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A COMPARATIVE STUDY OF TSUNAMI TRENDS IN INDONESIA AND TAIWAN OVER A DECADE

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ABSTRACT

Tsunami is one of the deadliest disasters in the world. Tsunamis in Indonesia (TI) and Taiwan (TT) are now wide open in all research fields. The purpose of this study is to analyze a comparison of research related to TI and TT from 2013-2023. This study used bibliometric analysis with metadata collected from the Scopus database and visualized using VOSviewer and Biblioshiny-Bibliometrix. The findings of this study indicate that the trend of research related to TI is more consistently increasing linearly than research on TT from 2013-2023. Citation trends per year in TI and TT research vary depending on the popularity of research topics and the impact of publications. The most dominant trend keywords used are Tsunami, Indonesia, and Taiwan. The authors who contributed the most to TI research were Syamsidik and Wu TR in TT research. Indonesia and China are countries that contribute and collaborate a lot. The highest and most relevant sources in TI research are the IOP Conference Series Earth and Environmental Science and Terrestrial Atmospheric and Oceanic Sciences in TT research. Syiah Kuala University and National Central University are top TI and TT research affiliations. Based on the network visualization, there is a very close relationship between tsunamis and earthquakes. This research aims to demonstrate the popularity of writing about Taiwan's and Indonesia's tsunamis so that future research might demonstrate more advantages of this subject. Researchers can learn about the advantages and disadvantages of each subject and discover updates for additional research with the help of this article. Recommendations for future researchers are to conduct research related to tsunamis and earthquakes with in-depth studies because of the high potential for further research.

Keywords: Disaster, Tsunami, Indonesia, Taiwan, Bibliometric

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1. INTRODUCTION

One of the deadliest disasters in the world is the tsunami. Tsunamis occur when huge sea waves are formed (Sari & Soesilo, 2020) and propagate toward the coast (Sudaryatno et al., 2022; Suppasri et al., 2017), often caused by earthquakes under the sea (Pongponrat & Ishii, 2018), volcanic eruptions (Nagata et al., 2022), or underwater landslides (Imamura et al., 2019). The waves can reach hundreds of meters high and travel at high speeds. Tsunamis can cause enormous physical damage (Adriano et al., 2021; Suppasri et al., 2021), including damage to buildings and infrastructure (Moon et al., 2022), and take lives (Adriano et al., 2021; Ahmadun et al., 2020; Sudaryatno et al., 2022; Sugawara, 2021).

Indonesia and Taiwan have a relatively large potential for a tsunami disaster because both are located in the Pacific Ring of Fire (Masum & Ali Akbar, 2019), known as seismically active areas (Klug, 2021; Martire et al., 2023). Earthquake activity in this region can trigger dangerous tsunamis (Fuady et al., 2021). Indonesia experienced its biggest tsunami disaster in 2004, caused by a magnitude 9.1 earthquake off the coast of Sumatra. This tsunami killed more than 230,000 people in 14 countries. Meanwhile, in Taiwan, the biggest tsunami disaster occurred in 1946 when an earthquake measuring 8.1 on the Richter scale shook the east coast of Taiwan (Cheng et al., 2023b). A tsunami more than 10 meters high hit coastal areas, killed around 2,000 people and damaged many houses and infrastructure (Cheng et al., 2023a; Yu et al., 2022).

Research on tsunamis is ongoing to deepen our understanding of tsunamis and how to reduce their associated risks. Such as research conducted by many researchers recently, such as by Alex et al. (2023) regarding perspectives from Nanggroe Aceh Darussalam, Indonesia, on women in local politics. Rana & Akbar (2023) reviewed submerged floating tunnel research advancements. A Narrative Review of Infectious Diseases in the Post-Disaster Period With a View to Disaster Risk Reduction: The Effect of Earthquakes on Public Health has also been done by Mavrouli et al. (2023). Moreover, Roy and Matsagar (2023) researched on “structures' multi-hazard design and analysis: current state of the art and future directions”. Then, Bhardwaj & Singh (2023), reviewed landslip susceptibility assessment using GIS and remote sensing. Srinivasa Kumar & Manneela (2021) have also reviewed Tsunami Early Warning Systems' Development, Issues, and Future Trends.

Therefore, a bibliometric analysis related to trend and visualization research of tsunamis in Indonesia and Taiwan is a novelty in this study. Bibliometric research on tsunamis is essential to provide a better understanding of research trends and directions. By using bibliometric analysis techniques, it is possible to identify the most relevant publications and the most cited research in the tsunami disaster field (Suprpto et al., 2021, 2022). In addition, bibliometric research also helps understand the interrelationships between different research topics and sub-fields (Hidaayatullaah & Suprpto, 2022) in the context of the tsunami disaster. It can help improve collaboration and exchange of information between researchers and strengthen early warning systems and mitigation strategies to reduce the impact of the tsunami disaster.

This research aims to compare tsunami trends in Indonesia and Taiwan over a decade using bibliometric analysis techniques. The specific research objectives are:

- a) Comparing research trends related to TI and TT during 2013-2023.
- b) Analyze comparing top productive and author impact in TI and TT research.
- c) Identify comparisons of co-authorship and collaboration countries in TI and TT research.

- d) Analyzing comparisons of top source fields, affiliations, and countries contributing to TI and TT research.
- e) Analyzing top cited global in TI and TT research during 2013-2023.
- f) Analyze mapping visualization and updates information about TI and TT.

2. RESEARCH METHOD

The research method is bibliometric research using descriptive analysis by tracking the frequency and impact of citations to scientific publications, authors, and institutions. Bibliometric analysis analyzes and evaluates the performance of these parties (Hidaayatullaah et al., 2021; Schiuma et al., 2023; Suprpto et al., 2021; Yang et al., 2023). This study uses the Scopus database (www.scopus.com). Scopus is a bibliographic database that gives users access to thousands of journals, conference proceedings, and other publications from various fields (Ali et al., 2023; Hidaayatullaah & Suprpto, 2022). This research also provides the latest updates regarding the Tsunami in Indonesia through the Meteorology, Climatology and Geophysics Agency website (<https://www.bmkg.go.id/>) and Taiwan through the Central Weather Bureau website (<https://www.cwb.gov.tw/eng/>). The four bibliometric stages, in general, are (1) data collection, (2) data cleaning and processing, (3) analysis, and (4) interpretation and visualization (J. Li et al., 2021; X. Li & Long, 2020). In this study, screening was carried out twice against the data criteria. The research analyzes TI and TT in all fields during 2013-2023. Then, the researcher determines the keywords to determine the impact or contribution of TI and TT research (Figure 1).

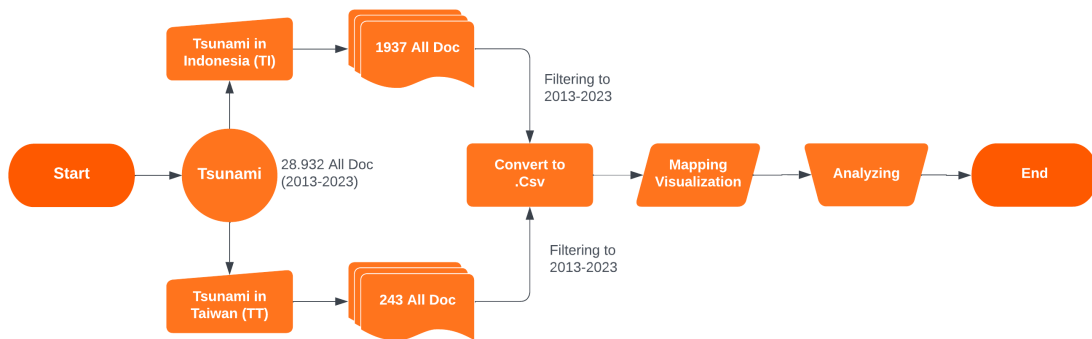


Figure 1. Research flowchart

Data was collected on April 13, 2023, and retrieved with the 2013 – 2023 limit. 28,932 all documents were obtained on searches with the keyword TITLE-ABS-KEY (tsunami). Researchers focused on searching for Tsunamis in Indonesia and tsunamis in Taiwan and obtained data for the last ten years (2013-2023), respectively, namely 1149 and 131 documents. Then, the data is downloaded in .csv format. In displaying detailed data and visualizing bibliometric assignments, the data is uploaded to the VOSviewer and Biblioshiny-Bibliometrix in R studio software. In the final stage, the data visualization results are analyzed and interpreted according to the research objectives.

3. RESULTS AND DISCUSSION

3.1 Comparison of Trends Research TI and TT during 2013-2023

Based on screening and analysis of data through Scopus metadata, it is known that research trends regarding TI and TT in all research fields during 2013-2023. This trend shows the interest of researchers to research the research subject, namely the tsunami. Research related to TI and TT in all fields in the last ten years is visualized in Figure 2.

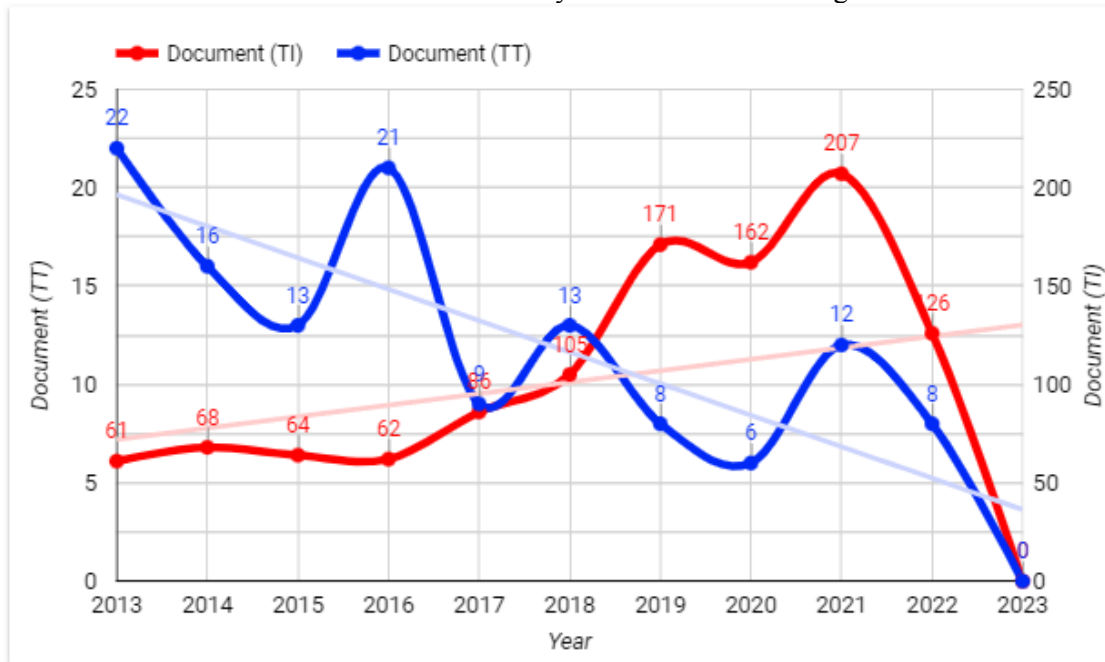


Figure 2. Comparison of TI and TT trend researches during 2013-2023

Based on Figure 2, research trends related to TI in all fields tend to increase linearly. Meanwhile, research trends related to TT tend to decrease linearly in all fields. This shows that TI-related research continues to increase and is an interesting topic for research. TI and TT documents from 2013 to April 2023 the last documents detected in 2022 with the document types of articles, books, book chapters, and review papers. The article is the most dominant type of document and is the most published at conferences.

While the trend of citations in TI and TT research from 2013 to April 2023 is presented in Table 1. The highest mean total citations per year (MTCpY) was in the TI research, namely in 2019 (3.82) and in the TT research, the highest MTCpY was in the same year at 3.84. In the TI study for MTCpY with the lowest value, namely in 2022 (0.79), and the TT study it occurred in 2013 (0.52). While the highest value in the mean total citations per article (MTCpA) in the TI study occurred in 2014 (23.41) and in the TT study it occurred in 2019 (15.38). The MTCpA with the lowest value occurs in the same year, namely 2022 in the TI (0.79) and TT (1.00) studies.

Table 1. Total citation per year and article in TI and TT research

Year	TI Research			TT Research		
	N	MTCpA	MTCpY	N	MTCpA	MTCpY
2013	61	16.07	1.61	22	5.18	0.52
2014	68	23.41	2.6	16	11.88	1.32

Year	TI Research			TT Research		
	N	MTCpA	MTCpY	N	MTCpA	MTCpY
2015	64	13.75	1.72	13	6.54	0.82
2016	62	12.29	1.76	21	5.43	0.78
2017	86	7.97	1.33	9	9.56	1.59
2018	105	8.88	1.78	13	6.23	1.25
2019	171	15.27	3.82	8	15.38	3.84
2020	162	6.71	2.24	6	3.83	1.28
2021	207	2.32	1.16	12	03.08	1.54
2022	126	0.79	0.79	8	1.00	1.00

Description.
N: Number of Documents; MTCpA: Mean Total Citation per Article; MTCpY: Mean Total Citation per Year

Annual citation trends in tsunami research can vary depending on many factors, including the popularity of the research topic, the impact of publication (Aldrighetti et al., 2019; Shanmugam, 2022), and how the research is accessed and used by the scientific community. However, in general, research on tsunamis generally has a fairly high citation trend in the first few years after publication (Suprpto et al., 2022), and then tends to decrease over time. Nevertheless, it is research on tsunamis that has significant scientific contributions. Trend keywords used in TI and TT research based on network visualization using VOSviewer are presented in Figure 3.

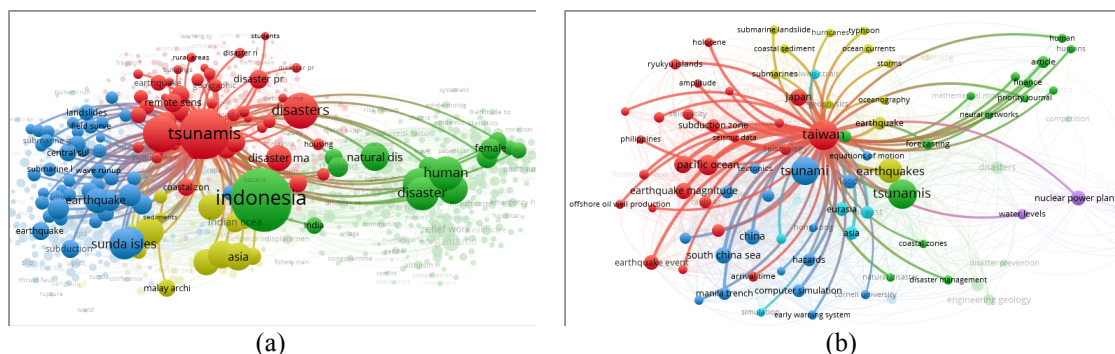


Figure 3. Trend keywords mapping in TI dan TT research during 2013-2023

Figure 3a shows that the keywords used in TI research are 4 clusters (red, green, blue, yellow) and the dominant keywords are Indonesia and tsunami. The Indonesian keyword is in cluster 2 (green) with 835 links and 10,382 total link strength. While the tsunami keyword is in cluster 1 (red) with 791 links and 7046 total link strength. In Figure 3b are the keywords used in the TT research. There are 6 clusters with the two most dominant keywords being Taiwan (cluster 1) and tsunami (cluster 3). There are 75 occurrences, 80 links, and 483 total link strengths for the Taiwan keyword. Whereas in the keyword tsunami, there are 65 occurrences, 74 links, and 431 total link strength. The use of keywords in VOSviewer can help identify trends, patterns, or groups of emerging words (Ding & Yang, 2022).

3.2 Comparison of Top Authors Productive and Impact in TI and TT Research

The metadata results on Scopus can show Authors on TI and TT research. In the TI study based on Scopus metadata through bibliometric analysis using Biblioshiny-Bibliometrix there were a total of 3346 and 437 authors in the TT study. The top 10 Authors in TI and TT research are presented in Figure 4. Meanwhile, Table 2 presents the top 10 local impact authors in TI and TT research from 2013 to 2023.

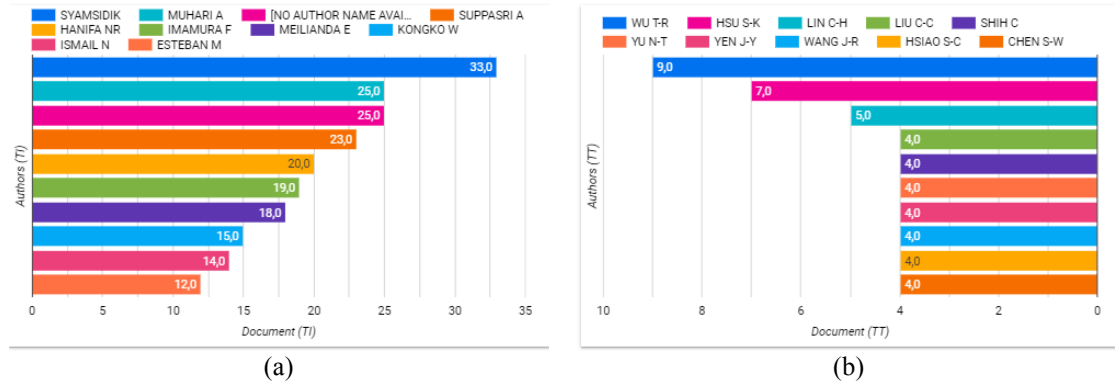


Figure 4. (a) Top 10 authors productive in TI; (b) Top 10 authors productive in TT

Table 2. Top 10 authors' local impact in TI and TT research during 2013-2023

TI Research					TT Research				
Author	h_index	g_index	m_index	TC	Author	h_index	g_index	m_index	TC
Muhari A	13	25	1.182	731	Hsu S-K	4	7	0.400	65
Syamsidik	12	22	1.091	525	Lin C-H	3	4	0.273	24
Suppasri A	11	20	1.000	431	Liu H	3	3	0.300	41
Daly P	8	9	0.889	272	Ren Z-Y	3	3	0.300	41
Esteban M	8	12	0.727	322	Wu T-R	3	6	0.273	36
Kongko W	8	15	0.800	394	Ando M	2	3	0.182	19
Fahmi M	7	9	0.778	85	Chang C-C	2	2	0.500	13
Imamura F	7	17	0.636	311	Chen G-Y	2	3	0.200	13
Mikami T	7	11	0.636	242	Chen W-S	2	2	0.182	21
Munadi K	7	9	0.636	141	Chung L-H	2	2	0.182	16

Description.
TC: Total Citation

Based on Figure 4a, it can be seen that the author who has contributed the most to TI research over the last 10 years is Syamsidik with 33 documents. The second and third positions respectively are Muhari A and no author name available with the same contribution over the last 10 years, namely 25 documents. While the top author in the TT research (Figure 4b), the biggest contribution over the last 10 years is in the first position, namely Wu T-R with 9 documents). Then followed by Hsu S-K (7 documents) in the second position and the third position is Lin C-H (5 documents).

The top 10 local impact authors on TI and TT research in the last 10 years are presented in Table 2. It can be seen that the author with the highest h-index in TI research is Muhari (13) and in TT research is Hsu S-K (4). The author also has the highest g-index scores in the

TI and TT studies, namely Muhari A (25) and Hsu S_K (7). While the highest m-index values were in the TI and TT studies respectively, namely Muhari A (1.182) and Chang C-C (0.400). The h-index, g-index, and m-index are bibliometric metrics used to measure the impact of the quality of a researcher's publications and their values vary depending on the research field, period, or data source used (Chaturbhuj & Motewar, 2021; Singh, 2022). The top three positions for authors with the most total citations in IT research in the last ten years are Muhari A (731), Syamsidik (525), and Suppasri A (431). Whereas in the TT research, namely Hsu S-K (65), Liu H (41), and Ren Z-Y (41).

3.3 Comparison of Co-Authorship and Collaboration Countries in TI and TT Research

Based on the bibliometric analysis of TI research during 2013-2023, the co-authors per document were 4.23 and 32.46 international co-authorships. Meanwhile, in the TT study, there were 4.22 co-authors per document and 22.14 international co-authorships. Collaboration network authors in the TI and TT studies are presented in Figure 5.

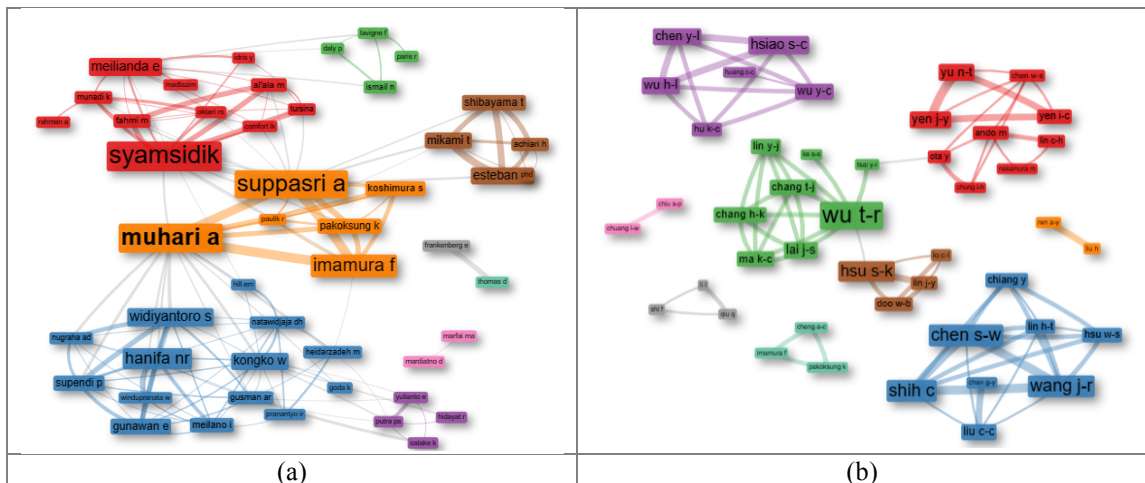


Figure 5. Co-authorship in TI and TT research

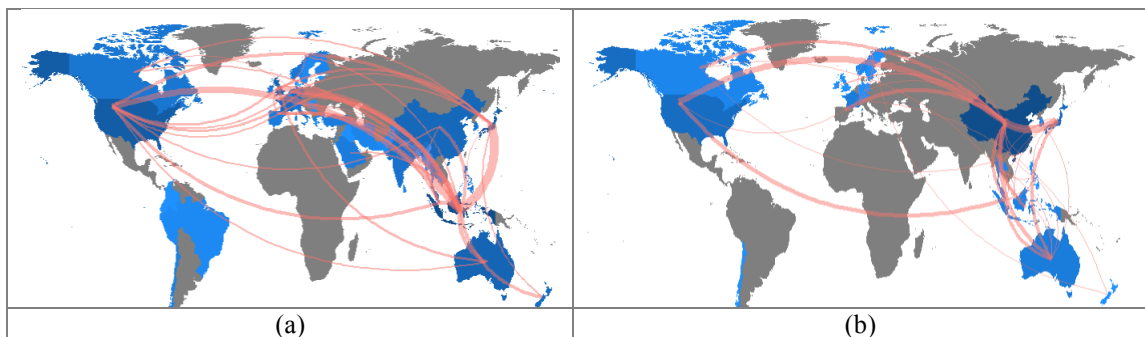


Figure 6. Collaboration network Countries in TI and TT research

Collaboration network authors are presented in Figure 5a (TI) and Figure 5b (TT). There are 9 clusters in both studies. It can be seen that in the TI research, there are 3 major clusters, namely clusters 1, 2, and 5. In cluster 1 (red) the collaboration network consists of 11 authors, namely Syamsidik, Meilianda E, Madlazim, etc. Cluster 2 (blue) consists of 14

authors, namely Hanifa NR, Konko W, Heidarzadeh M, etc. Cluster 5 (orange) has 6 authors consisting of Muhari A, Suppasri A, Imamura F, etc. Whereas in the TT study (Figure 5b) there are 4 major clusters namely clusters 1, 2, 3, and 4. In Cluster 1 (red) there are 9 authors consisting of Lin CH, Yen JY, Yu NT, etc. Cluster 2 (blue) consists of 8 authors, namely Chen SW, Liu CC, Shih C, etc. Cluster 3 (green) has 8 authors namely Wu TR, Lai JS, Tsai YL, etc and in cluster 4 (wait) there are 6 authors which include Hsiao SC, Chen YL, Wu HL, etc. In line with research by Lansford et al. (2019) namely, collaboration can improve quality, impact research, and provide greater opportunities for academic career development.

Figure 6 is a network of countries that have contributed to conducting TI and TT research over the last 10 years. The thickness of the network shows that the collaboration of researchers from these countries has contributed to and produced many documents. In Figure 6a it can be seen that in TI research, a country that contributes a lot and collaborates with other countries is Indonesia. The top 5 highest countries collaborating in TI research are Indonesia to Japan with a frequency of 102, Indonesia to USA (56), Indonesia to UK (43), Indonesia to Australia (25), and Indonesia to Germany (25). Whereas in Figure 6b, the Top 5 countries that collaborate and contribute a lot to TT research are China to Japan (8), China to the USA (6), China to Australia, France, and Singapore with the same frequency, namely 3. Collaboration between countries in TI and TT research will continue to increase every year. Because, cooperation between countries in research is very important to strengthen the capacity of researchers and institutions around the world (Zhang et al., 2022).

3.4 Most Relevant Sources, Affiliations, and Countries in TI and TT Research

A comparison of TI and TT research based on the most relevant sources and affiliations in the last 10 years is presented in Table 3. The top most relevant sources in TI research are the IOP Conference Series: Earth and Environmental Science with 187 documents in the last 10 years. Meanwhile, the top most relevant Affiliation is Syiah Kuala University with 171 documents. In contrast to TT's research, the top most relevant sources are Terrestrial, Atmospheric, and Oceanic Sciences with 7 documents and the top most affiliation is the National Central University with 64 documents.

Table 3. Sources and affiliation in TI and TT research

TI Research				TT Research			
Sources	N	Affiliation	N	Sources	N	Affiliation	N
IOP Conference Series: Earth and Environmental Science	187	Syiah Kuala University	171	Terrestrial, Atmospheric, And Oceanic Sciences	7	National Central University	64
International Journal of Disaster Risk Reduction	40	Universitas Syiah Kuala	165	Journal of Earthquake and Tsunami	5	National Cheng Kung University	25
Pure and Applied Geophysics	40	Tohoku University	121	Natural Hazards	4	National Taiwan University	17
E3s Web of Conferences	31	Institut Teknologi Bandung	120	Natural Hazards and Earth System Sciences	4	Institute of Earth Sciences	11
Journal of Physics: Conference Series	26	Universitas Gadjah Mada	108	Proceedings of The International Offshore and Polar Engineering Conference	4	Institute of Nuclear Energy Research	11
AIP Conference Proceedings	25	Nanyang Technological University	103	Seismological Research Letters	4	Ocean University of China	11
Science of Tsunami Hazards	24	Universitas Indonesia	45	Tectonophysics	4	Shanghai Jiao Tong University	10
Natural Hazards	21	Andalas University	40	Journal of Coastal	3	National Taipei	9

TI Research				TT Research			
Sources	N	Affiliation	N	Sources	N	Affiliation	N
				Research		University of Technology	
IOP Conference Series: Materials Science and Engineering	20	Bandung Institute of Technology	39	Journal of Geophysical Research: Solid Earth	3	Tohoku University	9
Natural Hazards and Earth System Sciences	16	Tadulako University	33	Applied Mechanics and Materials	2	Not reported	8

Figure 7 is a comparison of the top countries in TI and TT research. Top countries in TI research (Figure 7a) show that Indonesia is the most contributing country with 2622 frequencies. Then followed by Japan (416), the USA (391), the UK (151), and China (141). Meanwhile, the top 5 countries in TT research (Figure 7b) ranked in the top 5 consecutively, namely China (421), Japan (27), USA (19), and France (14).

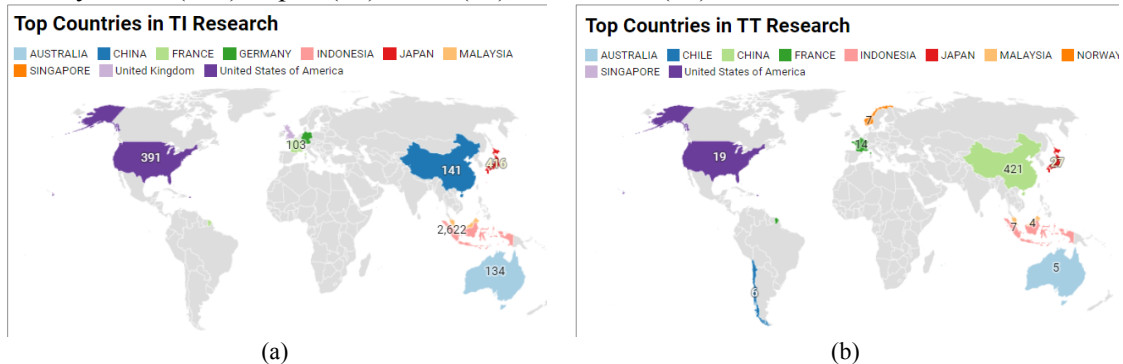


Figure 7. Comparison of top countries in TI and TT research

The State of Indonesia has contributed a lot to research related to T, both scientists, academics, and government agencies. This is because Indonesia is one of the countries where tsunamis frequently occur. Research by Arfianti et al. (2021) said that Indonesia is located on the Pacific Ring of Fire and has some active volcanoes, which makes it vulnerable to earthquakes and tsunamis. In addition, Indonesia also has a long coastline that is prone to high waves (Madlazim et al., 2021). Meanwhile, in the TT research, the country that contributed the most was China. China also has a long history of tsunamis. Some natural disasters that occurred on the east coast of China, including a large earthquake and tsunami (Wang et al., 2023), have caused significant damage and caused many casualties. Therefore, China also has a great interest in research on tsunamis. In addition, research by Li et al. (2022) stated that China also plays an important role in international efforts to strengthen tsunami early warning systems around the world.

3.5 Top Cited Global in TI ad TT Research during 2013-2023

Documents with global citations on TI and TT research are presented in Table 4. Murray Nj (2019) is the top author on TI research in the last ten years. The document that discusses “Tidal flats' global distribution and trajectory” has 392 total citations, 78.40 total citations per year, and 25.67 normalized total citations. The top global cited document written by Murray et al (2019) in the journal Nature explains that the increase in human population around global coastlines threatens coastal ecosystems, including tidal mudflats, which experience significant losses and have negative projections. Whereas in the TT study, the top

global cited document was written by Fujii et al. (2013) in the Ocean Science Journal regarding “An overview of oceanographic radar networks' evolution and uses across Asia and Oceania”. The document counts to date 57 total citations, 5.18 total citations per year, and 11.00 normalized total citations.

Table 4. Top 5 global cited documents in TI and TT research on last ten year

TI Research				
Paper	DOI	Total Citations	TC per Year	Normalized TC
Murray Nj, 2019, Nature	https://doi.org/10.1038/s41586-018-0805-8	392	78.40	25.67
Hiwasaki L, 2014, Int J Disaster Risk Reduct	https://doi.org/10.1016/j.ijdrr.2014.07.007	179	17.90	7.65
Socquet A, 2019, Nat Geosci	https://doi.org/10.1038/s41561-018-0296-0	157	31.40	10.28
Frankenberg E, 2013, Ecol Soc	https://doi.org/10.5751/ES-05377-180216	141	12.82	8.78
Grilli St, 2019, Sci Rep	https://doi.org/10.1038/s41598-019-48327-6	140	28.00	9.17
TT Research				
Fujii S, 2013, Ocean Sci J	https://doi.org/10.1007/s12601-013-0007-0	57	5.18	11.00
Sepúlveda I, 2019, J Geophys Res Solid Earth	https://doi.org/10.1029/2018JB016620	39	7.80	2.54
Huang Jp, 2018, Neural Network World	https://doi.org/10.14311/NNW.2018.28.009	39	6.50	6.26
Løvholt F, 2014, Int J Disaster Risk Reduct	https://doi.org/10.1016/j.ijdrr.2014.04.003	38	3.80	3.20
Gabuchian V, 2017, Nature	https://doi.org/10.1038/nature22045	37	5.29	3.87

In addition, bibliometric analysis can determine the top cited countries in TI and TT research during 2013-2023 (Table 5). In the TI research, the top cited countries namely Indonesia are ranked first with 1835 total citations. The second to fifth ranks with the highest total citations respectively are Japan, the USA, Australia, and the UK. Meanwhile, in the TT study, the top cited country was China with 407 total citations. Then in the next position followed by Korea, France, Japan, and the USA. Of the 10 top-cited countries in Table 5, the average article citation in the TI study with the highest score was Portugal (29.67), and in the TT study, namely the USA (39.00).

Table 5. Top 10 cited countries in TI and TT research on last ten year

TI			TT		
Country	TC	Average AC	Country	TC	Average AC
Indonesia	1835	4.83	China	407	5.65
Japan	1308	16.35	Korea	59	29.50
USA	1206	16.52	France	56	18.67
Australia	939	31.30	Japan	53	7.57
United Kingdom	648	17.05	USA	39	39.00
Singapore	493	18.96	Norway	38	38.00
France	485	25.53	Singapore	29	29.00
Germany	378	18.00	Thailand	6	6.00
China	202	08.08	Indonesia	3	1.50
Portugal	178	29.67			

3.6 Mapping Visualization and Updates Information about TI and TT

The results of network visualization related to TI and TT research using bibliometric analysis are presented in Figure 8. There are 4 clusters related to trend keywords in TI research (Figure 8a) with terms related to each cluster presented in Table 6. Meanwhile, Figure 8b and Table 7 present 9 clusters which is a trend keyword in TT research. The most dominant terms in TI research based on network visualization results are Indonesia, Tsunamis, Earthquakes, Disasters, and Sunda Isles. Taiwan, Tsunami, Pacific Ocean, Earthquakes, Hazard Assessment, and China

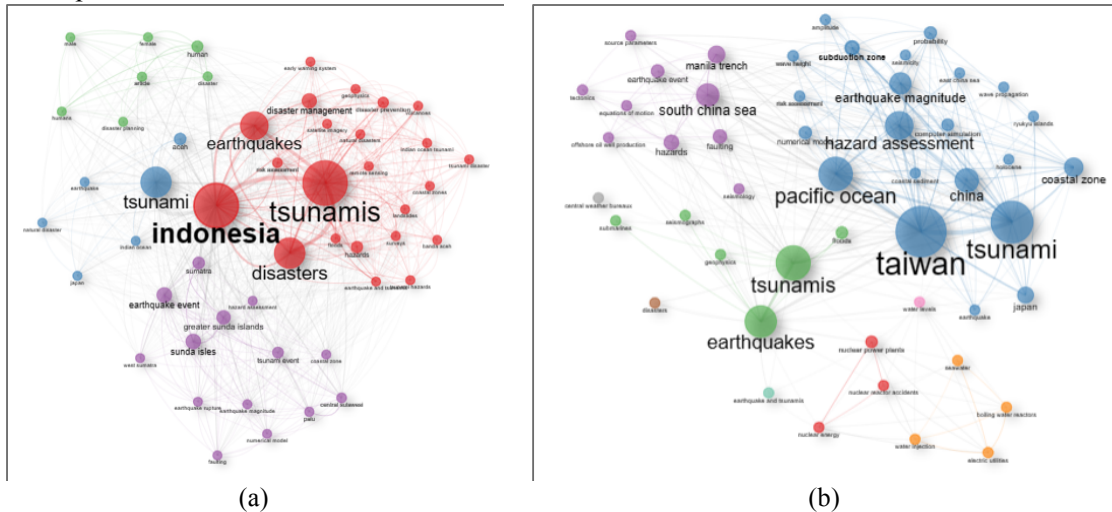


Figure 8. Network visualization related to TI dan TT research during 2013-2023

Table 6. Terms of the cluster in network visualization on TI research

Clusters	Terms
Cluster 1	: Indonesia, Tsunamis, Disaster, Earthquakes, Disaster Management, Disaster Management, Disaster prevention, Hazard, Risk assessment
Cluster 2	: Tsunami, Aceh, Indian Ocean, Natural disaster, Japan, Natural disaster
Cluster 3	: Human, Article, Female, Male, Humans, Disaster planning, Disaster
Cluster 4	: Sumatra, Hazard assessment, Faulting, Coastal zone, Earthquake rupture, West Sumatra, Central Sulawesi, Greater Sunda islands

Table 7. Terms of the cluster in network visualization on TT research

Clusters	Terms
Cluster 1	: Nuclear power plants, nuclear energy, nuclear reactor accidents
Cluster 2	: Taiwan, Tsunami, Pacific Ocean, Hazard assessment, Wave height, Amplitude, Coastal sediment
Cluster 3	: Tsunamis, Earthquakes, floods, geophysics, seismographs, submarines
Cluster 4	: South China Sea, Earthquakes event, faulting, hazards, tectonics, equations of motion
Cluster 5	: Electric utilities, Seawater, boiling water reactors, water injection
Cluster 6	: Disasters
Cluster 7	: Water levels
Cluster 8	: Central weather bureaux
Cluster 9	: Earthquake and tsunamis

Based on the results of network visualization, the TI and TT studies show that there is a very close relationship between tsunamis and earthquakes. This is because tsunamis can be triggered by earthquakes that occur under the sea. Tsunamis generated by earthquakes are often referred to as "seismic tsunamis" (Widiyantoro et al., 2020). Research by Suppasri et al. (2017) said that the greater the magnitude of the earthquake, the more likely the resulting tsunami will be larger and more dangerous (Katsumata et al., 2021). In addition, countries that have a close relationship with the tsunami are Indonesia, Taiwan, and China. Because these three countries are located in areas that are prone to tsunami natural disasters. Several tsunamis that have occurred in Indonesia include the Aceh Tsunami in 2004 and the Palu Tsunami in 2018 (Mutaqin et al., 2019). In 2009, Taiwan experienced a small tsunami after an earthquake measuring 6.4 on the Richter scale shook the southwestern coastal region of Taiwan (Liu et al., 2022). Meanwhile, China also experienced a tsunami in 2004 following an earthquake measuring 9.1 on the Richter scale off the coast of Sumatra, Indonesia (Wang et al., 2023).

To maintain the safety of yourself and others and reduce the damage caused by the tsunami, it is very important to always follow the latest information about the condition of the tsunami, either through the government's official website or through mass media coverage. Some websites to find updates and information about tsunamis are shown in Table 8.

Table 8. Update information about Tsunami

Name	Website	Description
Pacific Tsunami Warning Center (PTWC)	https://ptwc.weather.gov/	This website offers up-to-date details about earthquakes and tsunamis that may occur in the Pacific, along with tsunami warnings, advisories, and bulletins.
National Oceanic and Atmospheric Administration (NOAA)	https://www.noaa.gov/tsunamis	This website offers details on tsunamis, including their creation, the science underlying them, and the most recent alerts and warnings.
Tsunami.gov	https://www.tsunami.gov/	Real-time tsunami alerts and information are provided for the United States and its territories through this collaboration between multiple US government entities.
The International Tsunami Information Center (ITIC)	https://itic.ioc-unesco.org/	This is a central repository for data about tsunamis and related dangers. The website offers connections to information and resources from diverse sources throughout the globe.
Central Weather Bureau (CWB)	https://www.cwb.gov.tw/eng/	Taiwan's CWB, the country's national meteorological service, offers up-to-date information on the weather and natural calamities, such as tsunamis.
Badan Meteorologi, Klimatologi, dan Geofisika (BMKG)	https://www.bmkg.go.id/	The BMKG is Indonesia's official agency in charge of keeping track of the country's weather, climate, and geophysics and offers real-time updates on all types of natural disasters, including tsunamis.

It is essential to stay abreast of tsunami-related information. To help prepare for, respond to, and recover from potentially damaging natural disasters (Madlazim et al., 2021). Information updates

related to the tsunami in Taiwan can be through CWB and BMKG for tsunamis in Indonesia. CWB also updates hurricanes, floods, and other weather-related events that can trigger tsunamis. In addition to the CWB website, we can contact local authorities and emergency services in Taiwan for the latest information and guidance during a tsunami event.

Meanwhile, on the BMKG website, we can find information about current and past earthquakes, warnings, alerts, and tsunami bulletins. The BMKG also provides up-to-date information on weather-related events such as typhoons, floods, and landslides that can trigger tsunamis. Table 9 is the latest information update regarding the tsunami in Taiwan through the CWB website (<https://www.cwb.gov.tw/eng/>). The latest information regarding the tsunami in Indonesia can be accessed through the BMKG (<https://www.bmkg.go.id/>) is presented in Table 10.

Table 9. Top 10 latest updates related to information about Tsunami in Taiwan

No	Issued Time	Origin Time	Location	Magnitude
1	2023/03/16 10:01 (Taiwan Time: GMT+08:00)	2023/03/16 10:01 (Taiwan Time: GMT+08:00)	2023/03/16 10:01 (Taiwan Time: GMT+08:00)	2023/03/16 10:01 (Taiwan Time: GMT+08:00)
2	2023/03/16 09:06 (Taiwan Time: GMT+08:00)	2023/03/16 09:06 (Taiwan Time: GMT+08:00)	2023/03/16 09:06 (Taiwan Time: GMT+08:00)	2023/03/16 09:06 (Taiwan Time: GMT+08:00)
3	2023/01/18 14:54 (Taiwan Time: GMT+08:00)	2023/01/18 14:54 (Taiwan Time: GMT+08:00)	2023/01/18 14:54 (Taiwan Time: GMT+08:00)	2023/01/18 14:54 (Taiwan Time: GMT+08:00)
4	2023/01/18 14:14 (Taiwan Time: GMT+08:00)	2023/01/18 14:14 (Taiwan Time: GMT+08:00)	2023/01/18 14:14 (Taiwan Time: GMT+08:00)	2023/01/18 14:14 (Taiwan Time: GMT+08:00)
5	2023/01/08 21:47 (Taiwan Time: GMT+08:00)	2023/01/08 21:47 (Taiwan Time: GMT+08:00)	2023/01/08 21:47 (Taiwan Time: GMT+08:00)	2023/01/08 21:47 (Taiwan Time: GMT+08:00)
6	2023/01/08 21:09 (Taiwan Time: GMT+08:00)	2023/01/08 21:09 (Taiwan Time: GMT+08:00)	2023/01/08 21:09 (Taiwan Time: GMT+08:00)	2023/01/08 21:09 (Taiwan Time: GMT+08:00)
7	2023/01/08 20:42 (Taiwan Time: GMT+08:00)	2023/01/08 20:42 (Taiwan Time: GMT+08:00)	2023/01/08 20:42 (Taiwan Time: GMT+08:00)	2023/01/08 20:42 (Taiwan Time: GMT+08:00)
8	2022/11/22 11:58 (Taiwan Time: GMT+08:00)	2022/11/22 11:58 (Taiwan Time: GMT+08:00)	2022/11/22 11:58 (Taiwan Time: GMT+08:00)	2022/11/22 11:58 (Taiwan Time: GMT+08:00)
9	2022/11/22 10:45 (Taiwan Time: GMT+08:00)	2022/11/22 10:45 (Taiwan Time: GMT+08:00)	2022/11/22 10:45 (Taiwan Time: GMT+08:00)	2022/11/22 10:45 (Taiwan Time: GMT+08:00)
10	2022/11/22 10:13 (Taiwan Time: GMT+08:00)	2022/11/22 10:13 (Taiwan Time: GMT+08:00)	2022/11/22 10:13 (Taiwan Time: GMT+08:00)	2022/11/22 10:13 (Taiwan Time: GMT+08:00)

Table 10. Top 10 latest updates related to information about Tsunami in Indonesia

No	Origin Time	Latitude	Longitude	Magnitude	Depth	Location
1	2023-01-10 00:47:33	-7.37	130.23	7.5	130 Km	136 km BaratLaut MALUKUTENGGARABRT
2	2023-01-10 00:47:34	-7.25	130.18	7.9	131 Km	148 km BaratLaut MALUKUTENGGARABRT
3	2021-12-14 10:20:23	-7.59	122.24	7.4	10 Km	113 km BaratLaut LARANTUKA- NTT
4	2021-12-14 10:20:23	-7.59	122.24	7.4	10 Km	113 km BaratLaut LARANTUKA- NTT
5	2021-12-14 10:20:23	-7.59	122.24	7.4	10 Km	113 km BaratLaut LARANTUKA- NTT
6	2021-12-14	-7.59	122.26	7.5	12 Km	112 km BaratLaut LARANTUKA-

No	Origin Time	Latitude	Longitude	Magnitude	Depth	Location
	10:20:22					NTT
7	2019-11-14 23:17:43	1.67	126.39	7.1	73 Km	137 km BaratLaut JAILOLO-MALUT
8	2019-11-14 23:17:43	1.67	126.39	7.1	73 Km	137 km BaratLaut JAILOLO-MALUT
9	2019-11-14 23:17:43	1.67	126.39	7.1	73 Km	137 km BaratLaut JAILOLO-MALUT
10	2019-11-14 23:17:43	1.67	126.39	7.1	73 Km	137 km BaratLaut JAILOLO-MALUT

4. CONCLUSION

The research results related to the bibliometric analysis related to the Tsunami in Indonesia (TI) and the Tsunami in Taiwan (TT) obtained several conclusions. The conclusion is that the TI research trend is more consistently increasing linearly than research on TT from 2013-2023. Citation trends per year in TI and TT research vary depending on the popularity of research topics and the impact of publications. The highest mean total citations per year occurred in 2019, namely TI (3.82) and TT (3.84). The highest value in the mean total citations per article from TI research occurred in 2014 (23.41) and TT in 2019 (15.38). The most dominant trend keywords used are Tsunami, Indonesia, and Taiwan. The authors who contributed the most to TI research were Syamsidik and Wu TR in TT research. Indonesia and China are countries that have contributed a lot to and collaborated on TI and TT research. In TI research, the top 5 countries collaborating with Indonesia are Japan, the USA, the UK, Australia, and Germany. Whereas in the TT research, namely from China to Japan, USA, Australia, France, and Singapore. The highest and most relevant sources in TI research are the IOP Conference Series Earth and Environmental Science and Terrestrial Atmospheric and Oceanic Sciences in TT research. Syiah Kuala University and National Central University are top TI and TT research affiliations. The top document in TI research was written by Murray NJ, 2019, Nature, with the title "Tidal flats' global distribution and trajectory," which has 392 total citations, 78.40 total citations per year, and 25.67 normalized total citations. Whereas in the TT research, there is a document written by Fujii S, 2013, Ocean Scientific Journal regarding "An overview of oceanographic radar networks' evolution and uses across Asia and Oceania" with 57 total citations, 5.18 total citations per year, and 11.00 normalized total citations.

Based on the results of the network visualization, there is a very close relationship between tsunamis and earthquakes. It is because tsunamis can be triggered by earthquakes that occur under the sea (seismic tsunamis). Countries that have a close relationship with the tsunami are Indonesia, Taiwan, and China. Because these three countries are located in areas prone to tsunami natural disasters, several tsunamis have occurred in Indonesia, including the Aceh Tsunami in 2004 and the Palu Tsunami in 2018. In 2009, Taiwan experienced a small tsunami after an earthquake measuring 6.4 on the Richter scale shook the southwest coast of Taiwan.

Meanwhile, China also experienced a tsunami in 2004 following an earthquake measuring 9.1 on the Richter scale off the coast of Sumatra, Indonesia. The latest information updates regarding the tsunami natural disaster in Indonesia can be through the Meteorology, Climatology, and Geophysics Agency (BMKG). The tsunami in Taiwan can be through the Central Weather Bureau (CWB).

The implication of the research is to demonstrate the popularity of writing about Taiwan's and Indonesia's tsunamis so that future research might demonstrate more advantages of this subject. Researchers can learn about the advantages and disadvantages of each subject and discover updates for additional research with the help of this article. Recommendations for future researchers are to conduct research related to tsunamis and earthquakes with in-depth studies because of the high potential for further research.

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