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Coastal Flood Phenomenon in Terengganu, Malaysia: Special Reference to Dungun

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Abstracts: Dungun is one of the seven districts in the Terengganu State, Malaysia, located between 4°36ʹ10ʺ to 4°53ʹ02ʺN and 103°07ʹ25ʺ to 103°25ʹ50ʺE. It occupies an area stretching from hilly region in the western to coastal plain in the eastern. Topographically the Dungun district comprises 35% lowland area, 20% swamp and other water bodies and 45% forest reserves. The forest reserve area occupies the hilly region that is found scattered from beach to inland areas. Flood occurs almost every year in Dungun district. During flood, Dungun and its surrounding area was inundation by coastal flood water up to 1.50 m depth. The floods were caused either by tidal surges from the ocean or direct runoff from the rivers. Storm surges cause widespread devastation to low-lying coastal areas. Monsoon season in the east coast of Peninsular Malaysia which includes Terengganu is influenced by Northeast monsoon, characterized by heavy rainfall commencing from October and end of March annually. Consequently, severe floods occur almost every year all over Terengganu between November and December. Four factors are identified and related to the occurrence of flood phenomenon in Terengganu: (1) High intensity of rainfall, (2) River regime, e.g., low water current, (3) Back water phenomenon and (4) Velocity and wind direction that opposed to the direction of river flow. The occurrence of flashflood everywhere has caused property damages and lost of life.

Key words: Floods, monsoon season, low-lying coastal, rainfall, runoff

INTRODUCTION

Floods are the most widespread natural hazard in Peninsular Malaysia. Every state in the country has been affected with flood and flashflood, depending on the monsoonal season period. The increase toll from flashflood in the country is due to nature, performing as it usually does, colliding with an increased and more urbanized population settling and occupying sites that are ready targets for flood (Jamaluddin and Sham, 1987).

Terengganu is a state in the east coast of Peninsular Malaysia that has never missed a flooding event, which occurs between October and March every year during the northeast monsoon period. The occurrence of flood at Dungun district Terengganu state was due to a combination of physical factors such as elevation and its close proximity to the sea apart from heavy rainfall experienced during monsoon period. More than 70% of Terengganu was categorized as low-lying coastal area with an altitude of less than 200 m altitude and 30% of the area was identified as vulnerable to flashflood.

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Heavy rainfall during the north east monsoon season between October and March resulted severe floods almost every year all over Terengganu, especially during the months of November and December. Floods that affected Dungun district and other localities along the eastern coast of Terengganu were categorized as a coastal flooding. Watson and Burnett (1993) stated that storm surges can cause widespread devastation to low-lying coastal areas via estuaries, deltas and rivers. Environmental damages due to floods include the spread of diseases originating from dead rats and animals as well as contamination of floodwater from sewers, animal feedlots, etc.

Department of Irrigation and Drainage Malaysia had been measuring some the flood characteristics for many years. The characteristics of flood that was measured include water level, area inundation, peak discharge, volume of flow and duration. In term of water level, the Department of Irrigation and Drainage Malaysia has introduced three categories of critical level stages, which are alert, warning and danger. Only three major rivers in Terengganu i.e., Nerus, Chalok and Dungun Rivers have reached the danger level. This study attempts to analyze and describe the occurrence of flashflood in Dungun district of Terengganu between 2000 and 2004.

MATERIALS AND METHODS

Two topographical maps i.e., Dungun (Sheet 4463) and Bukit Besi (Sheet 4363) scaled at 1:50,000 were combined and used as baseline map to observe and analyze the geomorphology of the study area. 2000 to 2004 data rainfall and flood history database of Jerangau Rainfall Station (upper reach of Dungun River), was obtained from Department of Irrigation and Drainage (DID) Terengganu. Three categories of critical stages of river water level of the Dungun River at Jerangau Station were classified as alert (10.90 m), warning (11.70 m) and danger (12.50 m) stages. These stages of water level were designed to make the local authority aware of the level of danger posed by the raising water level so that a necessary emergency arrangement can be initiated for the welfare of the local community affected by the river.

RESULTS AND DISCUSSION

Geology of Terengganu

Distribution of rocks that are exposed along the east coast of Terengganu comprises three lithostratigraphic units: (a). Granite and associated rocks; (b). Meta sedimentary rocks and (c). Quaternary deposits. Granite intrusions were emplaced in the Eastern Belt during early Triassic (Tan, 1984) and surrounded by the older sedimentary rocks. Their sequences existed and distributed along NNW axis of the peninsular trend. Meta sedimentary rocks comprise a sequence of quartzite, phyllite and slate and these sequences contribute to the formation of roof pendants. The geological age of this succession is Carboniferous (Santokh Singh, 1985). Raised beaches are common features along the Terengganu coast as well as elsewhere along the east coast of Peninsular Malaysia. The raised beaches have been formed by a gradual isostatic uplift of the eastern coastline (MacDonald, 1968). The raised beach is composed of sand, which is mainly medium to very coarse in size. The sand composition is mainly quartz with minor amount of heavy minerals. Grain size analyses carried out on several sand samples collected from different raised level within the formation show that the sand is poorly sorted.

Geomorphology of Dungun

Morphology of Dungun area consists of a landform combination characterized by lowland in coastal area, swampy in the east and undulating area in the middle. Lowland area occupies about 35% of the area. It is characterized by settlements and agricultural activities. Swamp area and other water

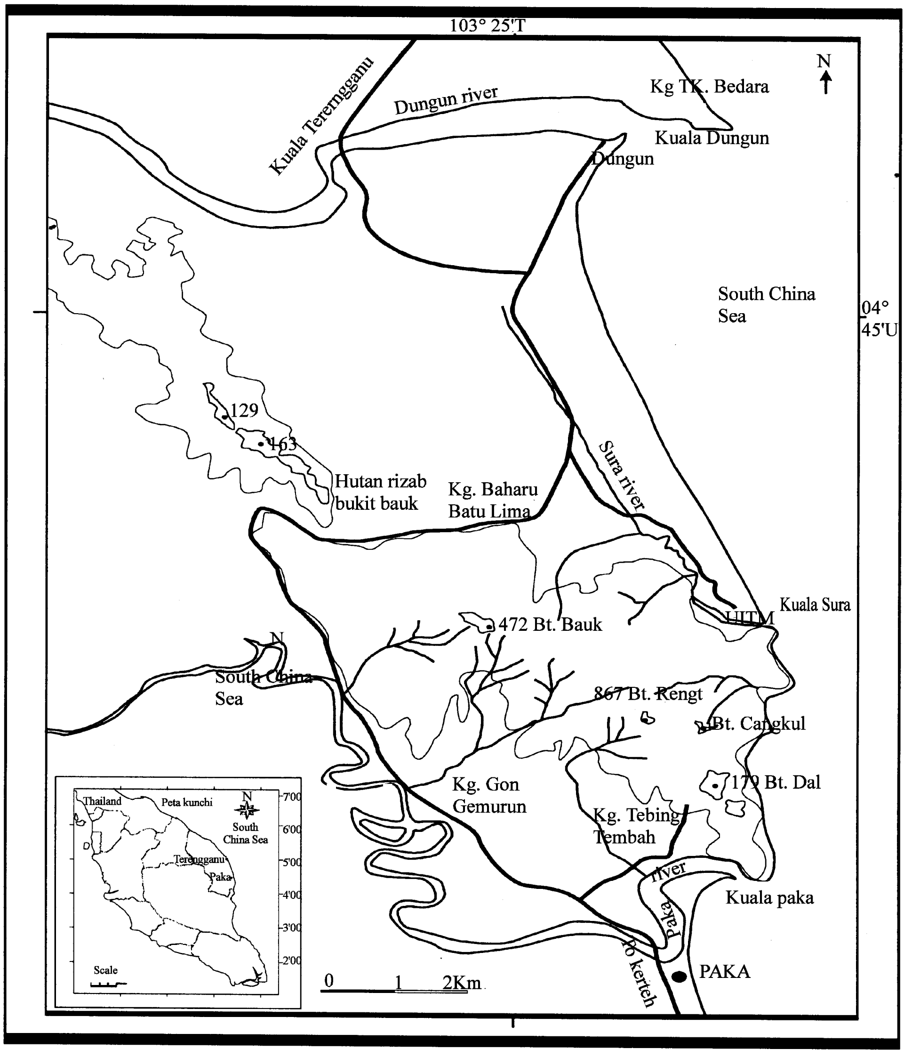

Fig. 1: Location of the study area between two main rivers

bodies such as rivers and floodplain covers about 20% of the area, where rest of the area (45%) is occupied by forest reserves. Swamp and lowland areas are scattered and can be identified by their undulating landform with an altitude range between 3-20 m ASL. Dungun District (3 km width and 20 km long) is situated at the coastal area between Dungun River (North) and Paka River (South). Dungun River is the longest river in Dungun. It flows about 110 km long before reaching South China Sea, draining about 2507 km of catchments area. The drainage system of Dungun area is divided into three main estuaries, which are: (1). Kuala Dungun and their branches: Dungun River and Pimpot River; (2). Kuala Suro and their branches: Suro River and Jawi River and (3). Kuala Paka and their branches: Paka River, Dol River, Kulim River, Gemuruh River and Sejuk River. Paka River is smaller than Dungun River, but some oxbow lakes are observed along Paka River; only sand bars are spotted along Dungun River (Fig. 1). Swamp areas (Paya Pak Sabah and Paya Tanah Hitam) with an area of 128 km^2, located at the end of Bt. Bauk (472 m). Between these two swampy areas is the Sura Ridge, which has a North west orientation, altitude range from 20-130 m. Sura Ridge is a continuation of Bt. Bauk to the north. Most of the highlands areas are located in the middle land. They are characterized by irregular morphology which consists of igneous and metamorphic rocks and covered by forests. In certain places, weathering of granite body penetrates to a depth of 17 m followed by incomplete weathering to more than 34 m, weathering in phyllite and quartzite penetrates only a few meters (Fitch, 1952). During the periods of unusually heavy rainfall, the rocks surface becomes over-saturated and slides away down the hillside.

Flood Histories

Four factors are identified and related to the occurrence of flood phenomenon in Terengganu: (1) high rainfall intensity, (2) river regime, e.g. low water current, (3) back water phenomenon and (4) velocity and wind direction that opposed direction of river flow. Four telemetric stations were set up by Department of Irrigation and Drainage in order to observe and monitor rainfall and water level pattern in Dungun area.

They are: Jerangau Station, Kuala Jengai Station, Pasir Raja Station, Department of Irrigation and Drainage Station with addition of 11 rainfall stations and 19 water level stations in the Dungun District will an operation of 24 h. Based on monthly rainfall data from 2000 to 2004, Dungun and its surrounding area received total monthly rainfall from as low as 21mm (March, 2004) to 968 mm (December, 2003) as shown in Fig. 2. Compared to the other districts in Terengganu, this amount of rainfall is considered moderate.

Flashfloods occurs almost every year in Dungun when the water level of Dungun River rises a few meters above the danger stage. Flood history from 2000 to 2004 started with flood from 22 to 24 of November 2000 (DID, 2001). The factor influencing the occurrence of 2000 flood is probably the pattern of monthly rainfall during the month of September to November 2000 (Fig. 3). In 2001, the flood initially occurred on the 16th and 17th of December and reoccurred on the 29th and 30th of December (DID, 2002). The triggering factor of the flood is highly monthly rainfall from October to December 2001 (Fig. 4). The Dungun River then might be over saturated and started to overflow and raise the water level.

December 2002 is the second highest total monthly rainfall (814.5 mm) for Dungun area from 2000 to 2004, but there was no flood occurrence reported. Perhaps it was due to low amount of rainfall (226.5 mm) in the previous month (November) (Fig. 5). Water accumulation in soil during these two months is low as indicated by the level of Dungun River, which is below the alert stage (DID, 2003). Dungun has experienced two bad flashfloods during 2003. The first flood event occurs on 30th of

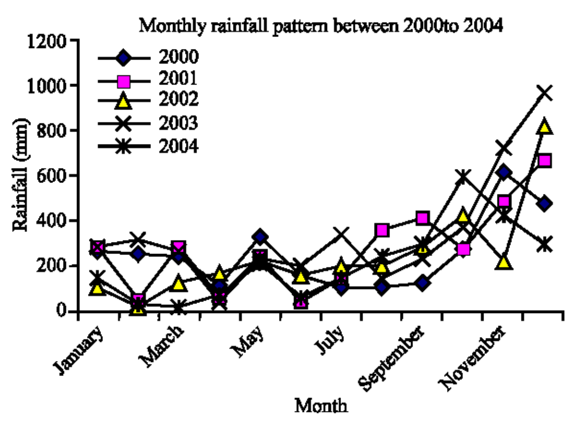

Fig. 2: Monthly rainfall pattern between 2000 to2004 for Dungun District

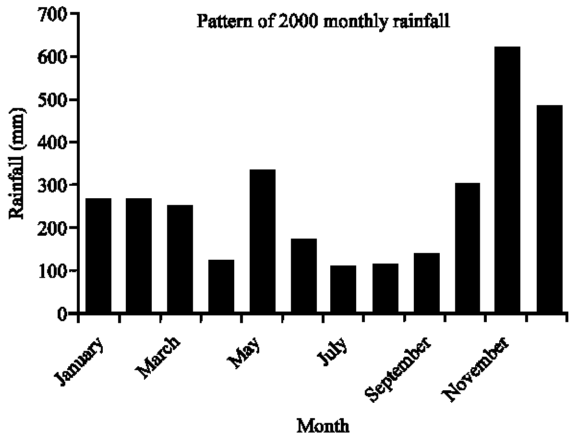

Fig. 3: Pattern of monthly rainfall for Dungun District in 2000

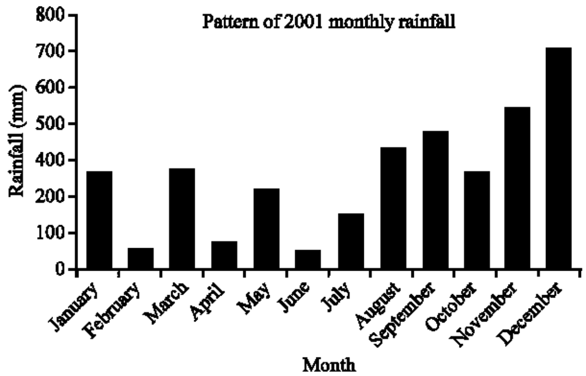

Fig. 4: Pattern of monthly rainfall for Dungun District in 2001

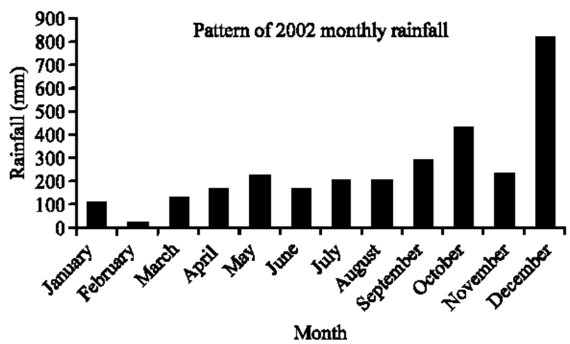

Fig. 5: Pattern of monthly rainfall for Dungun District in 2002

November and the second flood occurs on 8th of December until 16th of December (DID, 2004). During 2003, the monthly rainfall in the month of December (968 mm) was the highest within 5 years period (Fig. 6).

In 2004, October has recorded the highest total monthly rainfall (597.5 mm) (Fig.7). High amount of monthly rainfall occurred continuously from August (243.5 mm), September (299 mm), October

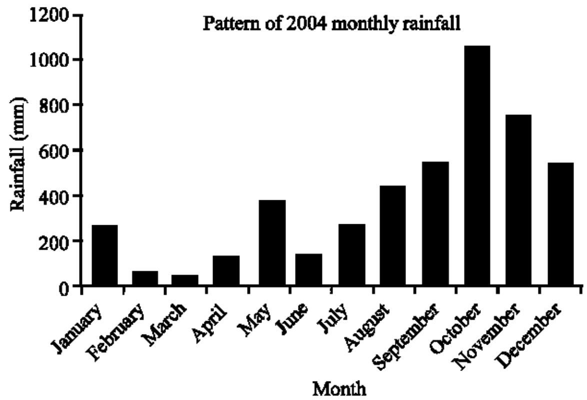

Fig. 6: Pattern of monthly rainfall for Dungun District in 2003

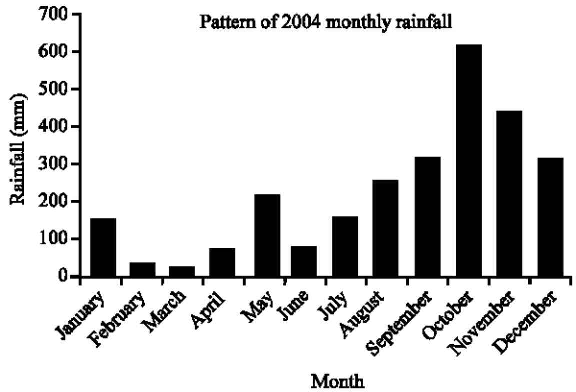

Fig. 7: Pattern of monthly rainfall for Dungun District in 2004

(597.5 mm) and November (428 mm). Continuous high amount of rainfall for four month period was enough to oversaturate the landform of Dungun area. Water level of Dungun River has increased since 8th of December up to the danger stage two days later. The highest-level 14.69 m was attained on the 12th December 2004 and then slowly decreases on 17th of December (DID, 2005).

The 2004 flood is considered as the longest flood in Dungun. The whole sequence of flood event is explained as following. Jerangau Station recorded rainfall intensity from 10 to 52 mm. This was due to 238 mm rainfall at 8 a.m. on 8th of December 2004. Intensity of rainfall was 2 mm at 2 p.m. on 9th December but increased to 38 mm at 2 a.m. on 10th December. At 8 p.m. on 11th of December the rainfall intensity increase to 38 mm but decreased to 10 mm at 12 pm on 11th December and then gradually rose to 55 mm at 2 a.m. on 12th of December (Fig. 8). The rainfall had even started as early as 7th of December in Dungun area and continued to pour until 13th of December, with intensity range from 2 to 261 mm/day. During the flooding period in 2004, at least two peaks of daily rainfall were identified, i.e., 8th of December (238 mm) and 12th of December (261 mm) (Fig. 9A). Water level of Dungun River at Jerangau Station was only 5.80 m on 7th of December, but gradually increased to alert stage on 8th and further increased to warning stage on the 9th and eventually rose to a danger stage in the afternoon of 12th of December 2004. Water level continuously increases to 14.68 m in the afternoon of 12th December due to prolonged raining. The water level of Dungun River slowly decreased to 5.40 m on the 14th of December 2004 (Fig. 9B).

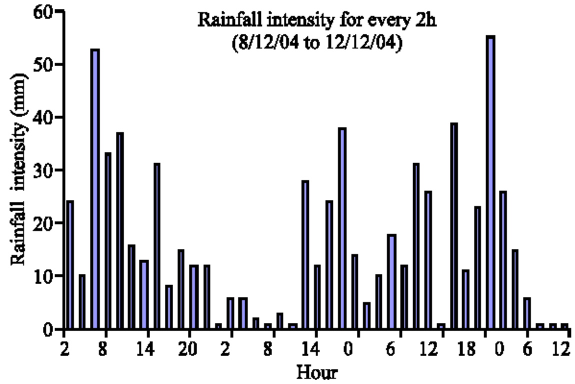

Fig. 8: Rainfall intensity from 8th to 12th of December 2004

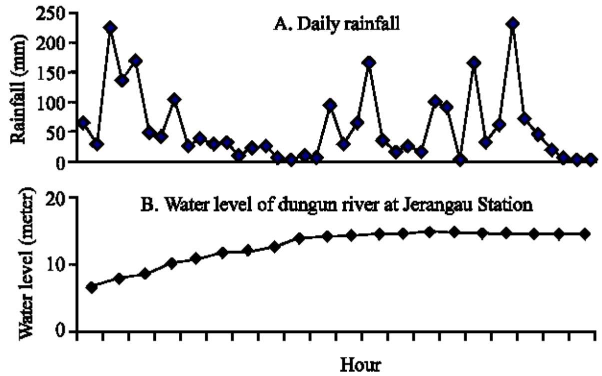

Fig. 9: Daily rainfall from 8th to 12th of December 2004 (A) and level of Dungun River at Jerangau Station

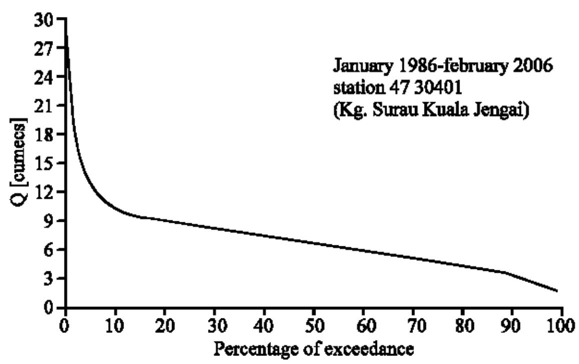

Fig. 10: Flow duration curve for Dungun River based on reconstituted station 4732461 (Paka River at Kampung Luit)

Flow Analysis

Station 4730401 (Kg Surau at Kuala Jengai Station, Catchment Area = 2507 km^2) is essentially used to reconstitute a series of daily flows in the Dungun River catchments. This station was selected because the catchments area is close to the Dungun River catchments and the flow series cover 20 complete years (Fig. 10). The missing data was reconstructed based on the neighboring station, that is station 4732461 (Paka River at Kampung Luit, Catchments Area = 854 km^{-2}). High correlation coefficients were found (R^2 = 0.90) between both stations (Fig. 10). The flow duration curve for 20 years data observation (Fig. 10) shows that 30 to 90% of the time flow discharge of the Paka River placed at the level 3 to 8 cumecs, whereas up to 25% of the time the flow discharge is located at the level 9 to 18 cumecs (flood).

CONCLUSIONS

A combination of bad weather during northeast monsoon, which occurs between October to December and the topographical pattern of the study area were concluded as the main reason for flooding occurrence in Dungun area. Low terrain of the study area makes it easier for the water level to rise to the danger level. Prolonged period of rainfall, which continuously occurred during the monsoon period with some of them at a very high intensity, rendered the land oversaturated with water thus initiate flashflood. The flashflood is also coincides with occurrence of high tides, which slow down the flow of river water into the sea. The death toll and property damage from flashfloods can be significantly reduced by the local authority if positive action such as (1) improve forecast and warning systems, (2) increased regulation of flashflood prone areas, (3) certification of dam safety, (4) better information on maximum precipitation and runoff and (5) program of public awareness and community warnings are taken.

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