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Integrated research on disaster risk: Is it really integrated?

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ABSTRACT

This paper traces the development of peer-reviewed, integrated research on disaster risk over the past fifteen years to assess the current state of knowledge. We define integrated research as those studies that engage multiple scales, stakeholders, knowledge (scientific to indigenous), disciplines, and methods. Using 39 peer-reviewed academic English-language journals as the basis of our analysis, we conducted both a content analysis and a bibliometric analysis on the characteristics of the research: disciplinarity, knowledge, place and scale, stakeholder involvement, and policy applications as well as the integration across these traits. While integrated disaster risk research has made great strides over the past 15 years, much of it is still discipline or multi-discipline centric and largely produced by North American and European scholars. The co-production of knowledge is limited and implementation gaps between research and practice persist.

1. Introduction

Calls for bridging disciplinary isolation in disaster risk research and/or infusing disaster risk research into planning, policy- and decision-making reverberate in the Hyogo Framework for Action and initiatives such as the Integrated Research on Disaster Risk (IRDR) Programme, and the International Society for Integrated Disaster Risk Management. The Hyogo Framework for Action, for example, encourages governments and organizations "to integrate disaster risk reduction considerations into their sustainable development policy, planning and programming at all levels" [1], p. 18. The IRDR initiative on the other hand [2,3] envisions an integration of "research expertise from the natural, socio-economic, health, and engineering sciences, as well as policy-making coupled with and understanding of the role of communication, and public and political responses to reduce the risk" from disasters [4], p. 4. The International Society for Integrated Disaster Risk Management, established in 2009 in Kyoto, Japan, also seeks to promote integrated research with an additional focus on "the implementation of disaster science, research, and education in real-world localities, varying in geographic, climatic, political, cultural, and social systems [5]. As highlighted in the above examples, the terms "integration" and "integrated", are used frequently and interchangeably yet differ in terms of meaning, approach, scale, and stakeholders.

To explore these various meanings of integrated disaster research, this paper systematically examines the characteristics, content, and production of integrated disaster risk research during the past fifteen years. The following questions provide the focus for the analysis: Who is engaged in integrated research and what is the geographic extent of participation and focus? What key topical areas are examined and where? What and where are the current gaps in integrated research on disaster risk? This overview is timely and contributes to the efforts by the IRDR working group on the Assessment of Integrated Research on Disaster Risk (AIRDR) to provide the science-based evidence for the development of the Post-2015 Hyogo Framework for Disaster Risk Reduction [6]. We briefly trace the development of peer-reviewed, integrated disaster risk research during the past fifteen years and qualitatively assess the current state of knowledge using two empirically-based approaches: (1) content analysis and (2) bibliographic network analysis.

2. What is integrated disaster risk research?

In its broadest sense, integrated disaster risk research engages multiple scales (local to global), stakeholders (experts, professionals, officials, etc.), knowledge (scientific, local), disciplines (physical, social, human sciences, etc.), methodological approaches, areas of application/implementation (planning, sustainable development, policy, etc.) and real world experiences [6,7]. A wide array of characteristics can be used to define integrated research: multi-disciplinary, decision-informing,

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risk-reducing, sustainable, policy-focused, place-based/autochthonous, participatory, holistic, and hybrid knowledge [8–10].

The discussions surrounding what constitutes integrated disaster risk research harken to earlier conversations on the nature of multi-inter-trans-disciplinary (MIT) research in hazards and disasters [11]. That NRC report states,

> "*There exists a spectrum of degrees of interdisciplinarity. These range from parallel efforts with a research team comprising different disciplines, to sequentially linked efforts where outputs of one disciplinary research effort provide inputs to another, to fundamentally integrated research where multiple disciplines interact in mutually transforming ways from problem definition through to research design and execution*" [11], p. 183.

The degree of "interaction among disciplines" is one way of distinguishing various types of interdisciplinarity. Multi-disciplinary connotes an additive or parallel function to producing knowledge (discipline A plus discipline B, each making their own contributions individually). Interdisciplinary research is a more cooperative model where methods, concepts, and research teams are developed collaboratively among two or more disciplines [11], p. 181, reflecting a holistic synthesis not just a sum of all the parts. The third type of interaction is often referred to as transdisciplinary research where research teams cooperatively tackle real world socially-relevant topics that cannot be addressed by single or multiple disciplines alone nor without the active engagement with stakeholders [8,9]. Transdisciplinary research is a collaborative process where researchers create new theoretical, conceptual, and/or methodological advancements that surpass discipline-specific contributions in addressing a solution for a common problem or sets of problems. Transdisciplinary research is focused on societal relevant problems, enables mutual learning among participants from various disciplines and actors; and tries to create solution-oriented knowledge that is equally socially responsive [12]. Integrated research on disaster risk can be multi-disciplinary, interdisciplinary, or transdisciplinary, the latter being the most difficult to achieve.

Some of the earliest work on integrated research resulted from the narrow stove-piped and fragmented nature of traditional discipline-based research that was inadequate for solving complex problems theoretically, conceptually, or methodologically. The need to focus on the "whole" including all the interdependencies not just the individual parts of complex problems (or systems) provided the stimulus for a new research approach [13]. The forerunner to this was based on the 1980s scientific understanding of the interdependencies between society and the environment and its movement into the political arena through such high profile reports as the Bruntland Commission's *Our Common Future* [14]. Much of this new thinking and approach to research came from the natural resources/ecosystem management fields [15] where there was a critical need to understand the interactions between biophysical processes, social issues, and socio/political/economic processes, and where the science was more often than not translated into practice. Integrated assessment models (IAM) were designed in the mid-1990s to combine atmospheric processes with the socio-economic aspects of climate change in order to provide policy options for climate change control [16]. Another example is the evolution of sustainability science as a field of recognized inquiry that assimilated multiple perspectives [14], [17–19] and in the process created its own trans-discipline. It is one of the best contemporary examples of integrated environmental research [19]—socially relevant problem; engagement of researchers and others in mutual learning and knowledge production; and new knowledge beyond disciplinary boundaries aimed at solutions that are socially beneficial.

Disaster risk research is multi-disciplinary as evidenced by the various disciplines such as economics, engineering, psychology, or geography that have been traditionally engaged in this field. How far along disaster risk research is on its path toward integrated research, though, remains murky at best. There is no systematic assessment of the status of integrated disaster risk research beyond research investigating scientific networks and the interaction among researchers and institutions. Examples are bibliometric research on specific hazards [20], case studies [21] or topical areas such as vulnerability and resilience research [22–24]. The results of these bibliometric studies underscore the multi-disciplinary background of disaster risk research and document the rise in disaster risk-related publications over the past years. However, they mostly infer integration based on the interaction between researchers or institutions rather than based on the substantive contribution of the research itself. In order to understand the state of integrated disaster risk research, an analysis of scholarly networks is insufficient and needs to be complemented with content analyses evaluating research in regard to the characteristics of integrated research such as methodological approaches, stakeholder engagement, knowledge domains, etc.

3. Methods

We focused our assessment of the current status of integrated disaster risk research on (a) the characteristics of integrated disaster risk research: disciplinarity, knowledge, place and scale, stakeholder involvement, and policy/application; and (b) the integration across these characteristics. An extensive bibliometric review allowed us to identify how integrated disaster risk research has been constituted and organized. Content analysis enabled us to determine to some degree what is known with some certainty and where research gaps exist in our present knowledge.

3.1. Content analysis

The content analysis included coding of reviewed publications, full text searches and a word count analysis. The content analysis drew on 39 peer-reviewed, academic, English-language journals (Table 1). The journals were selected based on expert judgments such as input from the IRDR Science Committee and our knowledge of the field. The review of these journals for the time period between 1999 and 2013 produced 1095 full text articles related to disaster risk. Publications on war or civil unrest, technological hazards (e.g., oil spills, nuclear accidents), climate (e.g., carbon dioxide concentration, El Niño), and diseases (e.g., HIV/AIDS, malaria) were excluded since the focus was on natural hazards. Furthermore, hazard-specific journals and conference proceedings were omitted as well since this research focuses on the interaction between nature and society and not just the geophysical aspects of hazards themselves (e.g., plate tectonics, hydrology, etc.).

English-language journals are the *lingua franca* of science, and while we realize shortcomings in regional coverage of the non-English reading world, it provides the starting point for an assessment of the state of integrated research on disaster risk. For the purpose of this work, we adhered to a conservative approach of focusing on peer-reviewed journal publications representing original research. Although some grey literature is rigorously reviewed and comparable in impact and quality to peer-reviewed literature, there are several reasons for its exclusion: First, the majority of grey literature is not peer-reviewed [25] and it is frequently impossible to determine authorship, partnership, and so forth, which makes grey literature incompatible with our methodological approach developed for peer-reviewed publications. Secondly, some grey literature is essentially a synthesis of original

Table 1
Journals reviewed for content analysis. In total, 1006 peer-reviewed publications were identified through a manual review of journal editions.

Journal	Number of reviewed articles	Date range of reviewed articles	Indexed in Web of Science
Applied Geography	26	2001–2013	x
CiiNii Journal/Journal of Natural Disaster Science	21	2000–2012	
Climate and Development	53	2009–2013	x
Climatic Change	31	1999–2013	x
Disaster Prevention and Management	40	2000–2012	x
Disasters	58	1998–2013	x
Ecology and Society	31	2008–2013	x
Environment and Planning B: Planning and Design			x
Environment and Planning C: Government and Policy			x
Environment: Science and Policy			x
Global Environmental Change	49	1996–2013	x
Global Environmental Change Part B: Environmental Hazards (formerly Environmental Hazards)	57	1999–2013	x
International Journal of Disaster Risk Reduction	14	2012–2013	
International Journal of Disaster Risk Science	24	2010–2013	
International Journal of Mass Emergencies and Disasters	29	2003–2010	
Journal of Climate	13	1999–2013	x
Journal of Coastal Research			x
Journal of Integrated Disaster Risk Management	7	2011–2012	
Journal of International Development	16	2007–2013	x
Journal of Latin American Studies			x
Journal of Urban Affairs			x
Mitigation and Adaptation Strategies for Global Change	87	1999–2013	x
Natural Hazards	87	1997–2011	x
Natural Hazards and Earth System Sciences	126	2003–2013	x
Natural Hazards Review	62	2000–2013	x
Population and Environment	14	2003–2013	x
Progress in Human Geography	7	2000–2013	x
Qualitative Research			x
Risk Analysis	83	1997–2013	x
Risk Management	13	1999–2011	x
Social Science Journal			x
Social Science Quarterly	1		x
Social Science Research	1		x
Sustainability	14	2009–2013	x
Urban Affairs Quarterly			
Urban Affairs Review			x
Urban Studies			x
Weather, Climate, and Society	29	2009–2013	x
World Development	13	1999–2013	x

research to support or formulate policy-relevant solutions but does not offer original research itself (e.g., IPCC reports). Thus, an inclusion of grey literature creates the potential of double-counting research already published elsewhere. Third, many researchers who publish original research in peer-reviewed journals also contribute to grey literature and vice versa meaning non-academic researchers working for organizations such as the World Bank, United Nations, Overseas Development Institute, Stockholm Environment Institute, publish in peer-reviewed journals. Our methodology therefore does not exclude authors of grey literature but only the outlet or channel of publication through which grey literature is shared. Fourth, research has shown grey literature is more likely to publish statistically non-significant results [25,26]. And lastly, there is no Web of Science or MEDLINE for grey literature. As such, any inclusion of grey literature in literature reviews, assessments of the state of science, and so forth, is inevitably reliant on subjective parameters regarding the "importance" or "quality" of these works. We defer any statements on the importance of grey literature in regard to integrated research on disaster risk to future research.

The culled publications were initially stored in an *EndNote* library and then transferred into *NVivo* to perform the content analysis. Each article was reviewed and classified based on: study area, number of authors, authors' disciplinary background, number of disciplines, authors' country of affiliation, and the type of research partnership (e.g., academic, academic-governmental, etc.) engaged in the writing of the publication. Information on disciplinary background and type of partnership was generally not derivable from the publication itself and had to be supplemented through Internet research. In addition, publication content was reviewed and classified by using codes capturing research topic, hazard type, major disasters, and methodology. We did not adopt the keywords supplied by the publication itself, opting instead to use our expert knowledge of the field to guide coding.

Many bibliometric studies use the software *HistCite* to glean information on author's discipline and country of origin. We chose to collect this information through content analysis since *HistCite* only considers the first author or corresponding author. Given our goal of assessing the state of integrated disaster risk research, information on co-authors (discipline and country or origin) was as important as the lead author's and was therefore inferred through content analysis.

Based on the content analysis, it was possible to investigate the following questions:

1. What are the central knowledge domains in disaster risk research?
2. In what countries or regions is most of the research conducted?
3. What is the disciplinary background of the researchers and what are the research partnerships they engage in?

Table 2
Keyword searches conducted in Web of Science (*WoS*) to identify highly cited publications. All *WoS* results were downloaded for bibliometric research up to a maximum of 500 records. (†) denotes searches exceeding the maximum limit of 500 records. (*) indicates a placeholder/wildcard to include variations of a term in the search.

Keywords	WoS results		Keywords	WoS results	
	AND disaster	AND natural hazard		AND disaster	AND natural hazard
Adapt*	1086†	486	Marginalized	418	9
Africa	580†	214	Mass media	103	16
Agriculture	508†	430	Mathematics	170	8
Anthropolog*	135	12	Mental health	1507†	32
Architect*	263	48	Meteorology	284	34
Asia	582†	154	Middle East	37	17
Assistance	639†	57	Migration	240	124
Atmospher* Science	210	314	Military	595†	43
Caribbean	85	45	Mitigation	1549†	124
Central America	38	13	Multidisciplinary	129	60
Children	1726†	330	National security	49	6
Climate change	1016†	560†	Poverty	330	73
Comprehensive planning	170	63	Preparedness	2016†	221
Computer science	51	24	Psychology	1761†	80
Conservation	282	212	Public health	1241†	326
Disaster stud*	76	513†	Public policy	113	40
Ecolog*	812†	515†	Public safety	271	28
Econom*	2226†	964†	Race	328	127
Economic development	518†	256	Recovery	1988	327
Engineering	775†	471	Resilience	961†	241
Environmental research	690†	311	Risk assessment	990†	609†
Ethnicity	257	74	Risk management	548†	300
Europe	589†	536†	Sea-level	197	163
Evacuation	500†	89	Social capital	95	16
Family	1055†	203	Social development	519†	175
Gender	593†	215	Sociology	155	29
GIS	453	411	South America	31	28
Governance	251	68	Statistics	239	767†
Hazard/disaster	2285†	2285†	Sub-Saharan Africa	62	12
Household*	445	137	Sustainable development	201	95
Infrastructure	954†	350	Tourism	244	126
Insurance	539†	182	Uncertainty	551†	363
International development	357	103	Vulnerability	2014†	821†
Land use	295	370	Total number of search hits	42,917	17,267
Latin America	74	15			
Loss	1866†	797†	Total number of retrieved Citations including duplicates	23,638	13,900
			excluding duplicates		16,541

3.2. Bibliometric network analysis

To study the research network more broadly and reduce selection bias, we performed 138 keyword searches using 69 terms each in combination with the term *disaster* as well as *natural hazard* using *Web of Science* (*WoS*), an academic citation indexing and search service by Thompson Reuter (Table 2). All search results were downloaded using the "full records with citations" options up to a maximum of the top 500 references with the highest citation frequency as measured by the Global Citation Score (GCS). Note that the GCS increases over time as new publications appear and cite previous research. The *WoS* results considered research previously excluded in the content analysis such as publications on technological hazards, diseases, or climate change.

Table 2 shows the individual keyword searches and associated search results, which collectively produced 60,184 search hits. Due to capping of downloads at a maximum of 500 records, only a total of 37,538 references could be downloaded. Thus, we retained about 62% of disaster- or natural hazards-related *WoS* search hits for our analysis. Out of the 37,538 references, 20,997 references were returned by multiple searches. After removing these duplicates, the final sample for the bibliographic analysis consisted of 16,541 peer-reviewed, mostly English-language publications that were authored by 43,893 researchers published in 4147 journals, with 480,917 citations.

The network analysis focused on the relationship or interaction between articles (e.g., who cites whom, who publishes where). More specifically, the network analysis consisted of an analysis of (a) bibliographic coupling and (b) co-citation. Bibliographic coupling studies the outgoing citations meaning the references utilized in publications indicating the "closeness" of publications. Bibliographic coupling is a static assessment since the cited references in a publication do not change over time. Co-citation on the other hand focuses on "incoming" citations meaning how often and by whom a publication was cited as well as which publications are cited together [27]. This provides information on the semantic relationship between the cited references. An analysis of co-citations extends beyond peer-reviewed publications and includes any cited references such as books or reports. Co-citation can change over time since new publications alter existing semantic relationships either by incorporating newer research, dismissing older work, and/or identifying new relationships between past and present research. Put simply, bibliographic coupling provides a static picture while co-citations are dynamic and evolve over time. To analyze as well as visualize network relationships derived from the *WoS* searches, we utilized two freely available software programs: *VOSviewer* (www.vosviewer.com) and Thomson Reuters' *HistCite*. Given the large sample of publications used in this bibliometric network analysis, *VOSviewer* allowed us to visualize the entire data set in terms of bibliographic coupling and co-citations by using density maps. These density maps offer a general overview of the current state of disaster risk research and how the field organizes itself in terms of scholarly networks and focal areas.

To explicitly show the citation network between highly cited authors, we used *HistCite*. By drawing on both bibliometric tools, we were able to identify key authors in the field of disaster risk research and more importantly their intellectual research network, which speaks to the degree of collaboration—not necessarily integration—across knowledge domains.

Again, the bibliographic network analysis investigated how (integrated) disaster research is constituted and practiced whereas the content analysis aimed at the identification of key topics, major disasters researched, study areas, research partnerships, and methodological approaches employed. The combination of these approaches facilitated a deeper understanding of the present status of integrated disaster risk research.

3.3. Identification of highly cited work

To ensure that we captured highly-cited, peer-reviewed articles that were either (a) published outside of our sample of 39 journals, and/or (b) published prior to 1999, we utilized the 138 keyword searches (Table 2) performed for the network analysis described above. For the purpose of this research, we defined highly cited publications as articles cited at least 30 times (equal to a Global Citation Score of 30) and appearing as search hits in at least two or

Table 3
List of seminal papers ($n=135$), which were identified through a combination of Web of Science's Global Citation Score (GCS) of at least 30 as well as repeat occurrence in at least two or more keyword searches.

Publication	GCS	Publication	GCS	Publication	GCS	Publication	GCS
Aalst et al. 2006 [28]	50	Cutter et al. 2000 [29]	196	Korup 2002 [30]	48	Pielke and Landsea 1998 [31]	190
Adger 2006 [32]	409	Dai and Lee 2003 [33]	61	Kovats et al. 2003 [34]	100	Poumadère et al. 2005 [35]	104
Adger et al. 2005 [36]	262	Dai and Lee 2002 [37]	242	Kunreuther 2006 [38]	39	Powell and Houston 1996 [39]	90
Akgun et al. 2008 [40]	72	Dai et al. 2001 [41]	124	Kunreuther and Pauly 2006 [42]	39	Powell et al 1998 [43]	184
Alcantara-Ayala 2002 [44]	69	De Sherbinin et al. 2007 [45]	48	Kunreuther 1996 [46]	118	Pradhan 2011 [47]	55
Alexander 1997 [48]	56	Dibben and Chester 1999 [49]	38	Landsea et al. 1999 [50]	163	Rashed and Weeks 2003 [51]	57
Allen 2006 [52]	54	Elliott and Pais 2006 [53]	90	Malamud et al. 2005 [54]	100	Revi 2008 [55]	41
Apel et al. 2006[56]	68	Faulkner 2001 [57]	205	Malamud et al. 2004 [58]	223	Ritchie 2004 [59]	68
Apel et al. 2004 [60]	68	Fiedrich et al. 2000 [61]	100	Manyena 2006 [62]	61	Rose and Liao 2005 [63]	62
Armenian et al. 2000 [64]	94	Fothergill et al. 1999 [65]	122	McCaffrey 2004 [66]	54	Rosenzweig et al. 2002 [67]	69
Bankoff 2001 [68]	65	Fothergill and Peek 2004 [69]	82	McGranahan et al. 2007 [70]	207	Saha et al. 2005 [71]	69
Barbarosoglu and Arda 2004 [72]	94	Froot 2001 [73]	74	Mishra and Singh 2010 [74]	142	Schipper and Pelling 2006 [75]	86
Barredo 2009 [76]	64	Fuchs et al. 2007 [77]	62	Morrow 1999 [78]	146	Schultz et al. 1996 [79]	85
Barredo 2007 [80]	64	Gaillard 2010 [81]	39	Nadim 2006 [82]	58	Siegrist and Gutscher 2008 [83]	46
Basoglu et al. 2002 [84]	83	Gaume et al. 2009 [85]	107	Nelson and French 2002 [86]	42	Siegrist and Gutscher 2006 [87]	55
Begueria 2006 [88]	71	Goenjian et al. 2001 [89]	161	Neumayer and Plümper 2007 [90]	59	Skidmore and Toya 2002 [91]	64
Beniston 2003[92]	281	Greenough et al. 2001 [93]	61	Neuner et al. 2006 [94]	61	Smit et al. 2006 [95]	502
Berke et al. 1993 [96]	43	Grothmann and Reusswig 2006 [97]	96	Nogues-Bravo et al. 2007 [98]	118	Stoffel and Bollschweiler 2008 [99]	94
Berkes 2007 [100]	90	Grünthal et al. 2006 [101]	41	Norris et al. 2008 [102]	163	Szczucinski et al. 2006 [103]	55
Bland et al. 1996 [104]	71	Guzzetti et al. 1999 [105]	463	Norris et al. 2002a [106]	216	Thieken et al. 2006 [107]	45
Bonanno et al. 2007 [108]	111	Haines et al. 2006 [109]	123	Norris et al. 2002b [110]	634	Thomalla et al. 2006 [111]	81
Bouwer 2011 [112]	48	Heltberg et al. 2009 [113]	48	Norris et al. 2001 [114]	52	Tierney 2007[115]	39
Brodie et al. 2006 [116]	111	Hunter 2005 [117]	50	Norris et al. 1999 [118]	82	Tierney et al. 2006 [119]	69
Brooks et al. 2005 [120]	217	Husar et al. 2001[121]	401	O'Brien et al. 2006 [122]	60	Tierney 1999 [123]	62
Burby 2006 [124]	81	Janssen et al. 2006 [22]	81	Oliver-Smith 1996 [125]	112	Tralli et al. 2005[126]	67
Carey 2005 [127]	45	Jonkman 2005 [128]	67	Opricovic and Tzeng 2002 [129]	103	Tsai and Chen 2011 [130]	42
Carrara et al. 1999 [131]	90	Kahn 2005 [132]	87	Ozdamar et al. 2004 [133]	102	Uitto 1998 [134]	24
Cevik and Topal 2003 [135]	76	Kaniasty and Norris 2000 [136]	55	Pareschi et al. 2000[137]	54	Vogel et al. 2007 [138]	92
Cioccio and Michael 2007 [139]	32	Karl and Easterlin 1999 [140]	79	Patz et al. 2007 [141]	55	Walsh 2007 [142]	62
Cochard et al. 2008 [143]	58	Kates et al. 2006 [144]	67	Peacock et al. 2005 [145]	58	Woodhouse and Overpeck 1998 [146]	290
Cook et al. 2007 [147]	184	Keim 2008 [148]	50	Peek-Asa et al. 1998 [149]	65	Wu et al. 2002 [150]	51
Cutter and Finch 2008 [151]	81	Klein et al. 2001 [152]	58	Perilla et al. 2002 [153]	88	Yesilnacar and Topal 2005 [154]	137
Cutter et al. 2008 [155]	82	Kenardy et al. 1996 [156]	69	Perry and Lindell 2003 [157]	76	Zhou et al. 2009 [158]	35
Cutter et al. 2003 [159]	330	Kogan 1997 [160]	158	Pielke et al. 2003 [161]	44		

more keyword searches. This produced 135 highly cited publications (Table 3), of which 46 had previously been identified and included in the initial culling of peer-reviewed journal articles. Full text versions of these additional papers were added to the *EndNote* library and *NVivo* resulting in a total of 1095 publications collected and reviewed for the content analysis.

It is important to point out that this approach of identifying highly cited works has shortcomings. Although we conducted keyword searches using both the term *disaster*, prevalent in the international context and in disciplines such as sociology or economics, as well as *natural hazard* commonly used in disciplines such as geography, public health or engineering, there is the potential that relevant works studying perils or risks may have been excluded. Thus, this paper makes no claim of a comprehensive identification of highly cited or even seminal works in the broader natural hazards or disaster risk research arena. For a discussion of limitations of *WoS* for the use in bibliometric analyses see elsewhere [162–164].

4. The state of integrated disaster risk research

The results are broken down into five thematic areas: knowledge; scale and geographic focus; disciplinarity; stakeholder engagement and policy; and research networks. These are described below.

4.1. Knowledge

Out of the 1095 reviewed articles 80 percent ($n=878$) were case studies at the local, country, regional or global scale of which about a third were assessments of local risk, vulnerability, hazards, or impacts. Assessments are generally focused on the spatial distribution of these elements as well as their relationship to assets at risk [159], [165–168]. Key concerns of assessments are economic—primarily loss estimation—and human impacts and their relationship to sustainable development and resilience; see [169–171]. There is limited research exploring methodological considerations or improvements to assessments, such as evaluations of the strengths and weaknesses of assessment methodologies.

The situational and contextual characteristics of communities are largely recognized in most disaster risk research resulting in unique assessments for individual locations. However, these characteristics are rarely considered as critical components of research, especially in the assessment work. There appears to be a paucity of research examining different types of settlements or communities—megacities, rural, or coastal.

Research on organizational and individual decision-making, including risk perception and communication, is heavily represented making up about 22 percent of reviewed publications. Central themes are decision-making in regard to reducing vulnerability and improving adaptation; see [21,172,173]. While there are many suggestions for better hazard mitigation and climate adaptation such as increase community participation [174], how to implement best practices, or devise policies in order to create more resilient communities appears to be an afterthought in most studies as are the consideration of environmental impacts.

All-hazards research, although recognized as important is exceedingly small and accounts for less than one percent of all reviewed studies. Single hazard analyses and assessments are much more frequent and tend to be dominated by floods (25 percent), earthquakes (14 percent), hurricanes/tropical cyclones (12 percent), drought (8 percent), and tsunami (7 percent). Research in the context of climate change tends to consider multiple hazards but predominantly investigates the effects on drought or flood exposure. The most studied disasters are the 2005 Hurricane Katrina and/or Rita, the 2004 Indian Ocean tsunami, the 2008 Sichuan earthquake, 1998 Hurricane Mitch followed by the 2010 Haiti earthquake, the 2011 Tohoku earthquake, and the 1995 Kobe earthquake. This list of events is not indicative of all focusing events and should be interpreted with caution since it is influenced by the geographic coverage of authorships and disciplinary focus.

Although, there is a myriad of definitions and varied interpretations of certain concepts, the collective body of disaster risk theory has significantly increased in recent years. Most notable are advancements on the topic of resilience, which spills over into research in climate adaptation and ecology. This is evidenced by the large body of conceptual research (20 percent or 215 publications) in our sample, which largely focused on advancing the framing of resilience, vulnerability, and adaptation; see [175,176]. This intellectual exchange between research on disaster risk and climate adaptation is also observable in more recent hazard, risk, and vulnerability assessments, which consider the sensitivity of hazards and vulnerabilities to climate change; see [177,178].

4.2. Scale and geographic coverage

Within the data sample, local case studies ($n=785$) dominate the research landscape with few global ($n=58$) or regional ($n=46$) scale papers. Only 6 percent of the local case studies are comparative or exhibit a multi-country design. Regional work focuses mostly on Europe ($n=19$) followed by the Caribbean and Small Island Developing States ($n=12$), Africa ($n=6$), South and Central America ($n=4$), and Asia ($n=4$).

Not surprisingly, more than a third of the case study research is conducted in North America (37 percent) followed by Asia (28 percent) and Europe (21 percent) (Table 4). The most studied countries are the United States (33 percent) followed with a significant margin by German, India, Indonesia, and Italy (all around 4 percent) as well as Japan and China with 3 percent each.

Table 4
Spatial coverage of single- and multi-country studies (785 case studies). Regional or global case studies were not considered in the tabulation. Research coverage by region represents the proportion of countries within a region covered by the reviewed studies. For example, there were studies on Canada, Mexico, and the United States resulting in coverage of 100 percent for North America.

Region	Research coverage[a] (%)	Research coverage by region (%)	Most researched country in region	
North America	37	100	USA	33%
Asia	28	68	India	4%
Europe	21	55	Germany	4%
Sub-Saharan Africa	8	46	Malawi	1%
Middle East, North Africa and Greater Arabia	5	39	Turkey	2%
Australia and Oceania	5	60	Australia	2%
Central America and the Caribbean	3	41	Honduras	1%
South America	2	50	Brazil	1%

[a] Exceeds a total of 100% since every country in a multi-country study was counted.

According to the indexed literature in *WoS*, there is a significant gap in English-language, peer-reviewed, academic research for the vast majority of countries across the various continents except North America. In fact, when we conducted keyword searches including the name of, for example, Latin American countries, the results did not change significantly. This paucity in spatial coverage is most likely heightened by the limited number of non-English-language journals indexed in *WoS* [162]. Thus, without inclusion in a scientific index, it is extremely difficult for non-native researchers to find and utilize country-specific research.

In addition, a significant number of scholars located in the United States, Europe, and Australia conduct research abroad (Table 4). This is most notable in Asia where foreign scholars (determined by their affiliation, not nationality) conduct nearly half of the research. This applies to Central America and the Caribbean, South America, and sub-Saharan Africa as well.

4.3. Disciplines

The disciplinary base has increased compared to past analysis of the research field [48]. We identified dozens of different disciplines conducting disaster risk research led by geography, engineering, environmental studies, and economics (Fig. 1). It is important to point out that the number of publications on disaster risk research may be influenced by the size of a discipline as well as the niche or mainstream character of disaster risk research within a discipline itself.

There is much collaborative research. Multi-authored work makes up about 60 percent of the reviewed publications—but many of these collaborations occur within similar fields of study. Of the reviewed publications, more than 40 percent originate from a singular disciplinary background even when authored by multiple researchers. Another 36 percent of multi-authored papers represent only two “different” disciplines—often closely related such as climatology and meteorology or geography and environmental studies. In sum, the majority of research has a multidisciplinary background, but at best, it involves only two (38 percent) or three (15 percent) different fields.

The limited cross-pollination is also reflected in the discipline-dependent use of methodological approaches as well as in the framing of concepts such as resilience, vulnerability, and adaptation. The majority of research draws upon common qualitative methods such as surveys, questionnaires and interviews. Risk, vulnerability, hazard and impact assessments rely extensively upon a combination of engineering and geospatial techniques such as remote sensing, geographic information systems, and environmental modeling to generate scenarios and forecasts. Advancements in these traditional assessment approaches can be largely attributed to the increasing use of indicators and indices along with quantitative methods such as probabilistic models. However, mixed-method approaches such as a combination of geospatial analytics with, for example, participatory approaches, are limited.

4.4. Stakeholder involvement and policy focus

Disaster risk research is squarely situated in the world of academia. Nearly 60 percent ($n=623$) of all publications engaged only academic partners. Collaborative research between academic and governmental, private, or non-profit organizations accounts for 31 percent of the reviewed work. Research without any academic participation accounts for only 19 percent of the 1095 reviewed publications. While governmental agencies participate in about

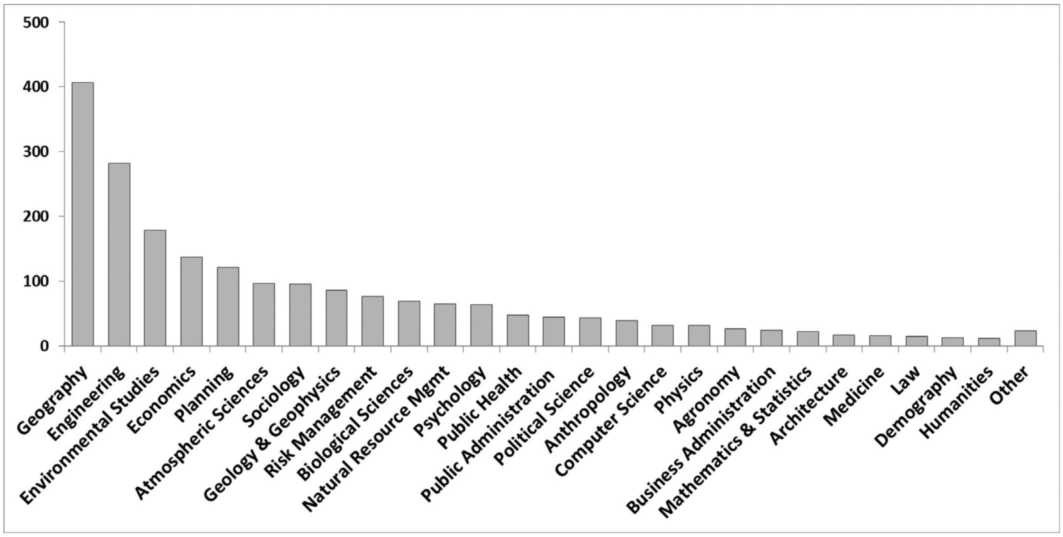

Fig. 1. Disciplines engaged in integrated disaster risk research.

9 percent of all disaster risk research, the engagement of private and non-profit organizations or sole authorship by any of these stakeholders is exceedingly low (less than 5 percent). The latter may prefer to publish in trade magazines rather than academic outlets.

It is important to point out that stakeholder involvement or policy focus in the context of this paper does not refer to the interaction of a researcher with stakeholders during the study or any policy descriptions made by research. Instead, it solely looks at the authorship of research and if original research has been co-authored by non-academic partners.

4.5. Research networks

The bibliographic coupling, i.e. the closeness of publications determined by the number of publications citing similar references, revealed four distinct research clusters: disaster psychology and trauma; disaster medicine and public health; natural hazards; and socio-economic dimensions of disaster risk. This clustering manifests itself in the choice of publication outlets by researchers. Fig. 2 shows the bibliographic coupling of journals and clearly illustrates this separation between these four groups. Within these research clusters, the following journals publish the most disaster- or hazard-related research: *Natural Hazards* (556 publications), *Disasters* (319 publications), *Natural Hazards and Earth System Sciences* (224 publications), and *Disaster Medicine and Public Health Preparedness* (176 publications). By contrast, researchers studying the socioeconomic dimensions or physical or engineering aspects of natural hazards are engaged with researchers beyond their discipline with the journal *Natural Hazards* serving a bridging medium between those communities.

Despite their seclusion, the few medical and psychological scientists engaged in disaster-related research such as Galea, Norris, and Pfefferbaum are among the most prolific and highest-cited and co-cited authors. However, many of these (co-)citations originate within their own research domains rather than from outside.

An analysis of bibliographic co-citations (i.e. the 480,917 references), the measure of the dynamic, semantic relationship within the literature, revealed that researchers engaged in medical and psychological research largely reference other medical or public health-related publications. Consequently, publications

Fig. 2. Density map showing publication outlets cited together in peer-reviewed publications (bibliographic coupling). The larger a journal's name, the more distinct publications have been cited. Out of 4147 journals only 758 had more than 5 disaster-related publications.

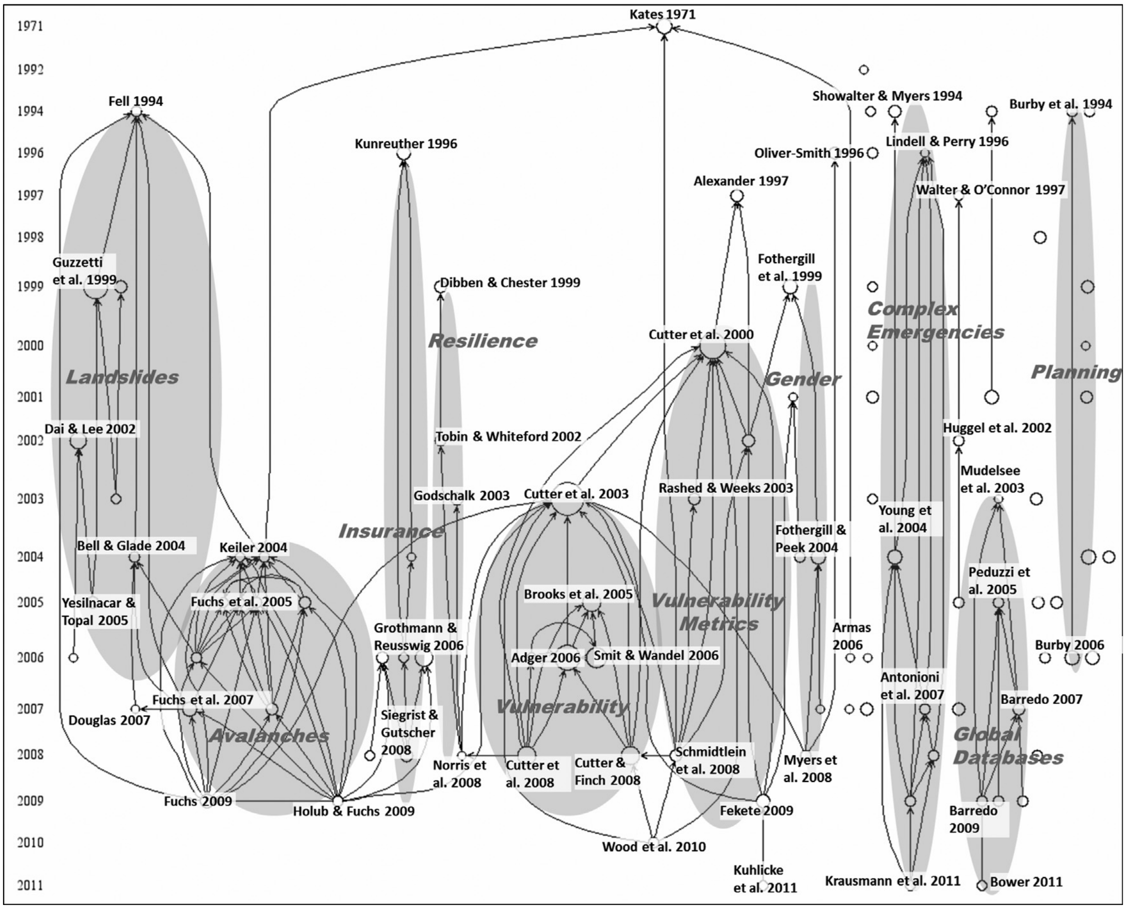

Fig. 3. Historiograph of the top 100 publications with highest citations within the *WoS* data sample showing the temporal evolution of the field and authors serving as linkages between research topics.

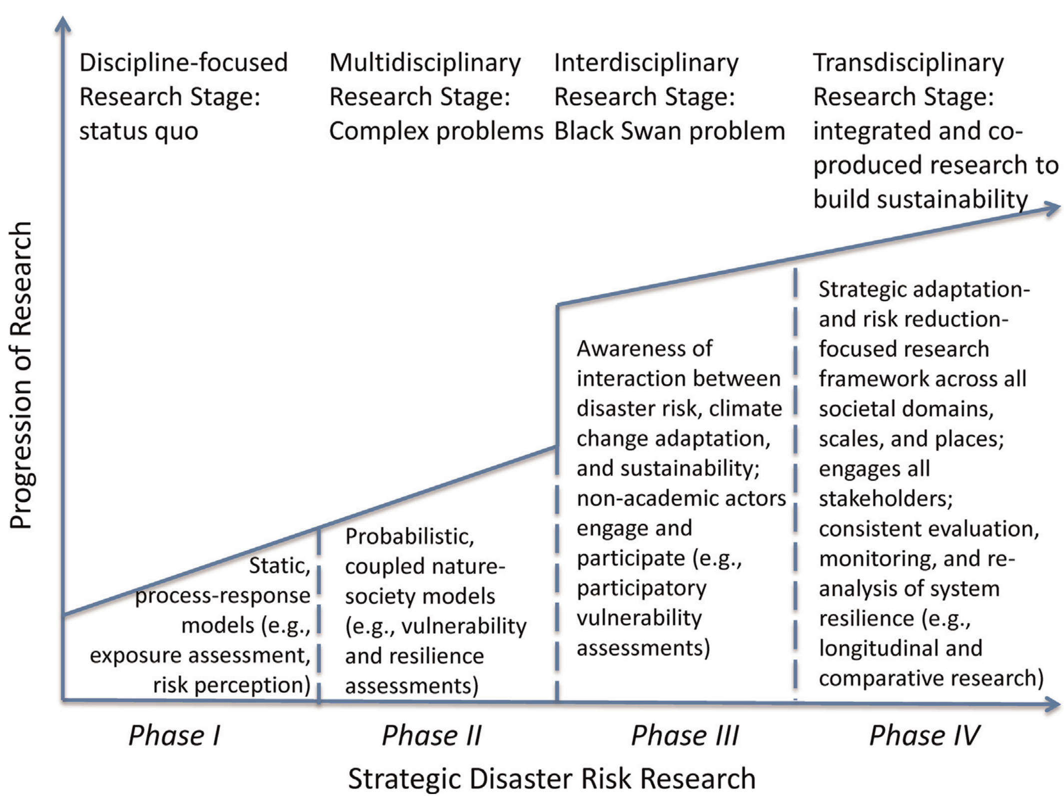

Fig. 4. Idealized progression from discipline-focused research to transdisciplinary research.

with the most co-citations are various editions of the *Diagnostic and Statistical Manual of Mental Disorders* [179] with 763 co-citations and Norris et al. [106] with 314 co-citations. Among the top 20 most co-cited publications, only five are from researchers in the hazards and socioeconomic dimensions cluster. Those include Wisner et al. [180] with 510 co-citations, Cutter et al. [181] with 176 co-citations, Slovic [182] with 129 co-citations, Cutter [183] with 128 co-citations, and Turner et al. [184] with 125 co-citations.

This limited research integration of the health sciences is contrasted by an increasing integration of physical, social, and engineering sciences as measured by publications in disaster-and hazard-related journals. While shared publication outlets facilitate the exchange of ideas and methodologies, it does not necessarily translate into integrated research as indicated in our findings on knowledge domains and partnerships. For example, when mapping the citation network within the hazard and vulnerability cluster, five distinct, high-citation research areas emerge (Fig. 3): disaster risk in mountain regions such as landslides and avalanches; vulnerability, adaptation, and resilience; metrics; disaster response and evacuation; and global assessments. Research on gendered perspectives or the benefits of planning in disaster risk research has only experienced limited success in citation impact. Overall, the collective knowledge of the natural, social, and engineering sciences is promising and forms a strong foundation for integrated research, the actual conduct of research and knowledge generation remains concentrated within particular academic disciplines based on our analysis.

5. Discussion

We began the paper with a discussion on disciplinarity (single, multi-, inter- and trans-) and the nature of integrated research. Fig. 4 provides a conceptual representation of the progression of disaster risk research from the initial disciplinary focus, moving into multidisciplinary stages (combining two or more disciplines) and then to interdisciplinary work where new knowledge is gained because of the interaction and integration of various disciplines with new tools and techniques. The last phase is transdisciplinary research which often involves stakeholders in the co-production.

Based on our findings, we conclude that most of the current research in integrated disaster risk still remains in the discipline-centric or multidisciplinary stages of research (Phase I and II). While there is an increasing body of interdisciplinary literature and publication outlets (Phase III), truly transdisciplinary or integrated research (Phase IV) remains elusive according to our findings.

Again, disaster risk research has made significant strides over the past two decades and the body of research has expanded immensely. Risk, hazard, vulnerability, and impact assessments have become commonplace due to better data and modeling capacity—in terms of hardware and more sophisticated software—allowing for more fine-scaled and reliable modeling and forecasting. Still, methodological rigor (performance of uncertainty and sensitivity analyses) is often missing in quantitative and/or modeling research limiting its reliability and ability to inform decisions and set policies.

Inconsistent and non-standardized conceptualizations and methodologies for impact assessments may be attributable to the absence of widely-accepted definitions of resilience, vulnerability, and adaptation. As a result discipline-specific interpretations remain and carry forward into assessment work. For example, the term vulnerability continues to range from defining vulnerability as susceptibility [175] to vulnerability interpreted as a consequence/impact or as pre-existing socioeconomic conditions [185]. Some equate vulnerability solely to exposure and therefore one's location in a hazard zone whereas others consider vulnerability to encompass exposure as well as the socioeconomic characteristics of a community's population to prepared for, respond to, and recover from a hazard [159]. Another example is the concept of resilience [186] where in the engineering sciences resilience is equated to recovery of functionality of infrastructure to pre-event conditions or levels of performance [187] whereas others in the field of adaptation or ecology consider resilience more from a systems perspective and ascribe it as the amount of disturbance the system could absorb without changing [188], or the ability to adjust to new conditions without necessarily bouncing back to pre-event stages [189]. These varied definitions continue to persist and influence how vulnerability/resilience assessments are implemented.

Scenario-based vulnerability and impact assessments provide a mechanism to both predict but also minimize future impacts through targeted actions. However, that is the point at which current research stops short: methodological uncertainties surrounding many assessments limit their use for evidence- and science-based policy-making. To overcome some of these shortcomings, vulnerability and impact assessment should be connected with disaster case studies to validate predicted impacts. Furthermore, integration of assessment research with longitudinal analyses of recovery or community development could strengthen the explanatory power and reliability of vulnerability assessments and showcase their ability to reliably inform decision-making or evaluate risk management policies. It is this interface between research and application/policy that is largely missing in the existing body of work on integrated disaster risk research.

Although multi-scalar and multi-disciplinary research is important, significant research gaps remain at the intersection of research and practice as well as research and policy. This also may be attributable to the limited engagement of non-academic stakeholders in disaster risk research as well as the lack of research performed by local investigators as our findings suggest. Infusing research into decision-making and policy-setting requires the establishment of social networks and trusted partnerships beyond the academic setting. It requires not only time to establish long-term relationships but also stakeholder access and cooperation—qualities that are difficult to foster during the short-term funding cycle of research projects. The fact that many researchers are affiliated with North-American institutions, but conduct research abroad may partially explain some of this inability to transform research into action. A first step toward remedying the gap between science and practice are empirical country-level case studies that synthesize the existing scientific knowledge and identify policy and planning avenues for their integration. In the case of flood management in Bangladesh, for example, Cook and Lane [21] documented how the lack of integration of academic knowledge on sedimentation and subsidence led to the design of inadequate, and ultimately failing, flood management strategy.

Again, to foster the conduct of integrated research, research as well as science-into-practice barriers need to be overcome [190]. There is a need for synthesizing disparate, scientific knowledge into practical knowledge and devising feasible management and policy strategies [21]. Gaining access to and reconciling empirical facts that are sometimes contrasting or fraught with uncertainties should not be left to practitioners alone. Examples of such synthesis studies are publications by the U.S. National Research Council that bring together a group of diverse scientists from different disciplines working on the same issue. Synthesis reports are only a first step though. In the U.S., notwithstanding these synthesis efforts, inserting disaster risk reduction knowledge into action remains elusive as the continuously rising losses from natural hazards demonstrate [191] or the abysmal response and short-sighted recovery decisions post-Hurricane Katrina attest [192–195].

6. Conclusions

In sum, most research on disaster risk remains academic and multi-disciplinary in nature with limited success as evidentiary basis for policy improvements. While the utilization of integrated disaster risk science has been improving, the science itself has not achieved the desired integration into practice and policy making, despite the capacity and willingness to do so. Perhaps in the next decade, the goal of transdisciplinary and integrated research on disaster risk will be achieved.

However, the outlook is bleak considering that rich countries pursue a "business as usual" approach with legislative actions and policies focused on short-term, easy fixes accommodating a largely myopic and disengaged constituency to whom disaster risk poses no threat to living standards and livelihoods. In countries such as the U.S., Australia, or Germany, economic losses from natural hazards are on the rise and changes in policies or legislation to reduce them are absent [196–200]. No developed country appears to have been able to either stop or reverse the trend of rising economic losses.

Engaging actors beyond the academic realm requires leadership and support for integrated disaster risk research and willingness to affect societal, transformative change. However, the conflicting premises behind the logics of government, which is power [201], and the logics of science, which is innovation [202], cannot be reconciled unless critical tipping points or thresholds are reached. Integrated research on disaster risk can help in the transformation, but only if it is truly integrated across all the domains examined in this paper.

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