Flood forecasting and early warning system for Dungun River Basin

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Abstract. Floods can bring such disasters to the affected dweller due to loss of properties, crops and even deaths. The damages to properties and crops by the severe flooding are occurred due to the increase in the economic value of the properties as well as the extent of the flood. Flood forecasting & warning system is one of the examples of the non-structural measures which can give early warning to the affected people. People who live near the flood-prone areas will be warned so that they can evacuate themselves and their belongings before the arrival of the flood. This can considerably reduce flood loss and damage and above all, the loss of human lives. Integrated Flood Analysis System (IFAS) model is a runoff analysis model converting rainfall into runoff for a given river basin. The simulation can be done using either ground or satellite-based rainfall to produce calculated discharge within the river. The calculated discharge is used to generate the flood inundation map within the catchment area for the selected flood event using Infowork RS.

1. Introduction

Flooding is the most frequent natural hazard that happened in Malaysia which we have suffering great economic losses in form of properties and crops, as well as losses in life. Every year, the government has to spend a lot of money in order to reduce the damage caused by flood. The main reason of the loss is people did not have enough time to make preparation and evacuate when the flood occurs. These loss can be minimize if the flood has been forecasted to determine the time and the duration of the flood before the actual flood happened so that people have enough time to make preparation and evacuate.

The basic cause of river flooding is the incidence of heavy rainfall and the resultant large concentration of runoff, which exceeds river capacity. However, in recent years, rapid development within river catchment has resulted in higher runoff and deteriorated river capacity; this has in turn resulted in an increase in the flood frequency and magnitude [1]. Developments of a flood forecasting & warning system is highly expected as a quick and efficient means to reduce flood disaster and minimize human damage, where river improvements and developments are not necessary sufficient.
2. Flood Forecasting Concept
In order to develop the flood forecasting & warning system, there are two methods used which are by real time flood forecasting and flood forecasting using forecast rainfall data [2]. Real time flood forecasting is a method of forecasting the flood using real time rainfall data. The rainfall data used for real time flood forecasting did not have lead time since it is not forecasted rainfall [3]. The input rainfall data is from either ground rainfall station or real time satellite rainfall. Since the real time flood forecasting use real time rainfall data, the lead time available for flood warning alert is also not very long depending on the lag time of the catchment.

The other type of flood forecasting & warning system uses forecasted rainfall as the input data for the simulation. The forecasted rainfall is numerically calculated based on the historical rainfall event to give lead time for the data before actual rainfall occurs [3]. As the result the flood forecasting & warning system will gives more time to the people before the real flood occurs. However, data from the forecasted rainfall always have problems in term of data accuracy.

3. Study Area
Dungun River (Figure 1) is located in Dungun district which has total catchment area about 1858 km² and river length of 110 km [4]. The catchment is influenced strongly by the Northeast monsoon which brings along heavy rainfall in the months of November to March [5]. The long duration of the rain events cause prolonged flooding along some stretches of the river.

![Figure 1. Dungun River Basin](image)

4. Methodology
The basic concept of developing the flood forecasting process for Dungun River Basin can be categorized in four stages which are the rainfall data, the runoff analysis model, the flood inundation model and the flood warning. Figure 2 illustrate the stages of flood forecasting process for Dungun River Basin.

4.1. Rainfall Data
The telemetry ground-based rainfall data is used as the input data in the hydrological model. The data which is collected from the Infobanjir portal will give the real-time rainfall input every hour. There are altogether six ground rainfall stations in the catchment area with four stations equipped with telemetry devices as listed in Table 1.

Two types of satellite-based rainfall data used which are the real time and forecasted satellite-based rainfall data. The quality of satellite-based rainfall data is high in term of coverage but low in term of accuracy. Table 2 and 3 show the details of the real time satellite-based rainfall and the forecasted rainfall respectively.

![Figure 2. Flood Forecasting Process for Dungun River Basin](image)
4.2. Runoff Analysis Model

IFAS is a runoff analysis model converting rainfall into runoff for a given river basin. It can be classified as conceptual or parametric and physically-based, fully distributed model [2]. The model can produce runoff simulation using both ground and satellite-based rainfall data.

4.3. Flood Warning

AutoIFAS is the model that will download data and run the simulation automatically based on the hydrological analysis in IFAS. The model can simulate the calculated flood discharge (Figure 3) using both telemetry and satellite rainfall data. Figure 4 shows the flood warning issued when the discharge reaches certain threshold level set according to level at Jambatan Jerangau river station as it is the only discharge data that available within Dungun River Catchment.

| Table 1. Ground-based Rainfall | | Table 2. Real Time Satellite-based Rainfall |
|-------------------------------|-----------------|------------------------------------------|
| Station Name                  | Station No      | Data Transmission                       | Name       | Coverage    | Spatial Resolution | Time Interval | Delivery Delay |
| Pasir Raja                    | 4529001         | Telemetry                               | GSMaP      | 60°N - 60°S | 0.1° (10km)       | 1 hour        | 4 hour        |
| Kuala Jengai                  | 4730002         | Telemetry                               |            |             |                 |               |               |
| SM Sultan Omar                | 4734079         | Telemetry                               |            |             |                 |               |               |
| Jambatan Jerangau             | 4832011         | Telemetry                               |            |             |                 |               |               |
| Delong                        | 4833078         | Manual                                  |            |             |                 |               |               |

Table 3. Forecasted Rainfall

| Forecast Rainfall Data | Forecast Frequency | Lead Time | Data Resolution | Data Format |
|-----------------------|--------------------|-----------|-----------------|-------------|
| JMA GSM               | Every 6 hours      | 192 hours (8 days) 6 hours and 12 hours | 0.5°x0.5°x17 levels (originally 20km horizontal resolution) | grib2       |

4.4. Flood Inundation Model

The hydrodynamic analysis of Dungun River based on the results from IFAS will be used to obtain the estimated inundation areas. The discharge of the flood event will be used as the input data for the hydrodynamic model InfoWorks which will used to account for the flood inundation analysis.
The inundation location of flood will be determined along Dungun River from the Jambatan Jerangau to the river mouth. Figure 5 shows the flood inundation map and Figure 6 shows the close up of the flood map at Taman Rakyat, Dungun during Dec 2012 flood event.

![Figure 5. Flood Inundation Map during 2012 Flood](image1)

![Figure 6. Flood Map at Taman Rakyat during 2012 Flood](image2)

4. Conclusion
IFAS software can be used in developing the flood forecasting and warning system with the presence of real time and forecasted rainfall from ground and satellite. The calculated discharge produced from the software used as the input of the hydrodynamic model to generate flood inundation map within Dungun River Basin. Warning will be issued when the calculated discharge reaches the certain value based on the threshold level at Jambatan Jerangau river station. People who lived in the flood prone area will have time to prepare and evacuate, hence the flood damages can be reduced.

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