Disaster response network analysis in rural Temerloh, Pahang communities during the Malaysia 2020-2021 flood

Foong Sin Lam[1*], and *Boon Yew* Chow[1]

[1]Universiti Tunku Abdul Rahman, Department of Civil Engineering, 43000 Kajang, Selangor, Malaysia

Abstract. Disaster risk reduction practices can be viewed as a collaborative environment managed by a diverse group of stakeholders including governments, private sectors and non-governmental organizations and research institutes as well as local communities. Insufficient collaboration and failure to coordinate across groups can lead to unsuccessful disaster recovery efforts. This study investigates the organizational roles and collaboration network among governmental and community organizations participating in Malaysia 2020-2021 flood response in rural Temerloh, Pahang. Social network analysis was conducted using Gephi open-source software to examine the general patterns of structures and the characteristics of the networks of stakeholders. News reports and organizational situation reports about the inter-organizational interaction and collaboration of stakeholders were identified using the manual coding analysis and analysed using Gephi, a social network analysis open-source software. The analysed results were ranked based on the categories of the centrality parameter, which highlights the extent of collaboration of key stakeholders in the network. The findings of this study indicate Malaysian Civil Defence (APM) and local government have high degree and betweenness centralities in the network. The number of private sectors active in disaster response was minimal, as were their centralities within the network, where they ranked last in every network measure. Rural communities and victims had lower betweenness centrality scores showed they had low network influence. NGOs are less involved in disaster response but are more involved in relief efforts such as cleaning muddy houses, recruiting medical and non-medical volunteers to help flood victims, distributing cleaning and healthcare supplies, and giving meals.

1 Introduction

Over the last two decades, Malaysia has seen several catastrophic floods with increased intensity and frequency. In late 2020 and early 2021, in Peninsular Malaysia, torrential rains caused severe flooding in many east coast states. The heavy rains in the South China Sea were caused by the Northeastern Monsoon winds in the region. Thousands of people were

* Corresponding author: lamfs@utar.edu.my

evacuated to evacuation centres. Pahang and Johor states were most affected by the flood. Other states involved were Terengganu, Kelantan, Selangor and Perak. Pahang was the worst-affected state with 17,903 people evacuated to evacuation centres. At least nine rivers in the state were above the danger level. The surge has affected land transport in these states and several casualties were reported [1].

Malaysian floods include both river and coastal flooding [2]. Rural communities that live near the coastal regions and river basins are particularly vulnerable to flood disasters. For instance, districts that are located in the Pahang River basin are prone to severe floods. They have poor socio-economic and food insecurity status, especially in Pekan and Temerloh, Pahang, where this study took place [3]. The rural communities in these regions can benefit from interdisciplinary research, multi-stakeholder collaboration, and engagement to reduce poverty, vulnerability to disaster, and increasing preparedness [4].

Rural indigenous communities face significant challenges in all phases of disaster management due to geographical remoteness and poor road conditions, healthcare facilities and limited resources. The rural indigenous communities in Malaysia also referred to as Orang Asli depend on the river for their drinking water, food, washing and transportation. In Malaysia, indigenous peoples are marginalized socio-economically and culturally. Approximately 50.92% of the Orang Asli population live below the poverty line; 34.34% live in extreme poverty, compared to 1.4% nationally [5]. Sadeka et al. [6], reported that Orang Asli at Tasik Cini, Pahang have low disaster preparedness and low participation in flood awareness programs. Most of the respondents in the study have low social capital and are not willing to be involved in any form of community or social organisation. Thus, they are disconnected from linking social networks with other organisations. Additionally, they expressed a lack of trust in local government agencies or outsiders, implying the need for a more targeted strategy and collaboration to re-establish their trust in government agencies and brokering connections between otherwise disconnected communities.

Insufficient collaboration and communication failure can lead to failed disaster recovery operations, as claimed by Sedfrey [7] who reported gaps in the disaster response systems following Typhoon Haiyan in the Philippines. Social Network Analyses (SNA) has been used to evaluate the performance of disaster management in various phases of disaster, including disaster response. One study found that encouraging disaster preparedness collaborations led to the formation of effective disaster response networks, demonstrating the necessity of facilitating collaborations before disaster strikes [8].

The purpose of this study is to understand the present state of disaster response networks for rural communities in Temerloh, Pahang and to evaluate the roles and communication and collaboration patterns between organizations involved in disaster response using social network analysis. To find effective strategies to rebuild rural communities frequently affected by monsoon flooding in Malaysia, we aimed to understand the structure and organizational network supporting flood response. The objectives of this study are as follow: 1) To study the roles of stakeholders in disaster response effort 2) To study social networks and generate sociograms to visualize the network in disaster-related efforts, communication and collaborations, sharing and knowledge exchange between organisations 3) To use Gephi to calculate the extent (i.e., strength, density) and pattern (i.e., degree centralization) among stakeholders in the area of flood response and recovery. We used these objectives to identify areas of collaborations that may improve the efficiency and effectiveness in meeting the disaster response needs of rural communities.

2 Method

2.1 Setting

This study involved political, academic, NGOs, community and disaster management agencies and stakeholders in Temerloh, Pahang. Temerloh is a town in Central Pahang, Malaysia. Excessive soil erosion and generation of sediment load from the upstream of Sungai Pahang Basin lead to an increased tendency of flooding. Most residential areas are located at the lowland and the flood plain region and amidst the bad irrigation system especially in big residential areas. Temerloh faces a larger magnitude of floods because it is located at the confluence of main tributaries (Sg. Jelai and Sg. Tembeling) in the mid-stream area.

The Temerloh district activates its Control Post on Scene (PKTK) and Disaster Operation Controlling Centre (PKOB) during disaster emergencies, as it did in response to the 2020-2021 Malaysia flood [9]. Emergency service providers and community stakeholders play essential roles in helping communities recover from disasters; however, their function and mechanism in collaborating and sharing resources to meet community needs are under-researched. This study contributes to the resilience planning efforts of rural communities. To evaluate organizational roles and collaborations, we conducted a manual content analysis.

2.2 Content analysis process

This study draws on data from the content analysis of English and Malays news sources and archives in Astro Awani, Berita Harianin, social media and and website using search query ("mission flood relief Malaysia Januari 2021") and (Temerloh and Pahang), situation reports from by Pahang State government departments, Malaysia Red Crescent (MRC) and Tzu Chi between January 8 and February 15, 2021.

Node and tie are two fundamental concepts of social network theory. A node represents various 'actors', i.e., people, organizations, or countries, acting within the context of an event or relationship. A tie is a term that refers to social connections that exist between any two nodes [10]. The types of ties could include similarities, social relations, interactions, and flows. The content analysis identifies nodes and ties in each article's disaster response actions, communications, interactions, information exchange, or resource flow. The people and major organizations that participated in the response operations were identified as node and the interactions between those organizations were identified as ties through content analyses. In this way, organizations collaborating with another organization in Malaysia 2020-21 flood response were identified [11]. The Gephi (Version 0.9.2) social network analysis programme was used to analyse the data acquired from the content analysis. The program contains several network analytic routines (e.g., centrality measures, dyadic and network-level measures) [12].

3 Results and discussion

3.1 Organizational roles

Among the 46 organizations on the actor list, the majority of participating organizations were federal/state/local government (59.57%), followed by non-profit (27.66%), and others stakeholders such as private sector and educational institutions (12.77%). Table 1 shows the stakeholders reported roles and response activities based on news and situation reports.

Table 1. Disaster Response roles and activities from news and situation reports

Disaster Response	Stakeholders Involved	Percentage (%)

Recovery/restoration of community functioning, outreach to flood victims, assistance in temporary emergency provisions such as shelter, food, basic needs, medical supplies	JKR, JKM, MERCY, MRC, TZU CHI, MPKK, KUIPSAS, IKMAL, MyCare Johor, WPP, USIM, ISMA, JAWI, JAKIM, MAIS, MCM MAIWP, FCMC, MAINPP, YSD, UPM	45.65
Damage and Situation Assessment and Reporting	APM, JKR, JPM, RELA, MUIP, MAINPP, RINTIS 3.0, UPM, MRC, MERCY, FCMC, KPPK	26.09
Facilitate financial assistance for the flood victims	YSD, Yayasan Petronas, MyCARE Johor, FCMC, WPP, MAIWP, MAIS, JAKIM, JAWI, PDT Bentong Welfare and Sports Body, KPPK, LGM	26.09
Information dissemination	APM, JPBD, PDRM, JKR, MPT, JKKK, JBPM, MPKK, Pahang State Government, Temerloh District & Land Office, JAKOA	23.91
Communicate with other organizations to facilitate operations	APM, JPBD, JBPM, JKR, MPT, RELA, JKKK, JBPM, JAKOA	19.56
Rescue mission and reach out to flood victims on the priority list	APM, JPBD, MRC, RELA, PDRM, JKKK, JKR, JKM, JAKOA	19.56
Activate the State Disaster Operation Control Centre (PKOB)	JPBD, APM, PDRM, JKR, MPT, JKKK, JBPM, MPKK	17.39
Communicate with the local stakeholder on the flood victims to report population needs	APM, JPBD, Pahang State Government, Temerloh District & Land Office, MPT, JKKK, MPKK	15.22
Outreach and ongoing care for the general public (shelter, food, basic needs, medical)	JKR, JKM, Pahang State Government, FCMC, MRC, MCM, Mercy	15.22
Volunteer Coordination	TZU CHI, RELA, KUIPSAS, UPM, RINTIS 3.0, Mercy	13.04

3.2 Network graph and structure

Figure 1 presents collaboration networks of the 46 organizations in emergency response and recovery, co-sponsoring relief missions, and supporting victims in Temerloh. The node size reflects their degree centrality within the network. The bigger the node, the more links it has. A line between two organizations shows collaboration in related task toward achieving a

common goal. Thus a more significant number of lines within the network indicates a denser collaboration pattern.

Some of the descriptive network statistics for the network were obtained from Gephi as shown in Table 2. In the network, 46 organizations that participated in disaster response were identified, of which 1 (0.02% percent) was an isolated node, i.e., an independent flood victim that did not collaborate with any other actors during the disaster response (Fig. 2). The in-degree is the number of incoming links and out-degree is the number of outgoing edges as shown in Table 3.

The degree to which a network is connected to the broader structure is referred to as its connectedness. Network density measures the proportion of potential linkages in a network that are connected. The calculation of network density is equal to known connections divided by maximum possible connections. (an ideal, fully connected network would have a density of 1.00) The result shows a network density of 0.032 and an average network degree of 1.679. To get the average degree for a graph, is the number of edges divided it by the total number of nodes in the graph. The average path length of the network is 2.52 based on the statistics, which means that to meet another organisation, a particular organisation must navigate roughly two organisational linkages. The average path length is the sum of all shortest paths between all nodes and divide number of all possible paths. On the other hand, the network diameter is 6, which means that the longest of all computed shortest pathways connecting all pairs of nodes in this network is 6. The longer the length, the weaker the connection which implies overall network structure is relatively constrained, preventing a specific organisation from effectively reaching other organisations via a shorter path.

The connectivity of a network is a measure of how well-connected the overall network structure is. The network density of a network indicates the proportion of potential connections that are connected. The results show a network density of only 0.032 (3.2%). These findings imply that 96.8% of the network's potential connections are not realised, and node connections are relatively limited on average. This finding is consistent with one study on social network analysis of disaster risk reduction in Asia and the Pacific which produced a similar result of 3% network density [13]. The low density can be explained by the lack of collaboration ties among the organizations participating in the disaster response network, which is typically lacking in most emergency management networks [14,15].

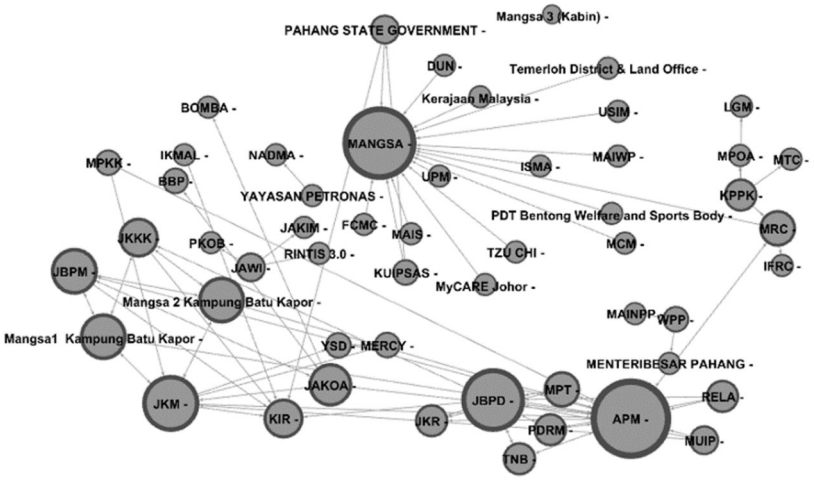

Fig. 1. Gephi Network Map of all actors

Fig. 2. An Isolate – Self-reliance as opposed to dependence during disaster: A man from Temerloh created a RM1000.00 floating hut for her mother. The destructive impact of 2014 flood and floating fish cage idea motivated him to be prepared for 2020-21 flood. [16]

Table 2. Summary of Social Network Analysis

Sizes of Organisational Networks	
Total number of nodes	46
Total number links	92
Type of Network	Directed
Network Diameter	6
Average path length	2.52
Connectivity of Organisational Networks	
Network Density	0.032
Average degree	1.679
Modularity of Organisational Networks	
Modularity	0.589
Communities (subnetworks)	8

Table 3. Results of the Network Characteristics of the Organisations.

Organization Type (Abbreviation)	Organization Type	Node Size	Degree	In-Degree	Out-Degree	Betweenness Centrality
APM	Civil Defense Force	200	18	11	7	193.33
JPBD	Jawatankuasa Pengurusan Bencana Daerah	58.33	13	5	8	76.0
PDRM	Royal Malaysia Poice	83.33	4	2	2	0.0
JKR	Public Works Department	83.33	4	3	1	0.0
MPT	Municipal Council Temerloh	91.67	5	3	2	35.5
RELA	The People's Volunteer Corps	83.33	4	1	3	0.0
MUIP	Majlis Ugama Islam Pahang	75.00	3	0	3	0.0
JKKK	Jawatan Kemajuan dan Keselamatan kampung	100.00	6	3	3	8.67
JBPM	Fire and Rescue Department Malaysia	6.67	8	4	4	52.17
TNB	Tenaga Nasional Berhad	83.33	4	2	2	16.5
MPKK	Majlis Pengurusan Komuniti Kampug	6.67	2	0	2	0.0
JKM	Jabatan Kebajikan Masyarakat	41.67	11	5	6	42.17
KIR	Ketua Isi Rumah	100.00	6	6	0	0.0
Mangsa 1 Kampung Batu Kapor	Victim 1 Kampung Batu Kapor	6.67	8	4	4	31.67
Mangsa 2 Kampung Batu Kapor	Victim 2 Kampung Batu Kapor	6.67	8	4	4	31.67
JAKOA	Jabatan Kemajuan Orang Asli	8.34	7	2	5	55.33
TZU CHI	TZU CHI	8.33	1	0	1	0.0
KUIPSAS	Kolej Universiti Islam Pahang Sultan Ahmad Shah	6.67	2	0	2	0.0
Pahang State Government	Pahang State Government	75.00	3	1	2	1.0
Mangsa 3 (Kabin)	Victim 3 (Kabin)	50.0	0	0	0	0
Yayasan Petronas	Yayasan Petronas	8.33	1	0	1	0.0
IKMAL	IKHTISAS KELAUTAN MALAYSIA	8.33	1	0	1	0.0

KPPK	Kementerian Perusahaan Perladangan dan Komoditi	83.33	4	0	4	0.0
MyCARE Johor	MyCARE Johor	8.33	1	0	1	0.0
WPP	Wakaf Pulau Pinang	6.67	2	0	2	0.0
USIM	University Sain Islam Malaysia	8.33	1	0	1	0.0
DUN	Dewan Undangan Negeri	8.33	1	0	1	0.0
ISMA	Ikatan Muslimin Malaysia	8.33	1	0	1	0.0
JAWI	Jabatan Agama Islam Wilayah Persekutuan	75.00	3	0	3	0.0
JAKIM	Jabatan Kemajuan Islam Malaysia	8.33	1	1	0	0.0
MAIS	Majlis Agama Islam Selangor	8.33	1	0	1	0.0
MCM	Muslim Care Malaysia	8.33	1	0	1	0.0
MAIWP	Majlis Agama Islam Wailayah Persekutuan	8.33	1	1	0	0.0
Temerloh District & Land Office	Temerloh District& Land Office	8.33	1	0	1	0.0
FCMC	Flood Concern Mission Program	8.33	1	0	1	0.0
PDT Bentong Welfare and Sports Body	PDT Bentong Welfare and Sports Body	8.33	1	0	1	0.0
Kerajaan Malaysia	Kerajaan Malaysia	8.33	1	0	1	0.0
MANGSA	Victim	83.33	16	16	0	0.0
MRC	Malaysia Red Crescent	91.67	5	2	3	52.0
LGM	Lembaga Getah Malaysi	8.33	1	1	0	0.0
MAINPP	Majlis Agama Islam Negeri Pulau Pinang	8.33	1	1	0	0.0
RINTIS 3.0	Rescue In Team Insan Sejahtera 3.0	8.33	1	1	0	0.0
IFRC	International Federation of Red Cross	8.33	1	1	0	0.0
MERCY	Malaysian Medical Relief Society	6.67	2	1	1	0.0
YSD	Yayasan Sime Darby	6.67	2	2	0	0.0
UPM	University Putra Malaysia	8.33	1	0	1	0.0

3.3 Degree centrality

Centrality measures are used to examine the most central actors. The top 10 most-central actors in the network were ranked: these were the actors that had the most connection in the network and an immediate influence on many other actors participating in disaster response. As it can be seen in Table 4, APM and Temerloh District Council scored the top 3 in terms of the number of interactions it had during the flood disaster response. One non-profit organisation made it to the top 10, i.e., the Malaysian Red Crescent.

As illustrated in Table 5, using the betweenness centrality measure, the top 7 gatekeeping government agencies and departments were positioned to broker connections between groups who could influence the flow of information among communities or organizations. Table 5 shows that APM has the highest betweenness centrality means it play as an important bridge among organizations in the network. JAKOA ranked third highest in the highest betweenness centrality, making JAKOA staff the most important government agencies as gatekeepers who could work well with Orang Asli families. Gatekeepers benefit significantly from pre-existing connections, indigenous knowledge and trusting relationship, all of which will help to engage the Orang Asli communities [15].

Malaysian Red Crescent (MRC) scored the 5th highest in its role as broker. The Malaysian is the only non-profit organization that is formally assigned disaster emergency functions and roles in Malaysia National Security Council Directive 2.0. MRC hands out cash assistance to the most vulnerable groups and coordinates with the disaster management of the national headquarters, the International Federation Red Crescent (IFRC) project coordinator and members of the regional and local disaster response team [9].

The betweenness centrality of the RELA, MPKK, PDRM, JKR, and KIR, on the other hand, is zero, implying that neither of these parties has the authority to connect the other organizations. Hence, they are unable to broker opinions or influence information flow. All of these parties should collaborate with other parties to share data and information to carry out effective emergency response.

Table 4: Top 10 Rank of Degree

Rank	Stakeholder	Degree
1	APM	18
2	Mangsa	16
3	JPBD	13
4	JKM/MRC	11
5	JBPM	8
6	Victim 1 – Kg. Batu Kapor	8
7	Victim 2 – Kg. Batu Kapor	8
8	JAKOA	7
9	JKKK	6
10	KIR	6

Table 5. Top 10 Rank of Betweenness Centrality

Rank	Stakeholder	Betweenness Centrality
1	APM	193.33
2	JPBD	76.00
3	JAKOA	55.33
4	JBPM	52.17
5	MRC	52.00
6	JKM	42.17
7	MPT	35.50
8	Victim 1 - Kampung Batu Kapor	31.67
9	Victim 2 - Kampung batu Kapor	31.67
10	TNB	16.50

4 Conclusion and Recommendation

A social network analysis of stakeholders involved in disaster response in Temerloh, Pahang, showed that governmental, non-governmental organizations are active in disaster response operations. The Malaysian Civil Defence (APM) played a crucial role in disaster response. APM and local government agencies occupy central positions in the network, as indicated by their high degree and betweenness centralities. Private sector participation in disaster response was limited in terms of the number of private sectors involved in disaster response and their centralities within the network, where they rank last in every network metric.

As indicated by their lower betweenness centrality scores, rural communities and victims had less power to influence the network. Such limited influence is consistent with research on the role of local communities in disaster management, where communities are excluded in the top-down rather than bottom-up decision-making processes. Rural communities in flood-prone areas can reduce their financial damage by adopting community-based disaster management approaches and self-protective behaviour, minimising the need for government assistance, supporting self-recovery, and building back safer through disaster risk reduction programmes and training.

NGOs groups have less collaboration ties in the areas of disaster response but have the highest involvement in relief mission by co-sponsoring relief activities, cleaning muddy homes, mobilizing medical and non-medical volunteers to aid flood victims, deploying hygiene, cleaning and healthcare kits and providing food in supporting the victims (Figs. 3 and 4). Further qualitative research need to be conducted to understand NGO roles and barriers and challenges in forming partnership with other NGOs, international NGOs and government institutions in the context of disaster response and recovery.

The flood relief efforts were short-lived. According to situation reports and newspaper publication, many organizations collaborated in flood response operations in the first few weeks with a subsequent drop in reporting. The areas with less collaboration were longer-term disaster recovery and development stages that represent areas to strengthen within disaster management practice such as limited access to resources to rebuild homes and replace damaged house contents.

Findings from one specific rural district may not generalise to another part of the country. Therefore, we did not use statistical techniques in this study for comparing two or more groups. Analysis of social networks on disaster response should include more

communities across a wider geographic area. Due to the Covid-19 lockdown, interviews with stakeholders involved in the Malaysia 2020-21 flood could not be conducted. Data collection on whether the organizations are collaborating with other organizations and method and frequency of communications can be analyzed using Gephi to supplement data obtained from content analysis of news and situation reports.

Acknowledgment: I would like to thank my co-author, Chow Boon Yew who contributed the findings from his undergraduate final year project on this study. I would also like to thank our co-researchers, Dr. Lee Jer Vui and Dr. Ngeow Yeok Meng
Funding: This study was funded by the UTAR Research Fund (UTARRF)
Conflict of interest: The authors declare no conflict of interest.

Fig. 3. Food aid distribution by members of Pemuda UMNO [17]

Fig. 4. Food distribution and cleaning up activities by Tzu Zhi. [18]

References

1. Floodlist, Malaysia <https://floodlist.com/asia/malaysia-floods-johor-pahang-january-2021> viewed 1 August 2021
2. L. Billa, M. Shattari, A.R. Mahmud, and A.H. Ghazalai, Dis. Prev. and Man., **15**(**2**): 233–240 (2006)
3. S. Chamhuri, A. Ferdoushi, D. Nor, I. Shaharudin, H. Amelia, and Z.Z. Siti, J. of App. Sci, **14**(**20**), 2632-2640 (2014)
4. S. Hallegatte, A. Vogt-Schilb, J. Rozenberg, M. Bangalore, and C. Beaudet, Econ. of Dis. and Cli. Chang, 4(1), 223-247 (2020)
5. Statista, https://www.statista.com/statistics/869756/malaysia-number-of-orang-asli/ viewed 1 August 2021
6. S. Sadeka, M.S. Mohamad, and M.S.K. Sarkar, Prog. in dis. science, **6**, 100070 (2020)
7. J.S.S. Santiago, W.S. Manuela Jr, M.L.L. Tan, S.K. Sañez, and A.Z.U. *Disasters*, **40(4),** 644-667.
8. Kapucu, N. and Hu, Q., *The Am. Rev. of Pub. Admin.*, **46(4)**, 99-417 (2016)
9. Malaysia: Floods Jan 2021 - Final Situation Report. International Federation of Red Crescent (IFRC) (2021)
10. S. Wasserman, and K. Faust, Social network analysis: Methods and applications (1994)
11. J. Yeo, L. Comfort, and K. Jung, *Online Infor. Rev.* (2018)
12. M. Bastian, S. Heymann, and M. Jacomy, 3rd Int. AAAI Con. on web. and soc. media (2009)
13. A.P.L. Trias, J. Lassa, and A. Surjan, Int. J. of Dis. Risk Reduc., **33**, 217-228 (2019)
14. N. Kapucu, F. Yuldashey, & M. A. Feldheim, European J. of Eco. and Poli. Stud., **4,** 83-112 (2011)
15. N. Oh, A. Okada, & L. K. Comfort, J. of Com. Policy Ana., **16**, 94-111 (2014)
16. J. Ball, and P. Janyst, J. of Emp. Res. on Human Res. Ethics, **3(2)**, 33-51 (2008)
17. Bernama 2021, https://www.freemalaysiatoday.com/category/nation/2021/01/17/man-builds-floating-cabin-to-save-household-items-during-floods/> viewed 1 August 2021
18. Pemuda UMNO, https://umno-online.my/2021/01/06/pemuda-umno-anggota-skuad-sabil-bantu-musibah-banjir-di-pahang-johor-terengganu/ viewed 1 August 2021
19. Tzu Chi Foundation Malaysia, https://www.tzuchi.my/en/covid-19/2021flood, viewed 1 August 2021