Research Trends in Natural Hazards, Disasters, Risk Reduction and Climate Change in Indonesia: A Systematic Literature Review

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Abstract. Indonesia is one of the most vulnerable countries from disasters and climate change. While there has been a proliferation of academic publications written on issues related to natural hazards, risks, and disasters on Indonesia, there has not yet a systematic literature review (SLR) to determine the progress, key topics and directions for further research. SLR is important so researchers can build upon existing works, avoid bias, determine major research and need for further research. It is also important to determine who, how, in which way the research has been conducted in order to strengthen research capacity in the future. The author conducted a SLR of publications indexed within the Scopus database from 1900 to 2016 on topics related to natural hazards, risks, risk reduction and climate change impacts on Indonesia. The findings are outlined in two parts. The first part focuses on the research topics and finds that publications can be categorized into three major 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 the publications fall into HRD and focus on volcanic eruptions, tsunami and earthquakes. Publications on DRR focus on governance, early warning systems and recovery and reconstruction. Those regarding CC mainly concern carbon emission, forestry, governance, and impacts. The second part focuses on roles of Indonesian researchers and organizations in these publications. 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. Moreover, of the international collaborations that took place, this was limited to only a few Indonesian organizations. Reasons for this could be limited experience in academic collaboration, power play amongst researchers, lack of research capacity, weak English academic writings skills as well as a lack of incentives for international collaboration and publication within the Indonesian higher education system.

Keyword: Systematic literature review; natural hazard; disaster; climate change; Indonesia

1 Introduction

Disaster events and their associated social and economical impacts are on the rise (EMDAT, 2016). The last decade has witnessed the highest number and impacts from disasters and 2015 has been declared as the hottest year ever (WMO, 2016). The Asia Pacific region has experienced the highest number of disasters on record (EMDAT, 2016), within which Indonesia is one of the most at risk countries to disasters and climate change impacts (EMDAT, 2016). Between the period of 1900 to 2016, there have been a total of 434 disasters in Indonesia caused by natural hazards, with 237,728 deaths, 29.1 million people affected and total damage almost 30 Billion USD (EMDAT, 2016). Geophysical hazards caused more than 90% deaths while the hydrometerological occur more frequently, affected more people, and caused three times damages (EMDAT, 2016). This paper aims to systematically review literature related to natural hazards, risk and disaster risk reduction, as well as climate change vulnerability, impact, and assessments in Indonesia. A systematic literature review (SLR) is defined as a method for systematically reviewing evidence or literature with explicit and transparent methods (Gill and Malamud, 2014). Even though there is vast material on these topics on Indonesia, there has not yet been a literature review that examines them in a comprehensive and systematic way. By reviewing published works in this fashion, researchers can build upon others´ works, avoid bias (Khan et al., 1996) and reinventing the wheel so that topics that have been heavily researched can be determined, and those that need further research can be outlined (Moher et al., 2009b). It is also important to gauge who, how and in which way the research has been conducted, and determining this will enable consideration for strengthening research capacity in the future (Mallett et al., 2012).

There are two research aims adopted. The **first** is to determine progress of research in natural hazards, risks, disasters and climate change in Indonesia within the timeframe from 1900 to 2016. The **second** is to examine roles of Indonesian authors in contributing to research, international publications and collaborations. The importance of conducting literature on these topics is manifold. The Sendai Framework for DRR (SFDRR) has just been adopted and with it an extension of the scope of hazards and risk reduction strategies (UN/ISDR, 2015). There is a move toward an integrated approach to DRR which calls for strategies and actions to reduce risks and associated impacts, as well as an inclusive role of multiple actors in DRR. This review will enable the identification of strategies that have been undertaken for DRR and hence suggest strategies for future DRR and implementing the SFDRR. Also, there is an increasing focus on the impacts of climate change in the changing profile of hazards and disasters, and hence this calls for integrated DRR and climate change adaptation (CCA) to manage climate risks. This review will try to capture whether consideration of climate change risks have been considered as part of research progress in Indonesia. This study attempts to determine whether progress towards more specific studies on the national and local level is observable. Moreover, determining the progress of Indonesian scholars is important and relevant for several reasons. These 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. Also, in Indonesia, there is an increasing pressure for scholars to write for international journal publications and collaborate. Any outputs from these

publications and collaborations are used toward counting their ranks as academics in universities and research institutions (GoI, 2014). Hence identification of this progress through systematic review will enable us to determine recent progress undertaken by Indonesian researchers, and can help outline recommendations for further actions in the future to increase the quality of publications and roles in collaborations in international spheres.

The structure of this paper is as follows. The first section of this paper has presented the rationale, aim and research questions. The second section outlines the research method related to data sources and document selection. The third section gives the analysis and presentation of results and is divided into two sub sections, the first on key research topics, and the second on the progress of Indonesian researchers and organizations. The last section presents the conclusion and recommendations for further research.

2 Research method

2.1 Data Collection

Systematic literature reviews (SLR) have been used widely. It has been used in the fields of health (e.g. Moher et al., 2009a), software engineering (e.g. Kitchenham et al., 2009), and engineering (e.g. Gosling and Naim, 2009). There have also been studies that use this form of review in topics related to natural hazards, disasters, and climate change. Examples include reviews of different natural hazards such as droughts (Woodhouse and Overpeck, 1998), landslides (Aleotti and Chowdhury, 1999), wildfires (Neale and Weir, 2015), tsunami (Chiu and Ho, 2007), and the interactions of those natural hazards (Gill and Malamud, 2014). Others focuses on the impacts (Hunt and Watkiss, 2011) and risk reduction strategies from social science perspectives such as ecosystem-based adaptation (Brink et al., 2016; Kabisch et al., 2015), education (Johnson et al., 2014), health and psychology after disasters (Kõlves et al.; Harada et al., 2015), volunteerism (Whittaker et al., 2015), disaster management and risk reduction (Beerens and Tehler, 2016; Lettieri et al., 2009; Gall et al., 2015). A significant works on the systematic review of climate change studies has been done by Berrang-Ford et al (2015; 2015; 2012).

Berrang-Ford et al (2011; 2015) suggested an analytical approach for a systematic review and research synthesis which gives outline on the research questions and aims, data sources and document selection, and analysis and presentation of results. They stated that the questions and aims needed to be clearly described and explicit; the data sources needed to be justified and described, including the articulation of the articulation of search term and description of inclusion and exclusion, along with the documentation of literature included and excluded. They added that the methods for analysis needed to be described and the quality of information needed to be critically appraised (Berrang-Ford et al., 2015). These steps are adopted in this paper.

In regards to the data sources and document selection, the author conducted a multi-layered literature review to study publications using the Scopus research engine, with a timeframe from 1900 to 2016. There have been several studies comparing the strengths and weakness of Scopus, PubMed, Web of Science and Google Scholar (e.g., Bakkalbasi et al., 2006; Bar-Ilan, 2008). The Scopus research engine was selected because it has the largest database of peer-reviewed

literature (Leydesdorff et al., 2010). Scopus has within its features the capability for search, discovery and analysis (SCOPUS, 2016b). Additional information is gathered from Google Scholar (Google, 2016c), Research Gate (Gate, 2016) or researchers´ profiles (if available) to give the full extent of particular scholars' works. The author checked the organizations, nationalities and genders of the researchers using Google search.

Multi-staged processes are taken to determine inclusion and exclusion for more relevant findings. The key research terms adopted are *natural hazard, disaster, disaster management, disaster risk reduction, climate change, climate change adaptation, resilience, vulnerability, geology, and Indonesia*. With these search terms inputted, the first stage gave a total hit of 8077 publications. The author applied the second stage 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 a total hit of 3447 publications. The third layer search involved the author downloading the results into xml format, saving and importing it into Microsoft Excel. When importing into Excel format the author chose all delimiters to ensure particular 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 that 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. It was also different when examining the profile of one particular author. Hence, to ensure consistency, higher number of publications and citations are selected. The results in the Excel format are examined line by line to further determine exclusion from the lists. Materials that were excluded in this final round were related to analysis of research in the mining industry in Indonesia, those that discuss the science of climate change and those that touch on the issue of disasters but not directly in Indonesia. Further exclusions were warranted when the author judged the scope was too broad to be included in the review. In the end 921 materials selected. The three stages along with the inclusion and exclusion terms are Table 1.

Table 1 Multi-Stage Processes for Inclusion and Exclusions for Search Terms

Stage	Inclusion	Exclusion	Results
First	Search Terms	(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	AND (EXCLUDE (EXACTKEYWORD , "Human") OR EXCLUDE (EXACTKEYWORD , "Humans") OR EXCLUDE (EXACTKEYWORD , "Female") OR EXCLUDE (EXACTKEYWORD , "Male") OR EXCLUDE (EXACTKEYWORD , "Adult") OR EXCLUDE (EXACTKEYWORD , "MajorClinicalStudy") OR EXCLUDE (EXACTKEYWORD , "ControlledStudy") OR EXCLUDE (EXACTKEYWORD , "Adolescent") OR EXCLUDE (EXACTKEYWORD , "Prevalence") OR EXCLUDE (EXACTKEYWORD , "Child") OR EXCLUDE (EXACTKEYWORD , "Thailand") OR EXCLUDE (EXACTKEYWORD , "Aged") OR EXCLUDE (EXACTKEYWORD , "China") OR EXCLUDE (EXACTKEYWORD , "India") OR EXCLUDE (EXACTKEYWORD , "Infant") OR EXCLUDE (EXACTKEYWORD , "Developing Country")) OR (EXCLUDE (EXACTKEYWORD , "Gold"))	3447
	Exclusion on subject area	AND (EXCLUDE (SUBJAREA , "ENER") OR EXCLUDE (SUBJAREA , "MEDI") OR EXCLUDE (SUBJAREA , "BIOC") OR EXCLUDE (SUBJAREA , "CENG") OR EXCLUDE (SUBJAREA , "MATE") OR EXCLUDE (SUBJAREA , "CHEM") OR EXCLUDE (SUBJAREA , "NURS") OR EXCLUDE (SUBJAREA , "DECI") OR EXCLUDE (SUBJAREA , "PHAR") OR EXCLUDE (SUBJAREA , "IMMU") OR EXCLUDE (SUBJAREA , "NEUR") OR EXCLUDE (SUBJAREA , "DENT") OR EXCLUDE (SUBJAREA , "Undefined"))	
	Exclusion	AND (EXCLUDE (EXACTSRCTITLE , "ChemicalGeology") OR EXCLUDE (EXACTSRCTITLE , "Jo	

Stage	Inclusion	Exclusion	Results
	on tittle	urnal Of Petrology") OR EXCLUDE (EXACTSRCTITLE , "Contributions To Mineralogy And Petrology") OR EXCLUDE (EXACTSRCTITLE , "SPE Asia Pacific Oil And Gas Conference") OR EXCLUDE (EXACTSRCTITLE , "International Conference On Health Safety And Environment In Oil And Gas Exploration And Production") OR EXCLUDE (EXACTSRCTITLE , "Society Of Petroleum Engineers International Petroleum Technology Conference 2012 Iptc 2012") OR EXCLUDE (EXACTSRCTITLE , "Acta Horticulturae") OR EXCLUDE (EXACTSRCTITLE , "Preventive Veterinary Medicine") OR EXCLUDE (EXACTSRCTITLE , "SPE Asia Pacific Oil Gas Conference") OR EXCLUDE (EXACTSRCTITLE , "Society Of Petroleum Engineers SPE Asia Pacific Oil And Gas Conference And Exhibition 2011") OR EXCLUDE (EXACTSRCTITLE , "Australasian Institute Of Mining And Metallurgy Publication Series") OR EXCLUDE (EXACTSRCTITLE , "Australian Systematic Botany") OR EXCLUDE (EXACTSRCTITLE , "Society Of Petroleum Engineers SPE Asia Pacific Oil And Gas Conference And Exhibition Apogce 2013 Maximising The Mature Elevating The Young") OR EXCLUDE (EXACTSRCTITLE , "AAPG Bulletin American Association Of Petroleum Geologists") OR EXCLUDE (EXACTSRCTITLE , "Bird Conservation International") OR EXCLUDE (EXACTSRCTITLE , "Construction And Professional Practices Proceedings Of The 10th East Asia Pacific Conference On Structural Engineering And Construction Easec 2010") OR EXCLUDE (EXACTSRCTITLE , "Corporate Ownership And Control") OR EXCLUDE (EXACTSRCTITLE , "Undefined"))	
	Exclusion on language	AND (EXCLUDE (LANGUAGE , "Italian") OR EXCLUDE (LANGUAGE , "Polish") OR EXCLUDE (LANGUAGE , "Spanish") OR EXCLUDE (LANGUAGE , "Afrikaans") OR EXCLUDE (LANGUAGE , "Swedish"))	
	Exclusion on subject area	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	AND (EXCLUDE (SRCTYPE , "d") OR EXCLUDE (SRCTYPE , "r")) AND (EXCLUDE (DOCTYPE , "cr") OR EXCLUDE (DOCTYPE , "no") OR EXCLUDE (DOCTYPE , "sh") OR EXCLUDE (DOCTYPE , "ed"))	
Third	Transfer to XML and excel Form	Topics too broad are excluded	921

2.2 Data Analysis

The author used Scopus features to analyze search results such as the article metric module, citation overview, and author profile pages (SCOPUS, 2016b). This final list was analyzed in terms of authorship, references, citations, keywords, places of focus, types and time of publications, impact factors and topics and sub-topics of research. The progress of Indonesian scholars is evaluated through counting total number of authors, research outputs and citations overall, and also comparing between papers first authored by Indonesians. The author cross-checked the number of citations from Scopus on the Internet through Google, and selected the higher citation counts. This was done because it is generally the case that data from a Google search for a publication and author leads to a higher and more up to date citation count. The author also consulted total citations and publications of researchers in Google Scholar, Research Gate or from other websites to make sure that the full list of publications was captured. There were also cases where the author had to specifically go back to Scopus and find particular author's works to make sure that all were captured.

3 Findings and Analysis

This section is structured into two main parts, first with research topics, and second with progress of Indonesian researchers and organizations.

3.1 Timelines and Research Topics

This part presents the more detailed findings of each of the research topics. The author categorizes the final list into three groups (Table 2), natural hazard, risk, disaster assessments (HRD), disaster risk management and reduction (DRR), and climate change vulnerability, impacts and adaptation (CC), in order to show and outline how changes in directions on research have taken place over the years and to reduce unbalance towards findings on hazard and risks assessments toward earthquake and volcanic eruption research. There are 56% of HRD, and the rest is shared almost equally by the DRR and CC literature (modified from SCOPUS, 2016a).

Table 2 Classifications of Findings Based on Topics of Research

Major topics groups	Definitions (IPCC, 2012; UNISDR, 2009)	Number of publications
(1) Natural hazard, risks, disasters 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. 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.	517
(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 analyze 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.	210
(3) climate change vulnerability, impacts and adaptation (CC)	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 (UNFCCC). 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
Total		921

The paper identifies key periods and timelines by which publications were published. In general, there are more research on the topic of HRD, followed by those in DRR, and then CC. The publications on the HRD are also some of the earliest publications indexed in Scopus. Although the search timeline was set between 1900 and 2016, the years in which publications were found ranges from 1934 to 2016 (Figure 1).

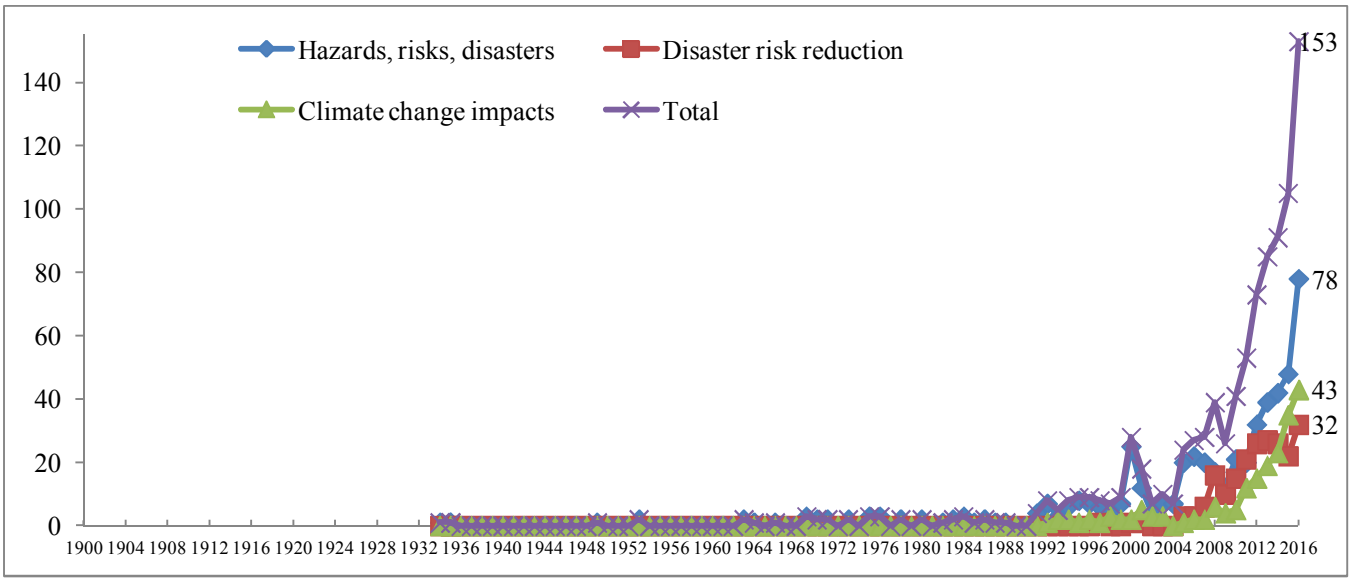

Figure 1 Number of Publications over the Year (modified from SCOPUS, 2016a)

The first period is from the 1934-1990s. There were no significant changes in the numbers of publications produced. Research in this period was heavily focused on the topics of geophysical hazards and risks related to earthquakes and volcanic eruptions (SCOPUS, 2016a). Within this period, 22 out of 58 events recorded by EMDAT were earthquakes and volcanic activities (EMDAT, 2016). The Bali earthquakes occurred in 1976 and 1979, which in total caused 1764 deaths, affected 563,150 people, and caused 215,150 USD in damages (EMDAT, 2016). The year 1979 was also the year in which the earthquake occurred the most (6 times), in Bali, Lombok, and Biak (near Papua) (USGS, 2016). The second period from the 1990s to 2000s shows a notable increase in the literature, up to an average there 10 publications per year. This gradual increase mainly corresponds to a rise in literature related to the assessments of hazards, risks and disasters, and is followed by a sharp increase in literature to its highest point in 2000 (SCOPUS, 2016a). The third period from 2000s-2010s was the most dynamic period for publications. While there was a sharp decline since it first peak in 2000, a surge of publications begun in 2004 in response to the Indian Ocean tsunami which devastated Indonesia especially. This increase has continued ever since. This is also a period characterized not only publications related to understanding the risks of earthquakes and tsunami, but also those related to DRR and CC. A peak occurs between 2010 and 2016 which shows soaring published materials in all topics. There were 153 publications in 2016 which is the highest ever produced in a single year. During this period, publications related to climate change and its impact on Indonesia has started to be considered and is expected to rise further in the future. Both publications on HRD and CC are expected to rise (SCOPUS, 2016a).

The following sub-sections outline research issues discussed within the three topic groups. Within each, the paper discusses timelines, focus areas of the research, early contributors, and categorization of key topics discussed.

3.1.1 Natural hazards, risks and disasters assessments (HRD)

The first sub-section explains findings on the topic of hazards, risks and disasters assessments and identifications. The EMDAT-CRED (2016) categorization of HRD that is used in this study to help more detailed analysis related to major research topics. Natural-disaster groups caused by geophysical, meteorological, hydrological, and climatologically hazards are included since it is determined that these are the most frequent and impactful disasters in the country. Those excluded are disasters caused by biological, extraterrestrial and technological hazards.

There are 535 publications in this category (SCOPUS, 2016a). The findings show that there has been a gradual increase in the number of published materials from 1934 to 2000. It first reached its first peak in 2000 that the research in this topic reached its first significant outputs of 25 publications, and reduced slightly after that. In 2004 the Indian Ocean tsunami occurred, initiated with the 9.8 M earthquake with the epicenter off the island of Sumatra, badly affecting Indonesian. Publications related to the tsunami continued to be published until it reached a peak in 2006. Then in 2009, the publications have increased rapidly ever since, reaching another peak in 2015 of 47 publications in a single year (SCOPUS, 2016a). The islands of Java and Sumatera are the two areas which receive most attention (more than 70%) (SCOPUS, 2016a). The studies in these two islands are mostly related to the study of volcanic eruptions, earthquakes and tsunami. This is not surprising considering that Indonesia has the most numbers of volcanoes and is located along the Pacific ring of fire where earthquakes occur the most (USGS, 2016). The island of Sumatera directly experienced and was impacted by one of the most powerful earthquakes of 8.9 R.S which caused the tsunami in 2004 and hit Aceh, in the north west of Sumatera (Ishii et al., 2005).

Most of the literature around this period focuses on the impacts of volcanic eruptions in Java and Sumatera. The oldest publications related to HRD in Indonesia listed in Scopus are those by Reinout Willem van Bemmelen, a Dutch national born in Batavia (Netherlands East Indies/Indonesia), on *Ein Beispiel für Sekundärtektogenese auf Java* (An example of secondary 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 Techtonophysics, and on Indonesia (van Bemmelen, 1935, 1941, 1949b, 1953, 1963). He then wrote in English on the Origin and Mining of Bauxite in Netherlands-India (Van Bemmelen, 1941) and on the Report of Volcanic Activity and Volcanological Research in Indonesia (1936-1948) (van Bemmelen, 1949b) from the *Bulletin of Volcanologique*. These works formed his greatest contribution: The Geology of Indonesia (Van Bemmelen, 1949a; Van Bemmelen and Bourter, 1970). In addition, Rittman (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, 1975, 1991, 1974, 1967, 1971, 1989, 1969a, 1978, 1986, 1981b; 1963; 1969b, 1981a, 1980, 1973). 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, 1965, 1964b, a; 1971, 1970, 1966; 1974). 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; cited in Rampino and Self, 1982).

The study finds the majority of publications are related to volcanic eruptions, dominated by the study of volcanoes in Java (almost half) such as Merapi (Verstappen, 1988; Lavigne, 1999; Voight et al., 2000; Andreastuti et al., 2000; Charbonnier and Gertisser, 2008; Gertisser et al., 2012; Suryo and Clarke, 1985), Galunggung (Suryo and Clarke, 1985), Semeru (Siswowidjoyo 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 other hazard that receives many studies is related to the examination of earthquakes (more than 30%), how they happened, and methods to assess the impacts. The research on tsunami received gradual attention especially after 2004 (Nakamura, 1980; Nakamura, 1978; Latter, 1981; Koshimura et al., 2009; Imamura et al., 1995). There are also a small numbers of publications related to landslides (Fathani et al., 2016; Karnawati et al., 2011; Liao et al., 2010) (Figure 2).

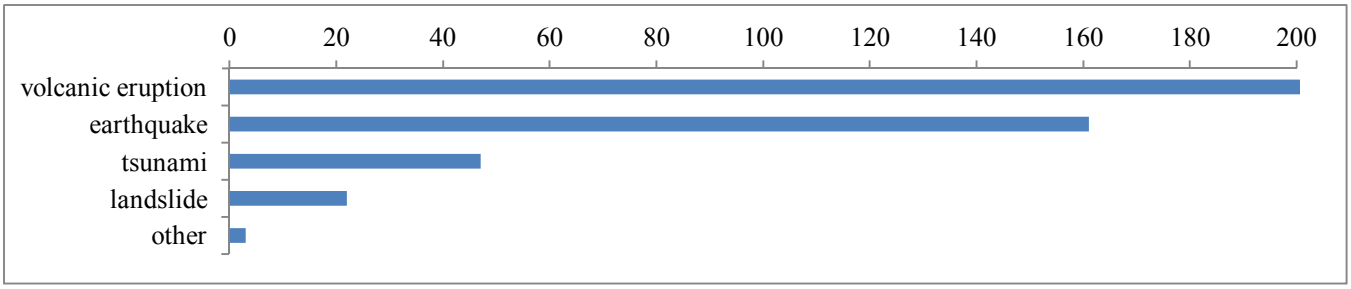

Figure 2 Key Topics in HRD Category (Source; modified from SCOPUS results)

3.3.2 Disaster risk reduction (DRR)

The second sub-section is on the topic of disasters risk reduction (DRR). In this study, DRR included those strategies that are aimed at reducing disaster risks and range from risk management, risk reduction and disaster preparedness activities. The definition is listed in Table 3. There are 206 publications in this category (SCOPUS, 2016a). 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 Sumatera and Java. However, there are also studies that examine Indonesia as part of worldwide, regional or national assessments (SCOPUS, 2016a).

The earliest accounts that explicitly examine DRR include Suryo and Clarke (1985) who wrote on 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 in the vicinity of active volcanoes´* (Suryo and Clarke, 1985, p. 90).

Verstappen (1994; 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'*. An Indonesian notable 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 examine disaster from geographical and social science perspectives (Sudibyakto and Haroonah, 1997; 1992; 1996).

The topic that receive most attention in this category is related to the governance of DRR (Bakkour et al., 2015; Chang Seng, 2013; Djalante et al., 2013; Djalante et al., 2012; Guarnacci, 2012; Lassa, 2013). The next key topic is on the evaluation of recovery and reconstruction that have taken 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 that are also related to the impacts of tsunami and disasters were the role of culture, gender , or religion in helping community resilience when facing disasters, and impacts of disasters on different community groups including children and woman (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., 2009; Schlehe, 2010). Some topics were related to examination of tsunami early warning system (Schlurmann and Siebert, 2011; Steinmetz et al., 2010). There are also a large number of publications which 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 regards the impacts of the tsunami on how it either become the precursor for peace process in Indonesia but still take time for the process in Sri Lanka (Enia, 2008; Gaillard et al., 2008a; Hyndman, 2009; Kelman, 2005). Some lower numbers of papers examine community-based DRR which is strongly 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 from continuous exposures to hazards and disasters (Du et al., 2012; Lawler and Patel, 2012; Taylor and Peace, 2015; Vignato, 2012), and on 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 DRR category.

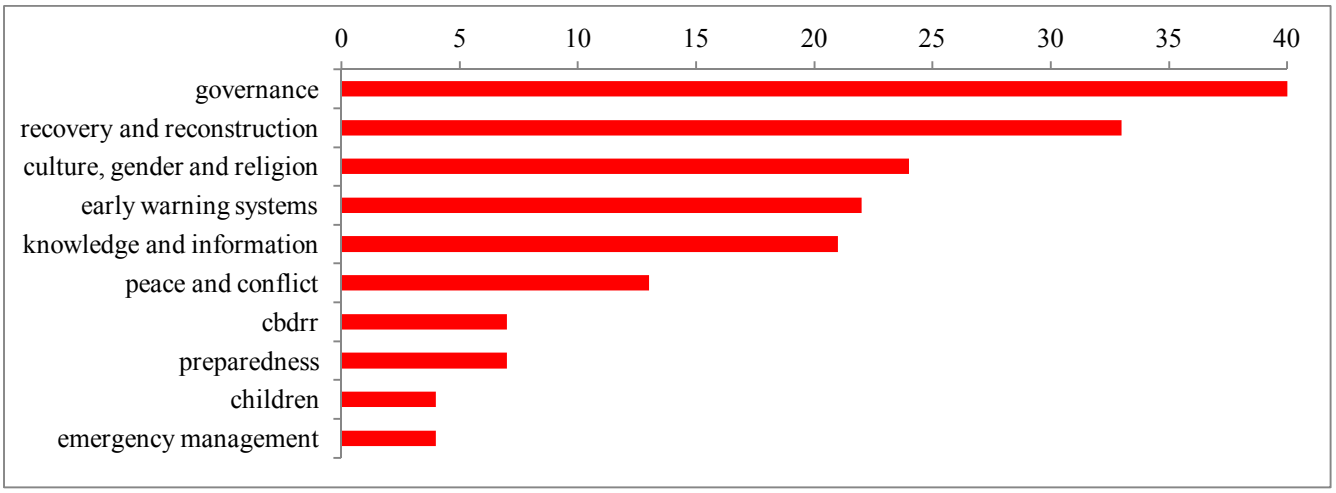

Figure 3 Key Topics in DRR Category (Source; modified from SCOPUS results)

3.3.3 Climate change risks, vulnerability, impacts and adaptation (CC)

The third sub-section is related to climate change risks, vulnerability, impacts and adaptation. 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 in different sectors such as agriculture, forestry, water and health. This has been done since the current Sendai Framework for Action calls for multi-risks perspectives (UNISDR, 2015). There are 182 publications in this category (SCOPUS, 2016a). 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, and then there were 5 pieces published in 2001. These are related to examinations of the causes and impacts of forest fires in Indonesia. The numbers of publications did 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 at 35 papers. The islands of Sumatera and Java has 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 are 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 (SCOPUS, 2016a).

Some earliest publication were written in 1992 by Subijakto (1992) who wrote Facts and Future Trends of Climate Change: A Case Study of the Eastern Part of the Indonesia Islands, and by Murdiyarso (1993) who examined the management of climate change impacts to reduce CO_2 release resulting from deforestation and biomass in Indonesia. The author categorizes the 182 publications in this group into three major discussions related to the impacts of climate change on Indonesia (almost 60%), the governance of climate change adaptation (less than 25%), and issues of deforestation and land degradation which had enormous impacts on the Indonesian rain forest. Indonesia houses some of the largest areas of rainforest in the world, especially on the islands of Sumatera and Kalimantan. Since the majority of materials published in

this category are related to the review of the impacts on climate change in Indonesia, this paper takes a deeper on those literatures (Figure 4). The impact on crop production, particularly rice, has been the subject of the majority of climate impact researches (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). This is strongly related to the examination of flood (Marfai and King, 2008; Marfai et al., 2008; Marfai et al., 2015, 2014; Muis et al., 2015; Neolaka, 2013, 2012; Sarminingsih et al., 2014; Shrestha et al., 2014) or droughts in Indonesia (Aldrian and Djamil, 2008; D'Arrigo and Smerdon, 2008; D'Arrigo and Wilson, 2008; D'Arrigo et al., 2006; Keil et al., 2009; Keil et al., 2008). A high number of publications also concern the link between droughts (Salafsky, 1994; D'Arrigo et al., 2006; D'Arrigo and Smerdon, 2008; Shofiyati et al., 2014) and fire occurrences (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), especially forest fires. There is also research on sea level rise and its impacts on coastal areas (Budiyono et al., 2016; Ward et al., 2013; Firman et al., 2011; Wassmann et al., 2009; Nicholls et al., 1995). A small number of research focuses on temperature, rainfall (D'Arrigo and Wilson, 2008; Aldrian and Djamil, 2008; Chrastansky and Rotstayn, 2012). The impact of climate change on health (Coughlan de Perez et al., 2015) and animal (Purnomo et al., 2011; Morwood et al., 2008) has also received some attention. Figure 4 summarizes the findings.

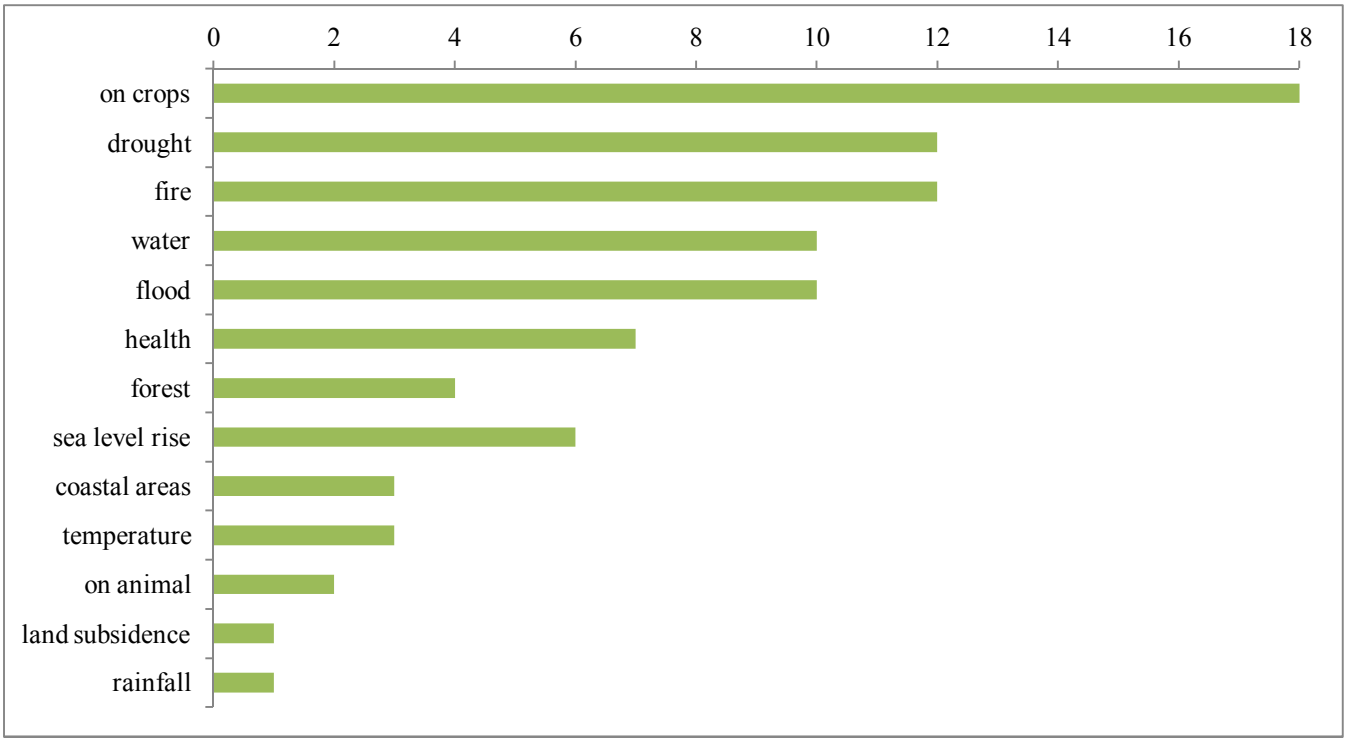

Figure 4 Key Topics in CC Category Researching on Impacts of Climate Change (Source; modified from SCOPUS results)

3.2 Roles of Indonesian Researchers and Organizations

This sub-section examines the roles of Indonesian researchers and organizations in contributing to the production of literature. It also address to what extent Indonesian researchers have been collaborating with other international/non-Indonesian researchers and organizations, and also in producing high impact English journal articles. The roles of authors are examined in general term, and also specifically looking at the 10 highly cited papers with Indonesian as first author. Studies on the roles of international and local authorships and collaborations show that although it rapidly increasing, there are still more efforts needed to strengthen and advance those collaborations (Bordons et al., 1996; Wagner and Leydesdorff, 2005b, a; Gazni et al., 2012). It further shows that there is still imbalance in the ratio of male to female scientists, as the global trends also show (Sidhu et al., 2009; Lewison, 2001; Koppel et al., 2002; Sugimoto et al., 2013). The importance of science communication and the increasing demand for researchers to publish their works outside of traditional methods such as journal articles, but also through blogs, websites, policy briefs, and popular media is now encouraged (Gu and Widén-Wulff, 2011; Thelwall et al., 2013; Bik and Goldstein, 2013).

3.2.1 Authorships

The review finds that out of the 3,000 names obtained from the Scopus search, there are more than 2 international authors for every Indonesian author. The contribution of international/non- Indonesian authors dominates the production of publications. 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 less than 100 authors with more than 2 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 social media account such as Google Scholar (Google, 2016a) or Research Gate (Research Gate, 2016b) or professional and personal websites. Figure 5 summarizes the roles of Indonesian authors within each publication category (HRD, DRR, CC). The figure shows that there are more authors, including Indonesian authors, in DRR category than the other two categories. This implies that there is room for increasing the involvement of Indonesian authors writing about various issues related to DRR, and also a greater opportunity for developing social science in DRR. From this it is clear that more Indonesians need to be involved in international publications and specific interventions are needed to enhance writing, publication and outreach skills.

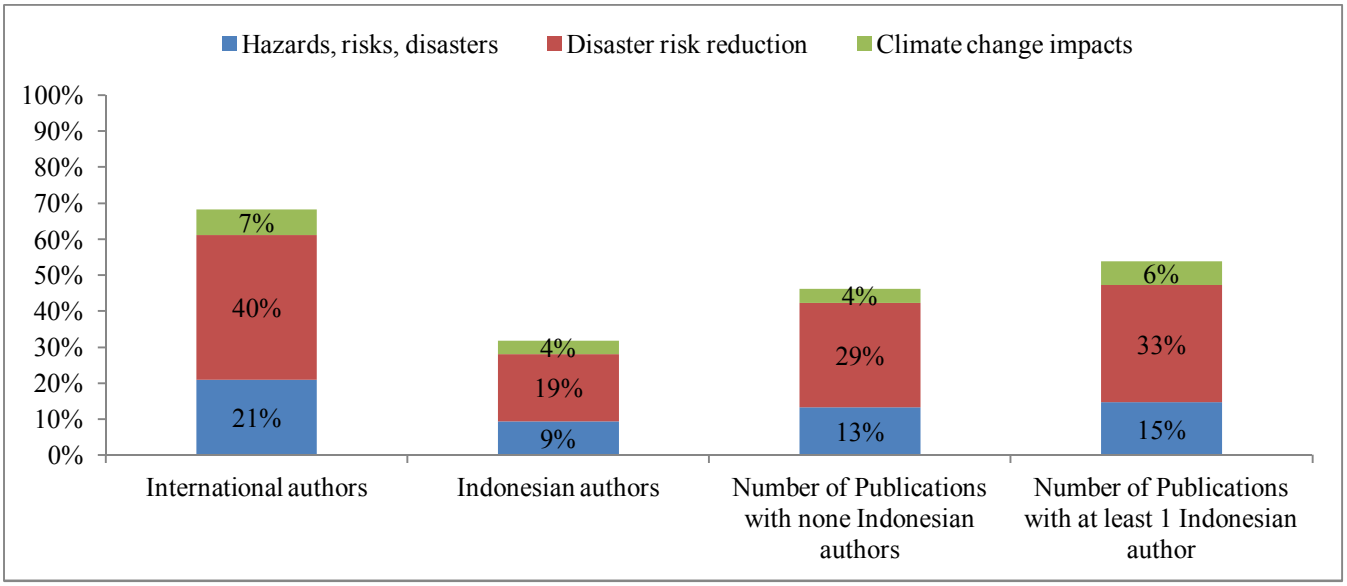

Figure 5 Comparing the Roles of International and Indonesian Authors in Each Publication category (source: modified from SCOPUS results)

Table 3 compares the list of the top ten authors with highest number of publications and also the Indonesian authors with the 10 highest publications. Highest in the list is Abidin of the Bandung Institute of Technology (ITB), with 71 publications listed in Scopus, while his Google scholar profile shows that he has published 172, with 1709 citations (Google Scholar, 2016b). Lavigne from Université Paris 1 Pantheon Sorbonne published the second highest numbers of papers (Google Scholar, 2016a). Lavigne worked closely with Thouret from Laboratory Magmas et Volcanis (LMV, 2016). Gertisser is a senior lecturer in Keele University (Google Scholar, 2016d). Natawidjaja works for Indonesian Institute of Science (LIPI) (Google Scholar, 2016c) but did his bachelor study from ITB. Sieh, from Earth Observatory of Singapore (EOS), has long collaborated with Natawidjaja on their works on seismology in Indonesia (EOS, 2016). Voight is a renowned geologist and volcanologist in USA who has worked on the Mount Merapi since the 1980s (Google Scholar, 2016e). Suwargadi is affiliated with LIPI and Surono works for the Center for Volcanology and Geological Hazard Mitigation (PVMBG, 2016). Table 3 also shows the top 10 Indonesian authors. In addition to the 5 Indonesians in the top 10 authors, Meilano, Andreas and Gumilar have worked closely with Abidin, and are all affiliated with ITB. Marfai and Sartohadi are from the Gadjah Mada University (UGM) and Ratdomopurbo works for Volcano Technology Research Centre (BPPTK) Yogyakarta and also graduated from UGM. This result shows a great deal of need for increasing the capacity of Indonesian authors meet standards for internationally regarded journal publications. In particular, 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 centered on ITB, UGM, LIPI and PVMBG. Despite some Indonesian researchers who have 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 did not submit their works into international mostly English language journals.

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Table 3 List of Top Ten Authors with Highest Number of Publications, and Top Ten Indonesian Authors (SCOPUS, 2016a; Google, 2016b; Research Gate, 2016a)

Note: NoP =Number of Publications, SC= SCOPUS Profile (publications, citations, h-index, co-authors, most frequent collaborator), GS = Google Scholar profile (citations, h-index, i10-index), RG = Research Gate profile (publications, citations, impact points), N/A = Not Available

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Top 10 Author (I=Indonesian)	Organization / Country	NoP	SC	GS	RG	Top 10 Indonesian Author	Organization	NoP	SC	GS	RG
Abidin, Hasanuddin Zainal (I)	Indonesia / Institute Teknologi Bandung (ITB)	71	71, 571, 11, 150, Andreas H	172, 1709, 21, 41	119,773,99.21	**Abidin, Hasanuddin Zainal**	ITB	71	71,493, 11, 121, Andreas H	N/A	119,773,99.21
Lavigne, Franck	France / Université Paris 1 Panthéon Sorbonne	59	66, 1356, 20, Wassmer, P	124, 1648, 21, 34	153, 1,430, 162.61	**Meilano, Irwan**	ITB	47	46,299,10, 143, Kimata, F	514,11,14	24,69,
Sieh, Kerry.	Singapore / Earth Observatory of Singapore	54	120, 5752, 43, more than150, Natawidjaja, DH	N/A	N/A	**Natawidjaja, Danny Hilman**	LIPI	43	43,1913, 21, 123, Sieh KE	147, 2964, 25, 33	123, 2788, 376.31
Natawidjaja, Danny Hilman (I)	Indonesia / LIPI (Indonesian Institute of Science)	43	42, 1913, 21,123, Sieh KE	147, 2964, 25, 33	123, 2788, 376.31	**Suwargadi, Bambang Widoyoko (I)**	Indonesia / LIPI	31	31, 1102, 17, 103, Natawidjaja, DH	97, 1585, 20, 24	N/A
Thouret, Jean-Claude	France / Laboratory Magmas er Volcanis	40	114, 1147, 20, More than 150,Gourgaud, A	N/A	N/A	**Surono (1 name only)**	PVMBG	28	28,348, 12, 125, Hendrasto M	N/A	N/A
Voight, Barry	USA / Pennsylvania State University	36	313,8185,53,128	250 5,307 570.75		**Andreas, Heri**	ITB	24	24,123, 6, 46, Abidin, H Z	N/A	N/A
Gertisser, Ralf	United Kingdom / Keele University	32	42,684,468,14,aboce150,Charbonnier SJ	86,1009, 19, 29	87 803 132,51	**Marfai, Muh.Aris**	Gadjah Mada University (UGM)	21	183, 8, 36, King, Lorenz	79, 517, 12, 14	N/A
Suwargadi, Bambang Widoyoko (I)	Indonesia / LIPI	31	31, 1102, 17, 103, Natawidjaja, DH	97, 1585, 20, 24	N/A	**Gumilar, Irwan**	ITB	20	20,68,3,44, Abidin HZ	N/A	N/A
Surono (I)	Indonesia / PVMBG (Center for Volcanology	28	28, 448, 13, 129, Hendrasto M	N/A	N/A	**Sartohadi, J**	UGM	19	19,378, 8, Lavigne, F	N/A	N/A

Top 10 Author (I=Indonesian)	Organization / Country	NoP	SC	GS	RG	Top 10 Indonesian Author	Organization	NoP	SC	GS	RG
	and Geological Hazard Mitigation)										
Andreas, Heri (I)	ITB	24	123, 6, 46, Abidin, HZ	N/A	N/A	**Hendrasto Muhamad**	PVMBG	18	18,92, 4, Surono	N/A	N/A
Total		416						306			

3.2.2 Affiliations

This section systematically examines the place, from regional to national, and organizations by which the researchers are affiliated in Indonesia. The organizations which house the ten most productive publications related to this review are shown in Figure 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 the Bandung Institute of Technology (ITB) and Gadjah Mada University (UGM) dominate almost half the total publications. There are also more twice universities in Java that those outside Java, while the rest of publications are contributed by national level organizations such as the Indonesian Institute of Science (LIPI) and Center for Volcanology and Geological Hazard Mitigation (PVMBG).

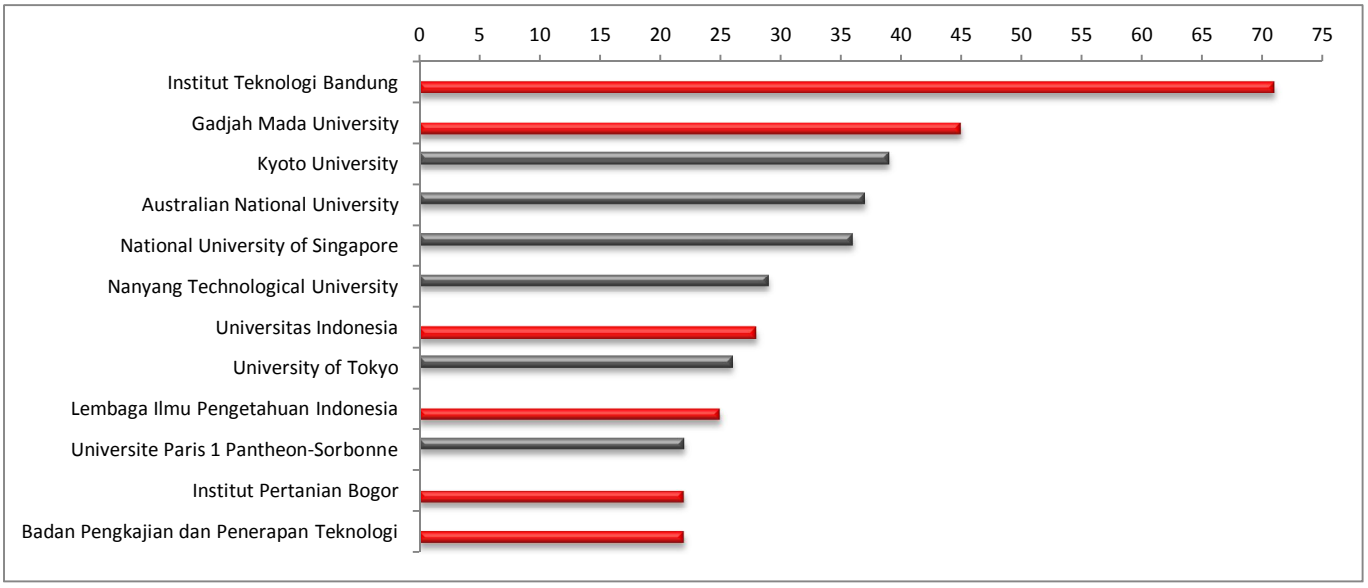

Figure 6 Organizations with Highest Number of Publications (Indonesian Organizations marked in Red) (source: modified from SCOPUS results)

3.2.3 Publications sources

This section presents the source of publications. It is clear that the great majority of publications from journals are those that got indexed, compared to conference proceedings, books, or others. A closer look at the journals shows those related to geophysical hazards (volcanoes, earthquakes, tsunami, etc) identification and assessments dominate the numbers of papers published on Indonesia (Table 4).

Table 4 List of most submitted journals (source: modified from SCOPUS results)

Publications	Number of papers	IF / SJR	Category		
			HRD	DRR	CC
1. **Journal of Volcanology and Geothermal Research**	75	2.543	x		
2. **Natural Hazards**	39	1.719	x	x	
3. **Natural Hazards and Earth System Science**	27	1.735	x	x	
4. **Bulletin of Volcanology**	22	2.519	x		
5. **Geophysical Research Letters**	17	4.196	x		
6. **Earth and Planetary Science Letters**	16	4.734	x		
7. **Pure and Applied Geophysics**	15	1.618	x		
8. **Nature**	14	41.456	x		x
9. **Journal of Disaster Research**	14	SJR 0.18		x	
10. **Journal of Geophysical Research: Solid Earth**	12	3.426	x		
11. **International Journal of Disaster Risk Reduction**	12	SJR 0.510		x	x
12. **Bulletin of the International Institute of Seismology and Earthquake Engineering**	12	SJR 0.12	x		

A very striking finding, however, the Indonesian Journal of Geography is the only Indonesian journal that is found this review. The journal was established in 1961 by the Faculty of Geography, UGM in cooperation with the Association of Indonesian Geographers (UGM, 2016). There are no clear counts on the number of academic journals in Indonesia, however, there are only 245 accredited by DIKTI (Higher education directorates of the Ministry of Education) (DIKTI, 2016b) and 17 indexed in SCOPUS (DIKTI, 2016a). In addition, none of these journals have yet obtained an impact factor, and hence a Scientific Journal Ranking (SJR) Score is presented instead (SJR, 2016).

3.2.4 Citations

This section analyzes 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 of the citation averages, however, shows quite a different story. Whilst the CC literature category has the least number of papers published (194), the citation average is twice 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; Hu, 2009). 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 needed to expand their collaborations with international scholars as a strategy to increase their number of citations and ability to submit for higher impact journals.

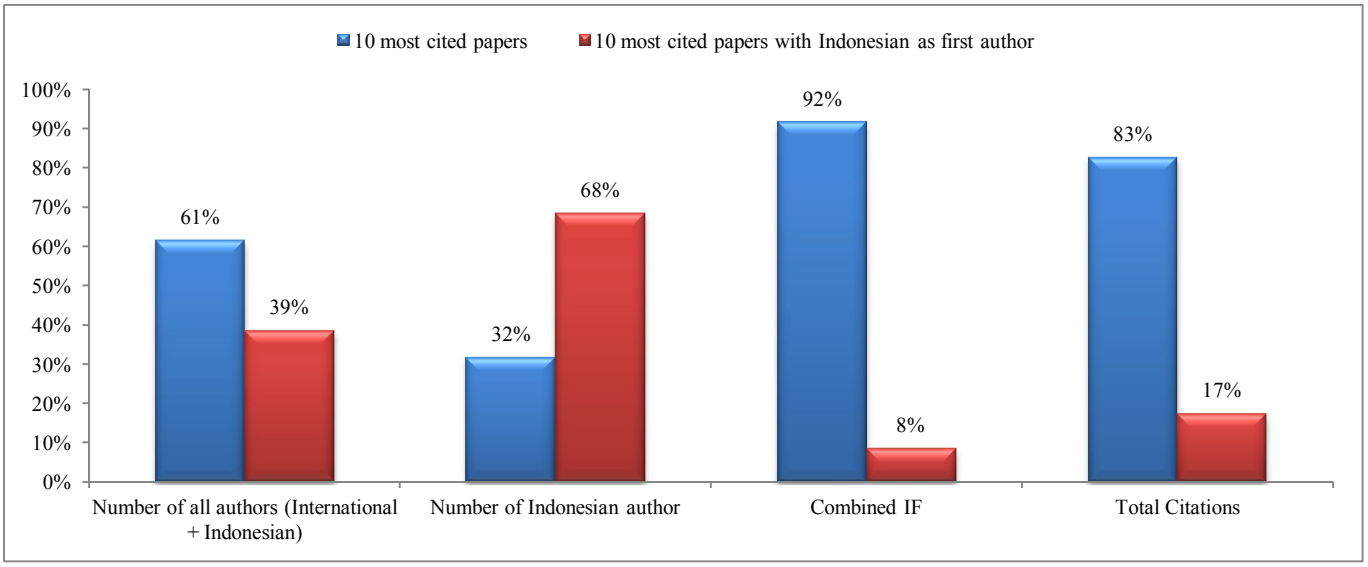

Figure 7 Comparing the Roles of Indonesian Researchers in the 10 Most Cited Papers (source: modified from SCOPUS results)

Table 5 shows the list of the 10 most cited papers of all publications. Within the 10 most cited papers, the total citations are 4,204 with a combined impact factor (IF) of 293.618, and only one third of the authors are Indonesian. The citation is three times of those first authored by Indonesians, and the IF is 4 times greater. It is shown that they are published in high impact factor journals such as Nature, Science, or those related to geophysical hazards. The two highest 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 citation of 1287 by Page et al (2002). The majority of the papers discuss major hazards from the earthquake in Sumatera (Ishii et al., 2005; Briggs et al., 2006; Hsu et al., 2006; Konca et al., 2008), to 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 was involved in five of them. Jaya and Limin are both lecturers from the Palangkaraya University in Kalimantan, where forest fires 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; Nalbant et al., 2005; Philibosian et al.,

2012; Prayoedhie et al., 2012; Schlurmann et al., 2010; Singh et al., 2010).

A closer examination of the list of ten most cited publications with Indonesian first authors shows a very striking picture. The total citations is only 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 (2003), Susanto (2003; 2001) and also Amien et al (1996) authored papers related to climate change or its impacts on Indonesia. Natawidjaja (Natawidjaja et al., 2006; Natawidjaja et al., 2004) and Abidin (Abidin et al., 2001; Abidin et al., 2011) both have 2 papers to contribute each within the list of most cited papers first authored by Indonesian 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 or Jakarta (Marfai and King, 2008; Marfai et al., 2008; Marfai et al., 2015; Ward et al., 2013; Marfai, 2014; Marfai and King, 2007). This table shows that in generals, Indonesia 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 which also show how social science perspectives needed to be taken up by the Indonesia researchers in dealing with the management of disaster risks and disaster risks in Indonesia.

420 **Table 5 Comparing Citations Authored in General and Those First Authored by Indonesian in 10 Most Cited Papers (source: modified from SCOPUS results)**

Note: Y=Year, J=Journal, C=Number of Citations, IF=Journal impact factors, I=Indonesia author (marked at the authors column)

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., Siegert F., Rieley 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), Dwi Susanto R. (I)**	Identification of three dominant rainfall regions within Indonesia and their relationship to sea surface temperature	2003	Internatio nal Journal of Climatolo gy	344	3.609
Siegert 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, JP, 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	Geophysi cal 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	Internat ional Journal of Climato logy	343	3.157	**Danny Hilman Natawidjaja (I), Kerry Sieh, Mohamed Chlieh, John Galetzka, Bambang W Suwargadi (I), Hai Cheng, R Lawrence Edwards, Jean-Philippe Avouac, Steven N Ward**	Source parameters of the great Sumatran megathrust earthquakes of 1797 and 1833 inferred from coral microatolls	2006	Journal of Geophysi cal Research: Solid Earth	156	3.318
Subarya, C (I), Chlieh, M, Prawirodirdjo, L (I), Avouac, JP, Bock, Sieh,	Plate-boundary deformation associated with the great Sumatra-	2006	Nature	343	41.456	**Danny Hilman Natawidjaja (I), Kerry Sieh, Steven N Ward, Hai Cheng, R**	Paleogeodetic records of seismic and aseismic subduction from central Sumatran	2004	Journal of Geophysi cal Research: Solid	119	3.318

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**
Meltzner, Natawidjaja (I), McCaffrey	Andaman earthquake					**Lawrence Edwards, John Galetzka, Bambang W Suwargadi (I)**	microatolls, Indonesia		Earth		
Rampino M.R., Self S.	Volcanic winter and accelerated glaciations following the Toba super-eruption	1992	Nature	333	41.456	**Hasanuddin Z Abidin, Rochman Djaja, Dudy Darmawan, Samsul Hadi, Arifin Akbar, H Rajiyowiryono, Y Sudibyo, I Meilano, MA Kasuma, J Kahar, Cecep Subarya (All Indonesian)**	Land subsidence of Jakarta (Indonesia) and its geodetic monitoring system	2001	Natural Hazards	103	1.719
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 tephrostratigraphic framework at Merapi Volcano, Central Java, Indonesia: Implications for eruption predictions and hazard assessment	2000	Journal of Volcanology and Geothermal Research	81	2.543
C Vigny, WJF Simons, S Abu, Ronnachai Bamphenyu, Chalermchon Satirapod, Nithiwatthn Choosakul, C Subarya, A Socquet, Kamaludin Omar, HZ Abidin, BAC Ambrosius	Insight into the 2004 Sumatra–Andaman earthquake from GPS measurements in southeast Asia	2005	Nature	329	41.456	**Marfai, M. A. (I), and King, L**	Monitoring land subsidence in Semarang, Indonesia	2007	Environmental Geology Journal of Geophysical Research: Solid Earth	68	3.318
Hsu Y.-J., Simons M., Avouac J.-P., Galeteka J., Sieh K., Chlieh M., Natawidjaja D. (I),	Frictional afterslip following the 2005 Nias-Simeulue	2006	Science	271	33.61	**Marfai, M. A. (I), and King, L**	Potential vulnerability implications of coastal inundation due to sea level rise	2008	Environmental Geology Journal of Geophysi	59	3.318

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**
Prawirodirdjo L. (I), Bock Y.	earthquake, Sumatra						for the coastal zone of Semarang city, Indonesia		cal Research: Solid Earth		
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	**Muh Aris Marfai, Hussein Almohammad, Sudip Dey, Budi Susanto, Lorenz King**	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), Rejekiningrum 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**

4 Conclusions and recommendations for future research

This paper has presented the results of a systematic literature review from Scopus to on the current research trends and progress related to natural hazards, disasters, and disaster risks 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 since 2000. It is found there are more publications on HRD, than those on DRR and CC. Moreover, there are twice international authors for every Indonesian author and the contribution of international authors dominates the production of publications. Male and advanced career authors still dominate, compare to the numbers and roles of female and early career researchers (ECR). Most of the high impact publications and international collaborations were conducted with the key institutions centered on ITB, UGM, LIPI and PVMBG. In addition, there are very few researchers have social media accounts such as Google Scholar (Google, 2016a) or Research Gate (Research Gate, 2016b) or professional and personal websites.

The first part of the recommendations 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. Majority of current research is still focused on geophysical hazards and those related to hydro-meteorological hazards have only received attention recently. Multi hazard, risks and vulnerability assessments are suggested. It has been seen that majority of research focuses on the Islands of Java and Sumatera. This is expected since both islands are the most at risks from natural hazards in Indonesia. However, other islands in Kalimantan, Sulawesi, Maluku and Papua in the eastern part of Indonesia have also been impacted by droughts, floods or strong winds and needs to be addressed in the future. The impacts of sea level rise on small islands, drought on forests in Kalimantan and Papua, raising sea level and ocean acidification on fisheries industry in Sulawesi and eastern part of Indonesia, are some of the increasingly worrisome issues expected from climate change. As the world is increasingly urbanized, there is strong international attention focusing and reducing risks in urban areas, in particular through concerted action in the New Urban Agenda (UN HABITAT, 2016). More research need to take into account the context of urban areas by which social risks and risks from natural hazards play out simultaneously, and the impacts on urban dwellers needs to be understood. Cities in Indonesia like Jakarta, Surabaya or 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). Disaster risk governance has not received much research especially on the interplay with decentralization which places responsibility for DRR and risk management at the local government level (Lassa, 2013; Kusumasari et al., 2010). Strategies and actions for integrating DRR and CCA need to be explored further (Djalante and Thomalla, 2012; Lassa and Nugraha, 2015) There is still greater need for research on climate change topics related to linkages between poverty and disaster vulnerability (Suryahadi and Sumarto, 2003), security (CSIS, 2016), loss and damages (Warner et al., 2012), impacts on key sectors such as fisheries (USAID Indonesia, 2015), coastal communities (Marfai, 2014; Marfai et al., 2008), food security (Measey, 2012; WFP, 2015) health (Ady Wirawan, 2010; Haryanto, 2009), migrations (Raleigh et al., 2008;

Reuveny, 2007), and community-based DRR (Heijmans, 2012). Many activities done by international and development agencies on their implementations for DRR or CCA programmes have focused on the community level. There is abundance of activity reports by donor and international agencies (e.g. USAID, 2016; USAID Indonesia, 2011, 2015); however, those reports are rarely made available or submitted for academic publications. There is abundance of materials within Indonesian repositories related to *bencana* (Indonesia word for disaster), especially within the repositories at ITB, UGM, and University of Syiah Kuala in Aceh. These materials and research activities done within the universities need to be reviewed and submitted for international journals in order to give a broader view on issues that have been discussed by scholars in Indonesia.

The next recommendation is on the need to strengthen the capacity of research collaborations between Indonesian and international researchers, multi disciplinarity research and publications in high impacts journals. It is clear that some of the very limited Indonesian research from key universities doing disaster research such as the Bandung Institute of Technology (ITB), Indonesia Institute of Science (LIPI), the Gadjah Mada University (UGM) have been involved in international collaborations and publications of high impacts journal (QS, 2016). There are only nine universities in Indonesia that are within the list of QS World University Rankings, with 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 (RISTEKDIKTI, 2016), however, the overall quality and quantity of papers by Indonesian researchers are still much less that those at comparable universities in Malaysia or Singapore (RISTEKDIKTI, 2016). The list from Scopus shows that there is still only small numbers of female and early career researchers (SCOPUS, 2016a). The first stage is to have proper identification of researchers and make this available to 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. There have been some concerns to strengthen the capacity of female researchers globally (Larivière et al., 2013), and also similarly in Indonesia. Early career researchers (ECR) are defined as those who are within 8 years after completing PhDs or within 6 years of trainings (AHRC, 2016). While globally there has been some systematic efforts to strengthen the capacity of ECR such as through mentoring (Clarke, 2004; Kram and Isabella, 1985), there are no clear strategies for the Indonesian ERC from the Indonesian governments. International journals (Elsevier, 2016) and international and other national research council (RCUK, 2016) have allocated resources and are funding research specifically for ECR. The Indonesian Association of Disaster Experts was formed in 2014 and meets annually to discuss their future research guidelines (IABI, 2016). 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 increasing call for more inter-disciplinary collaborations so that complex problems on social and environmental issues can be understood better and

problems identifications can better target those in needs (Future Earth, 2016). Hence this implies increasing importance of social science 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, 2005a), policy and industry (Lee, 1996) collaborations have taken place and were 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 hazards, 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 both of the Indonesian and international organizations that have worked and will work in Indonesia to be able to meet the needs in order for Indonesia to better understand, manage, and reduce its natural hazards and risks in the future and ultimately build a resilient and sustainable nation.

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