Spinning in circles? A systematic review on the role of theory in social vulnerability, resilience and adaptation research

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Abstract

An increasing number of publications focus on social vulnerability, resilience, and adaptation (SVRA) towards natural hazards and climate change. Despite this proliferation of research, a systematic understanding of how these studies are theoretically grounded is lacking. Here, we systematically reviewed 4432 articles that address SVRA in various disciplinary fields (e.g. psychology, sociology, geography, mathematics) for various hazards, including floods, droughts, landslides, storm surges, wildfires, tsunamis, earthquakes, and volcano eruptions. We focus on the extent to which these studies explicate the frameworks, theoretical constructs or theories they rely on. Surprisingly, we found that about 90% of the reviewed studies do not explicitly refer to a theoretical underpinning. Overall, theories focusing on individuals' SVRA were more frequently used than those focusing on systems, society, groups, and networks. Moreover, the uptake of theories varied according to the hazard investigated and field of knowledge, being more frequent in wildfire and flood studies and articles published in social science journals. Based on our analysis, we propose a reflexive handling of theories to foster more transparent, comparable, and robust empirical research on SVRA.

Keywords: natural hazards; preparedness; adaptive behaviour; coping; inductive research; deductive research; theorising

1. Introduction

Over the last decades, social vulnerability, resilience, and adaptation (SVRA) and related concepts[1] have been increasingly called upon to address natural hazard risk and adaptation to climate change (Mochizuki et al., 2018). Indeed, to effectively understand how hazards become disasters, it is widely accepted that we need to consider (1) people's behaviours and capacities, (2) collective norms and values, and (3) how resources and power are distributed (Wisner et al., 2012). The importance of these factors is highlighted, among others, by the Intergovernmental Panel on Climate Change (IPCC, 2022) and the Disaster Risk Management Knowledge Center of the European Commission (DRMKRC, 2020, 2017). Also, on the policy level, initiatives such as the Sendai Framework for

[1] These include concepts such as adaptive and coping capacity, adaptive and protective behaviour, preparedness, among others.

Disaster Risk Reduction (UNISDR, 2015) and a growing number of on-the-ground initiatives (e.g. Rockefeller Foundation, African Development Bank) invoke the relevance of individual and collective actions in building resilience. Similarly, frameworks such as 'Making Space for Water' (UK; DEFRA, 2005), 'Space for Rivers' (PKRR, 2006), 'German Federal Water Act' (WHG, 2009), the 'US National Flood Insurance Programme' (Shaeffer, 1960), and the 'Canadian National Disaster Mitigation Program' (Thistlethwaite et al., 2018) encourage or demand individuals to take adaptive actions to mitigate future risks (Kuhlicke et al., 2020).

The growing relevance of SVRA research is associated with a multiplicity of definitions of key terms, resulting in a Babylonian babble of voices (Vogel, 2006). The reasons for this include, among others, the considerable number of research domains involved. Each of these originates from different disciplines, including sociology, psychology, geography and mathematics, among many others, with varying backgrounds and interests (Alexander, 2013; Janssen et al., 2006; Reghezza-Zitt and Rufat, 2019). Although several authors suggest ways to specify the interrelations of key concepts (Gaillard, 2010; Lei et al., 2014; Reghezza-Zitt and Rufat, 2019; Wisner et al., 2012), SVRA research is still highly fragmented (Kuhlicke et al., 2020; Rufat et al., 2020). Even when considering single concepts like vulnerability and resilience, numerous, sometimes inconsistent, frameworks exist (Brand and Jax, 2007; Cutter, 2018; de Brito et al., 2017; Gallopín, 2006; Rufat et al., 2019).

While various reviews systematise SVRA terminology (e.g. Otto et al., 2017), methods (e.g. Siders, 2019), and case study applications (Ford et al., 2018; Moreira et al., 2021), few systematic reviews investigate the extent to which SVRA research is based upon theoretical constructs and frameworks. The exceptions are studies that address the use of theories but with a narrower focus than here, such as flood risk perception (Kellens et al., 2013), coastal adaptation (Koerth et al., 2017), and individual preparedness (Paton, 2019).

Here, we provide a base for substantiating the discussion on the role of theory in SVRA research. Although this field was, from its very beginning, underpinned by a strong pragmatic perspective (Wescoat, 1992), we argue that an explicit engagement with underlying assumptions and epistemological questions is relevant for ensuring scientific soundness, cumulative knowledge production as well as practical usefulness (Corley and Gioia, 2011). We consider that all SVRA research is based on a set of basic assumptions

about causes and effects and, hence, it is inherently based on a "theory", whether explicitly stated or not. Research is, therefore, never theory-free. However, publications often fail to explicitly articulate their assumptions, limiting the development of robust evidence on SVRA. We contend that this is a shortcoming of SVRA research.

Therefore, in this study, we reviewed 4432 scientific publications on SVRA that address different natural hazards (i.e. floods, droughts, heatwaves, landslides, storm surges, wildfires, tsunamis, earthquakes, and volcanic activity) and, by doing so, attempted to answer the following questions: (1) To what extent is the theoretical underpinning of SVRA research made explicit? (2) Which explicated theories are more popular and which are less often referred to? (3) If theories are made explicit, how are they used in empirical studies? Are they used to 'test' theories (e.g. deductive approach), or do they rather help to conduct theoretically informed in-depth case-study research (e.g. inductive approach)? (4) If theories are made explicit, are there differences in their use according to the field of knowledge and natural hazard investigated? Drawing on the findings, we aimed to encourage researchers engaged in SVRA to become more explicit and reflexive about the role of theory in their studies.

2. Methodology

A systematic review was conducted to synthesise the use of theories in empirical SVRA research following the PRISMA guidelines (Page et al., 2021). As the boundary of this field of research is hardly defined, we identified relevant papers through keyword searches containing SVRA and hazard-related keywords (Box 1) based on previous similar searches (Ejeta et al., 2015; Oktari et al., 2020).

Box 1: Search string used to retrieve relevant articles in Web of Science

Topic=("coping capacit*" OR "adaptive capacit*" OR "social resilience" OR "adaptive resilience" OR "community resilience" OR "household resilience" OR "adaptive behavio*" OR "social vulnerab*" OR preparedne*)

AND

Abstract, Title or Author keywords =(flood* OR inundation OR "storm wave*" OR "storm surge*" OR " tidal surge*" OR "storm tide*" OR "hurricane tide*" OR "tropical surge*" OR drought* OR heatwave* OR "heat wave*" OR "extreme heat" OR landslide* OR mudslide* OR mudflow* OR rockslide* OR "debris flow" OR lahar* OR earthquake* OR tsunami* OR "seismic sea wave" OR bushfire* OR wildfire* OR "forest fire*" OR "volcanic eruption*" OR "volcanic ash*" OR magma* OR lava OR volcano* OR "volcanic hazard*")

The search was restricted to peer-reviewed articles written in English that included the search keywords in their title, abstract, or keywords. No lower boundary time constraints were used, but only articles published until December 31st 2020 were considered. Review articles, commentaries, and opinion pieces were excluded. Based on these criteria, 4432 records were retrieved from the Web of Science (WoS) database (Fig. 1).

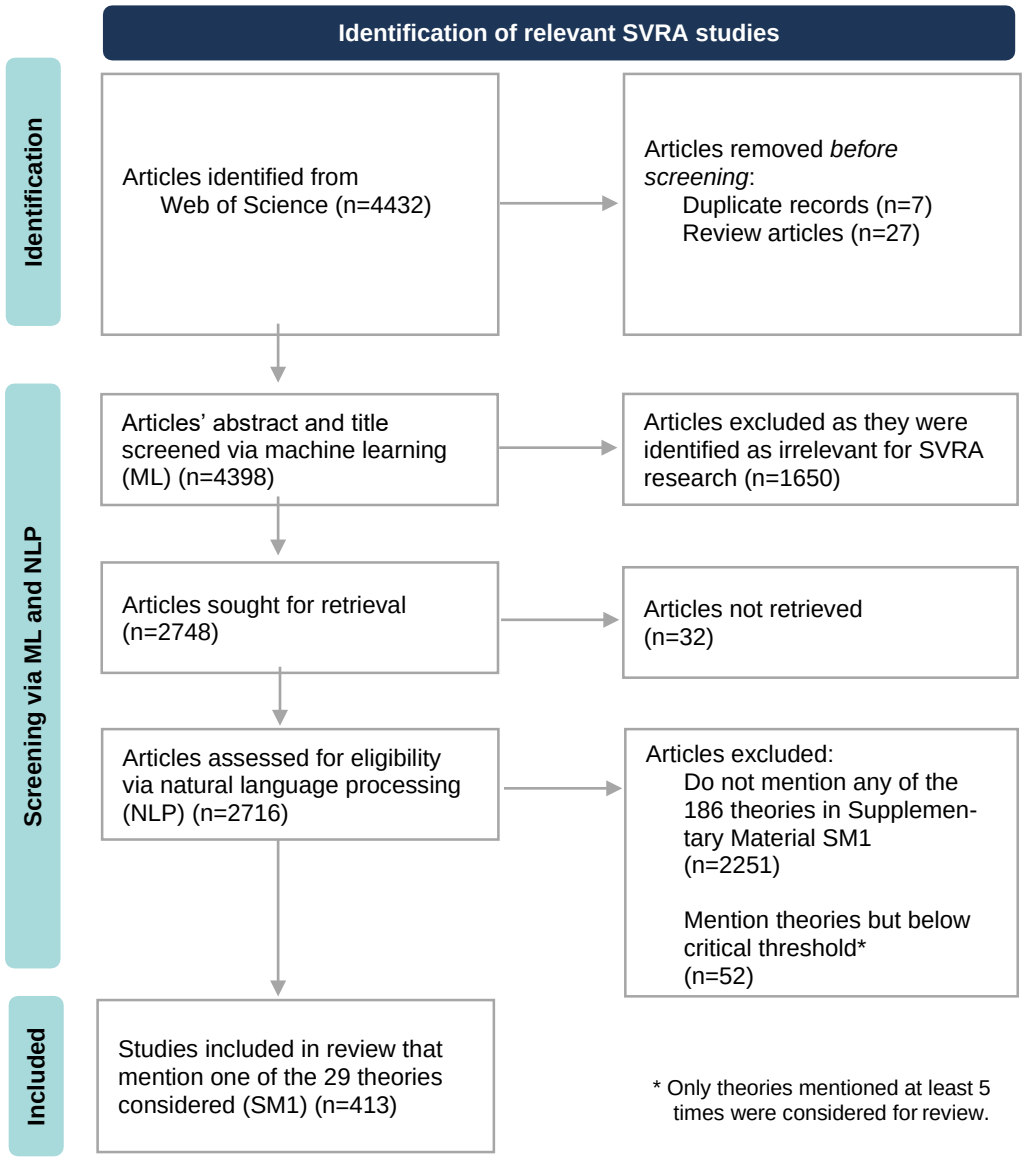


Figure 1: PRISMA flowchart with the underlying review process

2.1 Article screening using manual coding, machine learning, and natural language processing (NLP)

Article screening was done first at the title and abstract level following three inclusion criteria: (1) SVRA are assessed either qualitatively or quantitatively, or specific attention is given to their understanding, (2) the research is applied to natural hazards in general or to specific hazard types (floods, droughts, heatwaves, landslides, storm surges, wildfires, tsunamis, earthquakes, and volcanic activity), and (3) the research reports on analyses of empirical data (i.e., data derived from statistics, texts, self-reports, observation or experience). Articles whose contributions are primarily conceptual were treated as non-empirical and therefore excluded.

Screening entailed manual coding and supervised machine learning to determine whether the articles should be included. Following this criteria, a random sample of 1000 abstracts was read by the co-authors and classified as relevant or irrelevant. Then, a multinomial naïve Bayes model was built by splitting the labelled data into a training (80% of the articles) and a test set (20%). An accuracy of 0.89 was obtained. The model was then applied to classify the remaining articles. A random sample of 200 articles predicted as 'irrelevant' was read to verify if they could potentially be relevant. Among this group of articles, only two were found to be relevant. Given the low number of additional relevant articles identified, we concluded that the benefits of additional screening would be low. Hence, we considered the machine learning predictions for labelling the remaining articles.

Results indicated that potentially 2748 articles could be relevant for our analysis. Of these, 2716 were downloaded, and 32 were unretrievable. A total of 2716 articles thus constitutes the sample of potentially relevant articles included in our analysis.

In order to filter for the articles that mentioned theories, we used a series of NLP tools. First, the articles were converted from pdf files into plain text and tokenised into sentences with lowercase letters. The article's references were removed from the corpus to avoid bias. Then, we extracted 3-, 4- and 5-word strings that included the terms "theory", "model*", and "framework*". Although not labelled theories, we considered frameworks or models also as theories granted that they explicate "why empirical patterns were or are expected to be observed" (Sutton and Staw, 1995, p. 374) and, by doing so, help to show "how and/or why a phenomenon occurs" (Corley and Gioia, 2011, p. 12). Results were sorted by their number of occurrences. This allowed us to identify relevant theories to be considered. Additional theories were identified based on previous

reviews (Kuhlicke et al., 2020; Kwon and Silva, 2020). In the end, a list with 186 potentially relevant theories was compiled (see Supplementary Material SM1).

Pattern matching (de Brito et al., 2020) was used to identify articles that mentioned any of these theories. 465 articles mentioned at least one of the 186 theories. However, many of these theories were considered only by one article (SM1). As such, to refine our analysis, we considered only the theories cited in at least 5 papers (n=29 theories) for further analyses. After this process, 413 articles were deemed eligible for a closer reading as they mentioned at least one of the considered 29 theories within the actual text body, excluding references.

2.3 Close reading of articles mentioning theories

The remaining articles (n=413) were scrutinised in-depth to understand the role of theory in these studies. They were distributed among co-authors for close reading (de Brito et al., 2021). The co-authors come from diverse fields, including sociology, engineering, geography, psychology, and economics. Each article was read by at least two persons. Co-authors were given the option to respond 'in doubt' to any of the classifications in cases of uncertainty. In case of discrepancies, a third person read the article and the final classification was decided based on a discussion between the first authors. Reasons for the classification were documented.

The articles were coded across a set of questions, including: (1) if the theory was used deductively (e.g. testing a theory) and/or inductively[2] (e.g. developing a theory based on empirical observations) (Fig. 2); (2) the study design (e.g. experimental, longitudinal); and (3) the data collection methods (survey, interview, focus group or workshop, participant observation, document analysis, indicator-based-approaches, and computer modelling). The data collection methods were selected based on the co-authors' experience. Information on the investigated hazards and mentioned theories were extracted using text pattern matching. Results were supplemented and validated by the co-authors.

In addition, we pragmatically grouped theories according to their foci, including (1) theories with a focus on individual decision-making processes stemming mostly from

[2] We are aware that this differentiation is coarse and that many different, more blurred forms are possible and probably the reality of doing research.

behavioural sciences, economics, and psychology (e.g. bounded rationality and prospect theory); (2) theories with a focus on micro-macro processes, groups and/or networks often referred to in sociology, anthropology and human geography (e.g. PAR, networks and social capital, Cultural Theory etc.) and (3) theories with a focus on social-ecological systems (e.g. resilience, complex systems etc.).

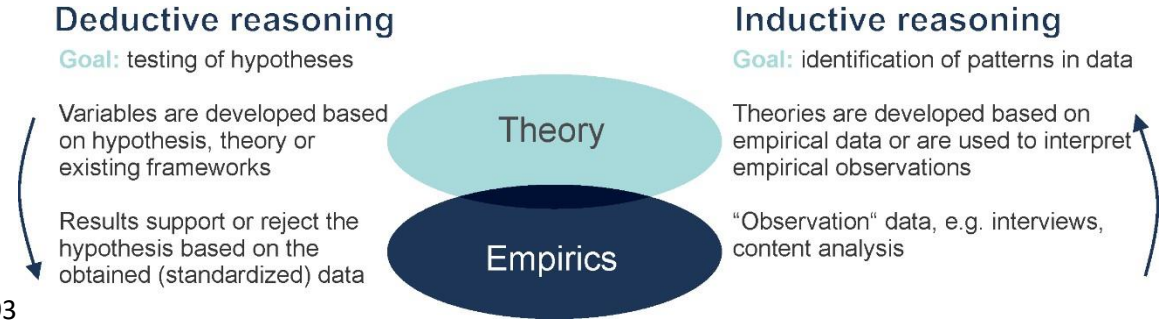


Figure 2. Differences between deductive and inductive reasoning. Here, deductive reasoning implies a process of translating theories (or parts of them) into hypotheses that are tested through specific variables; inductive reasoning implies starting from specific observation towards more general conclusions without making a priori assumptions about the interrelations among the variables.

2.4 Statistical analyses

The use of theories according to the hazard investigated, and the WoS field of knowledge[3] (e.g. Arts & Humanities, Social Sciences) were summarised with frequencies and percentages using the Clopper–Pearson methodology to calculate 95% Confidence Intervals (CI). Rates of theory use (e.g. the % of theory use in a subset of articles) were compared with pairwise comparison using Fisher's exact test.

3. Results

3.1. Trends in SVRA research

A total of 2716 potentially relevant articles addressing SVRA were retrieved by our search (Fig. 1). Since 1992, the number of SVRA articles has increased by more than two orders of magnitude (Fig. 3A). This increase is exponential even when normalising the data by the yearly number of all articles included in the WoS database. Regarding the hazard

[3] WoS research areas: https://images.webofknowledge.com/images/help/WOS/hp_research_areas_easca.html

types, most articles addressed floods (47.9%), followed by earthquakes (27.8%) and droughts (17.0%) (Fig. 3B).

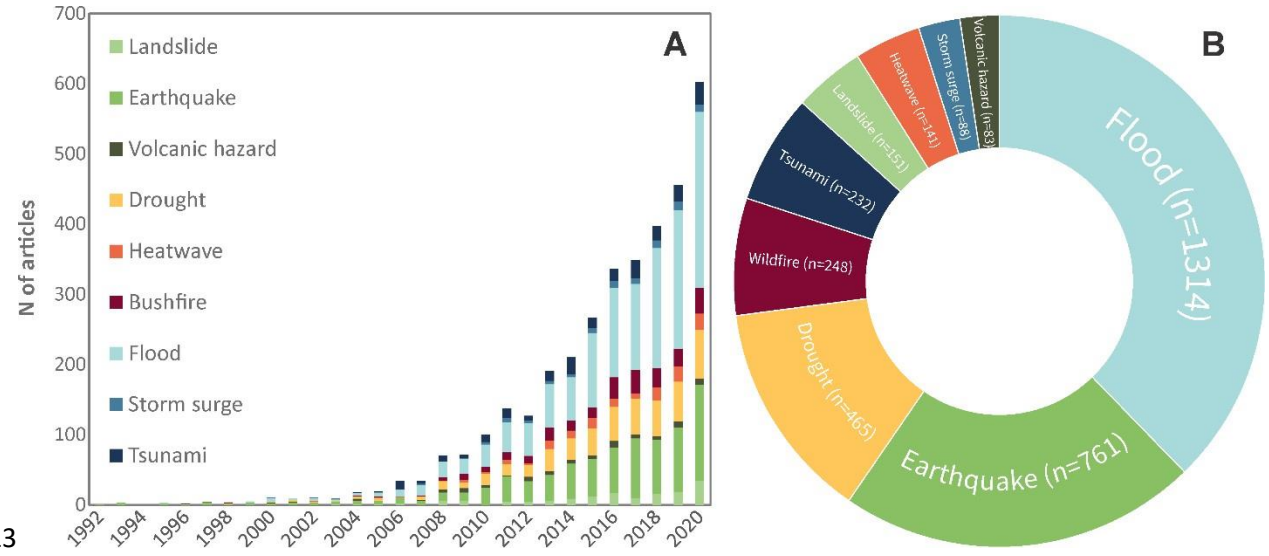
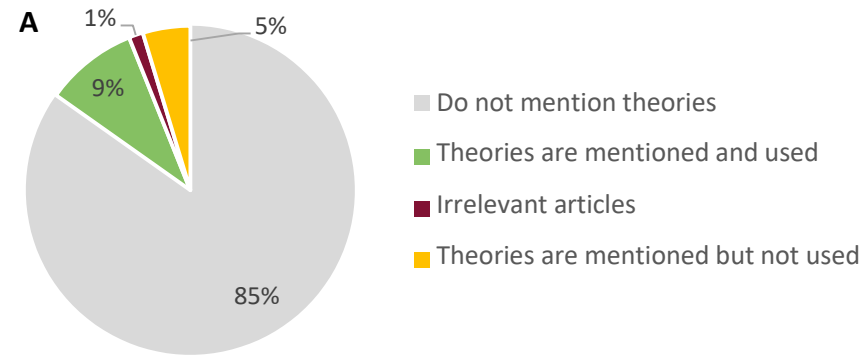


Figure 3. Distribution of the retrieved SVRA articles (n=2716) according to their (A) year of publication and (B) type of hazard addressed. Some articles tackled more than one hazard, totalling 3483 entries.

Out of the 2716 potentially relevant articles, 413 (15.2%, 95% CI [13.8%, 16.6%]) mentioned at least one of the 29 theories investigated (i.e. theories mentioned in 5 or more articles – SM1) (Fig. 4). We considered a paper as theoretically grounded only if the authors specifically mentioned that they used or tested a theory. By manually screening these 413 articles, we found that 38 were not empirical studies. Furthermore, 127 referred to theories in the text without applying or testing them. This was observed in articles that cited a theory in the introduction or the literature review sections, but the authors did not make explicit how the theory informed the empirical analysis (e.g. cases where a specific hypothesis was based on the theoretical framework or a theory informed the thematic coding).

Thus, only 9.1%, 95% CI [8.7%, 10.2%] (n=248) of the 2716 potentially relevant articles used theories to inform their empirical analysis and explicate the relationship between theory and empirical analysis (Fig. 4A). This implies that around 90% of the reviewed studies have no explicit theoretical underpinning. No temporal differences were observed in the use of theories (SM3), meaning that the share of theoretically-based studies did not increase over time.



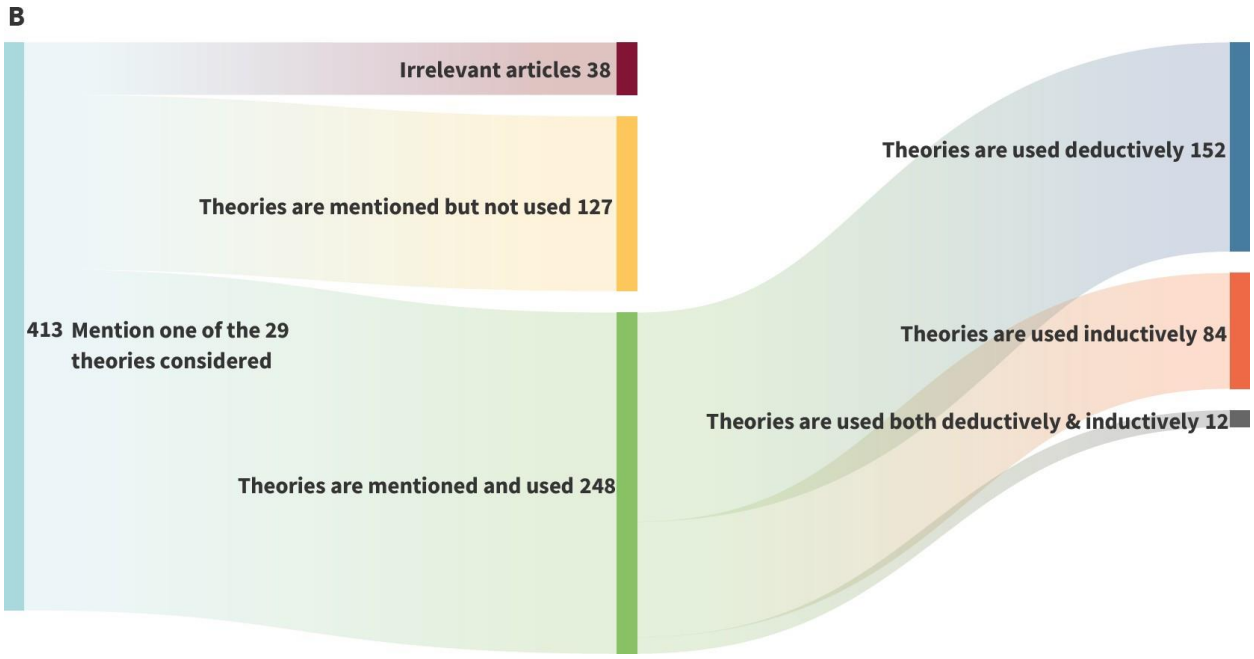


Figure 4. Results of the close reading screening process. (A) Distribution of the reviewed SVRA articles (n=2716) according to the use of theories. We considered that a study used a theory when the authors explicitly mentioned that they had considered a theory. (B) Sankey plot with the steps of the screening process.

4.2. Use of theories in SVRA research according to different fields of knowledge and hazard types

We compared the articles that used theories (n=248) against those which did not mention (n=2303) or use them (n=127). Results showed clear patterns in the use of the theories according to the journal' subareas of knowledge ($p = 0.0004$, Fisher's exact test), main field of knowledge ($p = 0.0324$, Fisher's exact test), and natural hazard type ($p = 0.0069$ Fisher's exact test) (Fig. 5). Studies published in 'Social Sciences' journals used theories more often than 'Engineering & Technology' and 'Physical Sciences' ones (Fig. 5B). In some subareas,

the percentage of articles that used theories was close to 0% (e.g. 'Medicine', 'Geochemistry' and 'Biodiversity'). Conversely, articles pertaining to journals in the WoS sub-fields of 'Mathematics', 'Psychology', and 'Sociology' tended to use more theories (an average of 25.6%) (Fig. 5A).

Regarding the hazard type, we found that 'Wildfire', 'Flood' and 'Storm surge' studies tend to be more (explicitly) theoretically grounded. Less than 5% of the articles that address 'Volcanic activity', 'Landslide', 'Heatwave', and 'Tsunami' used one of the 29 most frequent theories (SM1) to inform their empirical analysis (Fig. 5C). These hazards were often assessed using a 'Physical Sciences' point of view and are classified mostly with the 'Geology', 'Meteorology' or 'Water Resources' WoS subareas. Hence, we reason that the use of theories in SVRA research is more linked to the subarea of knowledge than the type of natural hazard investigated.

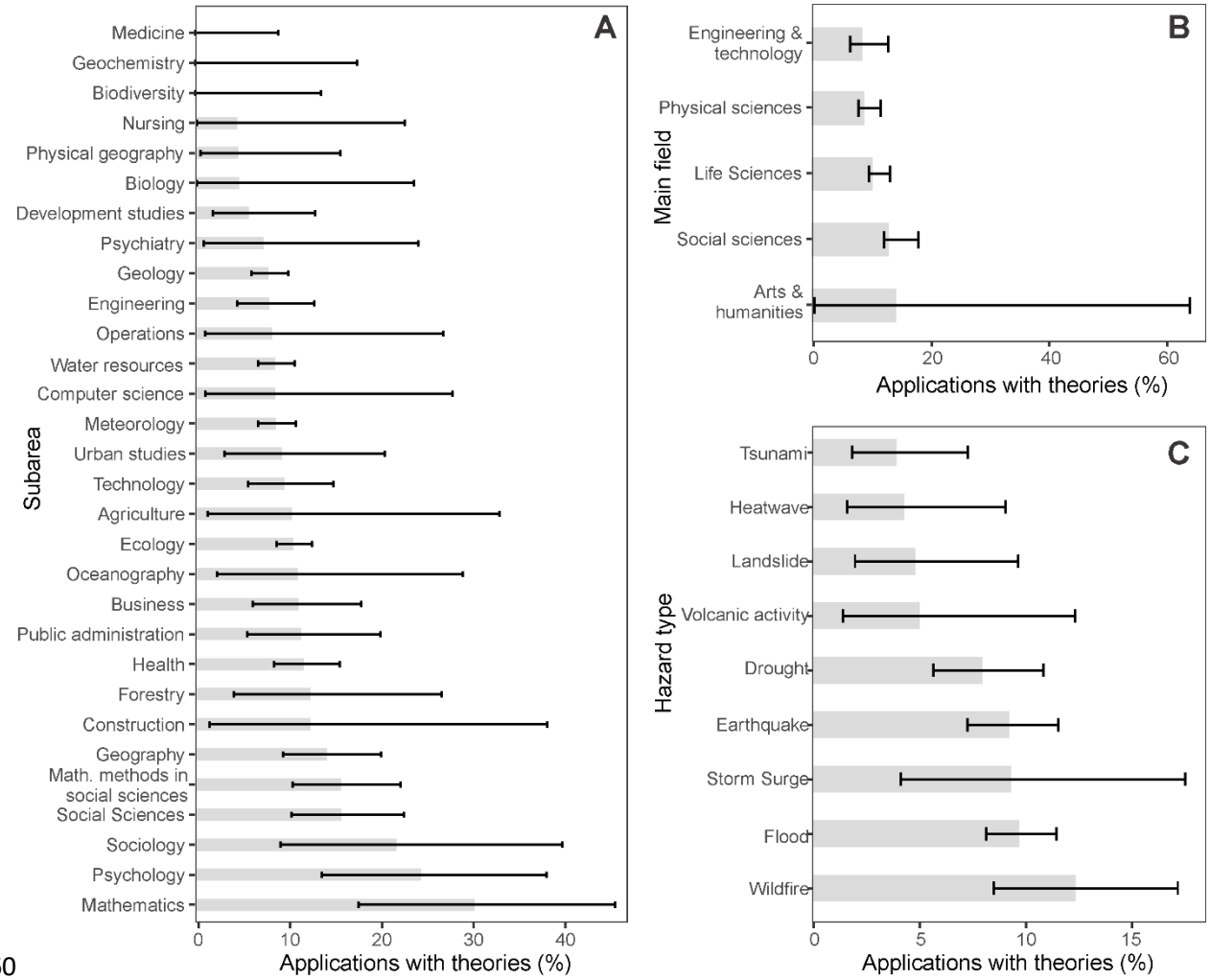


Figure 5. Share of articles that use theories according to (A) the journal subarea of knowledge, (B) the journal's main field of knowledge, and (C) the hazard type investigated. Since the articles can have multiple hazards and fields, the percentage is given in terms of the number of entries. Whisker lines show the Clopper–Pearson 95% confidence interval. To calculate the %, we compared articles that used theories (n=248) against the sum of those that did not (127 that mention theories but do not use them and 2303 that do not mention theories, see Fig. 1). For clarity purposes, only sub-fields with at least 15 articles are shown in Fig. 5A.

4.3. Use of theories in SVRA research according to the theory type, research methods, and study design

This section analyses the 248 SVRA articles (Fig. 3) that used theories in-depth and evaluates which theories, methods, and study design were applied. Table 1 presents an overview of the theories mostly used.

Theories that focus on individual decision-making processes were most prevalent and were used by 102 articles (Fig. 6). These include the 'Protection motivation theory' (PMT) (n=39) and the 'Protective action decision model' (PADM) (n=16). Both PMT and PADM use threat-based perceptions and coping appraisals, such as beliefs about the efficacy of protective measures, for investigating the adoption of protective behaviours. These highly individualistic approaches are often non-contextual since they usually do not consider the socio-cultural context of risk (for an exception, see Strahan and Watson, 2019; Noll et al., 2022). Similar to other reviews (Kothe et al., 2019), we found that the PMT and PADM constructs (e.g. threat appraisal, self-efficacy) varied considerably in how they were operationalised across studies (e.g. questions, scales). Therefore, even in the case of articles that considered the same theory, results may be comparable only with additional effort (or not at all) at identifying articles with similar operationalisation.

Theories that focus on micro and macro processes and how they are interconnected (e.g. society, groups and networks) were also prevalent (n=50). Geography-related theories such as the 'hazards of place' model (n=24), which operationalises vulnerability through composite indicators, were widespread in this group. The popularity of this model can be attributed to its flexibility, as multiple dimensions and data at different spatial scales can be considered. Few studies used social capital and network theories (both with n=7), which often focus on collective (support) behaviours before, during, and after crises. Cultural theory (n=7) was used mainly inductively to interpret empirical observations on

293 disaster response driven by the risk perception of different groups (e.g. Scolobig et al.,
294 2012; Snel et al., 2019). The pressure-and-release (PAR) model was mentioned in several
295 studies (n=28). However, it was only applied in 5 articles that investigated, among others,
296 how poverty and/or other specific pressures translate into vulnerable conditions.

Table 1: Theories used at least five times in the reviewed articles grouped according to their focus and disciplinary background

Focus	Theory	Focus	Description	Discipline	N of articles that used this theory	Key reference
Individual decision-making processes	Expected utility theory	Individual	Estimates the utility of an action when the outcome is risky by weighting possible outcomes by their respective probabilities, assuming that people will choose the action or event that will provide the maximum expected utility based on an individual's risk aversion and budget constraints.	Economics	8	(von Neumann and Morgenstern, 1944)
	Health belief model (HBM)	Individual	Explains and predicts health-related behaviour, particularly healthcare utilisation using constructs such as perceived susceptibility, benefits and barriers, modifying variables, and self-efficacy.	Psychology	7	(Carpenter, 2010)
	Person relative to event (PrE)	Individual	Explains that fear-arousing or negative threat appeals predict that growing threat levels would promote problem-focused coping when resources are judged to be adequate compared to the scale of the threat.	Psychology	6	(Mulilis and Duval, 1997)
	Prospect theory	Individual	Augments expected utility theory by accounting for people valuing gains and losses differently and non-linear processing of probabilities, affecting their evaluation of risky prospects.	Behavioural economics	5	(Kahneman and Tversky, 1979)
	Protection motivation theory (PMT)	Individual	Considers how individuals process threats and choose responses to deal with the risk based on their perception of severity, probability of losses, the effectiveness of protective action, self-efficacy, and response costs.	Psychology	39	(Maddux and Rogers, 1983; Rogers, 1975)
	Protective action decision model (PADM)	Individual	Describes people's responses to natural hazards based on three core perceptions (threat, protective action, and stakeholders), information processing and situational factors.	Interdisciplinary	16	(Lindell and Perry, 2012)
	Psychometric paradigm	Individual	Explains how laypeople perceive risks by assessing risk using qualitative information such as perceptions of dreadfulness and newness.	Psychology	6	(Fischhoff et al., 1978)
	Social cognitive theory (SCT)	Individual	Considers that people learn from their own experiences and by witnessing the experiences of others, and it does so via the use of three interacting key constructs (personal and environmental factors and behaviour aspects).	Psychology	5	(Bandura, 2002)
	Theory of planned behaviour	Individual	Assumes that individual behaviour is driven by behavioural intentions, which depend on attitudes, norms, and perceived behavioural control.	Psychology	10	(Ajzen, 1991)
Society	Pressure and release (PAR)	Society	Explores how societal structures translate into unsafe conditions. It conceptualises risk in the context of disaster and emergency and offers a framework for understanding how societal structures translate into vulnerability.	Geography	5	(Rauken and Kelman, 2010)

	Hazards of place	Society, Groups of people, places, regions	Ranks groups/places according to their vulnerability by using composite indicators. The degree to which people are vulnerable to hazards is influenced by socioeconomic variables such as income and housing qualities, as well as proximity to the potential source of the threat.	Geography, disaster studies	24	(Cutter, 1996)
	Cultural theory / Theory of plural rationality	Society	Postulates that stakeholder views about risk are plural but limited in number. The views stem from different contexts shaped by how people organise, perceive and justify their social relations. The theory argues that there are four ways of organising: hierarchy, individualism, egalitarianism and fatalism.	Anthropology	7	(Tansey and O'riordan, 1999)
	Social Capital Theory	Relationships between actors/ entities	Social relationships that produce reproductive benefits are recognised as resources that can lead to the development and accumulation of human capital.	Sociology	7	(Allan Schmid and Robison, 1995)
	Driver-Pressure-State-Impact-Response (DPSIR)	Policies	It is a causal framework that describes interactions between societal response (e.g. policy choice) and environmental feedbacks.	Policy analysis	7	(Malekmohammadi and Jahanishakib, 2017)
Systems	Diffusion of innovation theory (DOI)	Social systems	It explains how and in which new or innovative ideas or technologies develop, diffuse, and are adopted through a population or social system over time.	Social Science	6	(Rogers, 1995)
	Resilience theory	Systems	Describes hierarchies and adaptive cycles in complex socio-ecological systems.	Interdisciplinary	14	(Holling, 2001)
Theorising	Grounded theory	Not specified	It is a systematic methodology that can be used to generate theories and hypotheses based on empirical data.	Sociology, social sciences	47	(Glaser and Strauss, 2017)

Figure 6. Most commonly used theories in natural hazards SVRA studies that apply theories in either a deductive or inductive way. Some articles used more than one theory. For clarity purposes, only theories that were used by five or more articles are shown in this figure. For all the results, the reader is referred to SM4.

Grounded theory was used quite often (n=47). This methodological procedure is prominent in qualitative interpretative research to structure the data and inform, ideally, a process of theorising. Grounded theory, thus, does not represent a theory in our understanding as it makes no assumptions about the relationship between variables and constructs. It rather allows scientists to investigate how individuals or groups define a phenomenon via their social interaction (da Silva Barreto et al., 2018). As such,

researchers often use this inductive approach to interpret results about individuals' social and psychological aspects that shape their SVRA.

Few articles (n=20) have conducted in-depth analyses using theories that focus on systems. For instance, MacDougall et al. (2014) applied the diffusion of innovation (DOI) theory to explore how disaster mitigation measures may be spread within and across communities. Besides this, resilience theory was used inductively to establish new frameworks to understand adaptation to climate change (e.g. Hosen et al., 2020; Novalia and Malekpour, 2020).

Concerning how the theories were used, we found that 152 studies used the theories deductively, and 84 used them inductively (Fig. 3). Besides this, in 12 studies, the theoretical insights resulted from a combination of both deductive and inductive applications.

The methods used to collect data or assess SVRA varied according to the applied theories ($p=0.0004$, Fisher's exact test) (Fig. 7). For instance, PMT and PADM articles often used surveys as the main research tool. In contrast, interviews and other qualitative research methods like workshops or observations were most often connected with grounded theory to structure empirical data. In general, 'Surveys' (n=132) were the preferred tools for almost all theories, followed by 'Interviews' (n=107), 'Focus groups or workshops' (n=38), 'Composite indicators' (n=30), 'Observation' (n=26), 'Document or content analysis' (n=18), and 'Computer modeling' (n=17). This suggests the intricate connection between theory and empirical analysis.

With regard to the research design, only 9 used longitudinal and 16 (quasi)-experimental designs to produce data. Longitudinal studies allow scientists to measure changes in SVRA of an individual or system over time. Thus, they often have higher statistical power (i.e. the power of a hypothesis test) than cross-sectional studies (Baghfalaki, 2019). The advantage of (quasi)-experimental studies is that they allow scientists to control the variables of interest and draw causal conclusions. The reason for the lack of longitudinal studies could be that they can be expensive and time-consuming. Similarly, experimental studies can require more controlled settings than traditional non-experimental cross-sectional study designs.

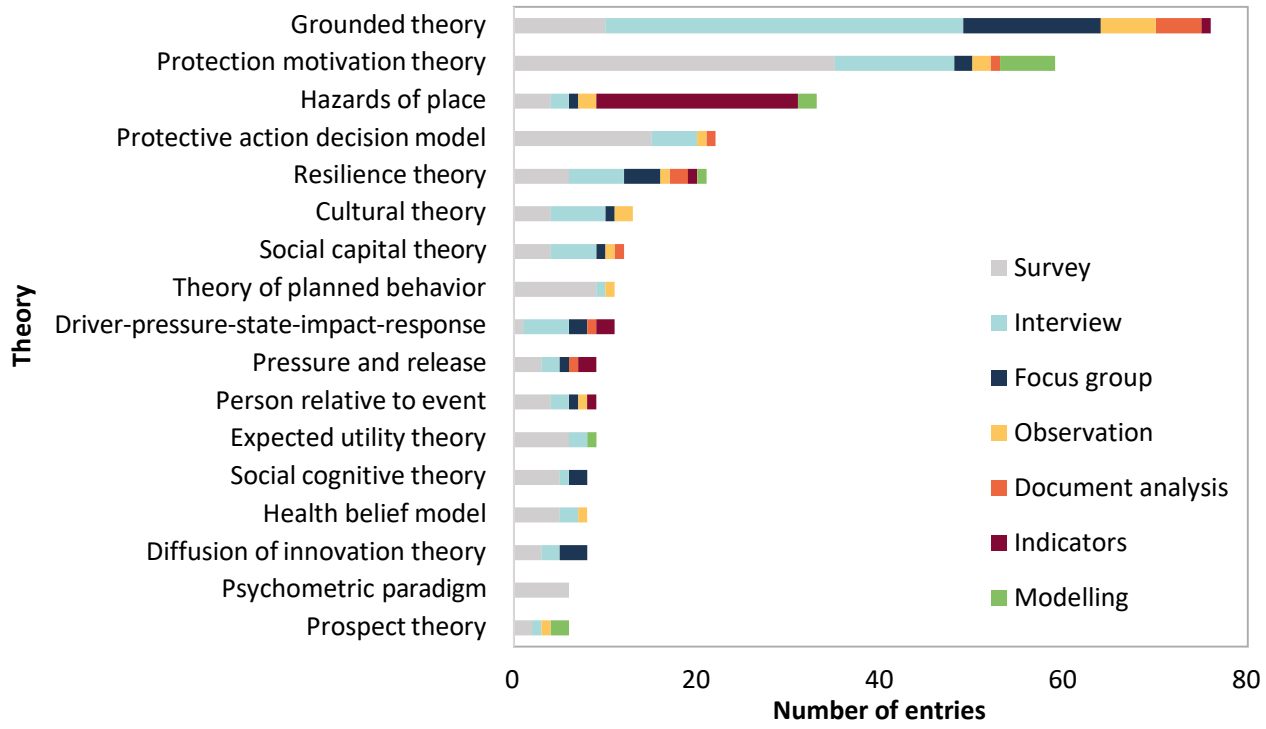


Figure 7. Research tools applied according to different types of theories used. Some articles used more than one method and theory. For clarity purposes, only theories that were used by five or more articles are shown in this figure. For all the results, the reader is referred to the SM4.

4. Discussion

This study systematically reviewed 4432 SVRA-related articles using both automatised text mining and close reading. In this section, we summarise and discuss our findings by referring to the guiding research questions underlying this study. Based on these, we raise reflexive questions on the role of theories in SVRA research.

4.1 To what extent is the theoretical underpinning of SVRA research made explicit?

Essentially, we can assume that all research is based on theoretical assumptions. Yet, as our analysis suggests, such assumptions are often not clearly stated, and researchers frequently use theories only implicitly and non-systematically. Only a small fraction, 9.1% (n=248 out of 2716), of the reviewed studies explicitly mentioned using one of the investigated theories (SM1) to inform their empirical analysis or explain the relationship between theory and empirical analysis. This proportion remained relatively stable over time (SM2), indicating that engaging with underlying ontological or epistemological

354 questions is not of primary concern in SVRA research. This contrasts more disciplinary-

oriented research fields in which "theory is the currency of […] scholarly realm" (Corley and Gioia, 2011, p. 12). However, we did not address the reasons for not explicitly explaining theoretical assumptions, which requires further analysis (see section 4.6).

4.2 Which explicated theories are more popular and which are less often referred to?

Theories with an epistemic interest in individual decision-making processes and behavioural aspects were most often used to inform the empirical analysis (n=102), including PMT, PADM, Theory of Planned Behavior, Expected Utility Theory, Health Belief Model, Person relative to Event, Psychometric Paradigm, Social Cognitive Theory, and Prospect Theory. The majority of these studies were based on survey data.

Our findings suggest that methodological individualism prevails in SVRA research, similar to other research fields (Jarvis et al., 2022). This means social processes are predominantly analysed and explained through the lens of individual actions and sense-making processes. This is presumably why the few existing quantitative meta-analyses focus on the individual and primarily rely on socio-psychological theories (Bamberg et al., 2017; Bubeck et al., 2018; van Valkengoed and Steg, 2019).

Theories focusing on collective social processes (e.g. Hazards of Place, DPSOR, Social Capital, Cultural Theory and PAR) and social or socio-ecological systems (e.g. Resilience Theories and Diffusion Innovation Theory) were less prominent in our sample, with 50 and 20 articles, respectively. Despite their low uptake, these theories have the potential to provide a deeper understanding of complex relationships and processes underlying SVRA. Nevertheless, they often require extensive data (Kiesling et al., 2012) or are rather time-consuming to apply (MacDougall et al., 2014), which might explain why they were used less often.

Grounded theory is a "false friend" in our sample. Although it mentions the term "theory", it is not considered a theory according to the understanding of this paper. However, the high prevalence of this method for structuring and interpreting data underlines the relevance of inductive qualitative research in this field.

4.3 If theories are made explicit, how are they used in empirical studies?

We observed a great variety of how theories are used to inform the analysis. Most studies subjected to in-depth analysis followed a deductive process of producing evidence by

testing existing theories (n=152). In contrast, 84 studies were designed more exploratively and followed an inductive research process. This implies that the prevailing focus in SVRA research is on testing existing theoretical frameworks and their associated assumptions rather than producing new insights through inductive reasoning (see section 4.5).

4.4 If theories are made explicit, are there differences in their use according to the field of knowledge and natural hazard investigated?

Clear patterns were observed in the relationship between the use of theories and the journals' area of knowledge. Studies published in social sciences journals explicated theories more often than studies published in the knowledge areas of engineering, technology, and physical sciences. Likewise, studies in mathematics, psychology, and sociology subfields used theories more often compared to other fields. These results are consistent with Rufat et al. (2022) findings, which revealed that researchers in psychology or sociology were 85% more likely to incorporate theories in their research design than those in geography or environmental disciplines. We also found differences in the use of theories across different hazards investigated. However, our findings suggest that the use of theories is more strongly associated with the subarea of knowledge than the natural hazard being investigated.

Our analysis suggests that, despite being an interdisciplinary field, theoretically explicit SVRA research is associated with specific "epistemic cultures" (Cetina, 1999). Such cultures influence what constitutes legitimate ways of collecting data and appropriate research methods, theoretical frameworks and models. Consequently, these factors affect the degree to which the findings of a study are considered a valid process of knowledge production (Cetina, 1999).

4.5 Reasons why greater reflexivity about the role of theory in (case-study) SVRA research is needed

Based on our findings, we argue that SVRA researchers should adopt a more reflexive approach towards the role of theory in their research projects as well as in the field as a whole. Before reasoning our claim, it is important to emphasise that we are not advocating for theoretical homogenisation. Furthermore, we do not question demand-

driven studies that respond to the immediate needs of first responders and practitioners (e.g. Williams and Webb 2021) nor studies that aim to enhance the capacities of vulnerable groups, or those that strive to give a voice to marginalised groups overlooked in disaster risk management (Hewitt, 1995). We also regard research following a case-study logic (Orum, 2015) as vital for SVRA research as they provide a deep insight into social phenomena and offer contextual insights that allow researchers to draw relevant conclusions (Ruzzene, 2012).

With this in mind, we argue that the abundance of empirical material in SVRA research that lacks consistent explicit theoretical reference systems is objectionable (Ridder, 2017). As a result, SVRA research seems to spin in circles: researchers repeatedly conduct similar analyses in different geographical settings with inconsistent or incommensurable findings. Therefore, we contend that explicit engagement with theories in SVRA research is required to ensure studies' (1) transparency, (2) incremental or revelatory advancements, (3) comparability of findings, and (4) thus informing and influencing decision-making processes on the policy level.

(1) The explicit use of theories reduces ambiguities and contributes to transparency

Whether explicated or not, theories influence the research design, including deciding which variables are elicited and how data are collected, analysed and interpreted. Explicitly referring to a theory/theories can help readers understand why scholars focus on specific SVRA aspects or why they chose certain factors (and, by doing so, exclude others). Making theoretical considerations salient thus supports understanding design choices in the empirical analysis and opens them up for scrutiny. In this sense, explicitly stating assumptions contributes to transparency. The documentation of empirical strategies and the underlying theoretical considerations is a precondition for further developing findings and evaluating their worth; it is the basis for evaluating the quality of research processes and results by disciplinary peers and experts from other scientific branches. The theory documentation deficits outlined in our analysis hamper the productive development of SVRA research: If we aim to reduce the conceptual ambiguity and the Babylonian babble of voices in SVRA research (Vogel, 2006), striving for inter-subject comprehensibility based on shared theoretical frameworks seems vital.

(2) The explicit use of theories ensures a productive development of SVAR studies

Theories support "incremental" as well as "revelatory" scientific advancements (Corley and Gioia, 2011). The role of theories is multifarious since there are different theory-grounded strategies for producing knowledge (Lange et al., 2021). Following a *deductive research* logic, one ideally departs from an existing theoretical framework and specifies hypotheses, variables, and survey questions, typically similar to past studies with comparable theoretical backgrounds. Such a single-theory strategy aims to test how well a specific theory explains the phenomena of interest (e.g. adaptive behaviour).

However, there may be situations where expanding the theoretical basis and following a multi-theory strategy that merges different theoretical frameworks or adds certain variables is necessary. Reasons include cases in which a theory only covers specific aspects of the study and/or it is known that the theory can only partially explain the statistical variance of an observed phenomenon (see Bamberg et al., 2017 for PMT). Additionally, practical reasons may arise where a study inspired by a single theory might not provide the answers that scientists or practitioners are interested in. Therefore, including additional variables or factors reflecting the interest of practitioners and researchers might be desirable. However, merging theories should be done in a systematic and cautious manner to ensure epistemological and/or methodological consistency and comparable results (Klöckner, 2013; Klöckner and Blöbaum, 2010). Both single and multi-theory strategies contribute to the cumulative understanding of the underlying social phenomena and thus support incremental advancements.

In contrast to deductive reasoning, *inductive approach* is more open and exploratory. Within this context, there are different views on which role theories should play in informing research. For instance, the initial conceptualisation of grounded theory required researchers not to rely on any pre-existing theoretical work in their qualitative research, as the research focus would emerge from the empirical data itself (Glaser, 1992). However, a later conceptualisation of grounded theory argues that *all* research is based on prior knowledge (e.g. research interests, published literature, thematic focus, implicit or explicit assumptions). Therefore, it is crucial to explicate such knowledge, including the theories informing qualitative research (Strauss and Corbin, 1996).

Inductive research can be the basis for transformative research findings as such a strategy helps reveal patterns that may not be explicitly articulated in existing theoretical formulations. By carefully observing and analysing qualitative data such as interviews,

researchers can develop hypotheses that can be used to guide further research (Wilson and Chaddha, 2009). Eventually, inductive research may lead to the process of theorising (i.e. a reflexive process of abstraction) (Weick, 1995), resulting in new models, frameworks or theories that provide a "novel or counterintuitive perspective that questions assumptions underlying the prevailing theory" (Corley and Gioia, 2011). If such a transformative perspective provides a novel perspective on a phenomenon presumably well understood, it might become the new prevailing theoretical frame. Within SVRA, for instance, the concept of social vulnerability emerged in response toa increasing dissatisfaction with the, at that time, "prevailing scientific view" (Hewitt, 1983) —the hazard research paradigm (White, 1974). Through a process of iterative theorising, scholars designed alternative theoretical frameworks resulting eventually in the concept of social vulnerability (Watts and Bohle, 1993).

(3) The explicit use of theories can enhance studies' comparability

Referring to a theoretical framework enables comparing studies conducted in different geographical settings and, by doing so, drawing more general conclusions. This is the basis for developing robust evidence on SVRA (Kuhlicke et al., 2020; Rufat et al., 2020). For standardised research, a shared theoretical framework associated with comparable operational procedures provides the basis for conducting a quantitative meta-analysis to identify relevant determinants shaping SVRA across different studies (van Valkengoed et al., 2021). Also, an explication of theoretical assumptions is vital for the comparability of case study research. It provides a frame for whether findings from case studies conducted in different contexts are comparable, thus drawing general conclusions beyond their immediate contexts (Ruzzene, 2012). Improved comparability then implies a more systematic identification of research gaps, reduction of redundancy across studies, and risk of "dead-end research endeavours" as well as a more straightforward synthesis of findings from large bodies of empirical literature.

(4) The explicit use of theories can support better evidence-based policy recommendation

The relatively low degree of studies with an explicit theoretical grounding also impacts how science feeds into policy-making processes. The lacking theoretical basis for ensuring the comparability of research outcomes (Kellens et al., 2013; Lechowska, 2018;

Rufat and Botzen, 2022) not only complicates the development of robust evidence base in SVRA research but it can also be challenging to distil a clear-cut message from science to stakeholders, especially for decision-making processes (Fünfgeld et al., 2019; Rufat et al., 2020). This results in a paradox: while SVRA concepts and vocabulary have strongly infiltrated the policy-making arena, the theoretical basis for providing evidence-based policy-recommendation from within this field is rather fragile. This might not just undermine the scientific originality of SVRA research but also deteriorate its capacity to inform and shape policy-making processes over time.

(5) The choice of theories can have practical and political implications

Theories also have practical and political implications as they shape our understanding of both the causes and effects of a disaster. In line with the concept of "the naturalness out of natural disaster" (O'Keefe et al., 1976), SVRA aims at unravelling social, economic, political and cultural root causes of disasters rather than attributing them solely to natural or climatic forces. By prioritising the study of the societal drivers of a disaster, we are better equipped to identify which decisions and policies led to them and, thus, hold institutions and specific actors accountable (Kuhlicke et al., 2016; Kuklicke and Demeritt, 2016; Ribot, 2022).

4.6 How to move forward?

The question of whether it is desirable, meaningful or possible to establish an agreement on research standards for theory use in SVRA remains open, given the sheer number of disciplines involved. Therefore, instead of providing such a standard, we outline here relevant factors that might support a more explicit and reflexive engagement with theories in this research field.

One of the questions left open by this study is: Why did the authors of the investigated studies hardly mention or use theories in their analyses? Our findings suggest that disciplinary cultures might be a reason. Students are differently exposed to theoretical debates in SVRA research, resulting potentially in a lacking awareness of and knowledge about the relevance and meaning of theories in studying social phenomena. We, therefore, consider it vital that disciplinary and interdisciplinary university programmes become more explicit about the relevance of theories in SVRA studies.

The field's publication culture might also be of importance. By scanning the "aims and scope" sections of leading journals in the field (see SM3), we found that only a few journals encourage theoretical contributions, and none of them explicitly states the role theory should play in submissions. Thus, journals could help raise awareness among researchers by emphasising that theoretically informed studies are welcome.

Finally, we should not neglect the impact of project-based research funding schemes on the use of theories. The pressure to design, conduct and publish over short periods favours reproducing past research designs and following the lowest friction slope to jump to actionable results. Furthermore, agencies funding applied projects often (1) foster collaboration with practitioners, less acquainted with the theoretical background, (2) value the societal relevance of the research and practical impact more than rigorous science (and theory building), (3) encourage collaboration of researchers from different fields with potentially conflicting traditions and theories, and/or (4) promote the opportunistic involvement of researchers with less expertise in the field but related expertise and skills required in other project aspects. As a result, theoretical debates might be considered counterproductive and therefore skipped or kept in the background. We, therefore, strongly believe that funding agencies and researchers should reflect on the decisive role of theory in applied research, which should not be considered a "residual category".

5. Limitations

In this article, we draw from an initial sample of 4432 SVRA-related articles to understand how theories are used in this field of research. Our goal was to underscore general patterns and trends. Given the sheer number of articles, several generalisations were made, influencing the results.

First, we considered only theories mentioned by 5 or more articles (SM1). As a result, 52 articles that mention 60 other theories were not read in detail. However, by scanning the name of these theories (SM1), it is possible to observe that they often focus on individuals (e.g. construal level theory, precaution adoption process model, social identity model), confirming the overall trend in this field of research.

Second, when reading the articles (n=413), we observed that several of those tagged as "do not use a theory" (n=127) seemed to be inspired by or even tested a theory. However,

the use of a theory was not explicitly mentioned. The lack of explicit references to theories is both a finding and a limitation: We, as readers, are limited to what can be directly understood from the papers. For the articles without an explicit reference to a theory, we could only know with certainty if the author used a theory by interviewing them.

Third, we classified the articles in a binary fashion (i.e. theory use or no theory use). However, there is a continuum between "theory mentioned as broad inspiration" and "the study design is strongly based on established theoretical constructs". In this regard, we should emphasise that using theories *in any way* is not necessarily better than not using them at all.

Fourth, we only focused on articles included in WoS. However, many SVRA studies are also published in grey literature, as book publications, in other languages, or in unlisted scientific journals. While this body of literature is relevant for this field of research, particularly in an applied context, we expect a lower degree of explicit theory uptake than in reviewed academic literature.

Finally, as with any systematic literature review (Vanelli et al., 2022), we may have missed relevant articles due to the terms used for the search and the fact that we considered only those mentioned in the abstract, title and keywords. Indeed, relevant articles which deal with the consequences of these hazards (e.g. migratory crises, food shortage, water scarcity) were ignored in cases where the hazard was not explicitly cited. These aspects should be considered as a qualifying boundary condition of our findings.

6. Conclusion

In this review, we explored the role of theories in SVRA research by systematically scanning 2716 and reading 413 articles to understand overall trends and patterns. Our analysis reveals that a relatively small proportion of articles explicitly articulate their theoretical underpinning. Among articles with an explicit theoretical framework, most follow the idea of methodological individualism. Based on our findings, we argue for a more reflective handling of theories in empirical SVRA research. The absence of a theoretical basis not only undermines the development of a more robust evidence base in SVRA research, but also hampers the generation of policy recommendations. Our call for a more explicit engagement with theories is not aimed at promoting theoretical homogenisation. On the contrary, we firmly believe that a greater diversity of theoretical

frameworks applied and developed further in SVRA research is vital for ensuring the originality and relevance of future studies.

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Supplementary material (SM)

SM1: List with the 186 theories searched and the number of articles that mention them. Theories that were mentioned in less than five articles were not included in our analysis.

Theory	N of articles	Theory	N of articles
protection motivation theory	77	behavioral priming theory	0
grounded theory	53	behavioral reasoning theory	0
protective action decision model	38	behavioral spillover theory	0
hazards of place	36	behaviorism	0
pressure and release	33	ceos theory	0
resilience theory	30	classical conditioning	0
person relative to event	26	cluster theory	0
cultural theory	25	cognitive hierarchy theory	0
psychometric paradigm	23	com b system	0
theory of planned behavior	23	common pool resource theory	0
social theory	20	communityattachment theory	0
event theory	18	conflict orientated policy theory	0
expected utility	17	connectionism	0
dpsir	15	consumption as social practices	0
social cognitive theory	14	containment theory	0
social learning theory	14	conventional risk theory	0
theory of reasoned action	14	differential association theory	0
prospect theory	13	dynamic field theory	0
health belief model	12	early systems theory	0
systems theory	10	environmental conflict theory	0
diffusion of innovations theory	8	environmental scarcity theory	0
network theory	7	expectancy disconfirmation theory	0
property level protection	7	extended information processing model	0
social capital theory	7	feedback intervention theory	0
bounded rationality	6	fogg behavior model	0
social amplification of risk framework	6	forensic investigations of disaster	0
structuration theory	6	goal directed theory	0
transtheoretical stages of change model	6	goal framing theory	0
game theory	5	habitual behavior	0
complexity theory	3	hazard preparedness theory	0
construal level theory	3	health behaviour goal model	0
narrative theory	3	health behaviour internalisation model	0
precaution adoption process model	3	health promotion model	0

social identity model	3	implementation theory	0
theory of social practices	3	inequalities norms capabilities	0
social vulnerability theory	2	information motivation behavioural skills model	0
organisational field theory	2	instance based learning theory	0
actor network theory	2	integrated theory of health behaviour change	0
attribution theory	2	integrative model of behavioural prediction	0
bayesian updating	2	integrative model of health attitude	0
complex systems theory	2	interdependence theory	0
environmental justice theory	2	kasperson s ecological model	0
goal setting theory	2	lead user theory	0
health action process approach	2	model of pro environmental behaviour	0
panarchy theory	2	motivation intention volition	0
rational choice theory	2	motivation opportunities abilities model	0
social representation theory	2	needs opportunities abilities model	0
sociological theory	2	neural networks theory	0
adaptive comfort theory	1	nudge theory	0
agency theory	1	one shot decision theory	0
attitude behaviour context model	1	operant conditioning theory	0
behavior change model	1	operant learning theory	0
behavioral theory of decision	1	pressure system model	0
behavioural decision theory	1	prime theory	0
broaden and build theory	1	problem behaviour theory	0
cognitive adaptation theory	1	prototype willingness model	0
cognitive dissonance theory	1	rank dependent expected utility	0
collective action theory	1	real options value analysis	0
control theory	1	reflective impulsive model	0
cybernetics theory	1	regret theory	0
ecosystem theory	1	regulatory fit theory	0
expectancy theory	1	reinforcement learning theory	0
extended parallel processing	1	resource dependence theory	0
focus theory of normative conduct	1	risk as feelings theory	0
free trade theory	1	risk reduction model	0
gender theory	1	self control theory	0
institutional economics	1	self determination theory	0
knowledge product evaluation	1	self regulation theory	0
learning and action alliance	1	signal detection theory	0
model of action phases	1	situational crisis communication	0
modernisation theory	1	six staged model of communication effects	0
non-linear structural theory	1	social action theory	0
norm activation theory	1	social change theory	0

organisational field theory	1	social choice theory	0
person in context model	1	social consensus model of health education	0
portfolio theory	1	social development model	0
social exchange theory	1	social ecological model of behaviour change	0
social influence model	1	social norms theory	0
socio cognitive theory of information systems	1	systems model of health behaviour change	0
stakeholder theory	1	technology acceptance model	0
structural reliability theory	1	temporal self regulation theory	0
structural theory of social influence	1	theory model of consumption	0
structure issue time	1	theory of change model	0
subjective expected utility	1	theory of delay discounting	0
theory of bounded rationality	1	theory of governmentality	0
theory of climate communication	1	theory of institutionalised culture	0
theory of purity and order	1	theory of interpersonal behaviour	0
trade dependency theory	1	theory of normative social behaviour	0
value belief norm theory	1	theory of triadic influence	0
adaptive resonance theory	0	transaction cost theory	0
affective events theory	0	transcontextual model of motivation	0
behavioral agency theory	0	unified theory of acceptance	0
behavioral portfolio theory	0		

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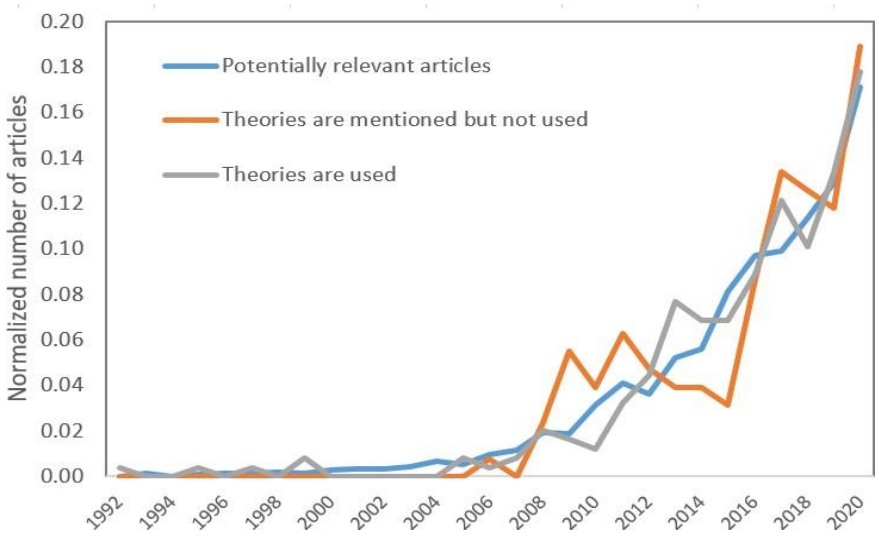
853 *SM2: Normalised number of SVRA articles according to the use of not of theories.*



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SM3: Top 20 journals with the highest number of SRVA articles and the % of articles that mention theories.

Journal	**Total N of articles**	**Do not mention a theory (%)**	**Mention a theory (%)**
International Journal of Disaster Risk Reduction	289	88.6	11.4
Natural Hazards	236	85.6	14.4
Sustainability	72	83.3	16.7
International Journal of Envir. Research and Public Health	63	82.5	17.5
Disaster Medicine and Public Health Preparedness	63	93.7	6.3
Disasters	56	89.3	10.7
Natural Hazards and Earth System Sciences	54	75.9	24.1
Disaster Prevention and Management	48	79.2	20.8
Regional Environmental Change	47	85.1	14.9
Risk Analysis	46	58.7	41.3
Climatic Change	41	92.7	7.3
Global Envir. Change-Human and Policy Dimensions	37	62.2	37.8
Environmental Hazards-Human and Policy Dimensions	37	83.8	16.2
Natural Hazards Review	37	83.8	16.2
International Journal Of Disaster Risk Science	36	80.6	19.4
Ecology And Society	35	74.3	25.7
Environmental Science & Policy	34	79.4	20.6
Climate And Development	33	90.9	9.1
Applied Geography	31	90.3	9.7
Water	28	89.3	10.7