Remote Sensing Imagery to Assess the Environmental Impacts of Flood

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Abstract

Developments in remote sensing technology have opened a new horizon in disaster management, particularly in the field of assessment of flood damages. Now a days, various kinds of satellite images have become readily available. Using these images, ground conditions can be assessed on a pixel by pixel basis enabling identification and analysis of land surface. The abundance of information available from these images makes it possible to address quarries in numerous environmental issues. This study focuses on the applicability of satellite images in the monitoring and analysis of environmental impacts including changes in land coverage and extent of flooding. A software has been developed for the analysis of satellite images. The software has been applied to analyze the images for predicting the changes in land coverage. The accuracy of the analysis depends on the resolution of the images. Although the images sometimes provide noisy spatial patterns, it has been observed that even the low-cost, low-resolution images can successfully be used for satisfactory analysis. For this purpose, appropriate filtering technique must be utilized to preprocess the image.

INTRODUCTION

During the last couple of years a lot of new remote sensing techniques have been developed and numerous satellites have been set up to monitor the changes on the earth's surface round the clock. Due to this evolution, satellite images have become readily available and widely used for different purposes including investment decisions, disaster management and even war monitoring and guidance (Eric and Laura, 1997 and Ramsey and Chappel, 1997). In the framework of integrated remote sensing and GIS, satellite images have become an integral tool for the planners and decision-makers. The cost of images vary widely depending on the resolution, accuracy and source. All the images are not suitable for all the purposes. For example, conventional broad band sensors such as Spot-XS, Landsat MSS and Landsat TM are not suitable for mapping minerals or soil properties (Jong, 1998). On the other hand, special purpose high-resolution images are extremely costly. Sometimes appropriately selected low-cost images can provide information, which are almost as good as the high-cost ones. For this purpose the images should be selected and pre-processed carefully. Appropriate merging and filtering techniques must be used for pre-processing the images. In Bangladesh, satellite data is primarily used for meteorological purpose by the Bangladesh Meteorological Department. In the country, SPARSO is the principal organization involved in the collection and study of satellite images. For the analysis of satellite images, costly softwares are imported from other countries. These softwares are usually tailored for specific kind of jobs, which limits the extent of analysis. This study explores the potential of satellite imagery for monitoring the extent of flood and its environmental impacts. The country suffers from flood every year, which cause significant damages to the economy and sufferings of the people. Appropriate monitoring systems will facilitate faster and more accurate monitoring of the extent of flooding then the conventional system of collecting information from the field. For the purpose of analyzing satellite images a software had been developed using Visual Basic Programming Language. Images acquired from GMS and NOAA satellites have been used for the analysis.

FLOOD OF 1998

Due to intermittent heavy rainfall in the country and in the upper catchment areas from July to early September of 1998, all the rivers of the country over-flowed and caused severe flood. The flood affected about 68 percent areas of the country. The rivers of the country started experiencing on-rush of flow from the middle of July and by that time the low-lying areas of the country had already gone under water. At that time, about 45,000 sq. km. of 37 districts of the country were affected by flood. Although flood situation started improving in early August, the flow of the two main rivers of the country- Padma and Brahmaputra-Jamuna increased significantly in the middle of August. This was caused by heavy rainfall in the upper catchment areas. By the end of August flood situation became worse and about 60,000 sq.km area of 42 districts were affected. During the early September the flow of the major rivers increased abruptly worsening the condition. The flood situation became worst in the second week of September and about 75,000 sq.km area of 52 districts were affected during that time. The flooded condition existed from early July to the last week of September, for nearly about three months at different places in different magnitudes. Thus flood of 1998 became the most prolonged flood in the history of the country. The total flood inundated area was about 1,00,250 sq.km (68 percent of the total area of the country) affecting 53 districts (Annual Flood Report, 1998).

METHODOLOGY

The main objective of the study is to develop a methodology to analyze satellite image for monitoring extent of flood and its environmental impacts. For this purpose the satellite images should be processed initially and then the information from those images is to be extracted.

Automated color based interpretation technique is applied to analyze the images. NOAA and GMS images are used for the purpose of analysis. Images from June to September of 1998 are used in the analysis, which are collected from SPARSO. A typical satellite image is shown in Figure 1. Color differences are considered in order to identify and classify flood-damaged areas. For the purpose of calibration of the software, ground information with respect to specific images of particular dates are utilized. Bangladesh Water Development Board (BWDB) provides the ground information. For a particular application, the land coverage is classified into four classes namely – (I) Severely Flood Affected Area, (II) Moderately Flood Affected Area, (III) Lightly Flood Affected Area, and (IV) Not Flood Affected Area.

In the calibration phase of the analysis, the color value in the form of Red, Green and Blue component is extracted for each of the types mentioned above by using calibration images and ground information provided by the relevant organizations. By analyzing the calibration images, the range of the values of each component for each of the classes is obtained which formulates the classification framework, which is shown in Table 1. This classification scheme is then applied on the satellite images to obtain the amount of areas in different classes and monitor their changes.

Table 1: Classification Scheme to Monitor Extent of Flood and Its Changes

Classification of Land Surface	Red	Green	Blue
Severely Flood Affected Area	75-125	35-65	55-140
Moderately Flood Affected Area	40-60	50-80	100-160
Lightly Flood Affected Area	85-190	75-225	85-180
Not Flood Affected Area	30-115	85-170	170-225

DESCRIPTION OF THE SOFTWARE TO ANALYZE THE IMAGES

A user-friendly software has been developed to analyze the images using Visual Basic programming language. Different interfaces of the software are shown in Figures 1 and 2. The reasons for the selection of designing the platform for the software is described below:

- Visual Basic 5.0 supports various types of common image files, e.g., BMP, JPG, WMF etc. So, it will be convenient to use the developed software for several types of images.
- Color value of any point in images can be read very easily.
- Color value of any point can be obtained in two ways – (1) read the value as a long color value, (2) read the value in RGB form (split the value in Red, Green and Blue color components).
- The developed software can be made efficient in browsing picture files and in loading them from anywhere of the hard drives of the computer.
- The output can be made in a presentable form and can be linked with any database file.
- More flexibility can be associated with the software so that it becomes more user-friendly.

Description of the Software

As stated earlier, the software has been designed to analyze images to extract data. The satellite images are not like normal photographs. The color of any object in a satellite image is not the same as in a normal photograph. For example, in a satellite image forest will not be as green as it is in a normal photograph. This variation is caused by noises due to air, temperature differential, suspended particles and sensor capabilities. To make the analysis practically meaningful, color property of various objects in this special image type needs to be identified and a range of color is to be set for each object. This phase of the analysis is called calibration phase. Afterwards the calibrated classification schemes can be utilized to analyze the images.

Calibration Phase

In this phase, color property is calibrated to identify the objects during the analysis. The calibration phase consists of a simple process to set a color range for selected objects. In this phase the objects are identified and the range of color value is established for each object. Color values or properties are read for a certain type of object from a satellite image for which the ground conditions are known. Three components in the color value i.e., Red, Green, Blue (RGB), are used to identify the color. After taking a number of color values (RGB) for a certain object they were scrutinized and compared with each other and a color value range is established which represents the color of that particular object. In this way, the color value ranges are established for all the selected objects and a "Decision Table" is prepared. This "Decision Table" is then used in developing the software for the analysis.

Analysis Phase

This is the main component of the software. After establishing the color value component (Red, Green, Blue) range properly for the selected objects, the analysis phase is implemented. In the analysis phase the red, green and blue color values of each pixel is extracted and the object in the pixel is identified using the decision table prepared in the calibration stage.

The components of the software for calibration and analysis inter-phases are shown in Figure 1 and 2.

RESULTS

Using the software described above satellite images taken in the months of June, July, August and September of 1998 have been analyzed in the study. Results obtained from the analysis are presented in Table 2.

The results obtained in the study are validated by using data from secondary sources such as Bangladesh Water Development Board (BWDB), Local Government Engineering Department (LGED) and Bangladesh Meteorological Department (BMD). The analysis by the computer program developed in the study is in close agreement with the results predicted by another program written in C++ programming language, which has been developed independently.

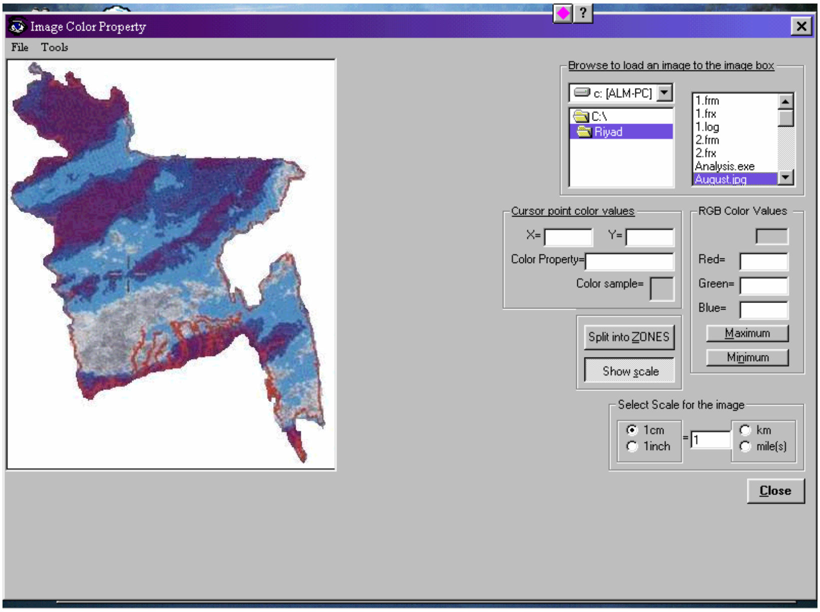

Figure 1: Software Inter-Phase for Calibration Stage

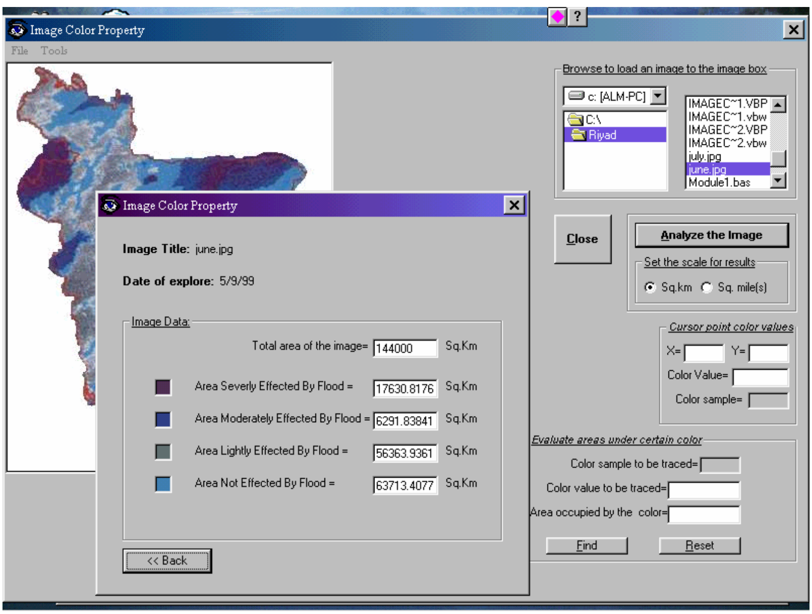

Figure 2. Software Inter-Phase for Analysis Stage

Table 2: Extent of Flood and Its Changes As Obtained from the Software

Classification of Land Surface	Date of Imaging			
	End of June, 1998	Middle of July, 1998	End of August, 1998	Beginning of September, 1999
Severely Flood Affected Area	17631	58670	49199	76565
Moderately Flood Affected Area	6292	6569	3534	324
Lightly Flood Affected Area	56364	20595	35917	35874
Not Flood Affected Area	63713	58165	55349	31237

CONCLUSIONS

The satellite based remote sensing techniques proved to be appropriate methods for documenting and analyzing damages caused by flood. Remote sensing provides an overview of a regional problem, particularly in extensive areas with scarce information. These techniques also provide a basis for monitoring the natural environment because the analysis of remote sensing data at regular intervals reveals the trends and changes. Due to low resolution and noise the extracted information may not be very accurate. But it acts as an instantaneous tool for decision-making. Also by using appropriate techniques and filtering the low-cost satellite images, the accuracy of analysis can be greatly improved. Compared with field survey, the remote sensing satellite images provide a lot of more information at much cheaper cost.

In this study, low cost satellite images have been successfully applied to monitor the impacts of the devastating flood of 1998. For this purpose, an integrated software has been developed to analyze the images. From the analysis it has been found that during the middle of July, end of August and Early September of 1998 about 65000, 53000 and 77000 sq. km. of the country was under flood. The accuracy of the analysis is checked by collecting information from organizations responsible for monitoring flood situation. It has been observed that the differences between the results of this study and relevant information from the sources mentioned above are less than 10 percent. The software developed in this study can be used to analyze any image for the purpose of studying land use, vegetation cover, soil properties, etc.

The study can further be extended incorporating GIS framework. GIS proved to be an excellent tool for studying the environment, combining different maps, layers, variables and data from diverse sources. Prediction analysis and trend assessment could be realized using a GIS framework.

The accuracy of the analysis can be improved by using images of higher resolution. For this purpose Airborne Visible/InfraRed Imaging Spectrometer (AVIRIS) or Landsat TM images can be utilized. Landsat TM records data in seven bands with a spatial resolution of 30mX30m. AVIRIS acquires images at a spatial resolution of 20m x 20m having 224 bands with a nominal band interval of 10 nm.

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