

How do we assess vulnerability to climate change in India? A systematic review of literature

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Abstract In countries like India where multiple risks interact with socio-economic differences to create and sustain vulnerability, assessing the vulnerability of people, places, and systems to climate change is a critical tool to prioritise adaptation. In India, several vulnerability assessment tools have been designed spanning multiple disciplines, by multiple actors, and at multiple scales. However, their conceptual, methodological, and disciplinary underpinnings, and resulting implications on who is identified as vulnerable, have not been interrogated. Addressing this gap, we systematically review peer-reviewed publications ($n = 78$) and grey literature ($n = 42$) to characterise how vulnerability to climate change is assessed in India. We frame our enquiry against four questions: (1) How is vulnerability conceptualised (vulnerability of whom/what, vulnerability to what), (2) who assesses vulnerability, (3) how is vulnerability assessed (methodology, scale), and (4) what are the implications of methodology on outcomes of the assessment. Our findings emphasise that methods to assess vulnerability to climate change are embedded in the disciplinary traditions, methodological approaches, and often-unstated motivations of those designing the assessment. Further, while most assessments acknowledge the importance of scalar and temporal aspects of vulnerability, we find few

examples of it being integrated in methodology. Such methodological myopia potentially overlooks how social differentiation, ecological shifts, and institutional dynamics construct and perpetuate vulnerability. Finally, we synthesise the strengths and weaknesses of current vulnerability assessment methods in India and identify a predominance of research in rural landscapes with a relatively lower coverage in urban and peri-urban settlements, which are key interfaces of transitions.

Keywords Climate change · Vulnerability assessment · Systematic literature review · India

Introduction

Vulnerability assessments (VAs) have emerged as an important tool to identify structural weaknesses which make a system vulnerable (Tonmoy et al. 2014), explore the capacity of people and systems to adapt (Ford and Smit 2004), and inform prioritising adaptation funding and implementation (Füssel 2007). Recognising the importance of VAs in informing climate change adaptation, there has been a rise in studies that assess, quantify, and identify vulnerability ‘hotspots’ (De Souza et al. 2015), vulnerable nations (Brooks et al. 2005), populations (Brenkert and Malone 2005), and communities (GIZ 2014) and explore drivers of this vulnerability (Hallegatte and Corfee-Morlot 2011; Mustafa et al. 2011).

Given that India is developing rapidly and is projected to face climate change impacts (MoEF 2008), VAs have been carried out at various scales, by various actors and towards various goals. For example, government-funded agricultural universities have studied crop vulnerability to climate change using modelling and impact assessment

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methods (Srivastava et al. 2010; Soora et al. 2013), while non-governmental agencies (NGOs) predominantly use VAs to identify vulnerable populations/households and target adaptation interventions (Watershed Organisation Trust 2013; GIZ 2014). However, there has been limited interrogation on whether the methodology used in these VAs has evolved with evolving definitions of vulnerability.

In this paper, we conduct a systematic review of literature to identify the span of methodologies used to assess climate change vulnerability in India and locate gaps between conceptualisation and assessment of vulnerability. We begin with a short review of how the concept of vulnerability has evolved in global research and within India. Using examples of VAs in India, we demonstrate that the methodologies to assess vulnerability have not seen a similar evolution, with critical implications for adaptation planning and fund allocation. Although we focus on methodologies used to assess vulnerability to climate change, we acknowledge that vulnerability is shaped by multiple factors that are not necessarily climatic and thus draw on a wide literature comprising disaster risk reduction, poverty, gender studies, rural development, and resilience. The four key questions we focus on are (1) how is vulnerability conceptually framed, (2) who is assessing vulnerability, (3) how is vulnerability assessed and what scale, and (4) what are the outcomes of these assessments?

Conceptualising and operationalising vulnerability

While we focus on vulnerability to climate change in this paper, vulnerability is conceptualised and operationalised differently by different research communities (Füssel and Klein 2006; O'Brien et al. 2007; Joakim et al. 2015). It has been used in various disciplines (Adger 2006; Joakim et al. 2015) ranging from economics (entitlements theory, which addresses issues of food insecurity, welfare) and anthropology (human ecology research which focusses on vulnerable groups) to development studies (livelihood vulnerability in agriculture), psychology (perceptions of risk), and hazards research. From this disciplinary diversity, five main conceptual lineages of vulnerability can be delineated (Fig. 1).

Recent research has also contributed to the conceptualisation of vulnerability by seeing it as an inherent condition and starting point of adaptation research (Joakim et al. 2015), highlighting how vulnerability is relational (Taylor 2014; Turner 2016) and temporally dynamic (Nair 2013; Singh 2014). Just as vulnerability research draws from various disciplines, it also benefits from a range of methodological approaches. These include qualitative case study-based methods (e.g. Tonmoy et al. 2014),

indicator-based assessments (e.g. Vincent 2004; Barnett et al. 2008), participatory VAs (e.g. Howe et al. 2013), and spatial mapping of vulnerable areas (e.g. Karmakar 2010).

Methodologies to assess vulnerability are shaped by how vulnerability is conceptualised, the purpose of the assessment, and the spatial, temporal, and decision scales of analysis (Eakin and Luers 2006; Füssel 2007; Joakim et al. 2015). It is argued that certain conceptualisations of vulnerability predispose them to certain methodological approaches. For example, studies conceptualising vulnerability as exposure to hazards, which draws from a technocratic understanding of hazards, use methods that view people as passive actors impacted by hazards external to them (Cannon 2008). Such methodological predisposition potentially overlooks the role that social differentiation, institutional processes, and economic dynamics play in constructing and perpetuating vulnerability.¹

Methodology

Systematic literature reviews

Systematic literature review (SLR) is a widely used research methodology for identifying, assessing, and interpreting the state of knowledge on a specific topic from primary research (Kitchenham 2004; Dixon-Woods et al. 2006; Ford and Pearce 2010; Ford et al. 2011). SLRs typically involve a process of reviewing literature using rigorous and replicable steps (Ford et al. 2011; Delaney et al. 2014).

SLRs are considered more robust than standard literature reviews because they are guided by clearly formulated research questions and have well-defined inclusion and exclusion criteria that minimise opacity and allow replication (Ford et al. 2011). Given these strengths, SLRs have been increasingly being used in climate change research (see Supplementary Material for a review). To make sense of the spectrum of vulnerability research which draws from multiple disciplines, each with their own set of conceptualisations and methodological approaches, we chose the SLR because it is well suited to 'help clarify and stabilize different conceptualizations of 'vulnerability' and identify methodological differences that are not otherwise apparent' (Delaney et al. 2014: 12).

¹ We acknowledge that the literature around risk has evolved substantially from a hazard-based, techno-centric focus to an approach that understands risks as intricately linked to physical, social, economic and institutional vulnerability and inclusive of endogenous risk.

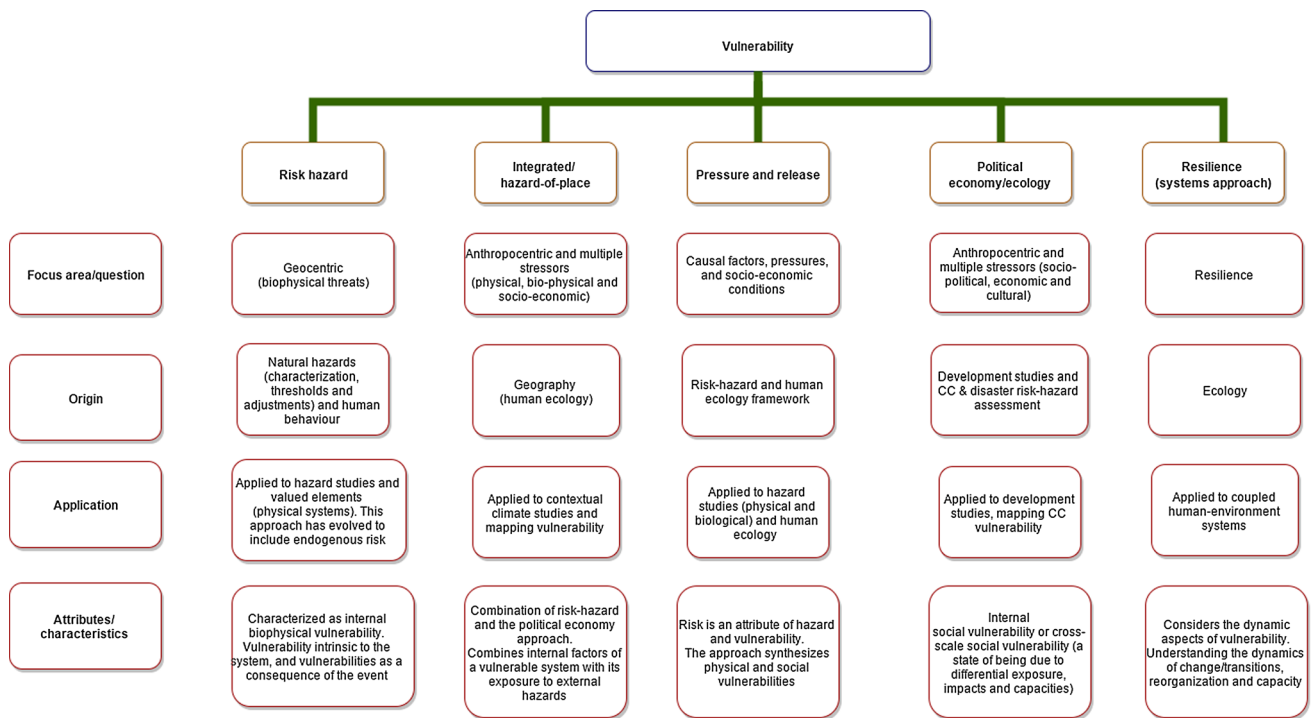


Fig. 1 Conceptualising vulnerability by different traditions. *Source* Adapted from Adger (2006), Fussler (2007), Eakin and Luers (2006), and Ribot (2009)

Data selection and review process

We conducted a SLR through five steps: (1) identification of literature, (2) consolidation of papers using inclusion and exclusion criteria, (3) creation of a database under relevant heads, (4) coding of papers to identify conceptual and methodological facets of VAs, and (5) data analysis.

Peer-reviewed articles and grey literature published from January 2005 to January 2015 in English were reviewed. This period was considered representative because of the surge in vulnerability research post the 2001 IPCC report. Year 2005 was chosen as a benchmark because most literature on climate change adaptation dates back to 2006, and information prior to 2006 is summarised in the IPCC’s Fourth Assessment Report (Berrang-Ford et al. 2011; Bizikova et al. 2014). While this argument is weakened by the publication of IPCC’s Fifth Assessment Report, we felt that using the 2005 benchmark will allow a sufficient sample size to draw conclusions. Grey literature included NGO reports, unpublished working papers, published theses, and working papers, and conference proceedings.

We reviewed literature across different scales and landscapes, and vulnerability to various stressors. Key-words were identified based on expert elicitation and literature (see Supplementary Material). Four search engines (Web of Science, JSTOR, Science Direct, and Google Scholar) were used to extract relevant literature. Literature

was also obtained from previously reviewed papers and their bibliography, government and NGO websites, and expert consultation.

The preliminary keyword search identified 382 documents. Of these, overlapping results (same papers identified by different searches) were removed resulting in 155 papers. Of these, 144 were selected as suitable based on inclusion and exclusion criteria. Papers were included if they were published between January 2005 and January 2015, focussed on India, and were relevant to vulnerability research either conceptually or methodologically. Papers with unclear methodology were not included. Wherever there was ambiguity, articles were read fully to ensure their relevance. Of the final list, 24 journal articles were not accessible due to paywall restrictions and we trimmed the final list to 120 publications (see Supplementary Material for complete list of references).

Analysis

A database of reviewed papers (henceforth used synonymously with VAs) was created in MS Excel. A coding protocol was developed to code information evenly and transparently and to extract data in a standardised format. To capture the breadth of conceptual frameworks used, VAs were coded into seven categories (See Supplementary Material). This categorisation draws from a similar exercise by Delaney et al. (2014), but goes beyond their

framing to include more constructs² of vulnerability. These constructs emerged from an iterative process of coding which went back and forth between papers reviewed and key literature on vulnerability (Adger 2006; Birkmann and Wisner 2006; Füssel 2007; Miller et al. 2010; Mustafa et al. 2011; Tonmoy et al. 2014; Joakim et al. 2015). The analysis was constrained because several VAs did not explicitly report constructs of vulnerability. Wherever there was no explicit definition or conceptualisation of vulnerability, this was coded as ‘unclear/not explicit’, which in itself is an important finding. As Delaney et al. (2014: 15) note, such VAs do not help in replicating research because it is ‘impossible for us to draw conclusions with respect to either the validity or utility of articles that had shallow reporting’. To analyse methodological frameworks, we coded papers based on reported methods.

Results

A total of 120 VAs were examined. These were typically in coastal regions (Fig. 2). A majority of the VAs are spread across peninsular India, with the highest number in Andhra Pradesh ($n = 20$). The northern and north-eastern states had lowest representation. The predominance of VAs in coastal regions with significantly fewer in arid and semi-arid regions indicates a skewed focus on areas that are vulnerable to external hazards (sea-level rise in coastal regions) with lesser emphasis on understanding how structural drivers of vulnerability and endogenous risks interact with these external hazards (which are played out in both coastal and semi-arid regions).

The following sections present findings around the four research questions this paper set out to answer: Sect. 4.1 covers how vulnerability is conceptually framed, Sect. 4.2 answers who is assessing vulnerability, Sect. 4.3 discusses how vulnerability is assessed and what scales, and Sect. 4.4 examines the outcomes of the assessment.

How is vulnerability conceptually framed?

Theoretical approaches and disciplinary backgrounds

Of the VAs, 27 % drew on vulnerability understood through concepts of disaster risk reduction (DRR), exposure to hazards, and risk of being affected by extreme events/stressors. Vulnerability to climate change (41 %) and a combination of climate change and DRR (25 %) emerged as dominant themes owing to a large sample of studies focussing on climate change themes such as

vulnerability and adaptation research and DRR studies in the context of climate change. Despite care taken to include search words from different disciplines, few VAs drew their conceptual framework from poverty (7 %), sustainable livelihoods (7 %), social protection (4 %), political economy (3 %), and feminist studies (1 %) as their core discipline.

As illustrated earlier, globally, vulnerability to climate change has been conceptualised through a range of discourses (Fig. 1). However, vulnerability assessments in India remain rooted in certain disciplines such as hazards management, disasters, and risks and these theoretical leanings find precedence over disciplines such as poverty and development, livelihoods, agriculture and gender studies, each of which have a rich body of evidence, especially around socially differentiated vulnerability. This disciplinary dominance is reflected in later results (Sect. 4.3.1) on the dominance of certain methodologies to assess vulnerability over others.

Conceptualisation of vulnerability

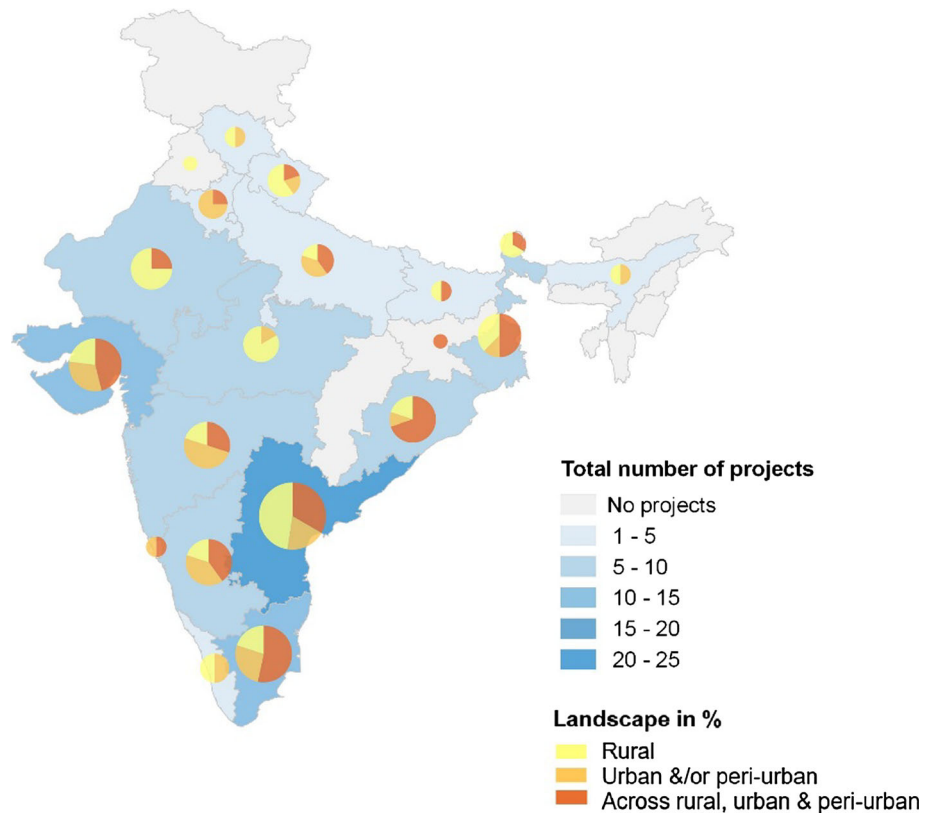
Several studies (26 %) used the IPCC definition of vulnerability seen as a composite of exposure, sensitivity, and adaptive capacity (IPCC 2007). The IPCC’s latest definitions of vulnerability as elaborated in the AR5 (IPCC 2014) were not included in any VA, probably because these definitions are more recent and are yet to percolate into the dominant conceptualisation of vulnerability. Typical lags between conceptual advancements and publication in peer-reviewed literature may be another reason for the AR5 definition not being used. In 30 papers (25 %), vulnerability was not clearly defined which worryingly highlights how assessments may be conducted without clear definitions of what vulnerability is. In 22 % papers, vulnerability was conceptualised as inherent and as an exposure to a risk, which draws mainly from hazards and disaster risk reduction research. Vulnerability as ‘erosion of resilience’ or as ‘expected poverty’ was least reported (3 and 4 %, respectively). This may be because we explicitly looked for vulnerability studies and not resilience-related research.

Vulnerability to what?

Most VAs (76 %) studied vulnerability shaped by climatic risks. This was in part due to the focus of our study, but also because we classified vulnerabilities to disasters such as floods and drought under climatic risks. Only 19 % studies assessed vulnerability to both climatic and non-climatic risks. This highlights that few studies view vulnerability as contextual (O’Brien et al. 2007) and inherent to a system (Joakim et al. 2015) and do not take a systems’ approach which recognises how multiple stressors shape

² A construct or conceptual framework is defined as the way in which vulnerability was defined or explained by the author.

Fig. 2 Locations of vulnerability assessments across India. The map uses a graduated scale to represent the number of VAs in a state (lighter shades of blue depict states with fewer VAs). Of the 120 VAs reviewed, 7 were at the regional level [e.g. South India (1), semi-arid tropics (2), coastal regions (1), forest areas (1), Western Ghats (1) and north-eastern region (1)], 22 at a national scale, and 1 at the international level have not been represented on this map. Thus, the total number of VAs mapped above is 90 (colour figure online)



vulnerability (O'Brien et al. 2004; Tschakert et al. 2013; Singh 2014). In particular, studies focussing on how governance and issues of power shape vulnerability were very few (notable exceptions include Shah and Sajitha 2009; Khan and Kumar 2010; and Santha et al. 2015).

Who assesses vulnerability?

Academic researchers (including non-university researchers) authored 80 % of the VAs. The involvement of donors and multilateral bodies, government agencies, and NGOs was significantly lower (between 3 and 7 %), while 9 % VAs were conducted by multiple actors collaboratively. The domination of academic actors in VAs may be because of the purely academic epistemological beginnings of vulnerability research (Jamison 2010) and policymakers' preference of results from academics because they are considered neutral and led by expertise (Rietig 2011). However, we cannot conclude that donors and NGOs did not conduct VAs. On the contrary, the results could be skewed because most VAs tended to be undertaken by multi-stakeholder partnerships where there is a donor for funding, an academic partner for designing the assessment, and an NGO partner for facilitating and conducting the assessment (for, e.g. Rajesh et al. 2014). The lower presence of donors could be because donors often work through NGOs and academicians.

Within researchers, 46 % VAs were by scientists (including climate scientists, agriculture researchers, and GIS specialists), 18 % by economists, and 30 % by other social sciences (including disaster management, development experts). This highlights the concern that the dominance of one disciplinary perspective potentially threatens to overshadow other methodologies and ways of identifying who is vulnerable.

Of the total VAs reviewed, 65 % were peer-reviewed literature, while 35 % were grey literature. However, these results may be skewed by the fact that practitioners often do not publish their work because of their focus on implementation compared to researchers' imperative on publishing and creating evidence and generating knowledge (Rynes et al. 2001). It has been argued that climate change research and vulnerability assessments 'rely preferentially upon specialized, academic knowledge' (Preston et al. 2011:192). Also, VAs are often commissioned by governments or donors with academic partners publishing findings in peer-reviewed journals with civil society or government partners putting that research into use.

The importance of grey literature in climate change adaptation studies has been recognised, especially in the context of providing local information, policy responses, and practice (e.g. autonomous adaptation) that often lie outside the ambit of journals (Pearce 2012). Often, the contestation of the 'lack of credibility' of grey sources

disallows vital knowledge from finding adequate mention in peer-reviewed journals, pushing researchers to partially draw from grey literature (Ford et al. 2011). Studies applying an SLR approach have acknowledged the importance of grey literature and adopted ways to sort and use select grey literature taking into account the constraints posed by grey literature in scientific reviews (Ford et al. 2011; Lesnikowski et al. 2011). Since the AR5, the IPCC has also included grey literature in their reviews (Pearce 2012).

How is vulnerability assessed?

Methods used

Of the 120 papers reviewed, 35 % used an indicator-based methodology (Fig. 3b). The least reported methodology used was participatory methods (1 %) followed by impact modelling studies (4 %) which mainly came from papers modelling crop vulnerability to future climate change impacts. The analysis shows a continued dominance of the use of quantitative and indicator-based methods with lower use of qualitative methods (12 %).

Spatial and temporal scales of assessment

The district was the most commonly used unit to assess vulnerability (reported by 19 % VAs) followed by studies conducted at city (14 %), region (coastal, catchment, forest) (13 %), and household (12 %) levels. Very few studies (3 %) were at the individual scale, which showed that intra-household dynamics are understudied. Of the VAs, only 9 % assessed vulnerability at multiple scales. The popularity of district-level VAs is attributed to the district being an intermediate unit that reflects dynamics at wider scales (national, state, landscape) as well as smaller scales (cities, villages, households) (e.g. in O'Brien et al. 2004). Another reason for the popularity of district-level assessments is that in the Indian context, there is availability of relevant biophysical and socio-economic data at district scale and it is a unit relevant to development planning and disaster risk reduction plans.

Only 3 % of the studies were at the individual level. This was because organisations disseminating information on climate change vulnerability function at larger and often multiple scales, and there is a lack of data on the influence of individual indicators on vulnerability (Tonmoy et al. 2014), challenges of communicating concepts and goals of the study to individuals (Ranjan and Narain 2012), and the difficulty of comparing contextual findings across individuals (Fekete et al. 2010). Being a dynamic concept that is not confined to a specific scale, vulnerability is shaped by various forces and processes (O'Brien et al. 2004),

which is why 9 % of the VAs reported assessing vulnerability at more than one scale.

Amongst the literature reviewed, very few have used a temporal scale of analysis (exceptions are Chhotray and Few 2012; Pranjay 2012; and Singh 2014). The lack of attention paid to temporal scales has implications on understanding vulnerability which is dynamic, especially in the context of seasonality and rural livelihoods (Singh 2014) as well as reporting differences in vulnerability to climate variability versus climate change (Nair 2013). VAs that do discuss temporality demonstrate how vulnerability can have repercussions over decadal timescales (Chhotray and Few 2012).

Landscape focus of the VA

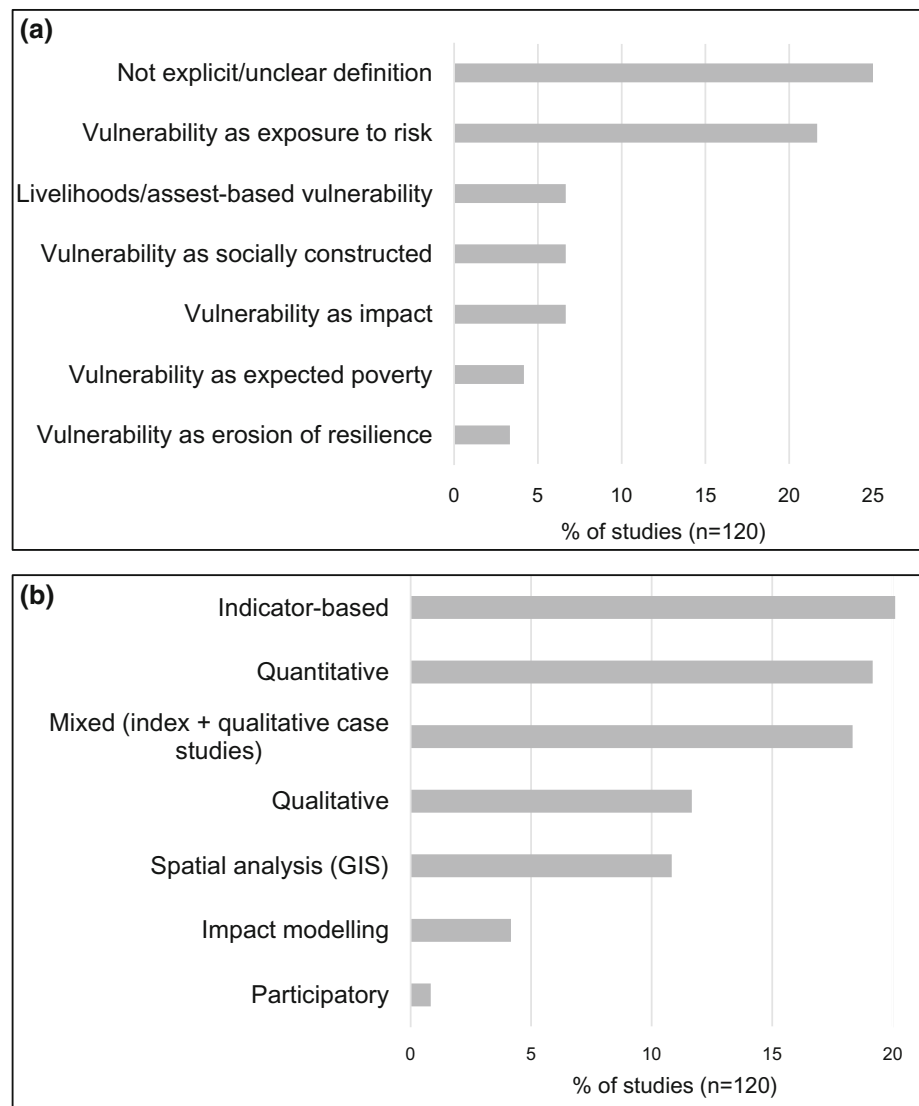
The landscape focus of most papers (41 %) spans across multiple landscapes (rural, urban, and peri-urban). This can be attributed to the predominance of assessments at the district level, which may contain urban and rural areas. A third of the VAs (34 %) were in rural landscapes, possibly because of dominant perceptions of rural areas housing the poor, agricultural livelihoods being most sensitive to climate change impacts, and rural communities being socio-economically disadvantaged and hence inherently vulnerable. Moreover, multilateral agencies and NGOs have a larger focus on rural areas (see for, e.g. SDC 2009; Practical Action 2009; GIZ 2014). Only 2 % of the VAs mentioned peri-urban areas possibly because the conceptualisation of the peri-urban, especially in highly dynamic developing country contexts, is still understudied.

Outcomes of vulnerability assessments

A qualitative analysis of the findings, discussion, and conclusion section of the VAs helped examine where the VA exercise hoped to either further the conceptual understanding of vulnerability, methodological aspects of assessing vulnerability or inform policy or practice. We identified five VA types (see below) and acknowledge that these types are not mutually exclusive, and many studies identified drivers of vulnerability (category 1) as well as made policy recommendations (category 4) based on their findings. However, for this paper, we categorised the VAs based on the key contribution the VA aimed to make, based on the authors' stated objectives.

- *Identifying structural drivers of vulnerability* Of the studies, 36 % VAs focussed on identifying the drivers of vulnerability. Most studies using disaster risk reduction as a primary disciplinary background (for example, De Sherbinin et al. 2007; Dwarakish et al. 2009; Chhotray and Few 2012) identified gaps

Fig. 3 Conceptualisation of vulnerability (a) and methods to assess vulnerability (b)



in the approach towards resilience building to climate change and focussed on the current drivers of vulnerability.

- *Identifying vulnerable people, places, sectors or systems* 25 % of the VAs focussed on categorising who is vulnerable by mapping vulnerable regions or sectors. Other assessments explored how different social structures may result in differential vulnerability (e.g. caste-driven vulnerability by Boshier et al. 2007 or gendered vulnerability by Garikpati 2008).
- *Contributing to methodology* Some studies (22 %) furthered methodological practices to assess vulnerability. For example, Garg et al. (2007) develop a toolkit to assess vulnerability and adaptation across multiple spatial and temporal scales. Studies using GIS such as Jain et al. (2009) also advance methods to assess

vulnerability by developing categories of drought vulnerability across time.

- *Enabling/supporting decision-making* Although most studies made policy recommendations, 15 % VAs explicitly stated that their findings intended to enhance the effectiveness of adaptation planning (e.g. Downing et al. 2005; Das et al. 2014) or considered policy-makers as their primary end users (e.g. Gaiha and Imai 2008).
- *Contributing to conceptual understanding of vulnerability* Only 3 % of the studies discussed the implications of their findings on vulnerability conceptualisation. Such studies use other framings to understand vulnerability—for example, risk assessment framing by Sharma and Bharat (2009)—or use theory and empirical evidence to revise existing frameworks (e.g. Singh et al. 2014).

Discussion

This review highlights the importance of scale and methodological approach when assessing vulnerability. The findings demonstrate that in India, vulnerability is conceptualised in multiple ways and draws from various theoretical lineages. We argue that different conceptualisations of vulnerability are predisposed to certain methodological approaches and thus have significant implications on who and what is rendered vulnerable. Through a systematic literature review, we find that the methods used to assess vulnerability to climate change in India are embedded in the disciplinary traditions and methodological approaches, of those conducting the assessment. The implications of this methodological conservatism are that in India, innovations in vulnerability research (for example, the role of risk perception in shaping adaptive capacity or how multi-scalar interactions shape local vulnerability) have yet to percolate into reported VAs. This in turn potentially portrays a myopic view of the factors shaping vulnerability.

We also identify gaps in current vulnerability research in India. First, despite repeated calls for expanding VAs from indicator-based approaches to more relational, context-based enquiries (O'Brien et al. 2007; Ford et al. 2010; Taylor 2014) that see vulnerable people and places as embedded in multi-scalar complex systems (Adger et al. 2008; Eakin et al. 2009), 26 % of the VAs used the IPCC framework (IPCC 2007). Second, most studies assessed vulnerability at one time, without attention to temporal vulnerability and past trajectories of change. Finally, the review highlights continued reliance on indicators to assess vulnerability, despite repeated critiques around choice and weighting of indicators (Vincent 2004; Hinkel 2011), lack of adequate data, the possibility of nonlinear relationships between determinants (Bhattacharya and Das 2007), and inability to capture vulnerability as experienced or perceived by the vulnerable (Tschakert 2007; Ford et al. 2010). The paper also provides the first comprehensive review of VAs for India in recent years and uncovers the conceptual and methodological breadth of VAs over the past 10 years.

Methodological approaches used

The predominance of indicator-based VAs raises questions about the continued dependence on quantitative methods for assessing vulnerability despite a growing call for contextual and relational vulnerability (O'Brien et al. 2007; Tschakert et al. 2013; Singh 2014; Taylor 2014), the need to understand vulnerability not only as inherent, but as accrued over time (Cutter and Finch 2008), and the lack of evidence of the social roots of vulnerability (Bassett and

Fogelman 2013). Although there has been a global shift towards more plural methodologies to assess vulnerability (e.g. participatory methods by Fazey et al. 2010; case studies and analogues to understand temporal vulnerability by Ford et al. 2010), this methodological progression is yet to be mirrored in India (notable exceptions include Chhotray and Few's (2012) qualitative analysis of ongoing vulnerability and response trajectories in post-disaster Orissa; the use of life histories to explore temporal vulnerability of smallholders in Rajasthan by Singh (2014)).

While we acknowledge the importance of indicator-based VAs in identifying differential vulnerability and informing resource allocation, given the dynamic nature of vulnerability and its multi-scalar drivers, we recommend supplementing such enquiries with methodologies that capture temporal aspects, explore how existing rules and values shape differential vulnerability, unpack seemingly homogenous categories of 'high', 'medium' and 'low' vulnerability, and match conceptual advances in vulnerability research.

Scalar issues: spatiality and temporality in vulnerability research

Vulnerability varies with location and requires place-based analysis. Our analysis revealed that most VAs were district level with few studies assessing drivers and manifestations of vulnerability at multiple scales. This approach ignores that vulnerability is not confined to a specific scale and is influenced by various forces and processes (Fekete et al. 2010), necessitating holistic assessments that envision vulnerable people and places as embedded in larger socio-ecological systems (Singh 2014).

In most VAs, vulnerability was assessed as a snapshot,³ thus rendering an inherently dynamic concept static. Such a static view of vulnerability tends to ignore that people are situated in highly dynamic systems. For example, rural livelihoods and food security are a function of seasonality (Singh 2014). Government terms (typically five-year periods) shape planning and resource allocation, which have direct repercussions on people's coping and adaptation behaviour. Most significantly, rapid urbanisation is poised to dissolve rural–urban binaries (Revi 2008), thereby changing the very context within which current VAs are done. Against this backdrop, the lack of VAs conceptualising and assessing vulnerability as something changing over time is a significant research gap.

³ Notable exceptions include Singh (2014), and Nair (2013), and to some extent Ranjan and Narain (2012).

Are findings from VAs informing research, policy, or practice?

Dialogues around uptake of climate change VAs have converged to identify a significant gap between mounting academic knowledge and translation of that knowledge into effective evidence-backed policies (Preston et al. 2011). While this may be due to hesitation of planners to hinge development and adaptation investments on climate impact studies that have high levels of uncertainty, it may also be due to the lack of salience, credibility, and extent of localisation of certain assessments (Chaudhury et al. 2014). Exceptions include VAs conducted by practitioners, which are implicitly aimed at informing future local interventions.

Our review highlights that peer-reviewed papers (specifically those based on modelling future impacts) did not clearly mention targeted or potential end users (for, e.g. Chatterjee et al. 2014). This raises questions around resources spent on doing VAs without a clear plan of uptake of such research into fund allocation or vulnerability reduction. We note that the uptake and utility of findings from VAs findings and their role in informing research, policy, or practice is an area of further research.

Reflections on using a systematic literature review

Systematic reviews have been criticised for being resource intensive (Kitchenham 2004), over-relying on quantitative analysis (Booth 2001; Dixon-Woods et al. 2006). In our study, although the SLR process was resource intensive, we attended to other limitations by keeping our analytical template flexible and coding iterative. Using a clear literature scanning and filtering strategy followed by a systematic analysis framework helped reduce time invested (this review took 5 months to complete from start to first draft stage).

Searching for literature using search engines (Google Scholar, JSTOR) potentially led to a bias towards peer-reviewed material. This was addressed by supplementing our search with consultations with experts and checking websites of donors and NGOs to identify vulnerability projects. Another constraint of an SLR is how choice of search words determines and limits the literature studied. In this paper, certain words were not explored which may have excluded certain disciplines/vulnerability assessments. For example, 'technological risk' or 'infrastructural risk' was not searched for and this potentially excluded studies on vulnerability of IT infrastructure, power, and road infrastructure to climate change.

We conclude that while SLR is useful to make sense of and categorise a wide literature, as in vulnerability research in India, for a more nuanced understanding of motivations

behind and implications of VAs, it must be followed by interviews with people conducting and utilising VAs.

Conclusion

The challenge of understanding the drivers of vulnerability is closely linked to how vulnerability is assessed. Focussing on India, this paper set out to review how is vulnerability conceptualised and assessed, who is assessing vulnerability, and what contributions VAs set out to make. We find that despite advances in vulnerability research over the past few years towards interrogating structural and socially constructed drivers (Tschakert et al. 2013, Turner 2016), most of the VAs reviewed were methodologically conservative. Thus, neither did they capture the nuances of who is vulnerable nor discuss how relatively passive drivers such as climate variability or natural resource degradation interface with highly political and contested factors such as changing caste dynamics, rising inequality, or political will and fund allocation. Our findings are echoed in other recent reviews of vulnerability methods, but in different contexts (for example, see Delaney et al. 2014, McDowell et al. 2016).

We suggest that just as the conceptualisation of vulnerability globally has shifted from a static frame to viewing it as a critical element shaping *pathways* of societal responses to climatic and non-climatic changes (Leach et al. 2010; Wise et al. 2014), the current methodological toolbox in India needs to be concurrently expanded. This expansion should be methodologically creative where current ways of assessment (e.g. indicator-based approaches) must be supplemented by methods drawing from other epistemic frames and disciplines (e.g. spatial mapping or ethnographic explorations in temporal vulnerability). Such a methodological expansion, which draws upon ongoing conceptual advances in vulnerability research, will lead to more holistic ways of assessing vulnerability and thereby highlight relationships, temporalities, narratives, and contexts of vulnerability. We also highlight that in India, the context of rapid and often unplanned urbanisation (Revi 2008) necessitates an exploration of how existing and future vulnerabilities are perpetuated and created in places of transition such as at peri-urban interfaces.

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