*, *49*(6), 711. https://doi.org/10.2307/2095526

Siegrist, M., & Árvai, J. (2020). Risk Perception: Reflections on 40 Years of Research. *Risk Analysis*, *40*(S1), 2191–2206. https://doi.org/10.1111/risa.13599

Sjöberg, L. (1998). Risk Perception: Experts and the Public. *European Psychologist*, *3*(1), 1–12. https://doi.org/10.1027/1016-9040.3.1.1

Sjöberg, L., Moen, B. E., & Rundmo, T. (2004). *Explaining risk perception. An evaluation of the psychometric paradigm in risk perception research (Working Paper No. 22)* (Rotunde Publikasjoner Rotunde).

Slovic, P. (1987). Perception of Risk. *Science*, *236*(4799), 280–285. https://doi.org/10.1126/science.3563507

Slovic, P., Fischhoff, B., & Lichtenstein, S. (1979). Rating the Risks. *Environment: Science and Policy for Sustainable Development*, *21*(3), 14–39. https://doi.org/10.1080/00139157.1979.9933091

Slovic, P., Fischhoff, B., & Lichtenstein, S. (1980). Facts and Fears: Understanding Perceived Risk. In R. C. Schwing & W. A. Albers (Eds.), *Societal Risk Assessment* (pp. 181–216). Springer US. https://doi.org/10.1007/978-1-4899-0445-4_9

Slovic, P., Fischhoff, B., & Lichtenstein, S. (1984). Behavioral decision theory perspectives on risk and safety. *Acta Psychologica*, *56*(1–3), 183–203. https://doi.org/10.1016/0001-6918(84)90018-0

Sunstein, C. R. (2020). *Behavioral Science and Public Policy*. Cambridge University Press.

Thaler, R. H., & Sunstein, C. R. (2008). *Nudge: The Final Edition*. Yale University Press.

The EndNote Team. (2013). *EndNote*. Clarivate. https://myendnoteweb.com

UNDRR. (2005). *Hyogo Framework for Action 2005-2015: Building the Resilience of Nations and Communities to Disasters*. https://www.refworld.org/docid/42b98a704.html

UNDRR. (2015). *Sendai Framework for Disaster Risk Reduction 2015-2030*. https://www.unisdr.org/we/inform/publications/43291

UNDRR. (2016). *Report of the open-ended intergovernmental expert working group on indicators and terminology relating to disaster risk reduction*.

United Nations. (2023). *Causes and Effects of Climate Change*. https://www.un.org/en/climatechange/science/causes-effects-climate-change

van Valkengoed, A. M., & Steg, L. (2019a). Meta-analyses of factors motivating climate change adaptation behaviour. *Nature Climate Change*, *9*(2), 158–163. https://doi.org/10.1038/s41558-018-0371-y

van Valkengoed, A. M., & Steg, L. (2019b). *The Psychology of Climate Change Adaptation*. Cambridge University Press. https://doi.org/10.1017/9781108595438

Viechtbauer, W. (2010). Conducting Meta-Analyses in R with the metafor Package. *Journal of Statistical Software*, *36*(3). https://doi.org/10.18637/jss.v036.i03

Viechtbauer, W., & Cheung, M. W.-L. (2010). Outlier and influence diagnostics for meta-analysis. *Research Synthesis Methods*, *1*(2), 112–125. https://doi.org/10.1002/jrsm.11

Wachinger, G., Renn, O., Begg, C., & Kuhlicke, C. (2013). The Risk Perception Paradox—Implications for Governance and Communication of Natural Hazards. *Risk Analysis*, *33*(6), 1049–1065. https://doi.org/10.1111/j.1539-6924.2012.01942.x

Weber, E. U., Blais, A.-R. E., & Betz, N. E. (2002). A Domain-specific Risk-attitude Scale: Measuring Risk Perceptions and Risk Behaviors. *Journal of Behavioral Decision Making J. Behav. Dec. Making*, *15*(4),

263–290. https://doi.org/10.1002/bdm.414

Wilson, R. S., Zwickle, A., & Walpole, H. (2019). Developing a Broadly Applicable Measure of Risk Perception. *Risk Analysis*, *39*(4), 777–791. https://doi.org/10.1111/risa.13207

Yin, H., Chen, J., & Michel-Kerjan, E. (2016). Availability Heuristic and Gambler's Fallacy over Time in a Natural Disaster Insurance Choice Setting. *SSRN Electronic Journal*. https://doi.org/10.2139/ssrn.2798371

Yu, T., Yang, H., Luo, X., Jiang, Y., Wu, X., & Gao, J. (2021). Scientometric Analysis of Disaster Risk Perception: 2000–2020. *International Journal of Environmental Research and Public Health*, *18*(24), 13003. https://doi.org/10.3390/ijerph182413003

Zander, K. K., Sibarani, R., Lassa, J., Nguyen, D., & Dimmock, A. (2022). How do Australians use social media during natural hazards? A survey. *International Journal of Disaster Risk Reduction*, *81*, 103207. https://doi.org/10.1016/j.ijdrr.2022.103207

APPENDIX A

Complete list of studies included in the meta-analyses.

N.	Auth	Year	Title	Journal/Book	Volume	Issue
1	Aksa et al.	2020	The role of knowledge and fatalism in college students related to the earthquake-risk perception	Jàmbá: Journal of Disaster Risk Studies	12	1
2	Ali et al.	2022	Flood risk perception and communication: The role of hazard proximity	Journal of Environmental Management	316	
3	Altarawneh et al.	2018	The influence of cognitive and affective risk perceptions on flood preparedness intentions: A dual-process approach	Procedia Engineering	212	
4	Altinay et al.	2020	Public risk salience of sea level rise in Louisiana, United States	Journal of Environmental Studies and Sciences	11	
5	Arbuckle et al.	2014	Understanding Farmer Perspectives on Climate Change Adaptation and Mitigation: The Roles of Trust in Sources of Climate Information, Climate Change Beliefs, and Perceived Risk	Environment and Behavior	47	2
6	Ariccio et al.	2020	Loving, leaving, living: Evacuation site place attachment predicts natural hazard coping behavior	Journal of Environmental Psychology	70	
7	Armstrong et al.	2021	Ready for disaster: information seeking, media influence, and disaster preparation for severe weather outbreaks	Atlantic Journal of Communication	29	3
8	Aslam et al.	2022	Impact of the built environment on climate change risk perception and psychological distancing: Empirical evidence from Islamabad, Pakistan	Environmental Science & Policy	127	
9	Azadi et al.	2019	Understanding smallholder farmers' adaptation behaviors through climate change beliefs, risk perception, trust, and psychological distance: Evidence from wheat growers in Iran	Journal of Environmental Management	250	
10	Babcicky et al.	2017	The two faces of social capital in private flood mitigation: opposing effects on risk perception, self-efficacy and coping capacity	Journal of Risk Research	20	8
11	Babcicky et al.	2020	Collective efficacy and natural hazards: differing roles of social cohesion and task-specific efficacy in shaping risk and coping beliefs	Journal of Risk Research	23	6
12	Basiru et al.	2022	Indigenous Perceptions of Factors Influencing Behavioral Intentions Towards Climate Change Mitigation: An Assessment	International Journal of Public Administration		
13	Beckmann et al.	2021	Heat adaptation measures in private households: an application and adaptation of the protective action decision model	Humanities and Social Sciences Communications	8	1
14	Beckmann et al.	2020	Predictors Associated with Health-Related Heat Risk Perception of Urban Citizens in Germany	International Journal of Environmental Research and Public Health	17	3
15	Begum et al.	2022	The Adaptation Behaviour of Marine Fishermen towards Climate Change and Food Security: An Application of the Theory of Planned Behaviour and Health Belief Model	Sustainability	14	21

16	Berlin Rubin et al.	2022	As California burns: the psychology of wildfire- and wildfire smoke-related migration intentions	Population and Environment	44	1-2
17	Bichard et al.	2012	Are homeowners willing to adapt to and mitigate the effects of climate change?	Climatic Change	112	
18	Bixler et al.	2021	Unpacking Adaptive Capacity to Flooding in Urban Environments: Social Capital, Social Vulnerability, and Risk Perception	Frontiers in Water	3	
19	Bogani et al.	2023	The near-miss effect in flood risk estimation: A survey-based approach to model private mitigation intentions into agent-based models	International Journal of Disaster Risk Reduction	89	
20	Botzen et al.	2009	Dependence of flood risk perceptions on socioeconomic and objective risk factors	Water Resources Research	45	10
21	Brügger et al.	2020	Social Identity and Risk Perception Explain Participation in the Swiss Youth Climate Strikes	Sustainability	12	24
22	Bremer et al.	2017	Determinants of the perceived importance of organisational adaptation to climate change in the Australian energy industry	Australian Journal of Management	42	3
23	Brody et al.	2008	Examining the relationship between physical vulnerability and public perceptions of global climate change in the United States	Environment and Behavior	40	1
24	Bustillos Ardaya et al.	2017	What influences disaster risk perception? Intervention measures, flood and landslide risk perception of the population living in flood risk areas in Rio de Janeiro state, Brazil	International Journal of Disaster Risk Reduction	25	
25	Buylova et al.	2020	Household risk perceptions and evacuation intentions in earthquake and tsunami in a Cascadia Subduction Zone	International Journal of Disaster Risk Reduction	44	
26	Cai et al.	2023	Influences of social environment and psychological cognition on individuals' behavioral intentions to reduce disaster risk in geological hazard-prone areas: An application of social cognitive theory	International Journal of Disaster Risk Reduction	86	
27	Carlton et al.	2013	Climate change and coastal environmental risk perceptions in Florida	Journal of Environmental Management	130	
28	Carmen Hidalgo et al.	2014	Determinants of risk perception and willingness to tackle climate change. A pilot study	Psyecology	1	1
29	Chang et al.	2016	Who Is Responsible for Climate Change? Attribution of Responsibility, News Media, and South Koreans' Perceived Risk of Climate Change	Climate and Sustainability Communication (book)		
30	Chen	2020	Structural analysis of how place attachment and risk perceptions affect the willingness to live in an earthquake-prone area	Disaster Prevention and Management: An International Journal	29	4
31	Cisternas et al.	2023	The influence of risk awareness and government trust on risk perception and preparedness for natural hazards	Risk analysis		
32	Costa-Font et al.	2009	Optimism and the perceptions of new risks	Journal of Risk Research	12	1
33	Damm et al.	2013	Perception of landslides risk and responsibility: A case study in eastern Styria, Austria	Natural Hazards	69	

34	Davis et al.	2005	Perceptions of Risk for Volcanic Hazards at Vesuvio and Etna, Italy	The Australasian Journal of Disaster and Trauma Studies	1	
35	De Dominicis et al.	2021	Experiencing, caring, coping: Vested interest mediates the effect of past experience on coping behaviors in environmental risk contexts	Journal of Applied Social Psychology	51	3
36	De Dominicis et al. - Study A	2015	We are at risk, and so what? Place attachment, environmental risk perceptions and preventive coping behaviours	Journal of Environmental Psychology	43	
37	De Dominicis et al. - Study B	2015	We are at risk, and so what? Place attachment, environmental risk perceptions and preventive coping behaviours	Journal of Environmental Psychology	43	
38	DeBono et al.	2012	Risk communication: Climate change as a human-health threat, a survey of public perceptions in Malta	The European Journal of Public Health	22	1
39	DeYoung	2014	Disaster Preparedness: Psychosocial Predictors for Hazard Readiness	/ (dissertation)		
40	Diakakis et al.	2022	Public Perceptions of Flood and Extreme Weather Early Warnings in Greece	Sustainability	14	16
41	Domingues et al.	2021	Place attachment, risk perception, and preparedness in a population exposed to coastal hazards: A case study in Faro Beach, southern Portugal	International Journal of Disaster Risk Reduction	60	
42	Domingues et al.	2018	How a coastal community looks at coastal hazards and risks in a vulnerable barrier island system (Faro Beach, southern Portugal)	Ocean & Coastal Management	157	
43	Duijndam et al.	2023	Drivers of migration intentions in coastal Vietnam under increased flood risk from sea level rise	Climatic Change	176	2
44	Elshirbiny et al.	2020	Public risk perception of climate change in Egypt: a mixed methods study of predictors and implications	Journal of Environmental Studies and Sciences	10	3
45	Eriksson	2017	The importance of threat, strategy, and resource appraisals for long-term proactive risk management among forest owners in Sweden	Journal of Risk Research	20	7
46	Fox Gotham et al.	2017	Hazard Experience, Geophysical Vulnerability, and Flood Risk Perceptions in a Postdisaster City, the Case of New Orleans	Risk analysis	38	2
47	Ghasemi et al.	2020	An examination of the social-psychological drivers of homeowner wildfire mitigation	Journal of Environmental Psychology	70	
48	Gilbert et al.	2023	The climate change risk perception model in the United States: A replication study	Journal of Environmental Psychology	86	
49	Golazad et al.	2022	People's post-disaster decisions and their relations with personality traits and decision-making styles: The choice of travel mode and healthcare destination	International Journal of Disaster Risk Reduction	83	
50	Goldberg et al.	2020	Predictors of global warming risk perceptions among Latino and non-Latino White Americans	Climatic Change	162	
51	Goodwin et al.	2012	Modelling Psychological Responses to the Great East Japan Earthquake and Nuclear Incident	PloS one	7	5
52	Greer et al.	2018	A serendipitous, quasi-natural experiment: earthquake risk perceptions and hazard adjustments among college students	Natural Hazards	93	
53	Greer et al.	2020	Place attachment in disaster studies: measurement and the case of the 2013 Moore tornado	Population and Environment	41	

54	Guillard et al.	2019	Flooding experience and assessment of climate change: implication of psychological distance, risk perception and place attachment	PsyEcology	10	3
55	Gumasing et al.	2022	Determination of factors affecting the response efficacy of Filipinos under Typhoon Conson 2021 (Jolina): An extended protection motivation theory approach	International Journal of Disaster Risk Reduction	70	
56	Gunay et al.	2022	The public as an audience for the securitisation of climate change: facilitating conditions at the identification stage	Journal of International Relations and Development	25	
57	Guo et al.	2016	Getting ready for mega disasters: the role of past experience in changing disaster consciousness	Disaster Prevention and Management	25	4
58	Halpern-Felsher et al.	2001	The role of behavioral experience in judging risks	Health Psychology	20	2
59	Han et al.	2017	The effects of trust in government on earthquake survivors' risk perception and preparedness in China	Natural Hazards	86	
60	Han et al.	2021	Trust in stakeholders and social support: risk perception and preparedness by the Wenchuan earthquake survivors	Environmental Hazards	20	2
61	Han et al.	2022	Trust and confidence in authorities, responsibility attribution, and natural hazards risk perception	Risk, Hazards & Crisis in Public Policy	13	3
62	Haque & Fatema	2022	Disaster risk reduction for whom? The gap between centrally planned Disaster Management Program and people's risk perception and adaptation	International Journal of Disaster Risk Reduction	82	
63	Horne et al.	2021	Determinants of visitor climate change risk perceptions in Acadia National Park, Maine, USA	Journal of Outdoor Recreation and Tourism	35	
64	Hornsey et al.	2015	Are People High in Skepticism About Anthropogenic Climate Change Necessarily Resistant to Influence? Some Cause for Optimism	Environment and Behavior	48	7
65	Howe	2011	Hurricane preparedness as anticipatory adaptation: A case study of community businesses	Global Environmental Change	21	2
66	Huang et al.	2010	Public Perception of Blue-Algae Bloom Risk in Hongze Lake of China	Environmental Management	45	
67	Huang et al.	2020	Affect Path to Flood Protective Coping Behaviors Using SEM Based on a Survey in Shenzhen, China	International Journal of Environmental Research and Public Health	17	3
68	Hudson et al.	2020	Potential Linkages Between Social Capital, Flood Risk Perceptions, and Self-Efficacy	International Journal of Disaster Risk Science	11	
69	Jaiswal - Study A	2021	Determinants of Residents' Shadow Evacuation Intention During a Hurricane in the Rio Gr Hurricane in the Rio Grande Valley, Texas	/ (dissertation)		
70	Jaiswal- Stuyd B	2021	Determinants of Residents' Shadow Evacuation Intention During a Hurricane in the Rio Gr Hurricane in the Rio Grande Valley, Texas	/ (dissertation)		
71	Kellens et al.	2012	The Informed Society: An Analysis of the Public's Information-Seeking Behavior Regarding Coastal Flood Risks	Risk Analysis: An International Journal	32	8

72	Kohl et al.	2022	Knowledge of majority scientific agreement on anthropogenic climate change predicts perceived global risk better than perceived personal risk	Journal of Risk Research	25	6
73	Kukowski et al. - Study A	2022	Climate policy support as a tool to control others' (but not own) environmental behavior?	Plos one	17	6
74	Kukowski et al. - Study B	2022	Climate policy support as a tool to control others' (but not own) environmental behavior?	Plos one	17	6
75	Kurata et al.	2022	Determining factors affecting preparedness beliefs among Filipinos on Taal volcano eruption in Luzon, Philippines	International Journal of Disaster Risk Reduction	76	
76	Kwon et al.	2019	Analyzing the Determinants of Individual Action on Climate Change by Specifying the Roles of Six Values in South Korea	Sustainability	11	7
77	López-Fletes et al.	2022	Risk Perception and Implementation of Mitigation Measures By Populations Living Near Volcán De Colima, Mexico	Human Ecology	50	
78	Lacroix et al.	2020	Climate change beliefs shape the interpretation of forest fire events	Climatic Change	159	
79	Lai et al.	2018	Digital disparities and vulnerability: mobile phone use, information behaviour, and disaster preparedness in Southeast Asia	Disasters	42	4
80	Li et al.	2021	Climate change risk perceptions, facilitating conditions and health risk management intentions: Evidence from farmers in rural China	Climate Risk Management	32	
81	Liu & Sun	2021	Examining the impact of fatalism belief and optimism orientation on seismic preparedness: Considering their roles in the nexus between risk perception and preparedness	Journal of Contingencies and Crisis Management	30	4
82	Lo	2013	The role of social norms in climate adaptation: Mediating risk perception and flood insurance purchase	Global Environmental Change	23	5
83	Lo & Cheung	2015	Seismic risk perception in the aftermath of Wenchuan earthquakes in southwestern China	Natural Hazards	78	
84	Lowe et al.	2022	The Influence of Evangelical and Political Identity on Climate Change Views	Society & Natural Resources	35	12
85	Luis et al.	2016	Is it all about awareness? The normalization of coastal risk	Journal of Risk Research	19	6
86	Lyu & Adams - Study A	2022	Preparing for real-time weather risk management: the decision models of household evacuation under uncertainty for Taiwanese and US residents	Natural Hazards	114	
87	Lyu & Adams - Study B	2022	Preparing for real-time weather risk management: the decision models of household evacuation under uncertainty for Taiwanese and US residents	Natural Hazards	114	
88	MacPherson-Krutsky et al.	2023	Residents' information seeking behavior and protective action for earthquake hazards in The Portland Oregon Metropolitan Area	Risk analysis	43	2
89	Mafuko Nyandwi et al.	2023	Differences in volcanic risk perception among Goma's population before the Nyiragongo eruption of May 2021, Virunga volcanic province (DR Congo)	Natural Hazards and Earth System Sciences	23	2
90	Masud et al.	2017	Impact of socio-demographic factors on the mitigating actions for climate change: a path analysis with mediating effects of attitudinal variables	Environmental Science and Pollution Research	24	

91	Mead et al.	2012	Information Seeking About Global Climate Change Among Adolescents: The Role of Risk Perceptions, Efficacy Beliefs, and Parental Influences	Atlantic journal of communication	20	1
92	Mumpower et al.	2016	Predictors of the perceived risk of climate change and preferred resource levels for climate change management programs	Journal of Risk Research	19	6
93	Navarro et al.	2021	Coping Strategies Regarding Coastal Flooding Risk in a Context of Climate Change in a French Caribbean Island	Environment and Behavior	53	6
94	Ndamani et al.	2017	Determinants of Farmers' Climate Risk Perceptions in Agriculture—A Rural Ghana Perspective	Water	9	3
95	Netzel et al.	2021	The importance of public risk perception for the effective management of pluvial floods in urban areas: A case study from Germany	Journal of Flood Risk Management	14	2
96	Ngo et al.	2020	Drivers of flood and climate change risk perceptions and intention to adapt: an explorative survey in coastal and delta Vietnam	Journal of Risk Research	23	4
97	Ogunbode et al.	2019	Attribution matters: Revisiting the link between extreme weather experience and climate change mitigation responses	Global Environmental Change	54	
98	Ogunbode et al. (1)	2020	Context-appropriate environmental attitude measurement in Nigeria using the Campbell paradigm	Environment, Development and Sustainability	22	
99	Ogunbode et al. (2)	2020	Exposure to the IPCC special report on 1.5 °C global warming is linked to perceived threat and increased concern about climate change	Climatic Change	158	
100	Ohe & Ikeda	2005	Global warming: risk perception and risk-mitigating behavior in Japan	Mitigation and Adaptation strategies for global change	10	
101	Papagiannaki et al.	2019	How awareness and confidence affect flood-risk precautionary behavior of Greek citizens: the role of perceptual and emotional mechanisms	Natural Hazards and Earth System Sciences	19	7
102	Peng et al.	2022	Smallholder farmers' behavioral preferences under the impact of climate change: A comparative analysis of two agricultural areas in China	Frontiers in Earth Science	10	
103	Rothermich et al.	2021	The influence of personality traits on attitudes towards climate change – An exploratory study	Personality and Individual Differences	168	
104	Sattler et al.	2021	Climate change threatens nomadic herding in Mongolia: A model of climate change risk perception and behavioral adaptation	Journal of Environmental Psychology	75	
105	Sattler et al.	2020	Climate Change in Tonga: Risk Perception and Behavioral Adaptation	Managing Climate Change Adaptation in the Pacific Region		
106	Sattler et al. - Study A	2000	Disaster Preparedness: Relationships Among Prior Experience, Personal Characteristics, and Distress	Journal of applied social psychology	30	7
107	Sattler et al. - Study B	2000	Disaster Preparedness: Relationships Among Prior Experience, Personal Characteristics, and Distress	Journal of applied social psychology	30	7
108	Savadori et al.	2022	Communicating Seismic Risk Information: The Effect of Risk Comparisons on Risk Perception Sensitivity	Frontiers in Communication	7	
109	Seebauer et al.	2021	(Almost) all Quiet Over One and a Half Years: A Longitudinal Study on Causality Between Key Determinants of Private Flood Mitigation	Risk Analysis	41	6

110	Soucy et al.	2022	Drivers of Climate Change Risk Perceptions among Diverse Forest Stakeholders in Maine, USA	Society & Natural Resources	35	5
111	Spaccatini et al.	2021	Individual cognitive style affects flood-risk perception and mitigation intentions	Journal of Applied Social Psychology	51	3
112	Sugiura et al.	2019	Psychological processes and personality factors for an appropriate Tsunami evacuation	Geosciences	9	8
113	Syal et al.	2011	Climate change and human health—what influences the adoption of adaptation programming in the United States public health system?	Mitigation and adaptation strategies for global change	16	
114	Tobin et al.	2024	The role of individual well-being in risk perception and evacuation for chronic vs. acute natural hazards in Mexico	Applied Geography	31	2
115	Trumbo et al.	2014	An Assessment of Change in Risk Perception and Optimistic Bias for Hurricanes Among Gulf Coast Residents	Risk analysis	34	6
116	van der Linden et al.	2015	The social-psychological determinants of climate change risk perceptions: Towards a comprehensive model	Journal of Environmental Psychology	41	
117	Wei et al.	2017	Assessment of households' responses to the tsunami threat: A comparative study of Japan and New Zealand	International journal of disaster risk reduction	25	
118	Weinstein et al.	2000	Changes in perceived vulnerability following natural disaster	Journal of Social and Clinical Psychology	19	3
119	Wu et al.	2017	Preparing for the new normal: Students and earthquake hazard adjustments in Oklahoma	International journal of disaster risk reduction	25	
120	Xie et al.	2019	Predicting climate change risk perception and willingness to act	Journal of Environmental Psychology	65	
121	Xu et al.	2020	Information credibility, disaster risk perception and evacuation willingness of rural households in China	Natural Hazards	103	
122	Xu et al.	2016	The association between exposure and psychological health in earthquake survivors from the Longmen Shan Fault area: the mediating effect of risk perception	BMC Public Health	16	1
123	Xu et al.	2019	Earthquake Disaster Risk Perception Process Model for Rural Households: A Pilot Study from Southwestern China	International journal of environmental research and public health	16	22
124	Yang et al. - Study A	2020	Information Seeking and Information Sharing Related to Hurricane Harvey	Journalism & Mass Communication Quarterly	97	4
125	Yang et al. - Study B	2020	Information Seeking and Information Sharing Related to Hurricane Harvey	Journalism & Mass Communication Quarterly	97	4
126	Yong et al.	2017	Risk Perception and Disaster Preparedness in Immigrants and Canadian-Born Adults: Analysis of a National Survey on Similarities and Differences	Risk analysis	37	12
127	You et al.	2019	Interaction of individual framing and political orientation in guiding climate change risk perception	Journal of Risk Research	22	7

APPENDIX B

Studies considered for each antecedent (alphabetical order).

Variable	Authors	Year
Age	Altinay et al.	2020
	Aslam e al.	2022
	Babcicky et al.	2017
	Babcicky et al.	2020
	Beckmann et al.	2021
	Bogani et al.	2023
	Botzen et al.	2009
	Bremer et al.	2017
	Brügger et al.	2020
	Buylova et al.	2020
	Chang et al.	2016
	Costa-Font et al.	2009
	Duijndam et al.	2023
	Elshirbiny et al.	2020
	Fox Gotham et al.	2017
	Gilbert et al.	2023
	Golazad et al.	2022
	Goldberg et al.	2020
	Greer et al.	2018
	Gunay et al.	2022
	Han et al.	2021
	Han et al.	2022
	Horne et al.	2021
	Huang et al.	2020
	Hudson et al.	2020
	Jaiswal - Study A	2021
	Jaiswal- Stuyd B	2021
	Kellens et al.	2012
	Kohl et al.	2022
	Kukowski et al. - Study A	2022
	Kukowski et al. - Study B	2022
	Lai et al.	2018
	Liu & Sun	2021
	Lo & Cheung	2015
	López-Fletes et al.	2022
	MacPherson-Krutsky et al.	2023

	Mafuko Nyandwi et al.	2023
	Masud et al.	2017
	Mead et al.	2012
	Mumpower et al.	2016
	Ndamani et al.	2017
	Netzel et al.	2021
	Ogunbode et al.	2019
	Ogunbode et al.	2020
	Rothermich et al.	2021
	Sattler et al. - Study A	2000
	Sattler et al. - Study B	2000
	Savadori et al.	2022
	Sugiura et al.	2019
	Trumbo et al.	2014
	Wei et al.	2017
	Xu et al.	2020
	Yong et al.	2017
	You et al.	2019
Altruistic Values	Elshirbiny et al.	2020
	Gilbert et al.	2023
	Horne et al.	2021
	Lacroix et al.	2020
	Soucy et al.	2022
	van der Linden et al.	2015
	Xie et al.	2019
Biospheric Values	Elshirbiny et al.	2020
	Gilbert et al.	2023
	Horne et al.	2021
	Lacroix et al.	2020
	Soucy et al.	2022
	van der Linden et al.	2015
	Xie et al.	2019
Children	Altinay et al.	2020
	Fox Gotham et al.	2017
	Greer et al.	2020
	Han et al.	2021
	Han et al.	2022
	Netzel et al.	2021

	Xu et al.	2020
Climate Change Awareness	Arbuckle et al.	2014
	Azadi et al.	2019
	Begum et al.	2022
	Carmen Hidalgo et al.	2014
	Horne et al.	2021
	Hornsey et al.	2015
	Kohl et al.	2022
	Lowe et al.	2022
	Ogunbode et al.	2019
	Peng et al.	2022
	Rothermich et al.	2021
	Soucy et al.	2022
	Yang et al. - Study A	2020
	Yang et al. - Study B	2020
Conservative	Altinay et al.	2020
	Carlton et al.	2013
	Chang et al.	2016
	Gilbert et al.	2023
	Goldberg et al.	2020
	Han et al.	2021
	Horne et al.	2021
	Kohl et al.	2022
	Kukowski et al. - Study A	2022
	Kukowski et al. - Study B	2022
	Kwon et al.	2019
	Lowe et al.	2022
	Mumpower et al.	2016
	Ogunbode et al.	2020
	You et al.	2019
Education	Altinay et al.	2020
	Aslam e al.	2022
	Botzen et al.	2009
	Bremer et al.	2017
	Brody et al.	2008
	Brügger et al.	2020
	Buylova et al.	2020
	Chang et al.	2016

	Duijndam et al.	2023
	Fox Gotham et al.	2017
	Gilbert et al.	2023
	Golazad et al.	2022
	Goldberg et al.	2020
	Greer et al.	2020
	Gunay et al.	2022
	Han et al.	2021
	Han et al.	2022
	Huang et al.	2020
	Jaiswal - Study A	2021
	Jaiswal- Stuyd B	2021
	Lai et al.	2018
	Liu & Sun	2021
	Lo & Cheung	2015
	López-Fletes et al.	2022
	MacPherson-Krutsky et al.	2023
	Mafuko Nyandwi et al.	2023
	Masud et al.	2017
	Mumpower et al.	2016
	Ndamani et al.	2017
	Netzel et al.	2021
	Ngo et al.	2020
	Sattler et al.	2020
	Trumbo et al.	2014
	Xu et al.	2020
	Yong et al.	2017
	You et al.	2019
Egoistic Values	Elshirbiny et al.	2020
	Gilbert et al.	2023
	Horne et al.	2021
	Lacroix et al.	2020
	Soucy et al.	2022
	van der Linden et al.	2015
	Xie et al.	2019
Event Perceived Likelihood	Berlin Rubin et al.	2022
	Bichard et al.	2012
	Bogani et al.	2023

	Buylova et al.	2020
	Greer et al.	2018
	Greer et al.	2020
	Huang et al.	2020
	Liu & Sun	2021
	Mumpower et al.	2016
	Ndamani et al.	2017
Expected Response Efficacy	Bichard et al.	2012
	Cai et al.	2023
	Eriksson	2017
	Haque & Fatema	2022
	López-Fletes et al.	2022
	Mead et al.	2012
	Xie et al.	2019
Fatalism	Aksa et al.	2020
	Liu & Sun	2021
	Lyu & Adams - Study A	2022
	Lyu & Adams - Study B	2022
	Seebauer et al.	2021
Woman	Altinay et al.	2020
	Armstrong et al.	2021
	Aslam e al.	2022
	Babcicky et al.	2017
	Babcicky et al.	2020
	Beckmann et al.	2021
	Brody et al.	2008
	BrŸgger et al.	2020
	Bustillos Ardaya et al.	2017
	Buylova et al.	2020
	Carlton et al.	2013
	Chang et al.	2016
	Costa-Font et al.	2009
	Duijndam et al.	2023
	Elshirbiny1 et al.	2020
	Fox Gotham et al.	2017
	Gilbert et al.	2023
	Golazad et al.	2022
	Goldberg et al.	2020

	Greer et al.	2018
	Gunay et al.	2022
	Han et al.	2021
	Han et al.	2022
	Haque & Fatema	2022
	Horne et al.	2021
	Hudson et al.	2020
	Jaiswal - Study A	2021
	Jaiswal- Stuyd B	2021
	Kellens et al.	2012
	Kohl et al.	2022
	Kukowski et al. - Study A	2022
	Kukowski et al. - Study B	2022
	Lai et al.	2018
	Liu & Sun	2021
	Lo & Cheung	2015
	López-Fletes et al.	2022
	MacPherson-Krutsky et al.	2023
	Mafuko Nyandwi et al.	2023
	Masud et al.	2017
	Mead et al.	2012
	Mumpower et al.	2016
	Ndamani et al.	2017
	Netzel et al.	2021
	Ogunbode et al.	2020
	Ogunbode et al.	2019
	Papagiannaki et al.	2019
	Rothermich et al.	2021
	Sattler et al.	2000
	Syal et al.	2011
	Trumbo et al.	2014
	Wei et al.	2017
	Xu et al.	2020
	Yong et al.	2017
	You et al.	2019
Home Ownership	Altinay et al.	2020
	Buylova et al.	2020
	Duijndam et al.	2023

	Greer et al.	2018
	Lo & Cheung	2015
	MacPherson-Krutsky et al.	2023
	Netzel et al.	2021
	Xu et al.	2020
Household Size	Aslam e al.	2022
	Buylova et al.	2020
	Duijndam et al.	2023
	Fox Gotham et al.	2017
	Hudson et al.	2020
	López-Fletes et al.	2022
	Mafuko Nyandwi et al.	2023
	Wei et al.	2017
Income	Altinay et al.	2020
	Aslam e al.	2022
	Babcicky et al.	2017
	Babcicky et al.	2020
	Beckmann et al.	2021
	Botzen et al.	2009
	Brody et al.	2008
	Buylova et al.	2020
	Chang et al.	2016
	Costa-Font et al.	2009
	Fox Gotham et al.	2017
	Gilbert et al.	2023
	Goldberg et al.	2020
	Gunay et al.	2022
	Han et al.	2022
	Han et al.	2021
	Huang et al.	2020
	Hudson et al.	2020
	Jaiswal - Study A	2021
	Jaiswal- Stuyd B	2021
	Lai et al.	2018
	López-Fletes et al.	2022
	MacPherson-Krutsky et al.	2023
	Mafuko Nyandwi et al.	2023
	Masud et al.	2017

	Mead et al.	2012
	Mumpower et al.	2016
	Ndamani et al.	2017
	Sattler et al.	2000
	Trumbo et al.	2014
	Wei et al.	2017
	Xu et al.	2020
	Yong et al.	2017
	You et al.	2019
Knowledge	Aksa et al.	2020
	Altarawneh et al.	2018
	Ariccio et al.	2020
	Armstrong et al.	2021
	Beckmann et al.	2021
	Beckmann et al.	2020
	Bichard et al.	2012
	Botzen et al.	2009
	Buylova et al.	2020
	Cisternas et al.	2023
	Damm et al.	2013
	DeBono et al.	2012
	Elshirbiny et al.	2020
	Gilbert et al.	2023
	Guo et al.	2016
	Horne et al.	2021
	Huang et al.	2010
	Kurata et al.	2022
	Kwon et al.	2019
	Lacroix et al.	2020
	Liu & Sun	2021
	Lowe et al.	2022
	Luis et al.	2016
	MacPherson-Krutsky et al.	2023
	Netzel et al.	2021
	Ngo et al.	2020
	Sattler et al.	2021
	Savadori et al.	2022
	Soucy et al.	2022

	Sugiura et al.	2019
	van der Linden et al.	2015
	Xie et al.	2019
	Xu et al.	2019
	You et al.	2019
Married	Duijndam et al.	2023
	Han et al.	2021
	Hudson et al.	2020
	MacPherson-Krutsky et al.	2023
	Ndamani et al.	2017
Media Use	Altinay et al.	2020
	Armstrong et al.	2021
	Chang et al.	2016
	Goldberg et al.	2020
	Gunay et al.	2022
	Howe	2011
	MacPherson-Krutsky et al.	2023
	You et al.	2019
Negative Emotions	Altarawneh et al.	2018
	Armstrong et al.	2021
	Brügger et al.	2020
	Diakakis et al.	2022
	Elshirbiny et al.	2020
	Eriksson	2017
	Guillard et al.	2019
	Huang et al.	2010
	Kukowski et al.	2022
	Kwon et al.	2019
	Lacroix et al.	2020
	Liu & Sun	2021
	Lyu & Adams - Study A	2022
	Lyu & Adams - Study B	2022
	MacPherson-Krutsky et al.	2023
	Mafuko Nyandwi et al.	2023
	Ogunbode et al. (1)	2020
	Ogunbode et al. (2)	2020
	Ohe & Ikeda	2005
	Papagiannaki et al.	2019

	Rothermich et al.	2021
	Seebauer et al.	2021
	Soucy et al.	2022
	Tobin et al.	2024
	van der Linden et al.	2015
	Weinstein et al.	2000
	Xie et al.	2019
Objective Risk	Altinay et al.	2020
	Babcicky et al.	2017
	Babcicky et al.	2020
	Botzen et al.	2009
	Brody et al.	2008
	Bustillos Ardaya et al.	2017
	Buylova et al.	2020
	Carlton et al.	2013
	Liu & Sun	2021
	López-Fletes et al.	2022
	MacPherson-Krutsky et al.	2023
	Navarro et al.	2021
	Wei et al.	2017
Place Attachment	Ariccio et al.	2020
	De Dominicis et al. - Study A	2015
	De Dominicis et al. - Study B	2015
	Domingues et al.	2021
	Ghasemi et al.	2020
	Greer et al.	2020
	Guillard et al.	2019
Preparedness	Begum et al.	2022
	Berlin Rubin et al.	2022
	Bixler et al.	2021
	Bustillos Ardaya et al.	2017
	Buylova et al.	2020
	Cai et al.	2023
	Damm et al.	2013
	DeYoung	2014
	Eriksson	2017
	Jaiswal	2021
	Kurata et al.	2022

	Lai et al.	2018
	Lo	2013
	Lo & Cheung	2015
	MacPherson-Krutsky et al.	2023
	Papagiannaki et al.	2019
Prior experience	Aslam e al.	2022
	Babcicky et al.	2020
	Babcicky et al.	2017
	Berlin Rubin et al.	2022
	Botzen et al.	2009
	Bustillos Ardaya et al.	2017
	Buylova et al.	2020
	Damm et al.	2013
	De Dominicis et al.	2021
	DeYoung	2014
	Duijndam et al.	2023
	Elshirbiny et al.	2020
	Gilbert et al.	2023
	Halpern-Felsher et al.	2001
	Han et al.	2022
	Horne et al.	2021
	Jaiswal	2021
	Kellens et al.	2012
	Liu & Sun	2021
	Lo	2013
	Lyu & Adams	2022
	Mafuko Nyandwi et al.	2023
	Netzel et al.	2021
	Ngo et al.	2020
	Ogunbode et al.	2019
	Sattler et al.	2000
	Soucy et al.	2022
	Sugiura et al.	2019
	Trumbo et al.	2014
	van der Linden et al.	2015
	Xie et al.	2019
	Xu et al.	2016
Prior Experience Severity	Bixler et al.	2021

	Domingues et al.	2021
	Greer et al.	2020
	Guo et al.	2016
	Han et al.	2021
	Han et al.	2017
	Howe	2011
	Lacroix et al.	2020
	MacPherson-Krutsky et al.	2023
	Papagiannaki et al.	2019
	Wu et al.	2017
Pro-environmental Orientation	Bremer et al.	2017
	Brody et al.	2008
	Carlton et al.	2013
	Mumpower et al.	2016
	Syal et al.	2011
Psychological Distance	Aslam et al.	2022
	Azadi et al.	2019
	Domingues et al.	2018
	Guillard et al.	2019
	Spaccatini et al.	2021
Religiosity	Costa-Font et al.	2009
	Gilbert et al.	2023
	Goldberg et al.	2020
	Gunay et al.	2022
	Han et al.	2021
	Han et al.	2022
	Kwon et al.	2019
	Lowe et al.	2022
	Mumpower et al.	2016
Residential Tenure	Aslam e al.	2022
	Bustillos Ardaya et al.	2017
	Buylova et al.	2020
	Fox Gotham et al.	2017
	Greer et al.	2020
	Greer et al.	2018
	Han et al.	2022
	Lai et al.	2018
	MacPherson-Krutsky et al.	2023

	Navarro et al.	2021
	Netzel et al.	2021
	Wei et al.	2017
	Xu et al.	2020
	Yong et al.	2017
Self-efficacy in Response	Berlin Rubin et al.	2022
	Brody et al.	2008
	Buylova et al.	2020
	Cai et al.	2023
	Carmen Hidalgo et al.	2014
	Davis et al.	2005
	DeYoung	2014
	Domingues et al.	2021
	Eriksson	2017
	Ghasemi et al.	2020
	López-Fletes et al.	2022
	Ogunbode et al.	2020
	Papagiannaki et al.	2019
	You et al.	2019
Sense of Community	Babcicky et al.	2020
	Babcicky et al.	2017
	Davis et al.	2005
	DeYoung	2014
	Greer et al.	2020
	Hudson et al.	2020
Social Norms	Basiru et al.	2022
	Chen	2020
	Eriksson	2017
	Gilbert et al.	2023
	Goldberg et al.	2020
	Goodwin et al.	2012
	Lacroix et al.	2020
	Li et al.	2021
	Lo	2013
	Sattler et al.	2021
	Soucy et al.	2022
	van der Linden et al.	2015
	Xie et al.	2019

Social Support	Babcicky et al.	2020
	Eriksson	2017
	Goldberg et al.	2020
	Han et al.	2021
	Seebauer et al.	2021
Trust in Authorities	Ali et al.	2022
	Aslam et al.	2022
	Azadi et al.	2019
	Carlton et al.	2013
	Chang et al.	2016
	Cisternas et al.	2023
	Ghasemi et al.	2020
	Han et al.	2021
	Han et al.	2022
	Han et al.	2017
	Huang et al.	2010
	Kwon et al.	2019
	Mafuko Nyandwi et al.	2023
	Mumpower et al.	2016
	Papagiannaki et al.	2019
	Peng et al.	2022
Trust in Community	Cai et al.	2023
	Han et al.	2021
	Han et al.	2017
	Hudson et al.	2020
	Mumpower et al.	2016
	You et al.	2019
Vulnerability	Buylova et al.	2020
	Gumasing et al.	2022
	Kurata et al.	2022
	MacPherson-Krutsky et al.	2023
	Mafuko Nyandwi et al.	2023
	Papagiannaki et al.	2019