

## Well Water Site Selection for Flood Victim in Malaysia

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**Abstract** Clean water supply is a major problem among flood victims during flood events. Field methods and Geographic Information Systems (GIS) were applied to determine the sites of well water sources that can be utilized during floods in the District of Kuala Krai, Kelantan. The data used were spatial data obtained well data, evacuation center data, and flood area data. The main GIS analyses used were locational analysis, overlay, and proximity analysis. The results showed that six (6) wells had been selected as water sources that could be consumed by the flood victims in helping to provide clean water supply, namely Kg. Keroh 16, Kg. Batu Mengkebang 10, Lapan Meranti, Kg. Budi, Kg. Jelawang Tengah 2 and Kg. Durian Hijau 1. With the presence of the well water sources that can be used during flood events, clean water supply can be distributed to flood victims at the evacuation centers. Many participation has been initiated independently by non-government organization as well as local stakeholder which need to be documented in order to ensure its merits.

**Keywords:** Clean water supply, well, flood, Kuala Krai district

**Abstrak** Pasokan air bersih adalah masalah utama di kalangan korban banjir saat banjir. Metode lapangan dan Sistem Informasi Geografis (SIG) diterapkan untuk menentukan lokasi sumber air sumur yang dapat digunakan selama banjir di Distrik Kuala Krai, Kelantan. Data yang digunakan adalah data spasial yang diperoleh data sumur, data pusat evakuasi dan data daerah banjir. Analisis SIG utama yang digunakan adalah analisis lokasional, overlay, dan analisis kedekatan. Hasil penelitian menunjukkan bahwa enam (6) sumur telah dipilih sebagai sumber air yang dapat dikonsumsi oleh korban banjir dalam membantu penyediaan air bersih, yaitu Kg. Keroh 16, Kg. Batu Mengkebang 10, Lapan Meranti, Kg. Budi, Kg. Jelawang Tengah 2 dan Kg. Durian Hijau 1. Dengan keberadaan sumber air sumur yang dapat digunakan selama peristiwa banjir, pasokan air bersih dapat didistribusikan kepada korban banjir di pusat-pusat evakuasi.

**Kata kunci:** Pasokan air bersih, sumur, banjir, Distrik Kuala Krai

### 1. Introduction

Clean water supply plays an important role during flood events to accommodate flood victims' water consumption, especially at evacuation centers. This is because those who are affected by floods often face difficulties in obtaining clean water sources for domestic use at the evacuation centers. This problem occurs because the water supply system is discharged due to the damage of water supply facilities submerged by flood water. This situation, in turn, causes a disruption of clean water supply to be distributed to the victims. The increase in flood water level may cause damage to the water supply infrastructure such as pumps and water treatment equipment (McCluskey, 2001). This damage may further affect the health of the population and increase the risk of spreading water-borne diseases during floods due to the difficulty in obtaining clean drinking water (Bariweni, Tawari, & Abowei, 2012; Shimi, Parvin, Biswas, & Shaw, 2010). In Malaysia, among the problems faced by flood victims are the pollution of water resources, the destruction of water

supply facilities, the pollution of drinking water and the spreading of water-borne diseases (Benacer et al., 2016). Among the common diseases associated with floods are malaria, cholera, eye diseases and skin diseases (Few, Tran, & Hong, 2004; Abbas & Routray, 2014). Hence, the discovery of clean water sources for consumption during floods plays a vital role in ensuring flood victims get proper clean water supply (Hossain, Juani, Shams, Rokonujjaman, & Shafiuddin, 2014). Therefore, this research was conducted to identify the location of wells that can be benefitted and utilized by the victims for when flood disaster hits Kuala Krai District by applying GIS.

In Malaysia, the state of Kelantan is one of the states that often have issues with water supply, especially Kuala Krai. This is due to the hilly earth surface of Kuala Krai that causes low reachability of water supply to the people, and most of them rely on groundwater. The situation gets worse when the Kuala Krai District is flooded during the monsoon season as the people who are affected by the floods will face difficulties in obtaining clean water sources especially at evacuation centers. In addition, the water supply problem remains if the flood continues for an extended period of time. March (2002) emphasized that the loss of clean water sources is the worst long-term impact in the event of a disaster. This situation can be seen in the catastrophic

flood that struck Kuala Krai in 2014 where Kuala Krai was the worst affected area. The flood event in 2014 was known as 'Bah Kuning'. The extreme flood event in Kuala Krai that year had caused 202,000 flood victims being evacuated to evacuation centers following the rise of the Sungai Kelantan water level (Kamarul Aryffin et al., 2015). According to Nor Eliza, Hazim, Wan, and Zulkifli (2016), the flood level reached more than 5 to 10 meters high which could submerge a building up to the 3rd or 4th floor. The high-water level had caused the communication and aid from the outsiders to the flood victims who were transferred to the evacuation centers to be interrupted. Additionally, the flood event that year had also caused traumatic effects on the victims due to the loss of shelter, income sources and mass destruction of property. This situation shows that extreme floods that occur in a long period contribute to high destruction (Rahman, Haque, Khan, Salehin, & Bala, 2005; M. Shah, 2008).

Therefore, this research was conducted to determine the location of wells for distributing water supply to the victims at evacuation centers during flood events. According to Rahm, Swatuk, and Matheny (2006), groundwater obtained from wells provides the most stable water source. The locations of these wells were to be determined by using GIS. In general, GIS is an information system used in the geographical context and applied in various fields related to earth surface phenomena (Nasir, 2010). According to Hinton (1996), spatial analysis methods in GIS had long been applied in the process of well searching and exploration of groundwater sources such as the researches conducted by Al-Abadi, Al-Temmeme, and Al-Ghanimy (2016); Cunningham and Daniel (2001); VanderPost and McFarlane (2007). GIS is also a tool that can help with flood management in identifying flood-prone areas (Abbas, Srivastava, Tiwari, & Bala Ramudu, 2009).

Hence, GIS software was used in this research to identify wells that were not flooded and flood victims evacuation centers affected by the floods. VanderPost and McFarlane (2007) explained that GIS technology was also used as a supporting tool for groundwater exploration in large areas in developing countries with less necessary mapping information and low availability of digital data. Therefore, this research is essential in the process of locating the water sources that can be used by the flood victims throughout Kuala Krai and subsequently overcome water problems during floods among the victims at evacuation centers.

## 2. The Methods

This research was conducted in Kuala Krai, Kelantan, located on the East Coast of Peninsular Malaysia. The district of Kuala Krai consists of three subdistricts, namely Batu Mengkebang, Olak Jeram, and Dabong. The Batu Mengkebang area is the most developed area compared to other subdistricts as Kuala Krai Town, which is the focal point of the people is located here. Kuala Krai has a hilly earth surface, where the west and east boundaries are highland areas with a height of more than 300 meters and less than 100 meters in the Kuala Krai Town (Town and Country Planning Department, 2011). The peak of Gunung Stong in Dabong District is the highest peak in Kuala Krai with a height of 1,800 meters. Therefore, areas that are often vulnerable to floods are Kuala Krai Town, Pahi, Manek Urai, Lela Jasa and Dabong as these areas are located along Sungai Kelantan. The main factor that causes the area to flood is the heavy rain during the monsoon season causing the overflow of Sungai Kelantan, Sungai Lebir and Sungai Galas. Figure 1 (a) shows the areas which are exposed to the northeastern monsoon rain every year. Kuala Krai is included in the severe flooding area during the major floods at the end of 2014 (Figure

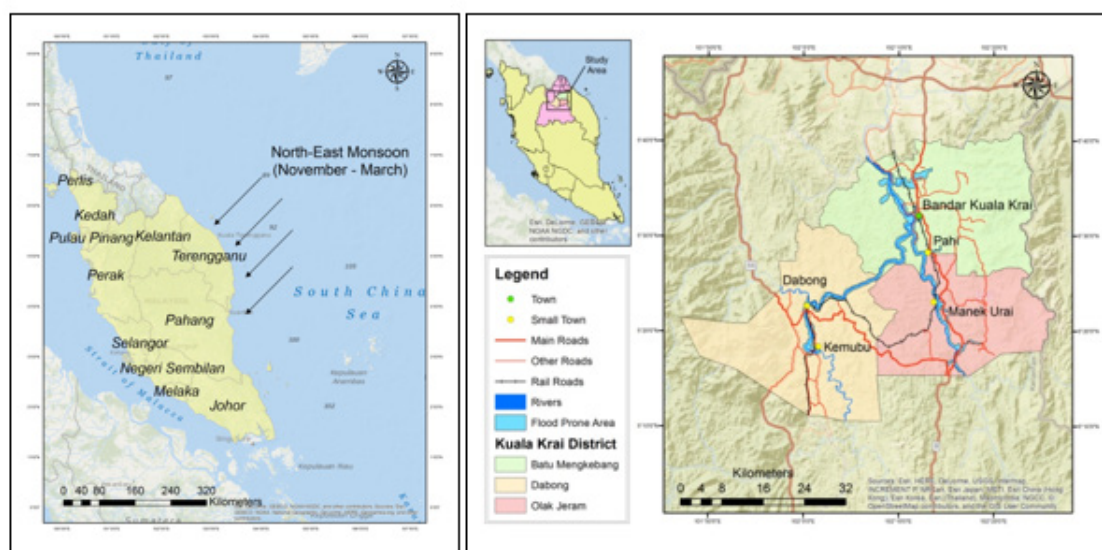


Figure 1. (a) Area Exposed to North-Eastern Monsoon Rain in November to March, (b) Flood Area in Kuala Krai District during 2014

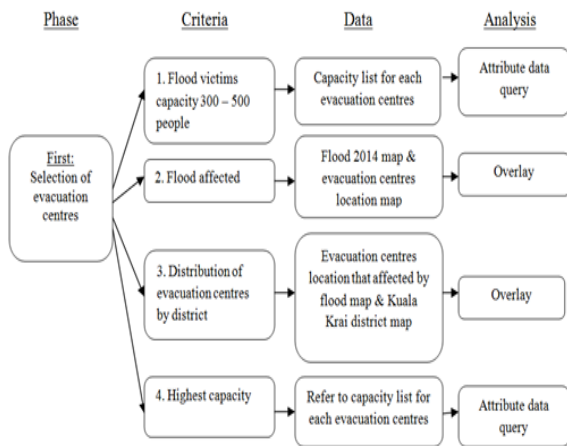


Figure 2. Selection Process of Evacuation Centres Based on Criteria

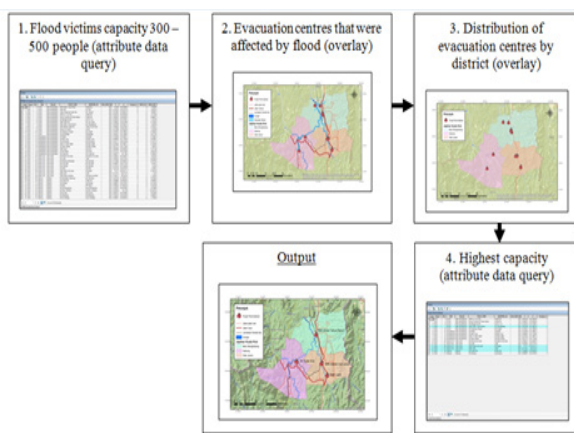


Figure 3. Selection Process of Evacuation Centres

1b). Various issues regarding flood evacuation centers and flood-affected residents have been implemented and are in planning programmes to be implemented to deal with the same problems in the future. One of the ongoing researches to deal with this is on how a water delivery model for domestic consumption and residents at the flood evacuation centers in Kuala Krai. Therefore, part of the research is to determine the use of well water as a water source for flood evacuation centers in Kuala Krai.

The research design used was exploratory research design to discover and explore new ideas on the issues studied. Thus, field methodology was used to obtain primary data which is the coordinates of well location with the help of the villagers. The type of well involved was open well. The secondary data were also collected which is the list of flood evacuation centers in the Kuala Krai district. The analysis method used was attributed data query using GIS and Microsoft Excel for the process of retrieving the data by using attributes (Kang, 2008). The locational analysis was also used to plot the location of wells and evacuation centers located in the Kuala Krai district. This research also involved overlay analysis, the main GIS operation to combine features and themes (Davis, 2001). As for distance measurement, proximity analysis was applied which is point distance, a distance

measuring device between each point in a point layer and all of the points in other layers (Kang, 2008). According to Dahlgren and Harrie (2007), proximity analysis is an important basic analysis technique in describing accessibility relationship and can be used to monitor changes in accessibility over time. In the process of selecting locations, whether the wells or the flood victim evacuation centers, the site selection method was used to determine the optimum location that would meet the selection criteria (Rikalovic, Cosic, & Lazarevic, 2014).

Figure 2 shows the sequence in determining the evacuation centers at the first stage based on the main criteria, namely the flood affected and the highest capacity of flood victims for each district in the Kuala Krai district that was structurally determined. In order to meet the criteria of flood victim's capacity between 300 and 500 people, an attribute data query was performed to remove the evacuation centers with a capacity of less than 300. Next, an overlay analysis of the 2014 flood map with the evacuation centers location map was done to identify the evacuation centers that were affected by the floods. An overlay analysis was also applied to identify the location of evacuation centers in three districts involving the location map of the evacuation centers and the Kuala Krai district map. The final process was to identify the evacuation centers with the highest capacity using attribute data query. This process can be seen as shown in Figure 3.

After the flood evacuation centers were selected, the location of the well was determined to provide domestic water supply to the flood victim evacuation centers during flood events. The well location was determined based on three criteria, namely not affected by the flood, the closest distance to the selected flood victim evacuation center and were situated in different locations. Figure 4 shows the sequence of well location determination. In the first criterion, an overlay analysis of the 2014 flood map and the well location map was performed to determine the wells that were not affected by the flood. Next, the calculation of the distance between the wells and the selected evacuation centers was performed using proximity analysis of point distance. Then, five nearby wells were selected using the attribute data query method with the help of Microsoft Excel. This initial determination was aimed at facilitating the determination of the final criterion which was the selection of two wells at different locations. The initial determination of the nearest well is dependent on the number of well sampling in research. The selection of the two wells was made using site selection. This process can be seen as shown in Figure 5.

### 3. Result and Discussion

#### Determination of evacuation centers

Figure 6 shows a chart of the selection of flood victim evacuation centers in a structured manner. The results of the analysis on the evacuation centers showed



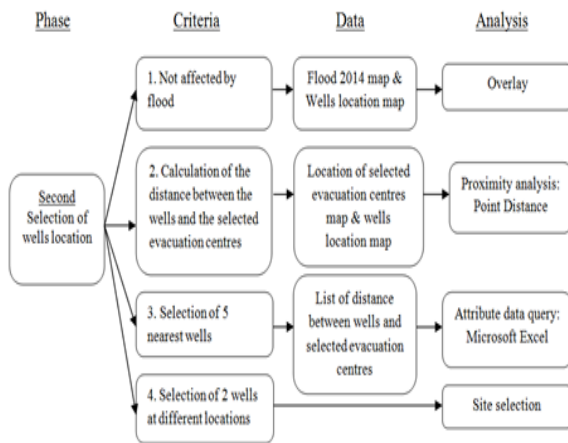


Figure 4. Selection Process of Wells Location Based on Criteria

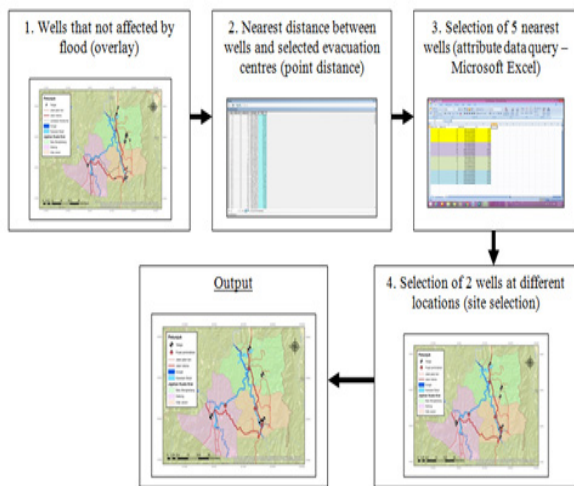


Figure 5. Selection Process of Wells Location

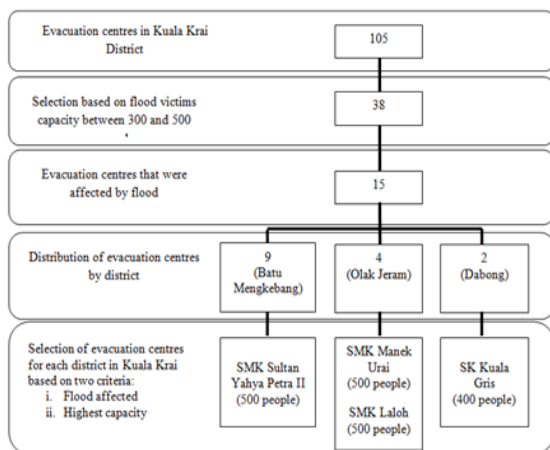


Figure 6. Selection of Flood Victim Evacuation Centres in a Structured Manner

that four flood evacuation centers selected were SMK Sultan Yahya Petra II in the Batu Mengkebang district, SMK Manek Urai and SMK Laloh in Olak Jeram district and SK Kuala Gris in Dabong district for clean water to be distributed to during flood events. The evacuation

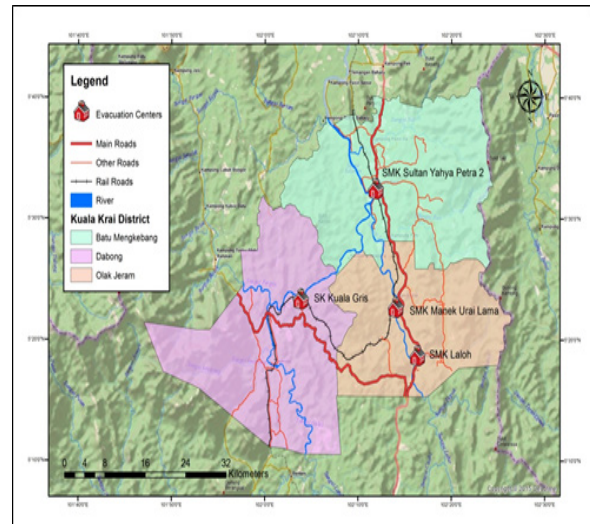


Figure 7. Location of Selected Evacuation Centres

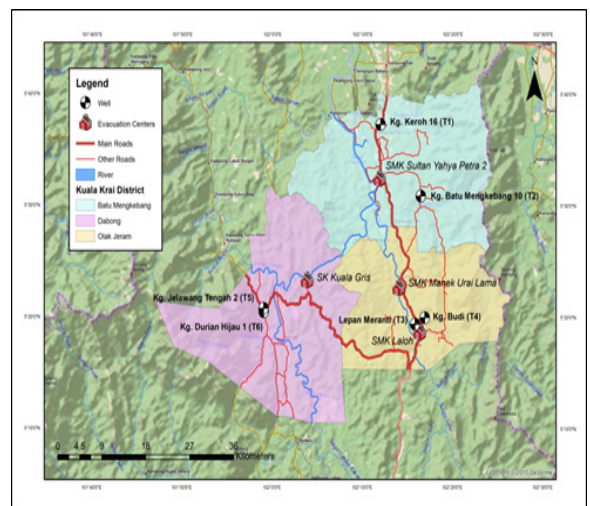


Figure 8. Location of Wells

centers were the affected centers during the floods and had the highest capacity in each district. Figure 7 shows the location of the evacuation centers selected for overcoming the problem of clean water supply during flood events.

**Determination of wells location**

Figure 8 shows the location of wells that can be utilized by flood victims at four selected evacuation centers. The results of the data processing found that 6 wells could be utilized by the flood victims, Kg. Keroh 16 (T1), Kg. Batu Mengkebang 10 (T2), Lapan Meranti (T3), Kg. Budi (T4), Kg. Jelawang Tengah 2 (T5) and Kg. Durian Hijau 1 (T6) after taking into account the three main criteria which are not affected by the flood, the closest distance to the selected flood victim evacuation centers and in different locations.

For each of the four selected flood victim evacuation centers, two well stations with the nearest distance have been appointed for distributing water sources during flood events. Based on Table 9, it shows the nearest wells for the four selected flood victim evacuation centers. In the Batu Mengkebang area, the nearest well

Table 9. Nearest Wells for Selected Evacuation Centres

District	Selected evacuation centers	Wells	Station	Nearest distance (km)
Batu Mengkebang	SMK Sultan Yahya Petra II	Kg. Keroh 16	T1	8.895
		Kg. Batu Mengkebang 10	T2	8.991
Olak Jeram	SMK Manek Urai Lama	Lepan Meranti	T3	6.942
		Kg. Budi	T4	7.316
		Lepan Meranti	T3	1.583
		Kg. Budi	T4	2.573
Dabong	SK Kuala Gris	Kg. Jelawang Tengah 2	T5	10.056
		Kg. Durian Hijau 1	T6	10.308

for flood evacuation center of SMK Sultan Yahya Petra II is Kg. Keroh 16 (T1) with a distance of 8,895km and Kg. Batu Mengkebang 10 (T2) with a distance of 8.991km. For evacuation centers of SMK Manek Urai Lama and SMK Laloh the same nearby wells are shared, namely the Lepan Meranti well (T3) and Kg Budi well (T4). The distance between SMK Manek Urai Lama and T3 station is 6.942km, and T4 station is 7.316km, while the distance between SMK Laloh with T3 station is 1.583km and T4 station is 2.573km. As for SK Kuala Gris, the nearest well is Kg. Jelawang Tengah 2 (T5) with a distance of 10.056 km and Kg. Durian Hijau 1 (T6) with a distance of 10.308 km.

The results of the mapping analysis showed that six wells could be utilized by the flood victims at the evacuation centers, namely Kg. Keroh 16 (T1), Kg. Batu Mengkebang 10 (T2), Lepan Meranti (T3), Kg. Budi (T4), Kg. Jelawang Tengah 2 (T5) and Kg. Durian Hijau 1 (T6). All these six wells can be channeled with the help of systematic water supply management especially in terms of distribution of water supply so that water can be channeled to flood victims at the evacuation centers. Indirectly, the use of GIS plays a vital role in the process of exploring clean water sources by determining the wells that can be used during floods through the mapping process. Elbeih (2015) emphasized that the mapping of groundwater is one of the key tools for the development of efficient and controlled groundwater sources.

Therefore, the determination of well location is an important step in addressing the water supply problem during floods, especially the spread of water-borne diseases. Indirectly, this method is a new approach in

the search for clean water supply, especially for water supply manager party. This situation may help the authorities in making the decision to overcome water supply problem in the occurrence of extreme floods like the flood events in 2014. To further strengthen such research in the future, the aspect of well quantity should be taken into account so that researchers can identify the number of wells needed to accommodate the victims at evacuation centers.

#### 4. Conclusion

In conclusion, the steps to determine the location of wells that can be used by the victims are essential in addressing the water supply problem during flood events. As well as able to improve the availability of water supply for the flood victims with a good water distribution system. Additionally, GIS is a very important tool in assisting the exploration of groundwater resources in an area to overcome water supply problems during floods. On the other hand, the absence of clean water supply during flood events could further enhance the impact of floods on the victims at evacuation centers, especially waterborne diseases.

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