

# **REMOTE SENSING AND GIS APPLICATIONS IN FLOOD MANAGEMENT**

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## **1.0 INTRODUCTION**

Floods are among the most destructive acts of nature. World-wide, flood damages to agriculture, houses and public utilities amount to billions of dollars each year in addition to the loss of precious human and cattle lives. In majority of cases, 'flooding' is caused by a river over-spilling its banks. This can be due to excessive precipitation, combined with inadequate channel capacity. Over-spilling can also occur due to obstruction in or aggradation of the river bed. Flooding can also result from inadequate water way at rail and road crossings, or when there are encroachments in the flood plain. Flooding can also occur at confluences of streams when the main river is in high stage and backs up into the tributaries and areas there about.

India is no exception as far as floods are concerned. Severe floods occur almost every year in one part of the country or the other causing tremendous loss of life, large scale damage to property and untold misery to millions of people. Floods mostly occur in the country during the south west monsoon period spread from June to September, though cyclonic storms are common during October to December.

## **2.0 FLOOD MANAGEMENT**

### **2.1 Structural and non-structural measures**

The huge losses sustained from floods throughout the World have stimulated actions to deal with flood problem as a priority issue. Both structural and non-structural measures have been undertaken to tackle the problem.

It was initially believed that the way to reduce flood damages was to manage the rivers through structural measures and moderate the floods. Structural measures, as the name implies, are those which involve construction of structures like dams, embankments, drainage channels, etc. However, after spending large amounts of money on flood management works, it was realized that this approach did not work very well. The reason is simple to understand. Anyone living near a river knows that it can flood and he is careful as to how much of his resources he should keep close to the river. But, when a dam or an embankment is built, he thinks that the river is now fully controlled. He, thus, becomes comparatively more complacent and builds his property even closer to the river. When a flood occurs which the structure cannot contain, this individual suffers more damage than what he would have suffered had the structure not been built in the first place. Besides, there are various difficulties in the construction of flood management structures (like financial constraints etc ). due to which it is not possible to protect all flood prone areas from floods of all magnitudes.

It was thus, learnt that we should not try to mitigate flood damages by only keeping the water away from the people. This also made the people realise the important of flood plains. Flood plain is the land adjoining the river which it occupies during floods. It may be dry for most part of the year and we may use it. But, we should always keep in mind that this land area belongs to the river and not to us. We should use the flood plain judiciously and also be prepared to vacate it whenever the river needs it. The study and use of Flood plain in this manner is called ‘ flood plain management’ and the reduction of flood damage in this way is called the ‘non-structural’ approach.

## **2.2 Structural Measures**

Structural measures are those which involve the construction of engineering works such as reservoirs, embankments, drainage channels, etc.

## **2.3 Non-structural measures**

As indicated earlier, an increasing stress is now being laid on the non-structural measures. The important non-structural measures are, therefore, described here.

#### 2.3.1 Flood Plain Management

The best thing would no not to occupy the flood plains at all. However, this is not possible due to the ever growing population and the consequent demands of land for habitation. Another important thing to remember is that at any many places in the world and particularly in Asia, the population is dependent on the large fertile plains adjoining the rivers to grow food and fibre. It is the regular inundation of these areas by sediment laden flood waters which makes them fertile. Thus, floods are both a blessing and a curse. Even if it were possible to prevent all floods, it would result in the elimination of both the curse and the blessings. Proper flood plain management helps in reducing the curse while retaining the blessing.

#### 2.3.2 Flood Plain Zoning

Flood plain zoning is the process of classification of areas liable to floods of different frequencies in the vicinity of a river. These areas are then marked/demarcated on large scale maps along with close contour intervals and displayed at public places for wide publicity. Very little work in this field has been done in India while this requires greater attention in our country because of its high population density.

#### 2.3.3 Flood Plain Regulation

The activities in various flood plain zones can be regulated by grouping these under various priorities. For example, buildings under defence installations, industries, public utilities like hospitals etc. can be put under priority and located in such zones that they are above the flood levels corresponding to 100 years frequency or the maximum observed flood levels. The buildings like government offices etc. can be located in zones corresponding to flood frequency of one in 50 or 25 years. Places like parks etc can be located in the areas vulnerable to frequent floods.

#### 2.3.4 Flood Forecasting

If those who are affected by floods have some advance warning, there are numerous things which can be done to reduce the loss of life and flood damage. Flood forecasting provides us with this warning. It tells us to when the river is going to rise and to what extent. The use of flood plains in this manner gives benefits far greater than the damage due to periodic flooding.

The science of flood forecasting is as old as mankind. Probably the first flood forecast was formulated thousands of years ago by a man sitting on a river bank, who, seeing that it was raining heavily, guessed that the river would rise. However, the first organized forecast service is believed to have been started for the Siene river in France in 1830. In 1890, a special scientific commission was set up in Germany to organize a flood forecast service.

A good flood forecasting system helps the concerned authorities in taking timely rescue and relief measures.

In India, the work of flood forecasting was initiated by the Central Water Commission. A Unit was established in 1958 for flood forecasting on the Yamuna at Delhi. It has gradually been extended to cover almost all the flood prone inter-state river basins.

Other important non-structural measures are Flood Proofing, Disaster Management, Relief & Rehabilitation and Flood Insurance .

### **3. BEST WAY OF FLOOD MANAGEMENT**

After discussing various measures for flood management and their limitation, now the question arises as to which is the best method of flood management? The answer is that no method can be termed as the best. Any method can be adopted according to the circumstances.

However, it has been experienced that a combination of various measures in the best way of flood management ; for instance, the construction of embankments along with the reservoir or a combination of structural and non-structural measures.

In the end it may be mentioned that we should learn to share the flood plains with the rivers. We can use the flood plains when the river does not need it.

Thus the flood plains may be used in such a manner that the benefits of using them would exceed the damage due to floods.

#### **4. ROLE OF SPACE TECHNOLOGY IN FLOOD MANAGEMENT**

The unique capabilities of satellites to provide comprehensive, synoptic and multi-temporal coverage of very large areas at regular interval and with quick turn around time have been very valuable in monitoring and managing flood dynamics. In fact, it is only space technology, which has for the first time provided the basic information needed in the space, time and frequency domain. In order that the appropriate flood control and anti-erosion works are scientifically planned, executed, monitored and maintained as per the best standards, it is necessary to acquire timely and reliable information about the flooded areas, watershed areas, river behaviour and configurations, etc. prior to floods, during floods, and after floods. Such information is difficult to acquire in time for decision making from conventional ground survey methods in vogue, which are arduous, time consuming and beset with various limitations, especially while studying floods of large river basins.

The earth Observation 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 flood. Satellites, by virtue of their remote sensing and data transmission capabilities to provide comprehensive multi-date and multi-spectral information on dynamic phenomena covering very large as well as small river basins, have been found to be admirably suited for mapping/monitoring and studying (i) flood inundated and drainage congested areas, (ii) extent of damages to crops, structures etc. (iii) river configuration, silt deposits, shoals etc. and vulnerable areas of bank erosion (iv) watershed characteristics and land cover/land use in command areas and (v) hydrological and meteorological data transmission from data collection platforms. The flooded areas, which extend to several thousands of square kilometers, could be mapped very effectively using the satellite data. They are also useful in

delineating the boundaries of flood prone zones. Digital analysis of satellite data can detect changes on the sections of the inundated flood plains as well as in water quality. The multi temporal data from satellites are proved to be very valuable in the identification of the site ideal for taking up structural measures to control floods.

Geostationary satellites provide continuous and synoptic observations over large areas on weather including cyclone monitoring. The use of meteorological satellites for forecasting heavy rainfall events, snowmelt run-off and monitoring of convective/frontal systems has improved the observational system greatly. The use of high resolution data from Indian Remote Sensing satellites has greatly contributed to our understanding of various parameters relevant to rainfall run-off analysis, flood forecasting and flood mapping including flood damage assessment.

The vast capabilities of communication satellites are available for timely dissemination of early warning and real-time coordination of relief operations. Satellite communication capabilities, fixed and mobile, are vital for effective communication, especially in data collection, distress alerting, position location and co-ordinating relief operations in the field.

Space technology can play an important role in providing valuable information particularly useful in the flood assessment, mitigation and preparedness phases of floods besides weather monitoring and effective communication for early warning and management of the floods. Some of the applications of Space Technology are development of early warning systems, monitoring & assessment, preparation of developmental plans for relief, rehabilitation and post-flood assessment, apart from tele-medicinal services. Advancement in the sensor technologies and hydrological and hydraulic models has paved the tremendous scope for remote sensing to play a greater role in the field of flood management.

## **5. REMOTE SENSING AND GIS APPLICATIONS IN FLOOD MANAGEMENT**

Advancements in the remote sensing technology and the Geographic Information Systems (GIS) help in real time monitoring, early warning and quick damage assessment of flood disasters. A Geographic Information System is a tool that can assist floodplain managers in identifying flood prone areas in their community. With a GIS, geographical information is stored in a database that can be queried and graphically displayed for analysis. By overlaying or intersecting different geographical layers, flood prone areas can be identified and targeted for mitigation or stricter floodplain management practices. Remote Sensing can be very effective for flood management in the following way:

- Detailed mapping that is required for the production of hazard assessment maps and for input to various types of hydrological models.
- Developing a larger scale view of the general flood situation within a river basin with the aim of identifying areas at greatest risk and in the need of immediate assistance.

Remote sensing and GIS technique has successfully established its application in following areas of flood management such as flood inundation mapping, flood plain zoning and river morphological studies.

### **5.1 FLOOD INUNDATION MAPPING**

Flood mapping during the flooding and flood plain mapping after the flood recedes is essential. One of the important information required is the nature and extent of the damage caused by floods in the flood prone areas. Satellite remote sensing provides synoptic view of the flood-affected areas at frequent intervals for assessing the progression and recession of the flood inundation in short span of time which can be used for planning and organizing the relief operations effectively. Remote sensing can effectively be used for mapping the flood-damaged areas. For mapping purposes, a pre-flood scene and a peak

flood image would be compared to delineate the inundated area. Flood inundation maps can be used:

- To define spatial extent of flood inundation.
- To identify the worst flood affected areas.
- To evaluate impact of flooding on environmental concerns, such as, coastlines, forests, open space etc.
- To plan relief operation.
- To assess damage.

## **5.2 FLOOD PLAIN ZONING**

Flood hazard zone mapping can be used as a means of non-structural flood control planning of the flood plain and for making policy decisions to regulate the flood plain development activities. Using historic satellite data combined with hydrological and close contour data, a flood hazard zone map can be prepared for flood prone basins.

## **5.3 RIVER MORPHOLOGICAL STUDIES**

River morphology is concerned with the structure and form of rivers including channel configuration, channel geometry, bed form and profile characteristics. Various flood control structural measures such as construction of embankments, channel improvements, raising of villages, selective dredging etc. have been implemented in past to reduce the impact of the flood disaster on human life and property. It is essential to monitor the embankments regularly to identify the vulnerable reaches. Conventional methods of river surveys time consuming and expensive. Most of the flood prone rivers in India change their course after every flood wave eroding river banks. Satellite remote sensing based morphological studies are quite useful in following areas:

- To identify the changes in river course over a time period.
- To identify the erosion prone areas along the river course



- To study the efficacy of flood management structures

The river configuration and flood control works maps can be effectively used to identify the vulnerable river reaches and status of the flood control embankments/spurs so that necessary measures can be taken accordingly to avoid breaches. The bank erosion maps can be used for planning bank protection works. The study of river configuration will be useful to understand the behavior of the river and can be used for laying physical models.

## 6. CONCLUSIONS

Floods are a natural phenomenon. Floods of varying intensity have been occurring in all the flood plains since time immemorial. However, the ever-increasing occupation (or shall we call it encroachment ? ) of the flood-plains results in huge loss of life and damages, causing the floods to be termed as 'disasters'. The problem is intricate. The solution is equally intricate, if not elusive. The occupation of flood plains continues to increase due to rise in population and economic, industrial and other activities. Consequently, the flood damages also continue to increase.

There is no simple or fool-proof solution to the problem. Various measures, or a combination thereof, have to be adopted depending on the situation. For instance, the structural measures have worked well in Delhi (except in the unusually high floods of 1977 and 1978). On the other hand, in states like Assam, although the structural measures have provided some protection, people have learnt to 'live with the floods'.

Satellite Remote Sensing and GIS techniques have emerged as a powerful tool to deal with various aspects of flood management in prevention, preparedness and relief management of flood disaster. They have greater role to play as an improvement over the existing methodologies. GIS is ideally suited for various floodplain management activities such as, base mapping, topographic mapping, and post-disaster verification of mapped floodplain extents and depths. Remote sensing and GIS techniques can replace, supplement or

complement the existing flood management system. Extensive use of these technologies have great prospect in creating long-term database on flood proneness, risk assessment and relief management.

## REFERENCES:

- Report of Rashtriya Barh Ayog, Govt. of India, 1980
- Rangahari R., Prasad R.S. and Khanna R.K. “High technology in the field of flood forecasting”, Proceedings – International Symposium – High Technology in Water Resources Engineering, CBIP, New Delhi, January, 1987.
- Bholra A.M., Char N.V.V. and Khanna R.K., “Flood disaster and its management” Symposium on Preparedness, Mitigation and Management of Natural Disaster, New Delhi, August, 1989.
- Rao M.S., Bholra A.M. and Khanna R.K., “Flood Forecasting and Mitigation” Indo French Seminar on Management of Water Resources, Jaipur , September, 1989.
- Khanna Rajender Kumar, “Barh Prabandh ke vividh Upaya”, Bhagirath, Kendriya Jal Ayog, April-June, 1990.
- Shukla R. and Khanna R.K., “An approach to flood management”- Theme paper – Workshop on Flood Management in Uttar Pradesh, Lucknow, March, 2000.