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Remote Sensing Method for Flood Management System

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ABSTRACT : *Flood occurred when heavy and continuous rainfall exceeding the absorptive capacity of soil and the flow capacity of rivers, streams, and coastal areas. Land areas that are most subjected to floods are areas situated adjacent to rivers and streams, that are known as floodplain and therefore considered as "flood-prone". These areas are hazardous to development activities if the vulnerability of those activities exceeds an acceptable level. The main objectives of this study are; to identify floodplains and other susceptible areas, and to assess the extent of disaster impact in the study area which is located at Kota Tinggi, Johor, Malaysia. This area experienced an unprecedented flood during December of 2006 to January of 2007.Questions such as how often and how long the floodplain will be covered by water, and at what time of year flooding can be expected need to be answered. Thus, an understanding of the dynamic nature of floodplains is greatly required. Multi-temporal Radarsat-1images, Landsat ETM+ image, topographical maps and land use maps were used in this study for the purpose of delineating the flood extend before, during and after the flood event. DEM acquired from topographic map is used to derive flood depth. The final outputs of this study are flood extent and flood depth maps where both of these maps show the impact of the flood to environment, lives and properties. This map is also important and can be applied to develop a comprehensive relief effort immediately after flooding.*

KEY TERMS: *Remote Sensing, Flood Mapping, Malaysia, Flood-prone.*

I. INTRODUCTION

The geographic of Malaysia is outside the Pacific Rim of fire and freely from any severe ravages and destruction caused by natural disasters such as earthquake, typhoons and volcanic eruptions; nevertheless the country is subjected to monsoon floods, landslides and severe haze episodes.[1] Flood is the most frequent disaster occurred in Malaysia shown in Figure 1.0.In Malaysia, flood can be divided into two categories: monsoon flood and flash flood[1]. Flood occurred when heavy and continuous rainfall exceeding the absorptive capacity of soil and the flow capacity of rivers, streams, and coastal areas. Land areas that are most subjected to floods are areas situated adjacent to rivers and streams, that are known as floodplain and therefore considered as "flood -prone"[2]

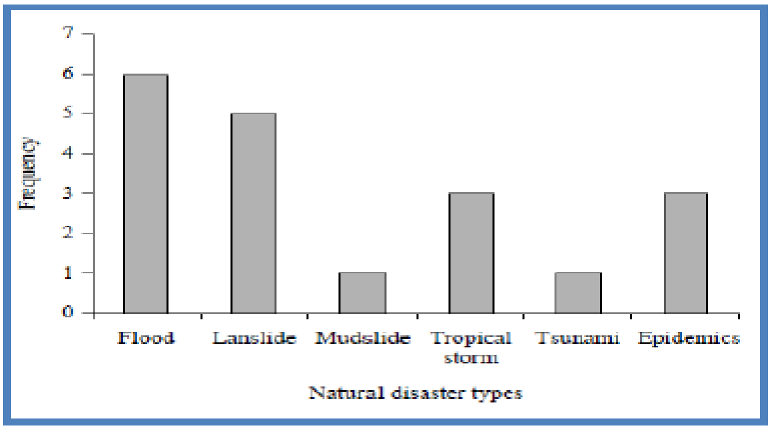

Figure 1.0: Types of natural disaster in Malaysia.

II. STUDY AREA & DATA USED

Kota Tinggi, Johor, Malaysia was chosen as study area in this study. During December of 2006 and January of 2007, an extreme rainfall hits at Kota Tinggi causing an unprecedented flood has been occurred. According to (DREF Bulletin, 2007; Yau, 2007),[3] the extreme of flood event of the year 2006/2007 at Johor is considered an effect of global warming. Total flood damages are estimated at RM 1.26 billion, with repercussions on the lives, livelihoods and businesses of the affected (source: government of Malaysia).[3] Figure 2.0 shows the location of study area.

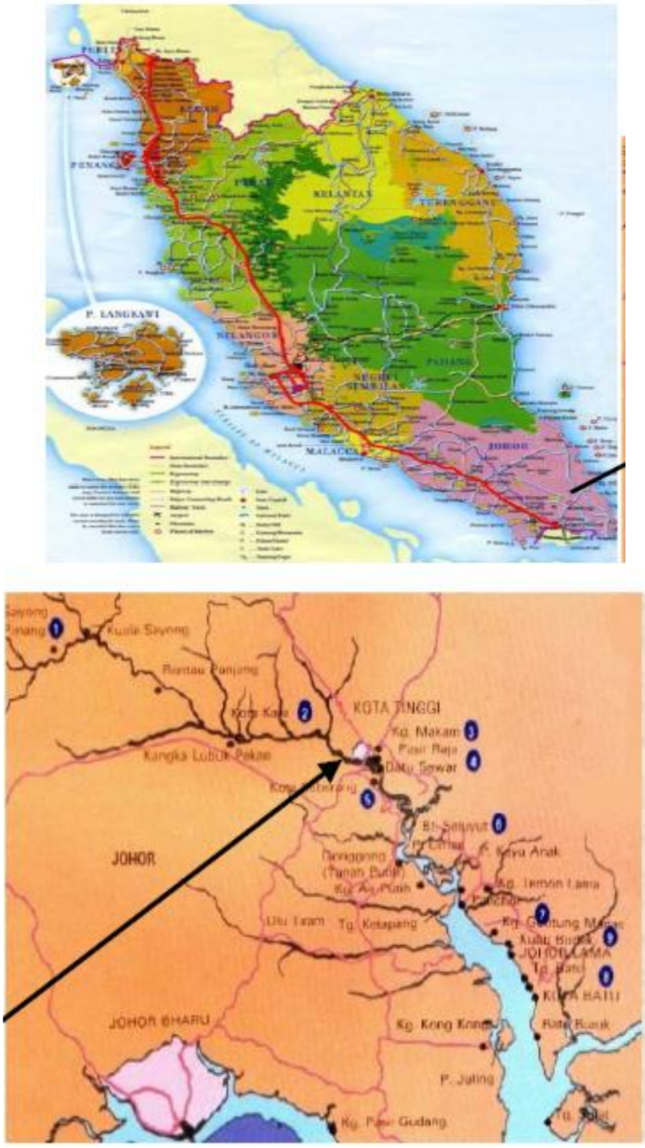

Figure 2.0: Study area

The data used in this study are listed at below:

RADARSAT-1	12-12-2006 (before flood) 19-12-2006 (peak flood) 11-01-2007 (peak flood)
Landsat ETM+	4-5-2000
Topography	20 m contour
Landuse Map	Johor District, year 2006

III. IDENTIFICATION OF WATER AREAS

Spectral signatures of water are distinct from other land use like vegetable and soil shown below

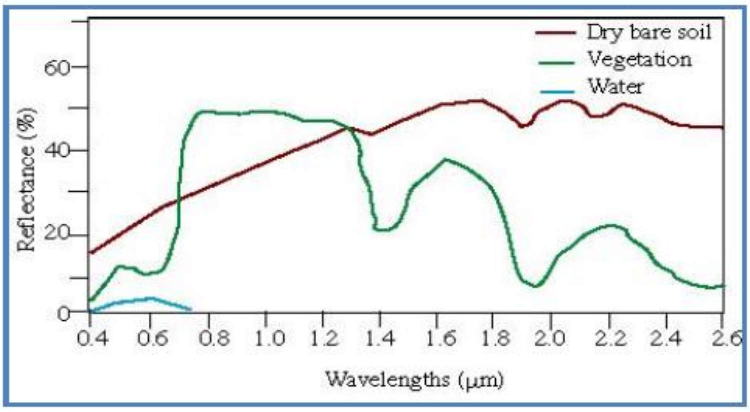

Figure 3.0: Typical spectral reflectances curve for vegatation, soil and water.

In the Figure 3, water has no reflectance at the approximately wavelength of 0.7 μm and beyond. In the order words, all infrared wavelengths are suitable for delineating water from other land use features. Baumann (1999) and Wang *et. al.* (2002) have successfully use infrared bands in Landsat TM to identify flood-inundated area. [1] In calm weather, flood water acts as a specular reflector (or forward scatterer) of the SAR signal, resulting in very low backscatter values for flooded areas that appear as a dark area in SAR image. Mason *et. al.* (2009) stated that wind or rain may cause roughening of the water surface. [4]Therefore, backscatter from the water may rise to similar or greater levels than the surrounding land. A further complicating factor may be the presence of emergent vegetation or buildings at the flood edge, leading to substantial increase in backscatter due to multiple reflections. These factors tend to reduce the accuracy of SAR-derived flood extent maps. [5]

IV. METHODOLOGY

The general idea is that RS provide spatial and temporal data input required by the distributed hydrological models in order to simulate runoffs and thus floods. RS data in some studies have also been utilized to calibrate and improve on the performance of distributed hydrological models. RS also provides an option of accessing information from otherwise physically inaccessible areas. This Figure provide a summary of how RS can be used in flood management. Flood damage assessment is Knowledge of damage inflicted by flood is required by the authorities and Insurance companies in order to effect compensation as well as to have an estimate of the cost of reconstruction.

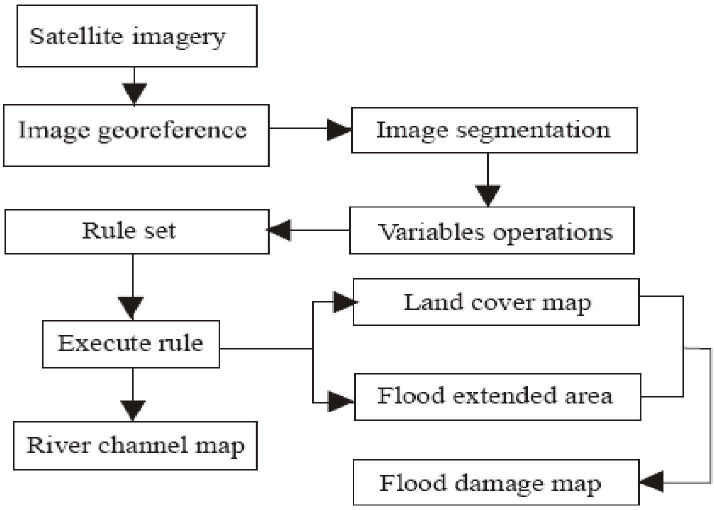

Fig. 4: Flow chart showing steps on how RS data can be processed for use in flood damage assessment.

V. PRE-PROCESSING FOR RADARSAT IMAGE

i. All pre-processing steps for RADARSAT image include geometric correction, convert digital number (DN) into backscattering coefficient, rescale 16-bit RADARSAT image into 8 bits image, and image filtering. All these pre-processing are implementing using PCI Geomatica software. [6]

ii. Since Landsat image downloaded at USGS website have been geometrical corrected. Therefore, RADARSAT image is registered to Landsat image. More ground control points (GCPs) extracted from Landsat image to rectify raw RADARSAT image to improve the accuracy of geometric correction. [7]

iii. Image filtering is used to reduce speckle noise in SAR imagery. Eight different adaptive speckle are process on SAR imagery and then using the equation 1 to determine the best adaptive speckle.[8] Standard deviation to mean (STM), to determine the ability to reduce speckle noise of a homogeneous land cover segment.

$$STM = \frac{SD}{M}$$

VI. EXTRACTING THE FLOOD EXTENT FROM SAR IMAGE

i. Extracting flood extend from SAR image by simple image processing technique: Threshold implies dividing the histogram into two or more parts. There is a clear distinction between water and surrounding objects on radar image with backscatter value. Therefore, flooded area is very easily delineated by using thresholding technique. [2, 8]

ii. According to Sanyal and Lu (2004), change detection is a powerful technique to detect flooded area in SAR imagery. It is generally performed by acquiring two imageries taken before and after the flood or during the flood. [9]Normalization have to be processed upon multiple images in order to all images have same atmospheric condition and improve result of change. One of the advantage of using change detection technique upon multiple images is we can study spatial and temporal changing of the flood extend.

iii. Extract flood extend from SAR image by visual interpretation usually takes a lot of time, labor and cost. The method of automatically extracting flood extends from RADARSAT image with the support of LNADSAT TM has been developed by Yang and Zhou, (2000).[10] The shade and water body from TM imagery were fused with water body from RADARSAT image with aim at extracting flood extent from RADARSAT imagery. The flood extent can be accurately, semi-automatically extracted from RADARSAT SAR by the method. [11]

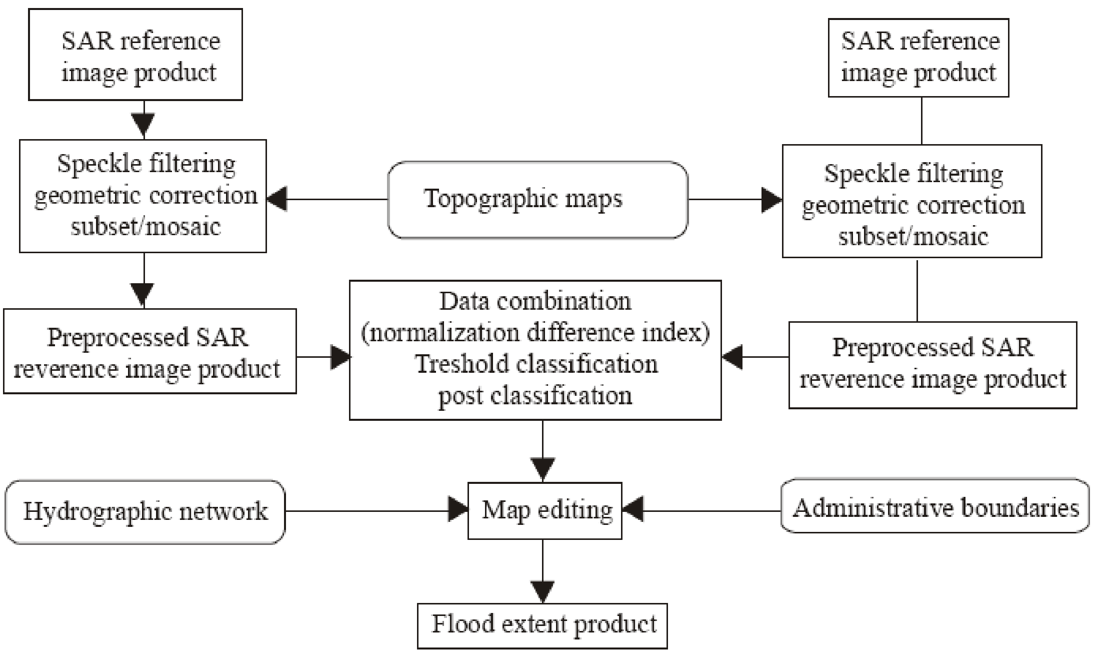

Fig. 5: Flowchart showing the generation of flood-extent maps from Satellite Radar (SAR) image.[5]

VII. RESULT ANALYSIS

Every flood extent map generate by each method is validated by existing flood map produced by Department of Irrigation and Drainage (DID). Flooded area convert into vector format to overlay on landuse map and DEM data to produce flood extend and flood depth maps respectively to indentify flood-prone area and study the impact of the flood event to environment, lives and properties.

VIII. CONCLUSION

From the preceding three sections of this review, quite a number of conclusions can be made. The first one is that flood hazard is the most widely distributed and devastating disaster, more so in this era of climate change. Secondly, knowledge of flood types is critical in flood prediction and flood damage assessment and here it is worth noting that although flash floods have not been very common compared to other types like river floods, they have caused more deaths and property damage than many other flood types. Flood management is a three phase procedure that includes pre-flood, during flood and post-flood activities. These three phases can further be subdivided into flood prediction, flood prevention and mitigation, flood risk identification and mapping and flood damage assessment. The lesson we learn from here is that flood management is very diverse and it requires multidisciplinary involvement. As an example flood prediction, mapping and damage assessment require disciplines of hydrology, soil science and geography. Flood prevention, mitigation and flood damage assessment require efforts from government, insurance companies, professionals and above all the general public.

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