



Review article: A systematic literature review of research trends and authorships on natural hazards, disasters, risk reduction and climate change in Indonesia

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Abstract. Indonesia is one of the most vulnerable countries to disasters and climate change. While there has been a proliferation of academic publications on natural hazards, risks and disasters on Indonesia, there has not yet been a systematic literature review (SLR) to determine the progress, key topics and authorships. SLR is important so researchers can build upon existing works, avoid bias, determine major research topics and the need for further research, and strengthen research capacity in the future. The author conducts a SLR of publications indexed within the Scopus database from 1900 to 2016 on topics related to disasters and climate change in Indonesia. Two major findings are outlined. The *first* is related to major research topics: (1) natural hazard, risk and disaster assessments (HRD); (2) disaster risk reduction (DRR); and (3) climate change risks, vulnerability, impacts and adaptation (CC). More than half are related to HRD and focus on volcanic eruptions, tsunamis and earthquakes. Publications on DRR are related to governance, early-warning systems, and recovery and reconstruction. Those on CC discuss carbon emission, forestry, governance and sectoral impacts. The author calls for future research on different hazards, different locations, and impacts of disasters and climate change. Risks and vulnerability assessments from hydro-meteorological and geophysical hazards are needed. Other locations beyond Sumatra and Java islands are to be examined. Urban risk assessments and the economic and social impacts of disasters and climate change on vulnerable places and communities are equally important. Risk governance at the national, local and community level is to be strengthened to increase resilience. The *second* find-

ing examines the roles of Indonesian researchers and organizations. Findings show limited progress in research, publication and collaboration. International/non-Indonesian authors dominate the literature, and only half of the publications are co-authored by Indonesians. International collaborations have been conducted by very few Indonesian organizations. This could be due to limited experience in academic collaboration, power play amongst researchers, lack of research capacity, weak English academic writings skills and limited provisions within higher-education systems. The author recommends more funding and incentives for collaborations; training on English academic writing and journal article publications; capacity building especially for early careers, female and social science researchers; encouragement of multi-disciplinary collaborations; and strengthening of science communication in social media and science-policy advocacy.

1 Introduction

Disasters and the associated social and economic impacts are on the rise (EMDAT, 2018). The last decade has witnessed the highest number of and impacts from disasters, and 2015–2017 were the hottest years ever (WMO, 2017). The Asia Pacific region has experienced the highest number of disasters (EMDAT, 2017), within which Indonesia is one of the most at-risk countries (EMDAT, 2017). Between 1900 and 2017, there were 489 disasters in Indonesia caused by natural haz-

ards, almost 242 000 deaths, 30.7 million people affected and total damage of almost USD 30 billion (EMDAT, 2017). Geophysical disasters caused more than 95 % of deaths, while the hydrological, meteorological and climatological disasters occurred more frequently, affected more people, and caused more damages (EMDAT, 2017). The Sendai Framework for Disaster Risk Reduction (SFDRR) calls for a multi-hazard, integrated and inclusive approach for DRR and climate change adaptation (CCA) (UNISDR, 2015; Aitsi-Selmi et al., 2016).

Studies on disasters have expanded enormously globally, which calls for frequent synthesis of the research trends and topics, issues, challenges, and strategies and innovations in dealing with disasters. The role of science in influencing DRR policy is recognized, and studies are needed to identify key lessons learnt and policy effectiveness. There is also a call to give more voices and strengthening capacities to local scientists in contributing to the generation of knowledge. It is often that local scientists are left out in international research collaborations and publications (Bordons et al., 1996; Gazni et al., 2012). The global progress on scholarly publications on disaster science has been documented recently in “A Global Outlook on Disaster Science” (Elsevier, 2017). It looks at scholarly outputs and impacts of disaster science according to the SFDRR and documents productivity of countries in producing scholarly studies. There are more than 27 000 outputs, which represent only 0.22 % of the world’s output, with China, the United States of America and Japan dominating. Countries that are most at risk tend to have the smallest number of publications (Elsevier, 2017). Indonesia is amongst the countries that produce more specialized outputs in disaster science than the global average (Elsevier, 2017). A detailed study that looks at progress of research and roles of researchers in Indonesia is however not yet available.

This paper aims to systematically review literature related to natural hazards and risks; DRR; and climate change vulnerability, impact and assessments in Indonesia. A systematic literature review (SLR) reviews literature with explicit and transparent methods (Gill and Malamud, 2014). It determines topics that have been heavily researched, builds upon others’ existing works and avoids bias (Khan et al., 1996). It gauges when, how and by whom the research has been conducted to formulate future strategies for strengthening research capacity (Mallett et al., 2012). There are two research objectives adopted. The *first* is to determine research progress on natural hazards, risks, disasters and climate change in Indonesia within the time frame from 1900 to 2016. The *second* is to examine the roles of Indonesian authors in research, international publications and collaborations. The structure of this paper is as follows. The first section presents the rationale, aim and objectives. Next it outlines the research method. The third section presents results and discussions. The last section outlines recommendations on future research topics and directions, and strategies

to increase the quality of publications and scientific collaborations in international spheres, along with policy-relevant recommendations.

2 Research method

2.1 Data collection and multi-stage processes

The SLR method has been used in health (e.g. Moher et al., 2009a), software engineering (e.g. Kitchenham et al., 2009) and engineering (e.g. Gosling and Naim, 2009) studies. There have also been studies that use this form of review in topics related to natural hazards, disasters and climate change. These include reviews of different natural hazards such as droughts (Woodhouse and Overpeck, 1998), landslides (Aleotti and Chowdhury, 1999), wildfires (Neale and Weir, 2015), tsunamis (Chiu and Ho, 2007) and the interactions of those natural hazards (Gill and Malamud, 2014). Others focus on the impacts (Hunt and Watkiss, 2011) and ecosystem-based adaptation (Brink et al., 2016; Kabisch et al., 2015), education (Johnson et al., 2014), health and psychology after disasters (Kölves et al., 2013; Harada et al., 2015), volunteerism (Whittaker et al., 2015) and disaster management (Beerens and Tehler, 2016; Lettieri et al., 2009; Gall et al., 2015; Goldschmidt and Kumar, 2016). Significant work using SLR on climate change studies was done by Berrang-Ford et al. (2011, 2015) and Ford et al. (2012, 2015). The author adopted their recommendations for an SLR mainly to outline the research questions and aims, data sources and document selection, and analysis and presentation of results. The author conducted a multi-layered literature review to determine inclusion and exclusion for more relevant findings to study publications using the Scopus research engine on publications by 26 February 2016., with a time frame from 1900 to 2016. Scopus was selected because it has the largest database of peer-reviewed literature (Leydesdorff et al., 2010; Bar-Ilan, 2008) and capability for searching, discovery and analysis (Scopus, 2017).

In the first stage, the author uses key research terms of *natural hazard, disaster, disaster management, disaster risk reduction, climate change, climate change adaptation, resilience, vulnerability, geology* and *Indonesia*. The keyword *geology* was added to capture some of the earliest and significant publications on Indonesia which use the keywords *geology* and *volcanology*. This gave 8077 publications.

The second stage involves exclusions to further refine the results. The exclusion included refinement in subject areas, document types and source title which did not directly related to the topics. This gave 3447 publications.

The final stage involves exclusion of those studies in the mining industry in Indonesia that discussed the science of climate change in a very general scope and those that touch on the issue of disasters but not specifically in Indonesia. Further exclusions are warranted when the author considers the scope

is too broad. The author downloaded the results in XML format, saved them and imported them into Microsoft Excel. When importing into Excel, the author chose all delimiters to ensure information went into the right column. However, the results were not always consistent, and hence a manual check on each entry row was needed. The author found the number counts on the authors' publications and citations presented in the Scopus search were sometimes different to the actual check of the Excel sheet. Hence, to ensure consistency, higher numbers of publications and citations were selected. The results in the Excel format were examined line by line to further determine exclusion from the lists. Finally, there were 921 materials selected. Table 1 summarizes the results.

2.2 Data analysis

The final list was analysed in terms of topics and sub-topics of research citations, keywords, places of focus, types and time of publications, impact factors (IFs) and authorships. The author used Scopus features to analyse search results, such as the article metric module, citation overview and author profile pages (Scopus, 2017; Bakkalbasi et al., 2006). The progress of Indonesian scholars was evaluated by counting the total number of authors, research outputs and citations overall, and comparing between papers first authored by Indonesians. The author also consulted total citations and publications of researchers on Google Scholar (Google Scholar, 2016a), Research Gate (2016) or other websites to make sure that the full list of publications was captured. It was generally the case that data from a Google search for a publication and author have a higher and more up-to-date citation count. The author checked researchers' organizations, nationalities and genders using Google search.

3 Findings and discussions

This section is structured into two main parts reflecting the objectives of the paper, first on progress of research in terms of key research topics and timelines, and second on roles of Indonesian researchers and organizations.

3.1 Research timelines and topics

The author categorizes the final list into three groups (Table 2) – natural hazard, risk and disaster assessments (HRD); disaster risk management and reduction (DRR); and climate change vulnerability, impacts and adaptation (CC) – to show and outline how changes in directions on research have taken place over the years and to reduce imbalance of findings on hazard and risks assessments toward earthquake and volcanic eruption research. In general, there is more research on the topic of HRD (56 %), followed by those in DRR (23 %) and then CC (21 %).

The paper further identifies key periods and timelines in which publications were published. Although the search timeline was set as 1900–2016, the years in which publications were found ranges from 1934 to 2016 (Fig. 1).

The first period is from 1934 to 1990. There are no significant changes in the numbers of publications produced. The publications on the HRD are some of the earliest publications indexed in Scopus. It heavily focuses on the topics of geophysical hazards and risks related to earthquakes and volcanic eruptions. Twenty-two out of 58 events recorded by EMDAT were earthquakes and volcanic activity (EMDAT, 2017). The Bali earthquakes occurred in 1976 and 1979, which caused 1764 deaths, affected more than 560 000 people and costed more than USD 200 000 in damages (EMDAT, 2017). The year 1979 had the most frequent earthquakes (six times), in Bali, Lombok and Biak (near Papua) (USGS, 2018). The second period from 1990 to 2000 shows a notable increase in the literature, up to an average of 10 publications per year. This gradual increase corresponds to a rise in literature related to the assessments of HRD and is followed by a sharp increase in literature to its highest point in 2000. The third period from 2000 to 2016 is the most dynamic period for publications. While there is a sharp decline since its first peak in 2000, a surge of publications begins in 2004 in response to the Indian Ocean tsunami which devastated Indonesia the most. This increase has continued ever since. This is also a period which characterizes increasing studies on climate-related hazards. A peak occurs between 2010 and 2016. There are 153 publications in 2016, which is the highest in a single year. Publications on HRD and CC are expected to rise. The following sub-sections outline the three topic groups. Within each, the author discusses timelines, areas and categorization of key topics.

3.1.1 Natural hazards, risks and disaster assessments

The first sub-section explains findings on the topic of HRD assessment and identification. The EMDAT (2016) categorization of HRD is used, namely geophysical, meteorological, hydrological and climatological hazards. Those are the most frequent and impactful disasters in the country. There are 517 publications in this category. There was a gradual increase in publications between 1934 and 2000. The first significant period is in 2000 of 25 publications and reduced slightly after that. After the 2004 Indian Ocean tsunami occurred, publications related to the tsunami continued to be published, reaching a peak in 2006. From 2009, the publications increased rapidly, reaching another peak in 2016 of 153 publications. The publications are mostly related to volcanic eruptions, earthquakes and tsunamis, and the islands of Java and Sumatra are the two areas which receive most attention (more than 70 %). The publications are related to volcanic eruptions in Java (almost half), such as Merapi (Verstappen, 1988; Lavigne, 1999; Voight et al., 2000; Andreas-tuti et al., 2000; Charbonnier and Gertisser, 2008; Gertisser

Table 1. Multi-stage processes for inclusion and exclusions for search terms.

Stage	Inclusion/exclusion	Description	Search terms	Results
First	Inclusion based on search terms	Keywords	(TITLE-ABS-KEY(hazard*) or TITLE-ABS-KEY(risk*) or TITLE-ABS-KEY(disaster*) or TITLE-ABS-KEY(disaster management*) or TITLE-ABS-KEY(disaster risk reduction*) or TITLE-ABS-KEY(climate change*) or TITLE-ABS-KEY(climate change adaptation*) or TITLE-ABS-KEY(resilien*) or TITLE-ABS-KEY(vulnerabili*) or TITLE-ABS-KEY(volcan*) or TITLE-ABS-KEY(geolog*) and TITLE-ABS-KEY(Indonesia)).	8077
Second	Exclusion on keywords	Those that are relate to clinical/health studies		3447
	Exclusion on subject area	Only those in environmental studies in general		
	Exclusion on title	Titles are deemed unrelated		
	Exclusion on language	Those that are not written in English and Bahasa Indonesia are excluded	and (EXCLUDE (LANGUAGE, "Italian") or EXCLUDE (LANGUAGE, "Polish") or EXCLUDE (LANGUAGE, "Spanish") or EXCLUDE (LANGUAGE, "Afrikaans") or EXCLUDE (LANGUAGE, "Swedish"))	
	Exclusion on subject area	Those that are too broad on the subject area are excluded	and (EXCLUDE (SUBJAREA, "ECON") or EXCLUDE (SUBJAREA, "COMP") or EXCLUDE (SUBJAREA, "BUSI") or EXCLUDE (SUBJAREA, "MATH") or EXCLUDE (SUBJAREA, "PSYC") or EXCLUDE (SUBJAREA, "VETE") or EXCLUDE (SUBJAREA, "HEAL"))	
	Exclusion on document type	Only journal articles are included	and (EXCLUDE (SRCTYPE, "d") or EXCLUDE (SRCTYPE, "r")) and (EXCLUDE (DOCTYPE, "cr") or EXCLUDE (DOCTYPE, "no") or EXCLUDE (DOCTYPE, "sh") or EXCLUDE (DOCTYPE, "ed"))	
Final	Transfer exclusion	Those that are too broad on the subject area are excluded	Transfer to XML and Excel Topics that are too broad, e.g. mining, general climate science, minor mention or not directly on Indonesia	921

Table 2. Major research topics, descriptions and numbers of publications.

Major topics groups	Definitions (IPCC, 2012; UNISDR, 2009)	Number of publications (Percentage)
(1) Natural hazard, risk and disaster assessments (HRD)	Hazards: a dangerous phenomenon, substance, human activity or condition that may cause loss of life, injury or other health impacts, property damage, loss of livelihoods and services, social and economic disruption or environmental damage (UNISDR). Risks: the combination of the probability of an event and its negative consequences. Disaster: a serious disruption of the functioning of a community or a society involving widespread human, material, economic or environmental losses and impacts, which exceeds the ability of the affected community or society to cope using its own resources (UNISDR).	517 (56 %)
(2) Disaster risk management or reduction (DRR)	The systematic process of using administrative directives, organizations, and operational skills and capacities to implement strategies, policies and improved coping capacities in order to lessen the adverse impacts of hazards and the possibility of disaster (UNISDR). The concept and practice of reducing disaster risks through systematic efforts to analyse and manage the causal factors of disasters, including through reduced exposure to hazards, lessened vulnerability of people and property, wise management of land and the environment and improved preparedness for adverse events (UNISDR).	210 (23 %)
(3) Climate change vulnerability, impacts and adaptation (CC)	Climate change: a change of climate which is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and which is in addition to natural climate variability observed over comparable time periods (IPCC). Climate change adaptation: the adjustment in natural or human systems in response to actual or expected climatic stimuli or their effects, which moderates harm or exploits beneficial opportunities (UNISDR).	194 (21 %)
Total		921 (100 %)

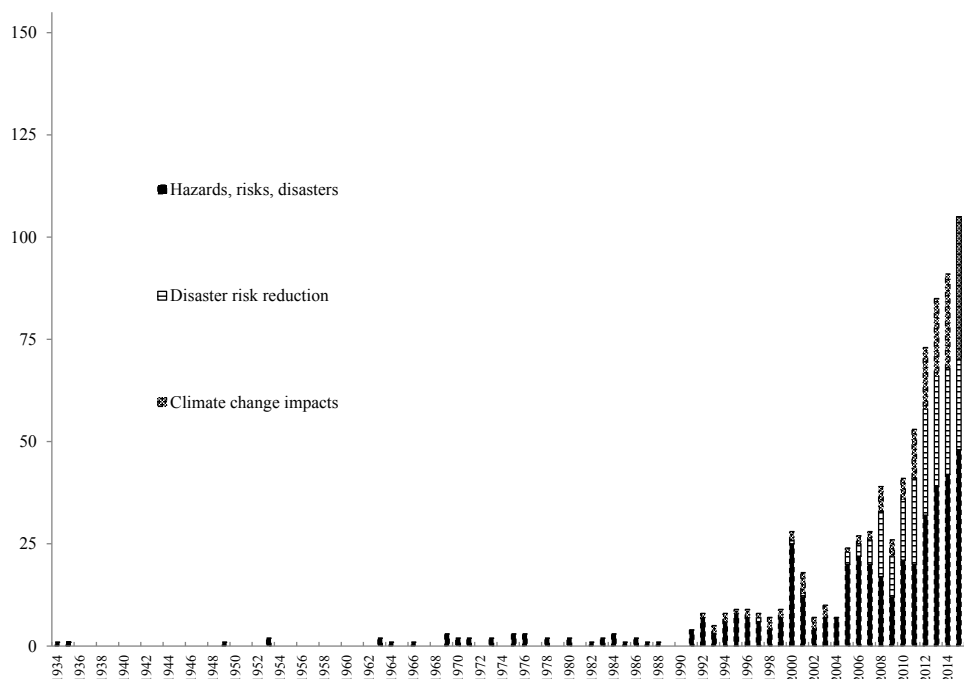


Figure 1. Number of publications over time.

et al., 2012; Suryo and Clarke, 1985), Galunggung (Suryo and Clarke, 1985), Semeru (Siswamidjono et al., 1997; Carn, 1999; Thouret et al., 2007; Solikhin et al., 2012), Kelud (Lubis, 2014; Nakada et al., 2016) or Ijen (Heikens et al., 2005; Trunk and Bernard, 2008; van Hinsberg et al., 2010). The next most significant hazard being studied is earthquakes (more than 30 %), in terms of how they happened and methods to assess the impacts. Research on tsunamis received gradual attention especially after 2004 (Nakamura, 1978, 1984; Latter, 1981; Koshimura et al., 2009; Imamura et al., 1995). There are also a small number of publications related to landslides (Fathani et al., 2016; Karnawati et al., 2011; Liao et al., 2010). Other hazards discussed include those on flood, strong winds, El Niño etc. (Fig. 2).

The above findings show that there has been enormous progress in publications on this topic. Some of the earliest publications overall also focus on the characteristics of geophysical hazards and risks. Many publications on this topic however still focus on geophysical hazards since Indonesia houses some of the most active volcanoes that lie along the “Pacific Ring of Fires” in the world and is located along the fault line of Asian and Australian lines. Studies on the characteristics of earthquakes in terms of hazard assessments are available. What is needed is publications on earthquake risk assessments at the national and smaller scale. The National Agency for Disaster Management (BNPB) has recently developed InaRISK, a web-based service of risk assessments from different hazards (BNPB, 2017). It is however not clear how this information has been utilized for research and most

importantly government decision making. The more recent trend of examining hydroclimatic hazards – of floods, landslides and typhoons – is encouraging but still not enough. It is quite surprising that studies on flood hazard and risks assessments are still very limited considering that floods are the most frequent disaster and affect the most people in Indonesia (EMDAT, 2017). Most of studies on floods focus on the impacts on society and how government agencies deal with the impacts. Considering that the impacts of climate-related disasters are increasingly felt in Indonesia, more hazard and risks assessments on floods, typhoons, wildfires and El Niño are needed, particularly those that examine trends in the past and project future trends.

3.1.2 Disaster risk management and reduction

The second sub-section is on the topic of DRR. DRR includes strategies that are aimed at reducing disaster risks and range from risk management to risk reduction. There are 210 publications. There have been very few publications published before 2003. It is only after 2004 that there was a gradual increase of publications. This reached its peak in 2008, after which the number slightly reduced, before continuing to increase. More than half of the DRR publications focus on Sumatra and Java. However, there are also studies that examine Indonesia as part of worldwide, regional or national assessments. The topic has received most attention in this category is related to the governance of DRR (Bakkour et al., 2015; Chang Seng, 2013; Djalante et al., 2012, 2013; Guar-

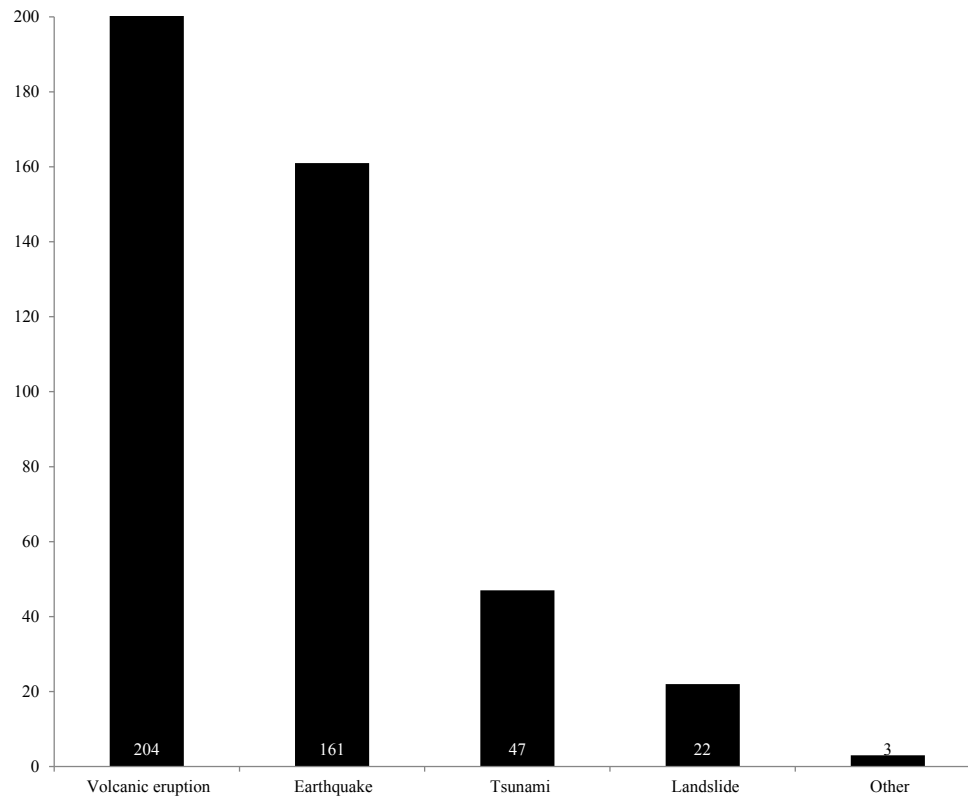


Figure 2. Key topics in the HRD category.

nacci, 2012; Lassa, 2013). The Indonesian government and other stakeholders are actively contributing to DRR (Chang Seng, 2013; Djalante et al., 2012, 2013; Lassa, 2013). The next key topic is on the evaluation of recovery and reconstruction that took place after the 2004 Indian Ocean tsunami (Chang et al., 2011; Daly and Brassard, 2011; Godavitarne et al., 2006; Guarnacci, 2012; Karan and Subbiah, 2011; Telford and Cosgrave, 2007; Lassa, 2015). Other topics are related to the social implications of disasters: culture, gender or religion in helping community resilience when facing disasters, and impacts of disasters on different community groups, including children and women (Baumann, 2008; Donovan, 2010; Donovan et al., 2012; Gaillard et al., 2008b; Islam and Lim, 2015; Balgos et al., 2012; Guarnacci and Di Girolamo, 2012; Hiwasaki et al., 2015; Siagian et al., 2014; Sagala et al., 2013; Schlehe, 2010). Some topics are related to examination of tsunami early-warning systems (Schlurmann and Siebert, 2011; Steinmetz et al., 2010). Others examine the role of knowledge and information to help communities be more prepared for disasters (Dicky et al., 2015; Hiwasaki et al., 2015; Rafliana, 2012). There are 13 publications comparing Indonesia and Sri Lanka in regard to the impacts of the tsunami, how it became the precursor for the peace process in Indonesia but still took time for the process in Sri Lanka (Enia, 2008; Gaillard et al., 2008a; Hyndman, 2009; Kelman, 2005). Limited numbers examine community-based

DRRs that are related to community preparedness (Adiyoso and Kanegae, 2013; Birkmann et al., 2015; Hidayati, 2012; James, 2008; Kusumasari and Alam, 2012), and others examine how children are affected psychologically (Du et al., 2012; Lawler and Patel, 2012; Taylor and Peace, 2015; Vignato, 2012) and emergency management at the local or national level (Esteban et al., 2013; Kusumasari and Alam, 2012; Djalante et al., 2012). Figure 3 summarizes the key topics in the DRR category.

The above findings show an encouraging sign regarding the great variety of research topics related to DRR. This also shows a great development and utilization of social science in understanding the impacts of disasters on society. The author expects enormous development in this topic. This is also where scholars from Indonesia can contribute significantly. Indonesian scholars have most likely lived in Indonesia for a considerable amount of time. They have experienced, assessed and examined those social and environmental changes that have shaped natural hazards and disasters in the first place, which will help them to be more focused and sharp in terms of documenting. However, very few studies have examined the legal and regulatory implications of disasters on government planning, programme implementation and society. While there are organizational reports discussing this (e.g. IFRC, 2016), scholarly articles are rare.

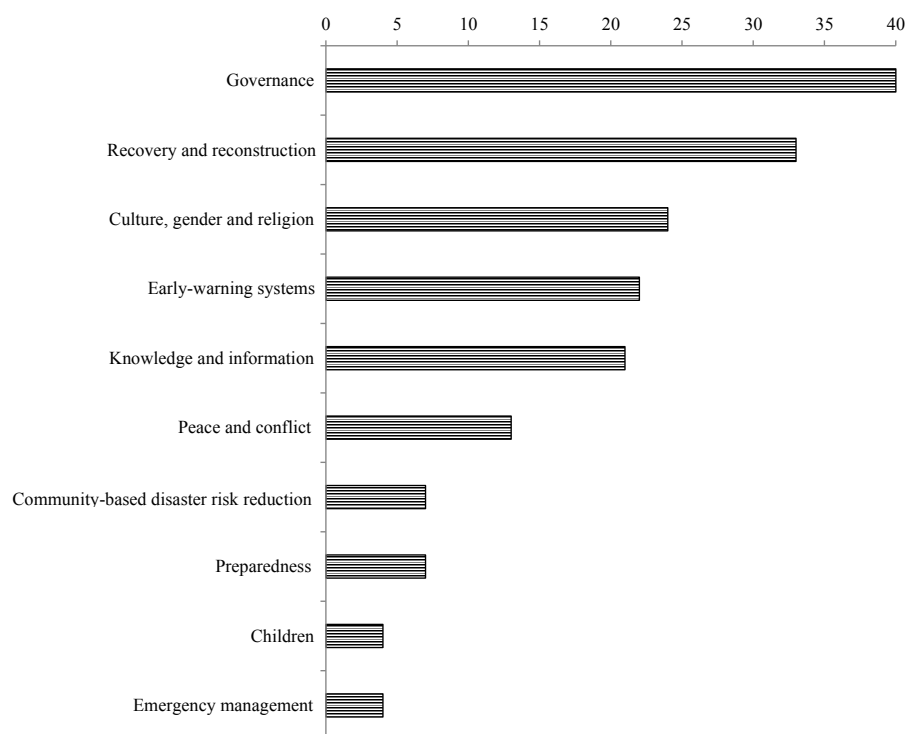


Figure 3. Key topics in the DRR category.

3.1.3 Climate change risks, vulnerability, impacts and adaptation

The third sub-section is related to CC. The research on climate change is interpreted broadly in this paper. The author included all materials that discuss the impacts of climate change not only on disasters caused by natural hazards but also impacts on different sectors such as agriculture, forestry, water and health. The Sendai Framework for DRR strongly calls for multi-risk perspectives and better integration of DRR and CCA (UNISDR, 2015). There are 194 publications in this category. There have only been a few publications within the period between 1978 and 1990. The second period between 1990 and 2000 saw a slight increase in the literature, with only five pieces published in 2001. These are related to examinations of the causes and impacts of forest fires in Indonesia. The numbers of publications do not change in general until 2008. It is only after 2010 that there was a sharp increase in the numbers of publications, reaching its peak in 2015 of 35 papers. The islands of Sumatra and Java have become the two major locations for the research of the climate impacts since they are the areas where the greatest number of paddy fields and crops production is concentrated (McCulloch and Peter Timmer, 2008). There is also increasing research related to climate change impacts on different sectors at various locations in Indonesia such as those in Sulawesi and in the eastern part of Indonesia. The author categorizes the publications in this group into three major

discussions on impacts of climate change (almost 60 %), the governance of CCA (less than 25 %), and deforestation and land degradation.

Since most of the materials published in this category are related to the review of the impacts on climate change in Indonesia, this paper takes a deeper look at that literature (Fig. 4). The impact on crop production, particularly rice, has been the subject of the majority of climate impact studies (Caruso et al., 2016; D'Arrigo et al., 2011; D'Arrigo and Wilson, 2008; Kawanishi and Mimura, 2015; Keil et al., 2009; Naylor et al., 2001; Sano et al., 2013; Shofiyati et al., 2014), which is strongly associated with droughts (Aldrian and Djamil, 2008; D'Arrigo and Smerdon, 2008; D'Arrigo and Wilson, 2008; D'Arrigo et al., 2006; Keil et al., 2008, 2009). A high number link droughts (Salafsky, 1994; D'Arrigo et al., 2006; D'Arrigo and Smerdon, 2008; Shofiyati et al., 2014) and forest fire (Usman and Hartono, 1997; Fang and Huang, 1998; Brauer and Hisham-Hashim, 1998; Jim, 1999; Stolle and Tomich, 1999; Page et al., 2002; Stolle and Lambin, 2003). Studies on water are related to impacts of climate change on ocean circulation (Susanto, 2001), water availability and quality (Rai et al., 2015), and water management (Poerbandono et al., 2014), especially those in urban areas (Larson et al., 2013) and major river basins (Sahu et al., 2012). Floods and sea level rise are another topic receiving strong interest (Marfai and King, 2008; Marfai et al., 2008, 2015; Muis et al., 2015; Neolaka, 2012, 2013; Sarminingsih et al., 2014; Shrestha et al., 2014), particularly on

the impacts on coastal communities and cities (Budiyo et al., 2016; Ward et al., 2013; Firman et al., 2011; Wassmann et al., 2009; Nicholls et al., 1995). The impact of climate change on health in Indonesia is discussed in terms of changing characteristics of tropical diseases (Coughlan de Perez et al., 2015) and impacts of increased temperatures on animals (Purnomo et al., 2011; Morwood et al., 2008). Indonesia houses some of the largest of rainforests, in Sumatra and Kalimantan. Forestry issues are discussed in relation to reducing emissions from deforestation and forest degradation, forest conservation and sustainable management, and enhancement of forest carbon stocks (REDD+) (Cerbu et al., 2011; Saatchi et al., 2011; Baccini et al., 2012; Margono et al., 2012; Hansen et al., 2013; Minang et al., 2014). A small number of studies are on the changing pattern of temperature and rainfall (D'Arrigo and Wilson, 2008; Aldrian and Djamil, 2008; Chrastansky and Rotstajn, 2012).

The above findings show that research on CC has made the least progress amongst the topics. This is an outmost concern considering that Indonesia is one of the most vulnerable countries to climate change (Birkmann et al., 2015). It is however encouraging to see that the range of research in this topic varies in terms of impacts on agriculture, water, health and forestry sectors. Indonesia is the third-largest emitter of greenhouse gasses emissions, especially from deforestation, and the situation is reflected in the literature. It is imperative that more studies be undertaken to understand the vulnerability of society to climate change, especially since 80 % of its population lives along the low-lying coastal areas (Neumann et al., 2015). Future societal disruptions due to probable loss of livelihoods, environmental migration and climate-induced conflicts needed to be understood. It is also important to equip decision makers on how to deal with climate impacts through mainstreaming in development planning.

3.2 Progress and roles of Indonesian researchers and organizations

This second section examines the roles of Indonesian researchers and organizations in contributing to the production of literature. It first describes some of the earliest literature and authors in each category. It also addresses to what extent Indonesian researchers have been collaborating with other international/non-Indonesian researchers and organizations, and in producing high-impact English journal articles. The roles of authors are examined in general terms, and specifically looking at the 10 highly cited papers with an Indonesian as first author.

3.2.1 Authorships

The oldest publications listed in Scopus are those by Reinout Willem van Bemmelen, a Dutch national born in Batavia (Dutch East Indies/Indonesia), on *Ein Beispiel für Sekundärtektogenese auf Java* (An example of sec-

ondary isogenesis on Java) (van Bemmelen, 1934) and *Über die Deutung der Schwerkraftanomalien in Niederländisch-Indien* (On the interpretation of the gravity anomalies in Dutch India) (van Bemmelen, 1935), both from the *Geologische Rundschau* (now listed as the *International Journal of Earth Sciences*). Van Bemmelen continued to write extensively on theories in *Tectonophysics* and on Indonesia (van Bemmelen, 1934, 1941, 1949a, 1950, 1953, 1954, 1963). He then wrote in English on the Origin and Mining of Bauxite in Netherlands-India (van Bemmelen, 1941) and the Report of Volcanic Activity and Vulcanological Research in Indonesia (1936–1948) (van Bemmelen, 1949a) in the *Bulletin of Volcanologie*. These works formed his most significant contribution: The Geology of Indonesia (van Bemmelen, 1949b; van Bemmelen and de Bouter, 1970). In addition, Rittmann (1953) wrote specifically on the Magmatic Character and Tectonic Position of Indonesian Volcanoes. In terms of contributions by Indonesian researchers, John Ario Katili of the Bandung Institute of Technology (ITB), considered one the founding fathers of Indonesian geology, wrote significant accounts on geotectonic knowledge of Indonesia from the period of 1963 to 1991 (Katili, 1960, 1974, 1980, 1983, 1985, 1986a, b; Katili et al., 1962; Katili and Reinemund, 1984; Katili and Sudradjat, 1984). Other early and significant contributions come from Mudaham Taufick Zen and Djajadi Hadikusumo, from the Geological Survey of Indonesia, who collaboratively wrote some of the earliest and most important accounts on volcanoes in Indonesia (Zen and Hadikusumo, 1964a, b, 1965; Zen, 1966, 1970, 1971; Zen and Radja, 1975). It is also important to mention, though not indexed in Scopus, the work by Kusumadinata (1979), of the Geological Survey of Indonesia, on the Catalogue of References on Indonesian Volcanoes with Eruptions in Historical Time, amongst others (Kusumadinata, 1963, 1964a, b, c). The earliest accounts that explicitly examine DRR include Suryo and Clarke (1985), who wrote the Occurrence and Mitigation of Volcanic Hazards in Indonesia and laid out strategies such as the prediction of volcanic activity, hazard zoning and maps, and control of hazards through engineering structures. They wrote that “the main purpose of hazard maps is to assist the protection of people and their property near active volcanoes” (Suryo and Clarke, 1985, p. 90). Verstappen (1993, p. 367) in his paper, the Volcanoes of Indonesia and Natural Disaster Reduction (with Some Examples), wrote that since emergency scenarios inevitably vary with intensity and type of land utilization, the compilation of vulnerability maps of the endangered areas merits consideration in the context of disaster reduction policy”. A notable Indonesian scholar is Sudibyakto, from the Faculty of Geography, University of Gadjah Mada, and also the head of the Indonesia Disaster Scientist Association (IABI), who wrote Natural Disaster Mitigation and Management in Indonesia (Sudibyakto and Haroonah, 1997) and examined disaster from geographical and social science perspectives (Sudibyakto and Haroonah, 1997; Sudibyakto, 1992). Some of the earliest publi-

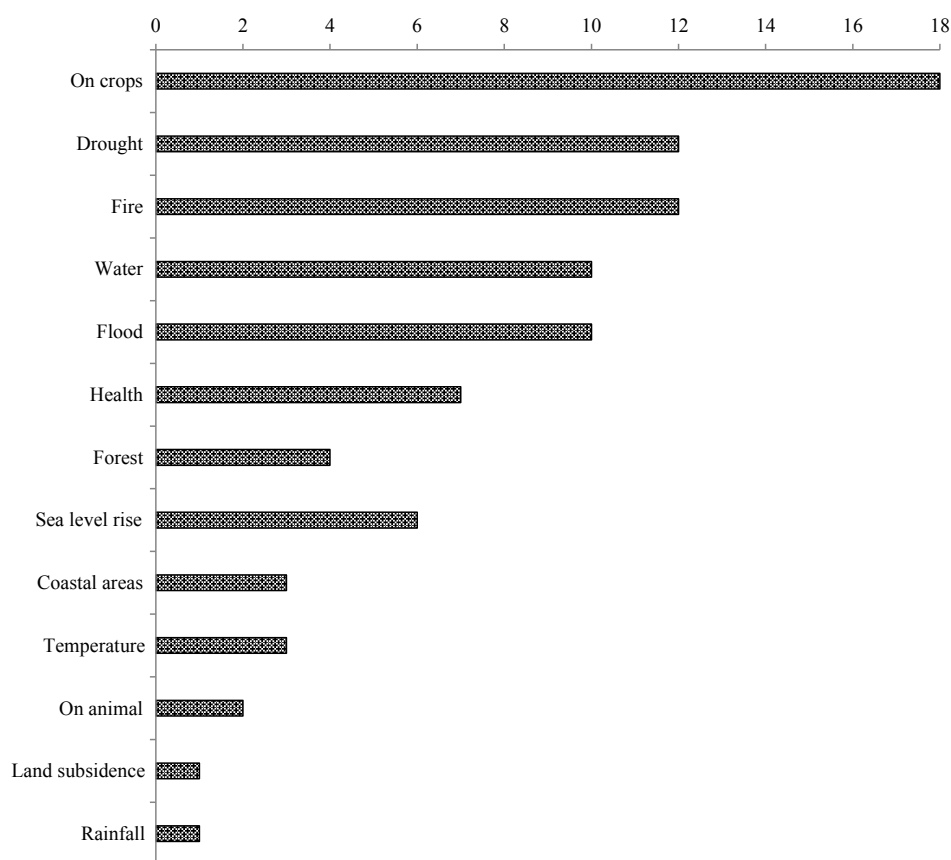


Figure 4. Key topics in the CC category on impacts of climate change.

cation were written in 1992 by Sudibyakto (1992), who wrote *Facts and Future Trends of Climate Change: A Case Study of the Eastern Part of the Indonesia Islands*, and by Muriyarto (1993), who examined the management of climate change impacts to reduce CO₂ release resulting from deforestation and biomass in Indonesia.

The review finds that, out of the 3000 names obtained from the Scopus search, 68 % of them are from international authors, compared to 32 % from Indonesian authors. The contribution of international/non-Indonesian authors dominates the production of publications. The figure shows that there are more authors, including Indonesian authors, in the DRR category than the other two categories. There are slightly more papers with at least one Indonesian author than those with no Indonesian authors. A more striking examination of Indonesia authors shows that there are fewer than 100 authors with more than two publications. The majority of authors work for organizations that are located in Java, where the high-quality education providers are mostly located (OECD and ADB, 2015), dominated by male researchers and only a small minority of these researchers, have a social media account, such as Google Scholar (Google Scholar, 2016a) or Research Gate (2016), or professional or personal websites. This implies that there is room for increasing the involvement

of Indonesian authors writing about various issues related to DRR and a greater opportunity for developing social science in DRR (e.g. Gu and Widén-Wulff, 2011). More Indonesians need to be involved in international publications, and specific interventions are needed to enhance writing, publication and outreach skills. Figure 5 summarizes the roles of Indonesian authors within each publication category (HRD, DRR, and CC).

Table 3 compares the list of the top 10 authors with the highest number of publications and the Indonesian authors with the 10 highest publications. Highest in the list is Hasanuddin Zainal Abidin of ITB, with 71 publications listed in Scopus, while his Google scholar profile shows that he has published 172, with 1709 citations (Google Scholar, 2016b). Franck Lavigne from the Université Paris 1 Panthéon-Sorbonne published the second highest numbers of papers (Google Scholar, 2016c). Lavigne worked closely with Jean-Claude Thouret from the Laboratoire Magmas et Volcans (LMV, 2016). Danny Hilman Natawidjaja works for the Indonesian Institute of Science (LIPI) (Google Scholar, 2016d) but did his bachelor studies at ITB. Kerry Sieh, from Earth Observatory of Singapore (EOS), has long collaborated with Natawidjaja on their works on seismology in Indonesia (EOS, 2018). Barry Voight is a renowned geologist and vol-

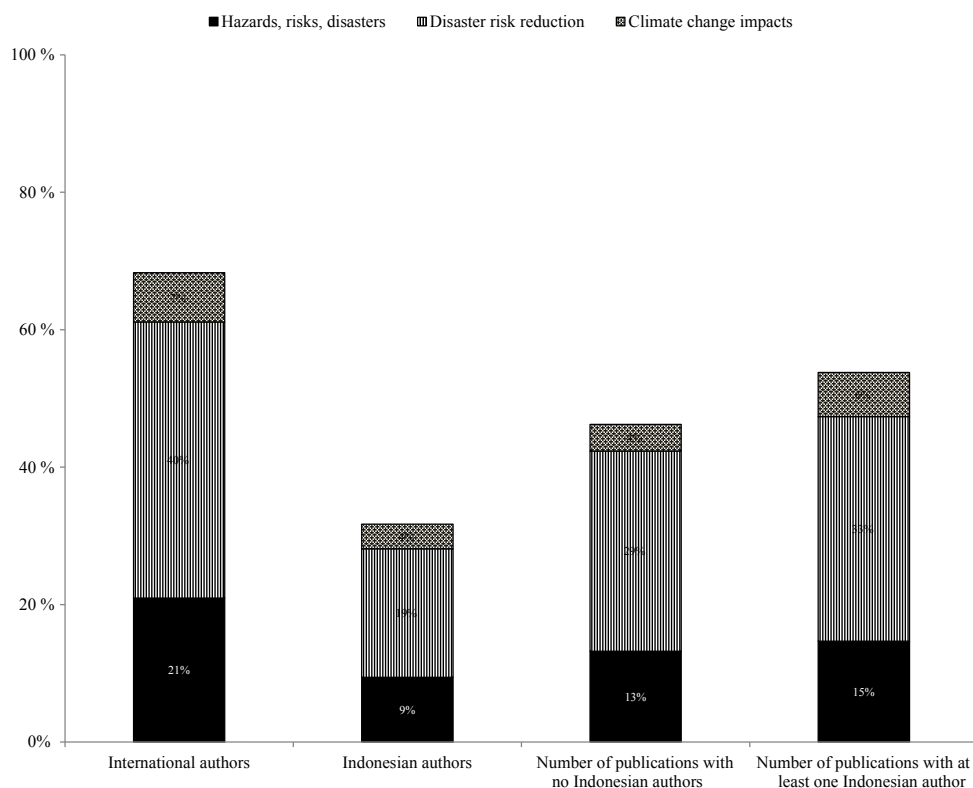


Figure 5. Comparing the roles of international and Indonesian authors in each publication category.

canologist in the USA who has worked on Mount Merapi since the 1980s (Google Scholar, 2016e). Ralf Gertisser is a senior lecturer at Keele University (Google Scholar, 2016f). Bambang Widoyoko Suwargadi is affiliated with LIPI, and Surono (one name only) and Muhammad Hendrasto both work for the Center for Volcanology and Geological Hazard Mitigation (PVMBG, 2018). In addition to the five Indonesians amongst the top 10 authors, Irwan Meilano, Heri Andreas and Irwan Gumilar have worked closely with Hasanuddin Zainal Abidin and are all affiliated with ITB. Muh. Aris Marfai (Google Scholar, 2016g) and Junun Sartohadi are from Gadjah Mada University (UGM). This result shows a great deal of need for increasing the capacity of Indonesian authors to meet standards for internationally regarded journal publications. There are a limited number of authors involved with publications in the highest-IF journals such as Nature and Science. Indonesian authors largely lack experience in international collaboration and the language and writing skills necessary for submitting their works to internationally accredited journals: high-impact articles and collaborations were only done through organizations centred on ITB, UGM, LIPI and PVMBG. Despite some Indonesian researchers having been strongly influential within the study of hazards, DRR or climate change in Indonesia and could potentially contribute to the global development of knowledge in these fields, they have only published in Bahasa Indonesia

and have not submitted their works to international, mostly English language, journals.

3.2.2 Affiliations

This section systematically examines the place, from regional to national, and organizations with which the researchers are affiliated in Indonesia. The organizations which house the 10 most productive publications related to this review are shown in Fig. 6. In general, there are an equal number of organizations that are based in Indonesia, and their contributions comprised slightly more than half the overall contributions amongst these most productive agencies. This paper looks deeper at the contribution of different organizations within Indonesia. It is shown that ITB and UGM dominate almost half the total publications. There are also more than twice as many universities in Java than outside Java, while the rest of the publications are contributed by national-level organizations such as LIPI and PVMBG.

3.2.3 Publications sources

This section presents the source of publications. Most publications that got indexed are those from journals, compared to conference proceedings, books etc. A closer look at the journals shows those related to geophysical hazard (volcanoes, earthquakes, tsunamis) identification and assessments domi-

Table 3. List of top 10 authors with the highest number of publications, and top 10 Indonesian authors (Scopus, 2016a; Google, 2016b; Research Gate, 2016).

Top 10 Author (I – Indonesian)	Organization/country	NoP	SC	GS	RG authors	Top 10 Indonesian	Organization	NoP	SC	GS	RG
Abidin, H. Z. (I)	Indonesia/Institute Teknologi Bandung (ITB)	71	71, 571, 11, 150,	172, 1709, 41	119, 773, 99.21	Abidin, H. Z.	ITB	71	71, 493, 11, 121, Andreas H	NA	119, 773, 99.21
Lavigne, F.	France/Université Paris 1 Panthéon Sorbonne	59	66, 1356, 20, >150, Wassmer, P.	124, 1648, 34	153, 1430, 162.61	Meilano, Irwan	ITB	47	46, 299, 10, 143, Kimata, F	514, 11, 14	24, 69,
Sieh, K.	Singapore/Earth Obser- vatory of Singapore	54	120, 5752, 43, >150, Natawidjaja, D. H.	NA	NA	Natawidjaja, D. H.	(Indonesian Institute of Science) LIPI	43	43, 1913, 21, 123, Sieh K. E.	147, 2964, 25, 33	123, 2788, 376.31
Natawidjaja, D. H. (I)	Indonesia/LIPI	43	42, 1913, 21, 123, Sieh K. E.	147, 2964, 25, 33	123, 2788, 376.31	Suwargadi, B. W. (I)	Indonesia/LIPI	31	31, 1102, 17, 20, 103, Natawidjaja, D. H.	97, 1585, 20, 24	NA
Thouret, J.-C.	France/Laboratory Magma et Volcanis	40	114, 1147, 20, >150, Gourgaud, A.	NA	NA	Surono (I name only)	(Center for Volcanology and Geological Hazard Mitigation) PVMBG	28	28, 348, 12, 125, Hendrasro M.	NA	NA
Voight, B.	USA/Pennsylvania State University	36	313, 8185, 53, 128	2505, 307 570, 75	NA	Andreas, H.	ITB	24	24, 123, 6, 46, Abidin, H. Z.	NA	NA
Gertisser, R.	United Kingdom/Keele University	32	42, 684, 468, 14, >150, Charbonnier S. J.	86, 1009, 19, 29	87 803 132, 51	Marfat, M. A.	Gadjah Mada University (UGM)	21	183, 8, 36, King, L.	79, 517, 12, 14	NA
Suwargadi, B. W. (I)	Indonesia/LIPI	31	31, 1102, 17, 103, Natawidjaja, D. H.	97, 1585, 20, 24	NA	Gumilar, I.	ITB	20	20, 68, 3, 44, Abidin H. Z.	NA	NA
Surono (I)	Indonesia/PVMBG	28	28, 448, 13, 129, Hendrasro M.	NA	NA	Sartohadi, J.	UGM	19	19, 378, 8, Lavigne, F.	NA	NA
Andreas, H. (I)	ITB	24	123, 6, 46, Abidin, H. Z.	NA	NA	Hendrasro M.	PVMBG	18	18, 92, 4, Surono	NA	NA
Total		416						306			

Note: NoP – number of Publications; SC – Scopus profile (publications, citations, h index, number of co-authors, most frequent collaborator); GS – Google Scholar profile (citations, h index, i10 index); RG – Research Gate profile (number of publications, citations, impact points); NA – not available

nate the papers published on Indonesia (Table 4). Moreover, the *Indonesian Journal of Geography* is the only Indonesian journal that is found in this review. The journal was established in 1961 by the Faculty of Geography, UGM, in co-operation with the Association of Indonesian Geographers (IJG, 2016). There are no clear counts on the number of academic journals in Indonesia; however, there are only 245 accredited by DIKTI (Indonesian Ministry of Education Directorate General of Higher Education) (DIKTI, 2018a) and 37 indexed in Scopus (DIKTI, 2018b). In addition, none of these journals have yet obtained an impact factor, and hence a Scientific Journal Ranking (SJR) score is presented instead (Scientific Journal Ranking, 2016).

3.2.4 Citations

This section analyses the citations for each topic category. Overall, the HRD category has the highest number of citations, in total more than two-thirds (3945/5291) of all citations. A look at the citation averages, however, shows quite a different story. Whilst the CC literature category has the smallest number of papers published (194), the citation average is twice that of the DRR category (3.18). Figure 7 shows the comparison between the progress of Indonesian researchers in the 10 most cited papers overall and those first authored by Indonesians. The role of first author has been considered significant since they are traditionally assumed to lead the research and write most of the content, and therefore receive most credit (Riesenberg and Lundberg, 1990). It shows that there are more authors, mostly international authors, in the 10 most cited papers, while there are more Indonesians in the 10 most cited papers first authored by Indonesians. This might suggest that Indonesian researchers tend to work with other Indonesians and hence need to expand their collaborations with international scholars as a strategy to increase their number of citations and ability to submit to higher-impact journals.

Table 5 shows the list of the 10 most cited papers of all publications. Within the 10 most cited papers, there are 4204 total citations, with a combined IF of 293.618, and only one-third of the authors are Indonesian. The citation is 3 times those first authored by Indonesians, and the IF is 4 times greater. It is shown that they are published in high-IF journals such as *Nature*, *Science* or those related to geophysical hazards. The two most cited papers are published in *Nature* and discuss the impacts of forest fires in Indonesia. The paper related to the examination of the amount of carbon released from peat and forest fires in Indonesia in 1997 has the highest amount of citations of 1287 by Page et al. (2002). The majority of the papers discuss major hazards from the earthquake in Sumatra (Ishii et al., 2005; Briggs et al., 2006; Hsu et al., 2006; Konca et al., 2008), as well as the impacts of Toba (Rampino and Self, 1992) and Merapi volcanic eruptions (Voight et al., 2000). Eight papers were also contributed by Indonesians, with Natawidjaja involved in five of them. Adi

Jaya and Suwido Limin are both lecturers from Palangkaraya University in Kalimantan, where forest fires have frequently occurred across the rain forest and impacted not only Indonesia but also surrounding countries in the region, such as Singapore (Tay, 1998) and Malaysia (Khandekar et al., 2000). Natawidjaja and Subarya, along with Sieh, contributed the most (Briggs et al., 2006; Hill et al., 2012; Horspool et al., 2014; Hsu et al., 2006; Konca et al., 2008; Muhari et al., 2010, 2011; Nalbant et al., 2005; Philibosian et al., 2012; Prayodhieh et al., 2012; Schlurmann et al., 2010; Singh et al., 2010).

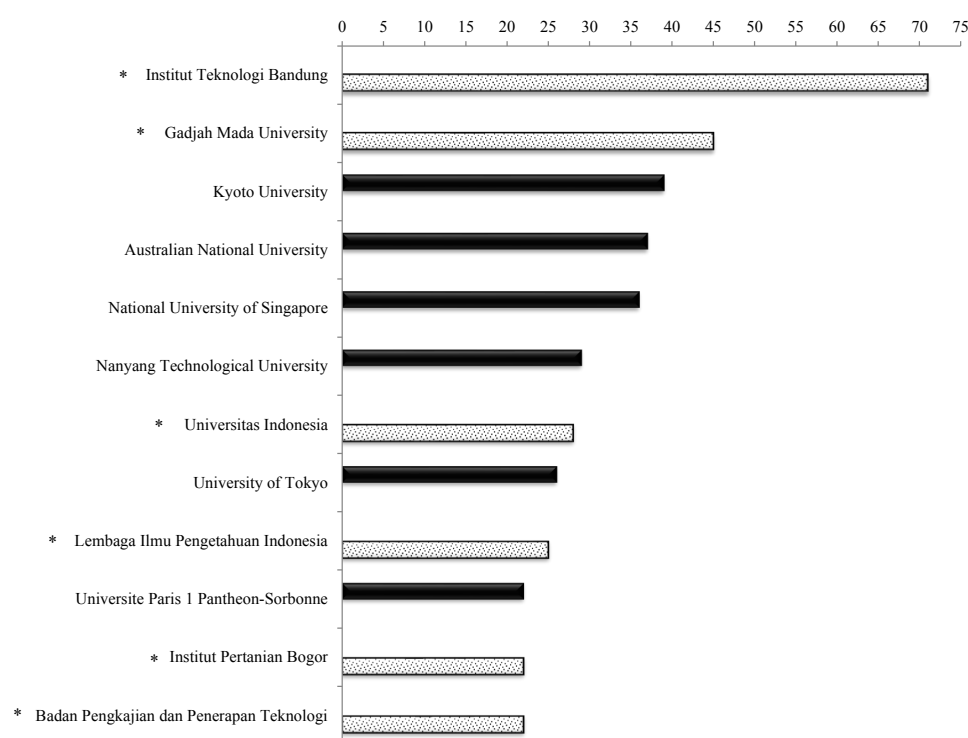
A closer examination of the list of the 10 most cited publications with Indonesian first authors shows a very striking picture. The total citations only amount to 1542, with a combined IF of only 70.012, with 80 % of all authors being Indonesian. The papers are much more varied in terms of topics they discussed. The first two most cited papers are related to impacts of climate change in Indonesia. Aldrian and Dwi Susanto (2003); Susanto (2001) and also Amien et al. (1996) authored papers related to climate change or its impacts on Indonesia. Natawidjaja (Natawidjaja et al., 2004, 2006) and Abidin (Abidin et al., 2001, 2011) have each contributed two papers within the list of the most cited papers first authored by Indonesians on earthquakes and land subsidence assessments. One paper examines the impacts of volcanoes (Andreastuti et al., 2000). Marfai wrote extensively on coastal risks and disasters in cities such as Semarang and Jakarta (Marfai and King, 2007, 2008; Marfai et al., 2008, 2015; Ward et al., 2013; Marfai, 2014). This table shows that, in general, Indonesian authors still write papers with fewer citations, and the organizations that house these authors are still extremely limited to ITB, UGM, LIPI and PVMBG. Another significant finding here is that there is no paper on DRR. This is an important finding that also shows how social science perspectives need to be taken up by the Indonesia researchers in dealing with the management of disaster risks and disaster risks in Indonesia.

4 Recommendations for future research and policy relevance, and conclusions

This paper has presented the results of an SLR from Scopus on the current research trends and progress related to natural hazards, disasters and disaster risk reduction, as well as increasingly climate change impacts and governance in Indonesia. The paper also examines the roles of Indonesian authors and organizations in contributing to publications related to these topics. We have seen that some of the earliest publications were written in 1934, and publications started to increase rapidly in 2000. It is found there are more publications on HRD than on DRR and CC. Moreover, there are two international authors for every Indonesian author, and the contribution of international authors dominates the production of publications. Most of the high-impact publications

Table 4. List of most-submitted-to journals.

Publications	Number of papers	IF/SJR	Category		
			HRD	DRR	CC
<i>Journal of Volcanology and Geothermal Research</i>	75	2.543	×		
<i>Natural Hazards</i>	39	1.719	×	×	
<i>Natural Hazards and Earth System Science</i>	27	1.735	×	×	
<i>Bulletin of Volcanology</i>	22	2.519	×		
<i>Geophysical Research Letters</i>	17	4.196	×		
<i>Earth and Planetary Science Letters</i>	16	4.734	×		
<i>Pure and Applied Geophysics</i>	15	1.618	×		
<i>Nature</i>	14	41.456	×		×
<i>Journal of Disaster Research</i>	14	SJR 0.18		×	
<i>Journal of Geophysical Research: Solid Earth</i>	12	3.426	×		
<i>International Journal of Disaster Risk Reduction</i>	12	SJR 0.510		×	×
<i>Bulletin of the International Institute of Seismology and Earthquake Engineering</i>	12	SJR 0.12	×		

**Figure 6.** Organizations with the highest number of publications (Indonesian organizations marked with *).

and international collaborations were conducted with the key institutions centred on ITB, UGM, LIPI and PVMBG. Male and advanced-career authors still dominate, compared to the numbers and roles of female and early-career researchers (ECRs). In addition, there are very few researchers who have social media accounts (Bik and Goldstein, 2013), such as Google Scholar (Google Scholar, 2016a) or Research Gate (Research Gate, 2016), or professional or personal websites.

The *first* recommendation is related to future research topics. More research is needed on different hazards, different

locations in Indonesia, and other topics in DRR and climate change. The majority of current research is still focused on geophysical hazards, and those related to hydro-meteorological hazards have only received attention recently. It has been seen that the majority of research focuses on the Islands of Java and Sumatra. This is expected since these two islands are the most at risk from natural hazards in Indonesia. Multi-hazard, risk and vulnerability assessments are suggested. Research and actions that focus on the most vulnerable places and communities are needed. As the world is increasingly urbanized, there is strong international atten-

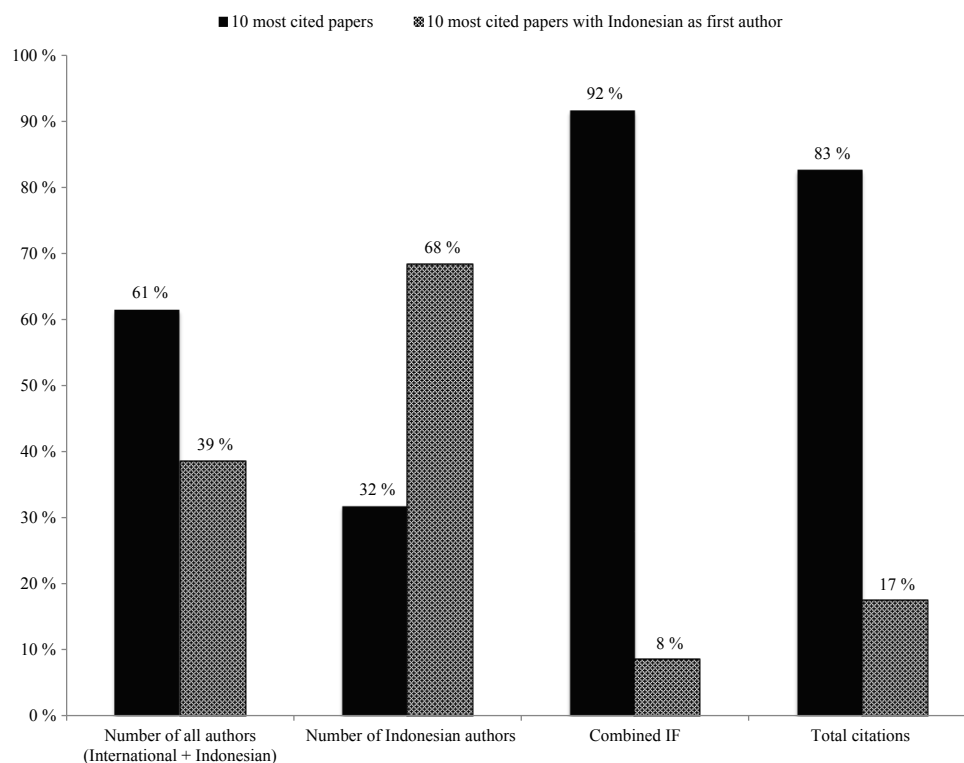


Figure 7. Comparing the roles of Indonesian researchers in the 10 most cited papers.

tion focused on reducing risks in urban areas, in particular through concerted action in the New Urban Agenda (UN-HABITAT, 2016). More research needs to consider the context of urban areas in which social risks and risks from natural hazards play out simultaneously, and the impacts on urban dwellers need to be understood. Cities in Indonesia like Jakarta, Surabaya and Makassar are rapidly urbanizing, and environmental and economic pressures increase risks for the inhabitants (Firman et al., 2011; Larson et al., 2013; Santosa, 2000; Firman, 2016; van Voorst, 2016).

Strategies and actions for integrating DRR and CCA need to be explored further (Djalante and Thomalla, 2012; Lassa and Nugraha, 2015). Disaster risk governance has not received much research (Djalante et al., 2017) especially on the interplay with decentralization which places responsibility for DRR and CCA at the local-government level (Lassa, 2013; Kusumasari et al., 2010). The strategies outlined are relevant not only for research but also for the governance of climate change. The islands in Kalimantan, Sulawesi, Maluku and Papua in the eastern part of Indonesia have also been impacted by droughts, floods or strong winds and need to be addressed in the future. The impacts of sea level rise on small islands, drought on forests in Kalimantan and Papua, and rising sea level and ocean acidification on fisheries in Sulawesi and the eastern part of Indonesia are some of the increasingly worrisome issues expected from climate change. There is still greater need for research and government action

on climate change topics related to linkages between poverty and disaster vulnerability (Suryahadi and Sumarto, 2003), security (CSIS, 2007), loss and damages (Warner et al., 2012), impacts on key sectors such as fisheries (USAID Indonesia, 2015), coastal communities (Marfai et al., 2008), food security (Measey, 2012; WFP, 2015) health (Ady Wirawan, 2010; Haryanto, 2009), migration (Raleigh et al., 2008; Reuveny, 2007) and community-based DRR (Heijmans, 2012). Many activities done by the Indonesian government and international and development agencies in their implementations of DRR or CCA programmes have focused on different administrative levels: national, regional, local and community. There is an abundance of activity reports by governments, donors and international agencies (e.g. USAID Indonesia, 2011, 2015); however, those reports are rarely made available or submitted for academic publications.

The *second* recommendation is on the need to strengthen the capacity of research collaborations between Indonesian and international researchers, multi-disciplinary research and publications in high-impact journals, along with the need for strengthening of science communication to social media outlets and science-policy advocacy. There need to be more funding and incentives for collaborations. More training on English academic writing and journal article publications is needed, including capacity building for early-career, female and social science researchers (Koppel et al., 2002; Lewison, 2001; Sidhu et al., 2006). It is clear that some of the very lim-

Table 5. Comparing citations authored in general and those first authored by an Indonesian in the 10 most cited papers.

Overall						First authored by Indonesian					
Authors (Indonesian are marked I)	Title	Y	J	C	IF	Authors (Indonesian are marked I)	Title	Y	J	C	IF
Page S. E., Siebert, F., Riele, J. O., Boehm, H.-D. V., Jaya, A., (I) Limin, S. (I)	The amount of carbon released from peat and forest fires in Indonesia during 1997	2002	Nature	1280	41.456	Aldrian, E. (I), Susanto, R. D. (I)	Identification of three dominant rainfall regions within Indonesia and their relationship to sea surface temperature	2003	International Journal of Climatol.	344	3.609
Siebert, F., Ruecker, G., Hinrichs, A., Hoffmann, A. A.	Increased damage from fires in logged forests during droughts caused by El Niño	2001	Nature	519	41.456	Subarya, C. (I), Chlieh, M., Prawirodirdjo, L. (I), Avouac, J. P., Bock, Sieh, Meltzner, Natawidjaja (I), McCaffrey	Plate-boundary deformation associated with the great Sumatra-Andaman earthquake	2006	Nature	343	41.456
Ishii, M., Shearer, P. M., Houston, H., Vidale, J. E.	Extent, duration and speed of the 2004 Sumatra-Andaman earthquake imaged by the Hi-Net array	2005	Nature	386	41.456	Susanto, R. D. (I), Gordon, A. L., Zheng, Q.	Upwelling along the coasts of Java and Sumatra and its relation to ENSO	2001	Geophysical Research Letters	161	4.196
Aldrian, E. (I), Dwi Susanto, R. (I)	Identification of three dominant rainfall regions within Indonesia and their relationship to sea surface temperature	2003	Int. J. Climatol.	343	3.157	Natawidjaja, D. H. (I), Sieh, K., Chlieh, M., Galetzka, J., Suwargadi, B. W. (I), Cheng, H., Edwards, R. L., Avouac, J. P., Ward, S. N.	Source parameters of the great Sumatran megathrust earthquakes of 1797 and 1833 inferred from coral microatolls	2006	Journal of Geophysical Research: Solid Earth	156	3.318
Subarya, C. (I), Chlieh, M., Prawirodirdjo, L. (I), Avouac, J. P., Bock, Sieh, Meltzner, Natawidjaja (I), McCaffrey	Plate-boundary deformation associated with the great Sumatra-Andaman earthquake	2006	Nature	343	41.456	Hilman, D., Natawidjaja (I), Sieh, K., Ward, S. N., Cheng, H. R., Edwards, L., Galetzka, J., Bambang, W., Suwargadi (I)	Paleogeodetic records of seismic and aseismic subduction from central Sumatran microatolls, Indonesia	2004	Journal of Geophysical Research: Solid Earth	119	3.318
Rampino M. R., Self S.	Volcanic winter and accelerated glaciations following the Toba super-eruption	1992	Nature	333	41.456	Abidin, H. Z., Djaja, R., Darmawan, D., Hadi, S., Akbar, S., Rajiyowiryo, S. Y., Meilano, I., Kasuma, M. A., Kahar, J., Subarya, C. (All I)	Land subsidence of Jakarta (Indonesia) and its geodetic monitoring system	2001	Natural Hazards	103	1.719

ited Indonesian research from key universities doing disaster research – such as ITB, LIPI and UGM – has been involved in international collaborations and publications of high-impact journal (QS, 2016). There are only nine universities in Indonesia that are on the list of QS World University Rankings, with the University of Indonesia at the top of the list (QS, 2016). Other universities on the islands of Sumatra, Sulawesi and Kalimantan and other locations need to address disaster issues as part of their research agendas (OECD and ADB, 2015). There is a need for better targeting of scholars to do more collaboration for research and writing for high-impact journals. This goes along with strengthening the capacity of researchers and lecturers at the universities to write and publish in international journals. The Ministry of Education has indeed conducted a training scheme and provided incentives for lecturers that have published internationally (GoI, 2014); however, the overall quality and quantity of papers

by Indonesian researchers are still much lower than those at comparable universities in Malaysia or Singapore (RIS-TEKDIKTI, 2016). The list from Scopus shows that there are still only small numbers of female and early-career researchers (Scopus, 2016a). There needs to be a proper identification of researchers made available to the public. The author could not find a repository of researchers from the Ministry of Education website, let alone systematically determining their progress, history of schooling and research. Policies and strategies to strengthen the capacity of female researchers globally are implemented (Larivière et al., 2013). ECRs are defined as those who have completed their PhDs with the previous 8 years or their training within the previous 6 years (AHRC, 2018). While globally there have been some systematic efforts to strengthen the capacity of ECRs such as through mentoring (Clarke, 2004; Kram and Isabella, 1985), there are no clear strategies for the Indonesian ERCs from

Table 5. Continued.

Authors (Indonesian are marked I)	Title	Overall				Authors (Indonesian are marked I)	Title	First authored by Indonesian			
		Y	J	C	IF			Y	J	C	IF
Sieh, Natawidjaja (I)	Neotectonics of the Sumatran fault, Indonesia	2000	Journal of Geophysical Research: Solid Earth	317	3.426	Andreastuti S. D. (I), Alloway B. V., Smith, I. E. M.	A detailed tephrostrati- graphic framework at Merapi Volcano, Central Java, Indone- sia: Implications for eruption predictions and hazard assessment	2000	Journal of Volcanology and Geothermal Research	81	2.543
Vigny, C., Simons, W. J. F., Abu, S., Bamphenyu, R., Satirapod, C., Choosakul, N., Subarya, C., Socquet, A., Omar, K., Abidin, H. Z., Ambrosius, B. A. C.,	Insight into the 2004 Sumatra–Andaman earthquake from GPS measurements in southeast Asia	2005	Nature	329	41.456	Marfai, M. A. (I), King, L.	Monitoring land subsi- dence in Semarang, In- donesia	2007	Environmental Geology Journal of Geophysical Research: Solid Earth	68	3.318
Hsu, Y.-J., Simons, M., Avouac, J.-P., Galetzka, J., Sieh, K., Chlieh, M., Natawidjaja, D. (I), Prawirodirdjo, L. (I), Bock, Y.	Frictional afterslip following the 2005 Nias-Simeulue earthquake, Sumatra	2006	Science	271	33.61	Marfai, M. A. (I), King, L.,	Potential vulnerability implications of coastal inundation due to sea level rise for the coastal zone of Semarang city, Indonesia	2008	Environmental Geology Journal of Geophysical Research: Solid Earth	59	3.318
Briggs, R. W., Sieh, K., Meltzner, A. J., Natawidjaja, D. (I), Galetzka, J., Suwargadi, B. (I), Hsu, Y.-J., Simons, M., Hananto, N. (I), Suprihanto, I. (I), Prayudi, D. (I), Avouac, J.-P., Prawirodirdjo, L. (I), Bock, Y.	Deformation and slip along the Sunda megathrust in the great 2005 Nias-Simeulue earthquake	2006	Science	226	33.61	Marfai, M. A. (I), Almohammad, H., Sudip, Dey, Susanto, B. (I), King, L.,	Coastal dynamic and shoreline mapping: multi-sources spatial data analysis in Semarang Indonesia	2008	Environmental Monitoring and Assessment	57	1.663
Konca, A. O., Avouac, J.-P., Sladen, A., Meltzner, A. J., Sieh, K., Fang, P., Li, Z., Galetzka, J., Genrich, J., Chlieh, M., Natawidjaja, D. H. (I), Bock, Y., Fielding, E. J., Ji, C., Helmberger, D. V.	Partial rupture of a locked patch of the Sumatra megathrust during the 2007 earthquake sequence	2008	Nature	207	41.456	Amien, I. (I), Rejekiingrum P. (I), Pramudia, A. (I), Susanti, E. (I),	Effects of interannual climate variability and climate change on rice yield in Java, Indonesia	1996	Water, Air, and Soil Pollution	51	1.554
Total				4547	296 775					1542	70 012

Note: Y – year; J – journal; C – number of citations; IF – journal impact factor; I – Indonesian author (marked at the authors column)

the Indonesian government. International journals (Elsevier, 2016) and international and other national research councils (UKRI, 2018) have allocated resources and are funding research specifically for ECRs. The Indonesian Association of Disaster Experts was formed in 2014 and meets annually to discuss their future research guidelines (IABI, 2018). One thing that should be on the agenda is to review current publications in Bahasa Indonesia and collaborations undertaken by Indonesian experts which can enable better identification of research progress and hence research needs in the future. There is an abundance of materials within Indonesian repos-

itories related to *bencana* (Indonesian word for disaster), especially within the repositories at ITB, UGM and the University of Syiah Kuala in Aceh. These materials and research activities done within the universities need to be reviewed and submitted to international journals to give a broader view on issues that have been discussed by scholars in Indonesia. There is an increasing call for more inter-disciplinary collaborations so that complex problems on social and environmental issues can be understood better and problem identification can better target those in need (Future Earth, 2018). Hence this implies an increasing importance of social sci-

ence adoption to study disasters and their impacts. The roles of private business and the communities at risk have rarely been part of the research and collaborations. It is also not clear how collaborations amongst scientists from social and physical backgrounds have taken place in Indonesia. It is also not clear how or whether science (Wagner and Leydesdorff, 2005), policy and industry (Lee, 1996) collaborations have taken place and are documented in these listed publications. These collaborations are important to face the complexities of future problems (Leydesdorff and Wagner, 2008), and also to help achieve the outcomes of the Sustainable Development Goals (United Nations, 2015).

In conclusion this study has been able to determine the progress in research related to natural hazard, risks and risk reduction and climate change impacts in Indonesia. It has also been able to examine the roles of Indonesian scientists in collaborations and towards high-quality publications. The recommendations are outlined toward these two issues, and it is the responsibility of both Indonesian and international organizations including governments that have worked and will work in Indonesia to be able to meet the needs for Indonesia to better understand, manage and reduce its natural hazards and risks in the future and ultimately build a resilient and sustainable Indonesia.

Data availability. No data sets were used in this article.

Competing interests. The author declares that she has no conflict of interest.

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