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Reappraisal: Floods Management and Monitoring Using Remote Sensing and GIS

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Abstract: **Space technology has made ample contribution in all the three phases such as preparedness, prevention and relief phases of flood disaster management. The Earth Observation satellites which include both geostationary and polar orbiting satellites provide comprehensive, synoptic and multi temporal coverage of large areas in real time and at frequent intervals and thus, have become valuable for continuous monitoring of atmospheric as well as surface parameters related to floods. Geo-stationary satellites provide continuous and synoptic observations over large areas on weather including cyclone monitoring. Polar orbiting satellites have the advantage of providing much higher resolution imageries, even though at low temporal frequency, which could be used for detailed monitoring, damage assessment and long-term relief management. Advancements in the remote sensing technology and the Geographic Information Systems help in real time monitoring, early warning and quick damage assessment of flood disasters. In this paper the use of remote sensing and GIS and the global scenario for the flood disaster management is discussed.**

Keywords: **Flood, Remote Sensing, GIS, Assessment, Management, Monitoring.**

I. INTRODUCTION

Floods are water-related natural disasters which affect a wide range of environmental factors and activities related to agriculture, vegetation, human and wild life. Floods are among the most devastating natural hazards in the world, claiming more lives and causing more property damage than any other natural phenomena.

Several users such as top level policy makers at the national and international organizations, researchers, middle level policy makers at the state and local levels consultants, relief agencies and local producers including farmers, suppliers, traders and water managers are interested in reliable and accurate flood information for effective management. The disaster management activities can be grouped into three major phases: The Preparedness phase where activities such as prediction and risk zone identification are taken up long before the event occurs; the Prevention phase where activities such as Early warning/Forecasting, monitoring and preparation of contingency plans are taken up just before or during the event; and the Response/Mitigation phase where activities are undertaken just after the event which include damage assessment and relief management.

Remote sensing techniques make it possible to obtain and distribute information rapidly over large areas by means of sensors operating in several spectral bands, mounted on aircraft or satellites. A satellite, which orbits the Earth, is able to explore the whole surface in a few days and repeat the survey of the same area at regular intervals, while an aircraft can give a more detailed analysis of a smaller area, if a specific need occurs. The spectral bands used by these sensors cover the whole range between visible and microwaves. Rapid developments in computer technology and the Geographical Information Systems (GIS) help to process Remote Sensing (RS) observations from satellites in a spatial format of maps. The integration of information derived from Remote Sensing techniques with other datasets (both spatial and non-spatial formats) provides tremendous potential for identification, monitoring and assessment of floods.

II. REMOTE SENSING FOR FLOODS

Floods are among the most devastating natural hazards in the world, claiming more lives and causing more property damage than any other natural phenomena. As a result, floods are one of the greatest challenges to weather prediction. A flood can be defined as any relatively high water flow that overtops the natural or artificial banks in any portion of a river or stream, seas and oceans. 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.

Forms of Floods: River Floods form from winter and spring rains, coupled with snow melt, and torrential rains from decaying tropical storms and monsoons; Coastal Floods are generated by winds from intense off-shore storms and Tsunamis; Urban Floods, as urbanization increases runoff two to six times what would occur on natural terrain; Flash Floods can occur within minutes or hours of excessive rainfall or a dam or levee failure, or a sudden release of water.

Flood Preparedness Phase:

Flood Prone/Risk zone identification:

The flood information (data) and experience (awareness) developed during the earlier floods may help in future events. The primary method for enhancing our knowledge of a particular flood event is through flood disaster surveys, where results such as damage assessment, lessons learned and recommendations are documented in a report (Annual Lagos flood disaster is a typical example). Flood risk zone map is 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. In this case, remote sensing may contribute to mapping of inundated areas, mainly at the regional level.

Flood Prevention Phase:

Flood Monitoring:

Though flood monitoring can be carried out through remote sensing from global scale to storm scale, it is mostly used in the storm scale using hydrodynamic models by monitoring the intensity, movement, and propagation of the precipitation system to determine how much, when, and where the heavy precipitation is going to move during the next zero to three hours (called NOWCASTING).

Flood Forecasting:

Hydrologic models play a major role in assessing and forecasting flood risk. The hydrologic models require several types of data as input, such as land use, soil type, soil moisture, stream/river base flow, rainfall amount/intensity, snow pack characterization, digital elevation model (DEM) data, and static data (such as drainage basin size). Model predictions of potential flood extent can help emergency managers develop contingency plans well in advance of an actual event to help facilitate a more efficient and effective response. Flood forecast can be issued over the areas in which remote sensing is complementary direct precipitation and stream flow measurements, and those areas that are not instrumentally monitored (or the instruments are not working or are in error). In this second category, remote sensing provides an essential tool.

Response Phase:

Assessment of Flood Damage:

The response category can also be called "relief," and refers to actions taken during and immediately following a disaster. During floods, timely and detailed situation reports are required by the authorities to locate and identify the affected areas and to implement corresponding damage mitigation. It is essential that information be accurate and timely, in order to address emergency situations (for example, dealing with diversion of flood water, evacuation, rescue, resettlement, water pollution, health hazards, and handling the interruption of utilities etc.). For remote sensing, this often takes the form of damage assessment. This is the most delicate management category since it involves rescue operations and the safety of people and property.

The following lists information used and analyzed in real time: flood extent mapping and real time monitoring (satellite, airborne, and direct survey), damage to buildings (remote sensing and direct inspections), damage to infrastructure (remote sensing and direct inspection), meteorological NOWCASTS (important real-time input from remote sensing data to show intensity/estimates, movement, and expected duration of rainfall for the next 0 - 3 hours), and evaluation of secondary disasters, such as waste pollution, to be detected and assessed during the crisis (remote sensing and others). In this category, communication is also important to speedy delivery.

Relief (after the Flood):

In this stage, re-building destroyed or damaged facilities and adjustments of the existing infrastructure will occur. At the same time, insurance companies require up-to-date information to settle claims, but this is not applied in third world. The time factor is not as critical as in the last stage. Nevertheless, both medium and high-resolution remote sensing images, together with an operational geographic information system, can help to plan many tasks. The medium resolution data can establish the extent of the flood damages and can be used to establish new flood boundaries. They can also locate landslides and pollution due to discharge and sediments. High-resolution data are suitable for pinpointing locations and the degree of damages. They can also be used as reference maps to rebuild bridges, washed- out roads, homes and facilities.

III. GLOBAL SCENARIO ON REMOTE SENSING USE

There have been many demonstrations of the operational use of these satellites for detailed monitoring and mapping of floods and post-flood damage assessment. Remote Sensing information derived from different sensors and platforms (satellite, airplane, and ground etc.) are used for monitoring floods in China. A special geographical information system, flood analysis damage information system was developed for estimation of real time flood damages (Chen Xiuwan). Besides mapping the flood and damage assessment, high resolution satellite data were operationally used for mapping post flood river configuration, flood control works, drainage-congested areas, bank erosion and developing flood hazard zone maps (Rao *et al.*, 1998). A variety of satellite images of the 1993 flooding in the St. Louis area were evaluated and combined into timely data sets. The resulting maps were valuable for a variety of users to quickly locate both natural and man-made features, accurately and quantitatively determine the extent of the flooding, characterize flood effects and flood dynamics. (Petrie *et al.*, 1993). Satellite optical observations of floods have been hampered by the presence of clouds that resulted in the lack of near realtime data acquisitions. Synthetic Aperture Radar (SAR) can achieve regular observation of the earth’s surface, even in the presence of thick cloud cover. Therefore, applications such as those in hydrology, which require a regularly acquired image for monitoring purposes, are able to meet their data requirements. SAR data are not restricted to flood mapping but can also be useful to the estimation of a number of hydrological parameters (Pultz *et al.*, 1996). SAR data were used for estimation of soil moisture, which was used as an input in the TR20 model for flood forecasting (Heike Bach, 2000). Floods in Northern Italy, Switzerland, France and England during October 2000 were studied using ERS-SAR data. Using information gathered by the European Space Agency’s Earth Observation satellites, scientists are now able to study, map and predict the consequences of flooding with unprecedented accuracy. SAR images are also particularly good at identifying open water - which looks black in most images. When combined with optical and infra-red photography from other satellites, an extremely accurate and detailed digital map can be created. Quantitative Precipitation Estimates (QPE) and Forecasts (QPF) use satellite data as one source of information to facilitate flood and flash flood forecasts in order to provide early warnings of flood hazard to communities. New algorithms are being developed that integrate the less direct but higher resolution (space and time) images. An improvement in rainfall spatial distribution measurements is being achieved by integrating radar, rain gauges and remote sensing techniques to improve real time flood forecasting (Vicente and Scofield, 1998). Potential gains from using weather radar in flood forecasting have been studied. (U.S. National Report to International Union of

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Geodesy and Geophysics 1991-1994). A distributed rainfall-runoff model was applied to a 785 km basin equipped with two rain gauges and covered by radar. Data recorded during a past storm provided inputs for computing three flood hydrographs from rainfall recorded by rain gauges, radar estimates of rainfall, and combined rain gauge measurements and radar estimates. The hydrograph computed from the combined input was the closest to the observed hydrograph. There has been considerable work devoted to developing the approach needed to integrate these remotely sensed estimates and in situ data into hydrological models for flood forecasting. A large-scale flood risk assessment model was developed for the River Thames for insurance industry. The model is based upon airborne Synthetic Aperture Radar data and was built using commonly used Geographic Information Systems and image processing tools. From the Ortho-rectified Images a land cover map was produced (Hélène M. Galy, 2000).

IV. CONCLUSION

Floods are among the most devastating natural hazards in the world, claiming more lives and causing extensive damage to agriculture, vegetation, human and wild life and local economies. The remote sensing and GIS technology significantly contributes in the activities of all the three major phases of flood management namely, 1. Preparedness Phase where activities such as prediction and risk zone identification are taken up long before the event occurs. 2. Prevention 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. Response/Mitigation Phase where activities just after the event includes damage assessment and relief management. In this paper, brief review of remote sensing and GIS methods and its utilization for flood management are discussed.

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