Using Remote Sensing to Monitor Floods in Indonesia

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Abstract

Flood is among the most devastating natural hazard in Indonesia, claiming more lives and causing more property damage than any other natural phenomena. Among the Asian countries, Indonesia is the third of the most frequently affected country by floods, after China and India. In February 2007, the flood has covered 60% of Jakarta and in some areas the water depth has reached more than 3 meters. Even during the dry season on 2007, there were hazardously floods in a number of provinces such as NTT, Central of Sulawesi, South Sulawesi, NAD Aceh Darussalam, and North Sulawesi. Remote sensing and Geographical Information (GIS) technologies are useful technologies in flood disaster monitoring. In this paper the use of remote sensing and GIS for floods disaster monitoring in Indonesia is discussed.

1. Introduction

In general flood is defined as any relatively high water flow that overtops the natural or artificial banks in any portion of a river or stream. When a bank is overtopped, the water spreads over the flood plain and generally becomes a hazard to society. When extreme meteorological events occur in areas characterized by a high degree of urbanization, the flooding can be extensive, resulting in a great amount of damage and loss of life. Heavy rain, snowmelt, or dam failures cause floods. The events deriving from slope dynamics gravitational phenomena) and fluvial dynamics (floods) are commonly triggered by the same factor: heavy rainfall. Especially in mountainous areas, analyzing flood risk is often impossible without considering all of the other phenomena associated with slope dynamics (erosion, slides, sediment transport, etc.) whereas in plains damages are caused by flood phenomena mainly controlled by water flow.

There have been many demonstrations of the operational use of the satellites for detailed monitoring and mapping of floods and post-flood damage assessment. Sandoz, *et al* (2007) purposed an operational methodology for inventory and monitoring of wetland habitats and wetland flooded duration in South of France; Aduah *et al.* (2006) compared and combined the optical and radar satellite images to map and monitor flooding system in Southern Zambia; Pham (2004) used remote sensing and GIS technologies for monitoring and assessment of flooding status at the Coastal Zone in Central Part of Vietnam; Sandholt *et al.* (2003) compared several different sensors (optical and radar) and validated against ground based surveys in Senegal river valley; and Choudhury (1994) monitored and forecasted of disasters using NOAA and GMS images in Bangladesh.

Following those research evidence, this paper reviewed the application of the remote sensing and GIS technologies in monitoring the flood events in Indonesia, which already done by several institutions such as Indonesian National Institute of Aeronautics and Space Agency (LAPAN), Ministry of Agriculture, Operations Centre, etc.

2. Recent Flood Events in Indonesia

Dutta and Herath (2004) founded out that that in Asia; floods are by far the most frequent and devastating compared to other natural disasters, like drought, earthquake, extreme-temperature, landslide, volcano, wild fire, and winds storm. There were on average about 10 flood events annually in 1970s, it become 30 in 1990s, and in the last three years it has increased to about 50 events per year. Among the Asian countries, the ten countries which the most frequently affected by floods are China, India, Indonesia, Philippines, Bangladesh, Iran, Thailand, Sri Lanka, Vietnam, and Pakistan in descending order. The 5-year average flood statistics of last 30 years show that flood frequency in increasing in the top ten flood affected countries in Asia. It is no debatably since the Intergovernmental Panel on Climate Change (IPCC) noted that number of heavy daily precipitation events that lead to flooding have increased due to the global climate change (IPCC, 2007).

In South East Asia (Figure 2) and Indonesia (3), flood also is the most frequent natural disaster (CRED, 2007). In period of 1960-2007, about 37% of all natural disasters is flood and occurred almost in all

provinces of Indonesia, and it was increasing year by year (Figure 1 and Figure 3). The worst flood in Indonesia occurred in 2007, when 454,8 km^2 of Jakarta areas have covered by floods, and 590,000 people were forced to leave their domiciles (National Planning Board, 2007).

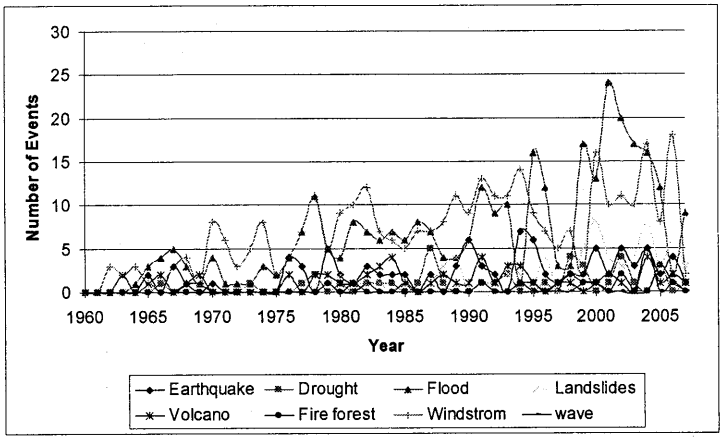


Figure 1. Flood trend in most frequently flood affected countries in South East Asia from 1960 to 2007.

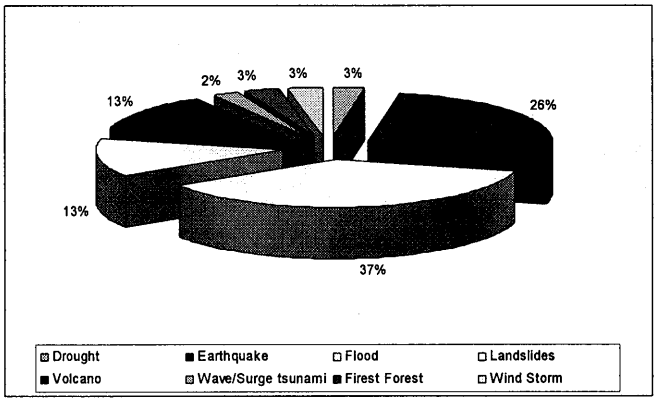


Figure 2. Flood disaster data in Indonesia compared to other natural disasters from 1960 to 2007.

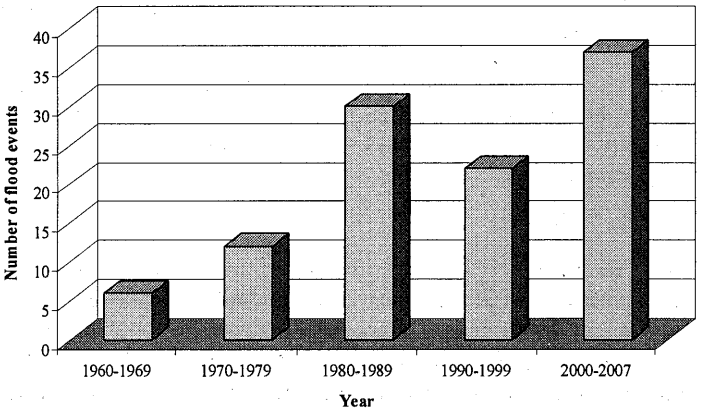


Figure 3. Flood disaster data in Indonesia from 1960-2007.

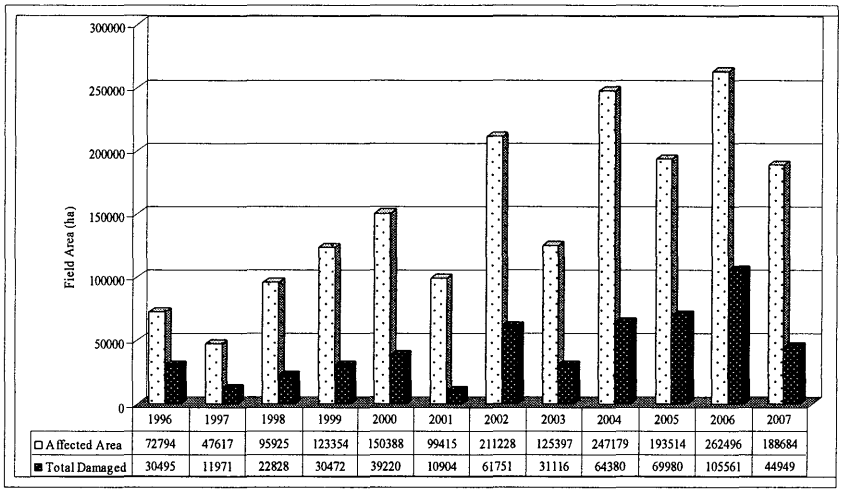


Figure 4. Flood impacts on rice fields' period of 1996-2006, and Jan-July 2007. (Source: Directorate of Food Crop Protection, Ministry of Agricultural, 2007).

3. How Remote Sensing/GIS Technologies Could Contribute to Monitor Remote Sensing

Jeyaseelan *et al.* (2003) noted that the remote sensing and GIS technology significantly contributes in the activities of all the three major phases of flood management, *i.e.* (1). Preparedness Phase, where activities such as prediction and risk zone identification are taken up long before the event occurs, (2). Response Phase, where activities such as early warning/forecasting, monitoring and preparation of contingency plans are taken up just before or during the event and (3). Recovery/Mitigation Phase, where activities just after the event includes damage assessment and relief management.

3.1. Preparation phase

The preparation phase occurs prior to and in anticipation of a severe flood. In this phase, remote sensing may contribute to mapping of inundated areas, especially at the regional level based on the flood information and experience developed during the earlier floods. Flood risk zone map may consist of two types: (1) A detailed mapping approach, that is required for the production of hazard assessment for updating (and sometimes creating) risk maps. The maps contribute to the hazard and vulnerability aspects of flooding. (2) A larger scale approach that explores the general flood situation within a river catchment or coastal belt, with the aim of identifying areas that have greatest risk (Jeyaseelan, *et al.*, 2003).

3.2. Response phase

The response phase occurs prior to the onset of a flood and is based on weather reports and information from spotter groups. The response phase actins to be taken after the receipt of evidence indicating likely flooding (Gissing, 2003). Three kinds of contribution might be done by remote sensing in this phase, there are (1) Flood prone/Risk zone identification, (2) Flood monitoring, and (3) Flood forecasting.

3.3. Recovery/mitigation phase

The recovery phase usually overlaps the previous phase. The recovery phase may begin just after the flood and can last for several years. In this phase, the remote sensing might contributed on assessment of (1) Flood damage rehabilitation – immediately during flood, and (2) relief efforts – after the flood.

4. Example Of Remote Sensing Application For Flood Monitoring In Indonesia

4.1. Delineation of Flood Prone Paddy Fields Based on Landsat TM

Ministry of Agriculture (2002) delineated the flood prone in paddy field area of Java Island based on Landsat TM, land characteristics, and rainfall data. The divided into four level of flooding, *i.e* (1) the very vulnerable, (2) vulnerable, (3) less vulnerable, and (4) non vulnerable.

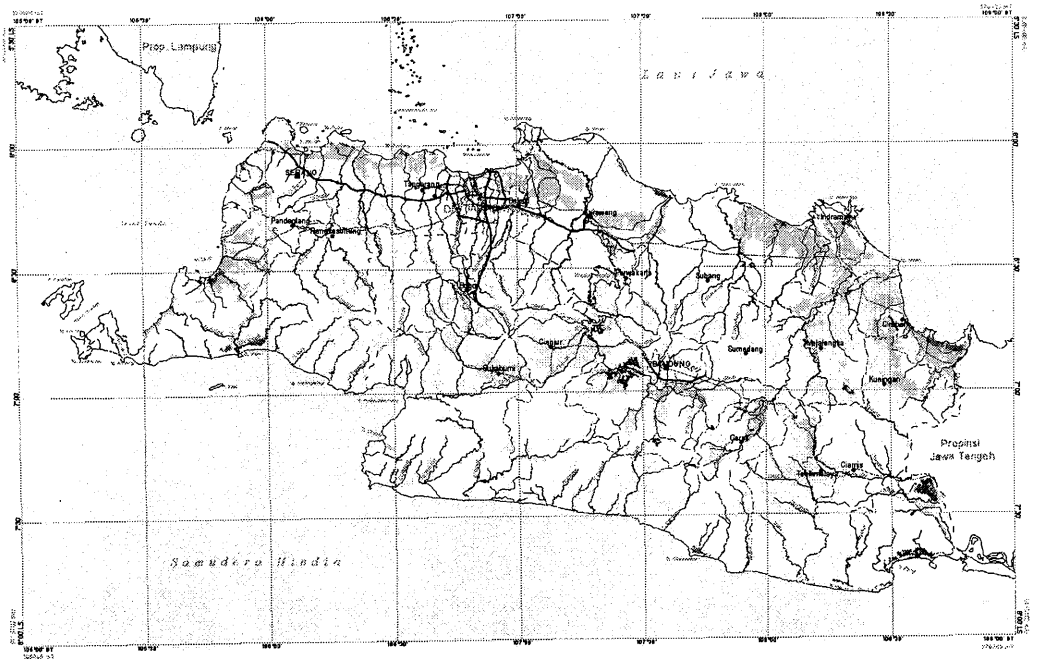
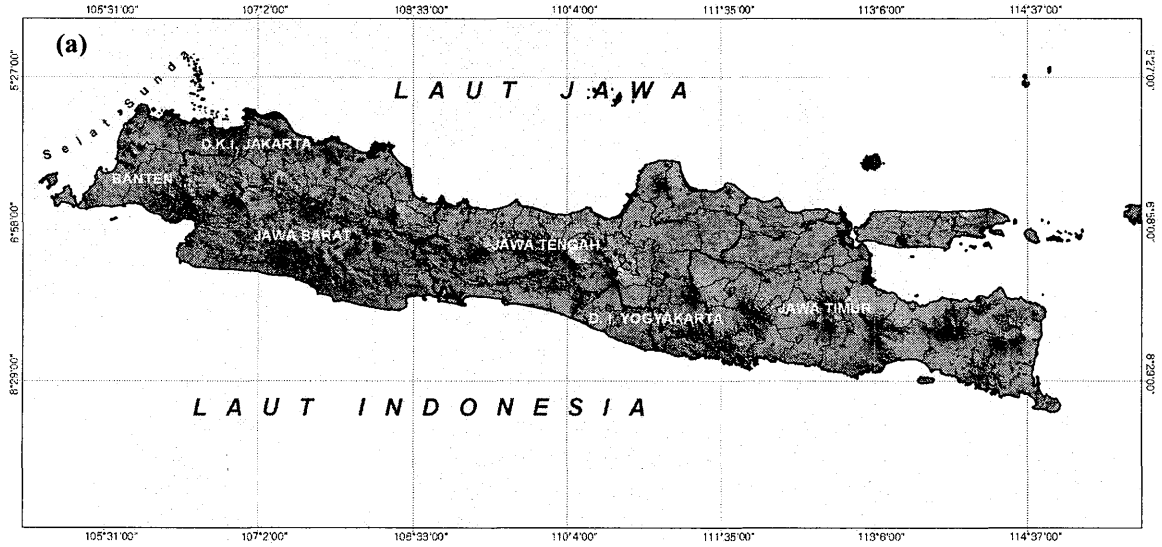


Figure 5. The paddy field area that influenced by flood. Red shown the very vulnerable, pink shown vulnerable, yellow shown less vulnerable, and green shown non vulnerable.

4.2. Delineation of Flood Prone Areas Based on Landsat TM (LAPAN, 2002)

Lapan is the one institution in Indonesia that has mandate to inventory remote sensing data and using it for multiple purposes. In 2002, Lapan delineated the floode prone area for whole Indonesia, as shown in Figure 6.



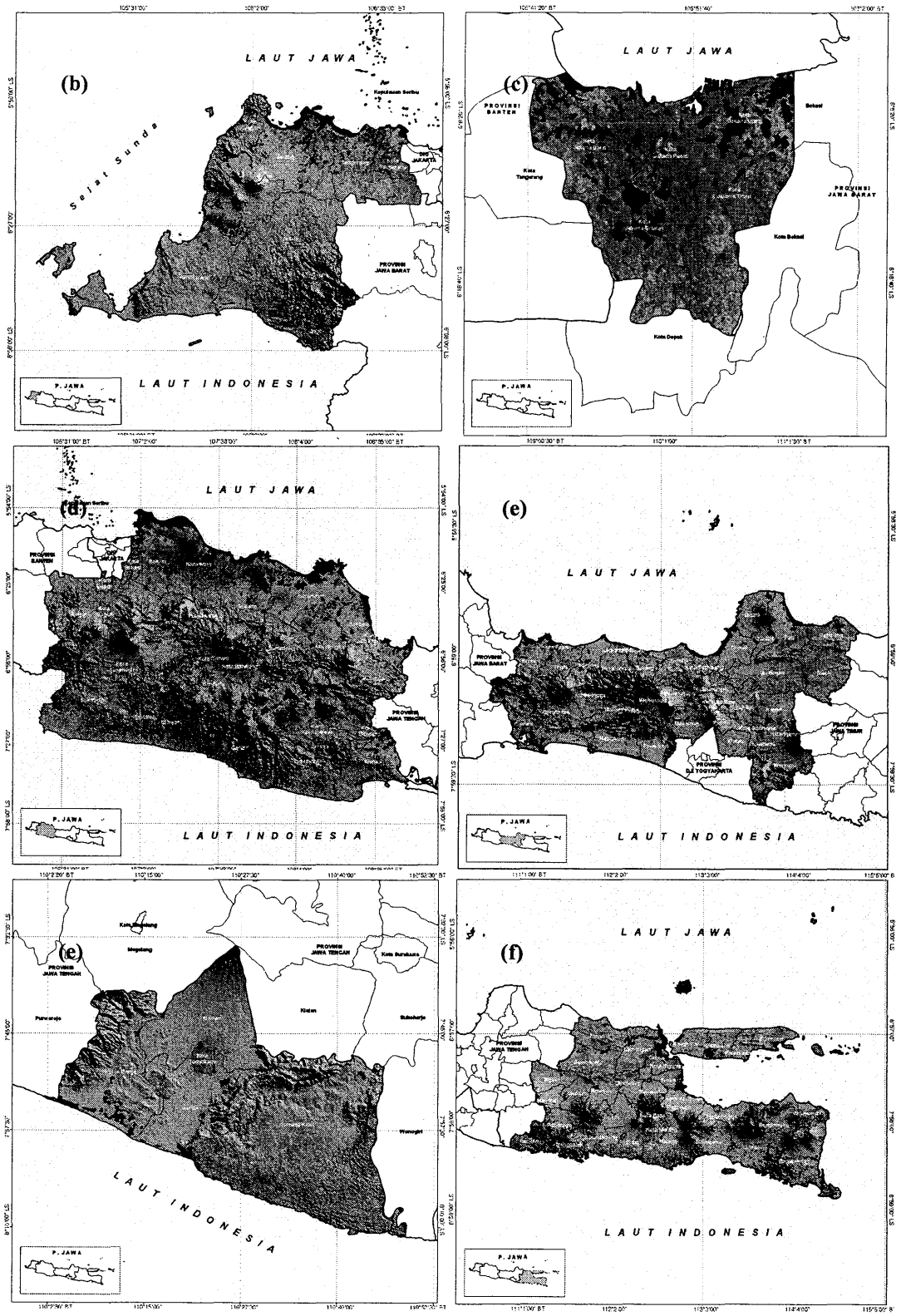


Figure 5. The flooded area delineated using LANDSAT TM (a) Java Island, the Province of: (b) Banten, (c) Jakarta, (d) West Java, (e) Center of Java, (f) Yogyakarta, and (g) East Java. (Source: Lapan, 2002).

4.3. Daily Potential Flooded Area (MTSAT) Information

LAPAN also used MTSAT-1R (Multifunction Transport Satellite - 1R) for monitoring the daily potential flooded area, as shown in Figure 6.

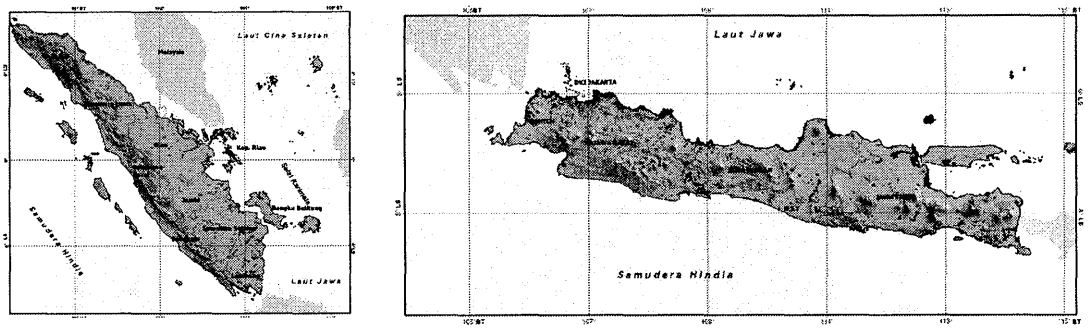


Figure 6. The flooded area delineated using MTSAT-1R of (a) Sumatera and (b) Java islands (Source: Lapan, 2007).

5. Conclusions

Flood is a recurrent problem in Indonesia. Application of the remote sensing technologies is necessary in the activities of the three major phases of flood management (preparation, prevention, and recovery phases). In this paper, brief review of remote sensing and GIS methods and its utilization for flood management in Indonesia are discussed.

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