Application of GIS as Part of Flood Risk Management for Evacuation of Vulnerable Communities during Disaster in Kenyir, Terengganu Darul Iman

Fatin Faiqa Norkhairi, Sivadass Thiruchelvam, Hasril Hasini, Lariyah Mohd Sidek, Rahsidi Sabri Muda, Azrul Ghazali, Kamal Nasharuddin Mustapha, Hidayah Basri, Ranjit Singh Dharam Singh

ABSTRACT--- Flood due to the dam break incidence could hardly happen although there are some isolated cases reported around the world. While the probability of the dam to break might be lower, we should be cautious that disaster might strike at any time due to natural or manmade reasons. The flood management plan due to dam break need to be prepared as part of flood risk management which will act as a guideline for the dam owner to manage impending threats. The flood due to dam break could leave catastrophic impact towards the affected area in terms of loss of lives as well as destruction of properties. The usage of geographic information system (GIS) application software in the flood management could assist the dam owner to obtain a clearer picture of the disaster-stricken area should any untoward incidents occur in the future. The GIS data is important in the production of the flood risk management plan. The aim of this study is identify the probable flood risk area by using GIS method. The hydrodynamic data obtained from MIKE-21 will be layered with the image on the Google Earth to obtain the affected area during such flood. The results show that the area that are near to the dam will have high probability to be shattered by the flood.

Index Terms— Dam, flood, GIS, high vulnerable area, risk management.

I. INTRODUCTION

Disaster is one of the common events that happened all around the world. There are many kind of disaster that may occur due to natural causes as well as attributed to the manmade reasons. Earth-quakes, landslides, flooding and droughts are several natural disasters that terrifies the community. Flood that caused by the dam may rarely occur but we should not neglect the possibility of such occurrence. Throughout the history, dam failure has been occurring around the world and one of the largest dam failure in history is Teton Dam [1].

In Southeast Asia the flood incident related to dam failure has occurred in Laos on July 2018. The dam collapsed during the construction due to the consecutive heavy rain have made about 5,000 cubic meter of water being released to the nearest area [2]. The impact of the flood caused an unknown number of houses being washed away and at least 27 people have being killed from this disaster [3]. The ultimate consequences from catastrophic dam failure may impact the country, its economy and infrastructure. Loss of life and destruction on infrastructure are common consequences which need to be dealt by the victims. Another tragic flood causes by dam failure has occur recently in Myanmar on August 2018 where it affected 85 villages unleashing more than 20,000 cubic meter of water to be released [4]. The report says that the causes of the dam failure is due to the internal problem where the water drop a few meters during the repairing session. From this two major dam failure happen in a row, the spotlights have been concerns on the dam safety in Southeast Asia. Although the safety inspection has been made to the dams frequently but the possibility for the dam failure to occur cannot be avoid. The dam failure is considering as high hazard, but low frequency events where the consequences causes a great impact towards the properties and loss of human life.

The introduction of flood risk management intends to prevent or minimize loss of properties, assets and life caused by flood. To reduce the loss of life, first step in flood management and mitigation is to identify the area that have high risk of flooding [5]. Flood planning and mitigation is important to be carry out as a measuring guideline in the future even though the total flood prevention might not be feasible.

In this paper, the identification of flood-affected area is to be deter-mined by using GIS and digital elevation model (DEM). It is important to note that this process cannot replace the comprehensive flood risk assessment of the studied area but it is important as a screening tool that can help to identify the highly vulnerable area in the event of

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Fatin Faiqa Norkhairi, Institute of Energy Infrastructure, Universiti Tenaga Nasional, Jalan IKRAM-UNITEN, 43000 Kajang, Selangor, Malaysia.

Sivadass Thiruchelvam, Special Officer, Canselori, Universiti Tenaga Nasional, Jalan IKRAM-UNITEN, 43000 Kajang, Selangor, Malaysia.

Hasril Hasini, Mechanical Department, College of Engineering, Universiti Tenaga Nasional, Jalan IKRAM-UNITEN, 43000 Kajang, Selangor, Malaysia.

Lariyah Mohd Sidek, College of Engineering, Universiti Tenaga Nasional, Jalan IKRAM-UNITEN, 43000 Kajang, Selangor, Malaysia.

Rahsidi Sabri Muda, TNB Research Sdn. Bhd., No. 1, Lorong Ayer Itam, Kawasan Institusi Penyelidikan, 43000 Kajang, Selangor.

Azrul Ghazali, College of Engineering, Universiti Tenaga Nasional, Jalan IKRAM-UNITEN, 43000 Kajang, Selangor, Malaysia.

Kamal Nasharuddin Mustapha, Canselori, Universiti Tenaga Nasional, Jalan IKRAM-UNITEN, 43000 Kajang, Selangor, Malaysia.

Hidayah Basri, College of Engineering, Universiti Tenaga Nasional, Jalan IKRAM-UNITEN, 43000 Kajang, Selangor, Malaysia.

Ranjit Singh Dharam Singh, Infrastructure University Kuala Lumpur, Jalan IKRAM-UNITEN, 43000 Kajang, Selangor, Malaysia.

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such calamity. Geographic information system (GIS) is one of the commonly used method in flood related studies. The ability for it to store and access the data made it easier for the users to use the system for management and planning [6]. The mapping methods is important in this study as it provide a visual information which act as a guidance to the users. GIS also can be used to measure the location of the flooded area and can estimate the affected land and infrastructures. The main advantages of using GIS is that it can visualize the flood prone area and analyze the potential area of flooding. The flood mitigation plan can be considered as successful when the detailed knowledge can be obtained by through the expected frequencies, magnitude and the hazardous area as well. This study focuses on the surrounding vicinity of Sultan Mahmud Power Station, a hydroelectric dam located in Kenyir, Terengganu.

II. STUDY AREA

The Kenyir dam is located in the central portion of Terengganu State on the east coast of Peninsular Malaysia. Kenyir Hydro Scheme is mainly designed for hydroelectric power generation, and flood mitigation purposes owned by Tenaga Nasional Berhad (TNB). Its history of construction spanned 15 years, from the planning stage to the completion. It was first suggested in 1961 but proved not feasible due to the small demand and the high cost of production. In the early 1970's, the government revived the study and further site investigations were carried out. Even though the original survey for the project was conducted in 1972, the construction only started in 1978 and was successfully completed in 1985. In 1987, the whole project was formally opened by his Royal Highness the Sultan of Terengganu Darul Iman and was named after his Royal Highness Sultan as "Sultan Mahmud Hydro Electric Power Station". An easy way to comply with the paper formatting requirements is to use this document as a template and simply type your text into it.

The Kenyir reservoir was created by impounding the Sg. Terengganu; 15 km west of Kuala Berang and 55 km upstream of Kuala Terengganu, as shown in Fig. 1. The reservoir is formed by high hills from the south to the west but the north-east side was formed by a low ridge with a number of saddles that are below the full supply level (FSL) of elevation (EL) 145.00 m. These are bounded by eight separate saddle dams which are A, B & C, D, E, F, and G & H. The dam has four turbines with each of them consists of 100 MW that could annually produce energy output for about 1600 GWh. The dam is 150 m height, with crest length of 800m and the volume dam fill can reach to 15.2 million cubic meter. The maximum flood level is 153 m while the operating maximum level is 145m. The surface area reservoir at 145m above sea level (ASL) is 370km^2 with catchment area of 2600km^2. The storage capacity is 13600 million cubic meters. With these large volume of water, it could lead to severe impact towards the affected area in the event of flooding. From Fig. 2, it is evident that there are populated residential near to the dam.

Fig. 1: Layout plan of Kenyir Hydro Scheme

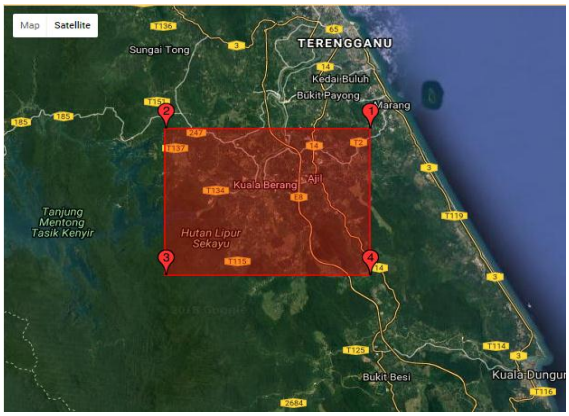

Fig. 2: Study area in Kuala Berang

III. METHODOLOGY

In this study, the satellite image is captured by using the google earth programs. The study area covers from the Kenyir Dam to Kuala Berang. The criteria for this studies is based on the total distance of the residential area with the dam. Leveraging on the topographic data, the focus is on smaller study area. High resolution of imagery is important for clear depiction. This high resolution of imagery can be obtained through the Google Earth application and the analysis is carried out by using ArcGIS 10.3 software.

In the first phase of the study, the latitude and longitude of the area is delineated in the Google Earth. The image as Fig. 3 will be exported to the GIS software with geo-referenced map in WGS 1984 coordinate system [7].

Fig. 3: Google image Kuala Berang

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The hydrodynamic data is obtained from MIKE-21 which is the main comprehensive flood risk of the event. It is assumed that the scenario is based on the PMF failure where the Kenyir reservoir is set to the full supply level of 145m and slowly increase to the maximum flood level 151m and start to fail due to PMF inflow that was routed to the reservoir. ArcGIS 10.3 software is used to display the spatial and attribute data that use to produce the potential flooding data area. The data analysis process is described in Fig. 4.

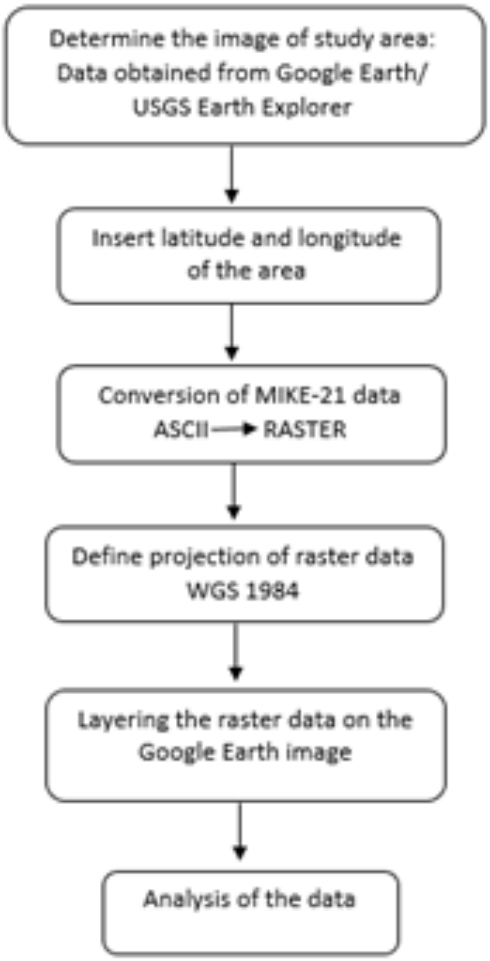

Fig. 4: Process of determining inundation extents

Each criteria is necessary to establish the potential flood area and need to be converted into the shapefile, so it can be read by the ArcGIS software. Hydrodynamic data will be overlaid on the google earth image to estimate the potential flood prone area.

IV. RESULTS AND DISCUSSION

The aim of this study is to determine the potential flood prone area due to the dam break events. To determine the area, hydrodynamic data from MIKE-21 is obtained and it is overlaid with the image on the google earth. The following results of the study area is shown in Fig. 5.

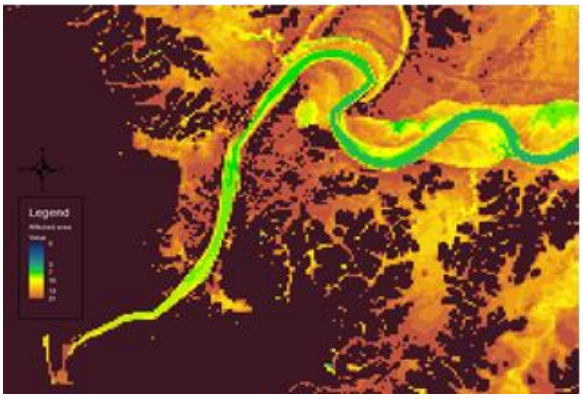

Fig. 5: Image obtained from MIKE-21

The results shows that the area located near the dam have high potential to be flooded during the dam break. The reddish area in the results indicate the flood may reach up to Kuala Berang and could possibly cause the destruction of human settlements and related infrastructure along the flood route. Each of the grid layer in Fig. 6 indicate the cell size to be 50 meters. With the high number of the reddish spots, it clearly indicates the severity of the flooded area.

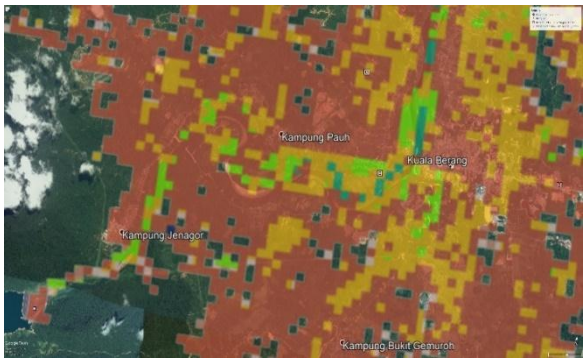

Fig. 6: Layer image on the Google Earth

The nearest residential area is Kampung Jenagor which located 4.41 km from the dam. However, it is interesting to note that the impact of dam break could be felt by Kuala Berang which is 18.04 km from the dam. Breach outflow of the PMF failure scenario was use to route the flood from dam to the downstream of the area. The flood wave would travel along and within the Sg. Terengganu main channel in high velocity. The water level would rise rapidly in the channel until it burst its banks and inundate the flood plain. The flood will travel along 62 km in Sg. Terengganu before it will finally flow into the sea.

V. CONCLUSION

Since the volume in the dam is quite large, therefore the effect of the flood is quite severe. The importance of flood management and mitigation come in place, as it becomes an important document if the dam failure occurs. In the state of community awareness, it is important for the dam owner to always reminding the communities on the appropriate evacuation procedures should in case any untoward incidents occur in the future. From the GIS data discussed in this paper, it is clearly describes the potential of populated area to be flooded in the event of a dam failure. Therefore,

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communities should have high interest in assessing potential hazards. Finally, the obtained results could assist in the formulation of disaster management framework especially in terms of developing evacuation plans and determining safe havens for evacuees.

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