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THE USE OF REMOTE SENSING TECHNIQUE TO ASSESS FLOOD HAZARD IN CITY OF JEDDAH, SAUDI ARABIA

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ABSTRACT

The City of Jeddah became lately one of the typical regions that affected by natural hazard. Previous flood that occurred in 2009 was one the most tragic natural disaster in the history of Saudi Arabia, which caused death for more than one hundred people. On 17th of November 2015, Jeddah turned into a disaster zone again due to heavy rainfall and the lack of drainage system. The objectives of the study are (1) To illustrate the hazard areas in the City of Jeddah that need an urgent drainage system; and (2) To evaluate the threats that the City of Jeddah is facing by simulating the floods. In this context, two multi-temporal Landsat 8 images (before and after the flood), Digital Elevation Model (DEM), and rainfall data sets have been analyzed and used to simulate the floods in the City of Jeddah. The study integrates different techniques from remote sensing, Geographic Information System (GIS) and hydrological modelling for flood estimation. All information extracted from the Landsat satellite images, DEM, and rainfall data sets are imported into an existing hydrological model built in Storm Water Management Model (SWMM) software. The designed storm data obtained from the SCS (U.S. Soil Conservation Service) type II is used in SWMM software to calculate the runoff water. The results from the model are used to estimate the amount of water to be collected by the drainage system and further estimate any potential flood hazard based on the topography and the designed drainage water system. The outcome of the study will contribute to the design and development of a robust and comprehensive drainage system for the study area.

Keywords: Remote sensing, GIS, SWMM, hydrological modelling, Landsat 8, flood assessment

1. INTRODCTION

Flood is one of the most devastating natural hazards of the world, especially in the areas of heavy rainfall. Excessive rainfall within relatively a short duration of time could result in flooding. Consequently high river discharge may damage crops and infrastructures, such as roads and reservoirs. In order to build a strategy to deal with flood, it is essential to identify the most vulnerable areas to flooding. Currently, some equipment are needed to be installed at river to record water levels, it is sometimes difficult to record an extreme flood event having a very high return period. (Prathumchai and Samarakoon, 2005). In addition, installing equipment at small distance to cover all areas subjected to potential flood could be very expensive.

Remote sensing is a very reliable way of providing coverage over a wide area in very cost effective manner. Remote sensing also could register data in an extreme hydrological event (Sanyal, 2004), such as floods, which could be challenging task using ground stations. In addition, multi-date provides investigators with an additional tool of monitoring the change or reconstruct progress of a past flood. Recently, significant developments occurred in the field of remote sensing and its application in flood monitoring.

Several researchers have used remote sensing and GIS to assess the flood hazard in Saudi Arabia (Al Saud, 2010; Al-Momani et al. 2013). The results showed that damaged areas and the movement of flooding can be identified using remote sensing and GIS technique.

In this research, numerous remote sensing and GIS data will be discussed in order to assess the flood hazard risk in Jeddah region. The primary objectives of the research are:

1. To illustrate the hazard areas in the City of Jeddah those need an urgent drainage system.
2. To evaluate the threats on the City of Jeddah by simulating the floods, which may cause by the sub catchment that are located in the eastern valleys.

2. DATASETS AND METHODS

2.1 Datasets

Jeddah is considered a developing city, which is located in arid environment area. Jeddah is located between the geographic coordinates 21°17′, 21°47′ N& 39°05′, 39°39 E′ with total areas about 688 km^2.

The data used in this research work can be described as in the following table:

Tools and documents	Description
Data and records	Hydrological records – Rainfall data – Drainage data – Manhole data
Topographic maps	Contour interval 25 m
Satellite images	Two Landsat 8 (OLI) images – 2015-11-03 before the flood – 2015-11-19 two days after the flood
Software	PCI Geomatica 2015 Arc GIS 10.1 SWMM PC

2.2 Methodology

The overall workflow for this research work can be summarized in the following steps. All images were clipped to the study area to speed up the data processing. All image subsets were projected into the UTM coordinate system; then, atmospheric corrections were carried out on all of the multi-temporal Landsat images. The atmospheric correction model (ATCOR2) was utilized to remove the effects that change the spectral characteristics of the land features. After conducting the atmospheric correction, the biophysical parameters were derived from the Landsat images. Green Band and middle infrared band of the Landsat multi-spectral image were used to determine the biophysical parameters; Modified Normalized Difference Water Index (MNDWI) is calculated for the study area in order to extract the water body areas before and after the flood. Then, the drainage and manhole system of the city were digitized in Arc GIS for further analysis. SWMM software was used to design the hydrological simulation model in City of Jeddah. The MNDWI data were used as a reference for the hydrological simulation modelling result.

3. RESULTS AND DISCUSSION

The preliminary findings of this research work illustrate the hazard areas in the City of Jeddah that need an urgent drainage system. The MNDWI image represents the flooded zones that have various levels of damages. The lack of drainage systems, with a low sloping terrain and mountain chains in City of Jeddah may cause an essential flood in few minutes. Moreover, the privation of green areas within the city, which is less than 1%, may exacerbate the significance of the flood. Therefore, it is essential to build a full drainage system that covers the entire city. The environmental properties including green areas may play an important role in reducing the effect of the flood.

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