ASSESSMENT, MODELLING AND MANAGING OF FLOOD RISK

By: Dr. Suwarna Gawde
National Insurance Academy, India

Assistant Administration Officer
Tariff Advisory Committee, India

Introduction

Researchers are still to understand the processes through which large floods impact social and market processes and mental health at the community scale. This paper has started by asking what can be done to reduce increasing flood losses. The prevailing wisdom favours wise floodplain use, but "wise use" is a term which is too vague to guide policies and programs that can improve the economy and quality of life in a flood-prone community. Reliable, current, location-specific information is a key factor. Then, organizations at all levels, residents, and businesses in cities on wide floodplains can interact from a base of solid information on their best interests.

A pool of highly specialised skills is required when it comes to assessing the river regime for changes in the flood plain and the determination of standards of protection along the river system. Not only in India but worldwide, flood risks have recently become a matter of growing concern for the insurance industry. Record losses in several worldwide flood events have clearly demonstrated the requirement for software tools to better manage growing flood exposure.

Flood losses in the United States are increasing. Investigators have documented increases in economic losses and also noted large intangible losses including "environmental and habitat damage, loss of treasured possessions and pets, disruption of family life, and emotional turmoil" (Platt 1999). Unfortunately, these trends continue after years of public funding for flood damage mitigation through flood forecasting and warning, structural and non-structural measures, flood insurance, and disaster relief. It is time to ask why and what is to be done. In a volume assessing performance of the first 50 years of the national flood control program, 1936–1986, (White 1988) presents floodplain management as a quest for optimal floodplain use. The general context is one of restraining development on strips of land along streams or rivers

During the 1990s many severe floods occurred in South and East Asia. These floods seem to be occurring more frequently and caused many casualties and significant destruction of infrastructure. Growing human population in the South and East Asia and their movement into flood plains have increased the vulnerability of the threat of floods.

In the past decade thousands of lives have been lost directly or indirectly from flooding. In fact, of all natural risks, floods pose the most widely distributed risk to life today. It is also clear that no mitigation measure can offer a hundred percent security against floods.

Flood Risk Assessment

To assess the impact of the flood, additional information is needed viz. land-use units in the inundated territory and their value. If the value of the exposed elements is known, the risk can be expressed in monetary terms and the total damage can be estimated, for each of these elements relationships have to be established between the flood hazard parameters and the degree of damage that they cause. However the value of many elements go beyond the direct value (e.g. hospitals, energy plants) or cannot easily be expressed in monetary terms (e.g. human suffering).

There are two vital areas relating to flood risk assessments. First is outlined in the 'Primary information for Flood Risk Assessments' which discusses the site data, general methodologies and what basic information is needed to be reported. The second part consist of 'Hydrological and Hydraulic Modelling',

Primary Information for Flood Risk Assessments

Site Data

This consists of site plan, showing any existing information on extent and depth of flood events, geographical features which identifies all water sources in the vicinity which may have an influence on the site. This should include drainage outfalls, overflows and, if necessary, cross-refer to their operational arrangements in the body of the report, street names etc. The Information may be anecdotal, photographic.

The flood events should be identified with date/time, source of the data and supporting information viz. rainfall and/or return period, probability of occurrence of the flood and/or storm surge event. Recorded data are particularly valuable and, if available, should be highlighted along with evidence of any observed trends in flood occurrence.

General methodology

Whatever method is applied, the model must be supported by appropriate input data, and validated to available data (gauging station levels / historic floods), Identification of the source of potential flooding – pluvial, riverine, tidal, ground water or combinations. Appropriate sensitivity analysis should be carried out to determine the sensitivity of design water levels to key model parameters.

Basic Information to be reported

An assessment of the appropriate design flows and levels at the site. This should provide sufficient information on the derivation of the design flows and hydraulic modelling, cross-sections of the site showing finished floor levels, or other relevant levels, relative to the source of flooding, to anticipated water levels and associated probabilities. It is advisable to give details of flood mitigation measures / strategies employed.

Hydrological and Hydrolic Modelling

Flood hazard is modelled using a rainfall-runoff approach, and flood intensity at a given point is quantified using water depth, flow velocity and the effect of debris impacts. These parameters are related to damage using a series of vulnerability functions developed using engineering data, academic studies and insurance claims information. The risk models are based on a systematic examination of the various factors that determine the likelihood of people being located within a flood hazard zone and the probability of people being killed and property damaged due to the floodwaters. The essence of modelling is being able to look at situations before they occur in reality. So modelling is an ideal approach to the examination of extreme conditions such as flooding. The ideal model represents the detailed hydrodynamic and hydrological processes that are at work throughout the system, hence it is advisable to work at this detailed level, for evaluating and mitigating flood risks.

Hydrological Modelling: Estimation of the design flow is often the most significant variable in determining the risk of flooding at a site. Best practice application of the Flood Estimation Handbook (FEH) should be used to derive design flood flows and/or flow hydrographs to be used in Flood Risk Assessments. FEH provides a framework for flood estimation and requires user expertise / experience to judge the most appropriate methods / data to use in any individual circumstance. However, the FEH statistical method is often not suited to small catchments. There is a lack of small auged catchments in the original FEH database and the updated Hi Flows database.

FEH Rainfall-Runoff Method: The FEH rainfall-runoff method can be more appropriate than the statistical method for small catchment applications. In general rainfall records are longer than river flow records. These can be used for both input into the rainfall-runoff models as well as improving the parameter estimation of the model. The estimation of percentage runoff is the most uncertain part of flood estimation. A better estimate of the standard percentage runoff parameter SPR is the most significant single improvement that can be made for flood estimation. There are number of alternative methods for estimating SPR, both theoretically and from observed data.

Hydraulic Modelling: Hydraulic modelling applications can range from simple Manning's calculations to complex hydraulic modelling solutions. The following components should be taken into account while considering the hydraulic modelling for the flood risk assessment.

- Objectives of the modelling: Study which explains clearly the situation being modelled including details of the output required from the model.

- Collection of relevant data: Data should be collected to support the objectives of the studies
- Model calibration and validation: calibration coefficients used must be clearly stated and model should be validated against historical/high flow flood events. Where limited data is available to validate the model, the sensitivity analysis must be presented to demonstrate the effect on the key output parameters resulting from variation of input data and controlling assumptions.
- Quality assurance and auditability: This ensures that the model has been subject to an evaluation procedure establishing its suitability for the relevant tasks and that relevant method checks have been carried out by an appropriately qualified person.

Use of Remote Sensing for Flood Risk

Risk is defined in general terms as the product of the frequency (or probability) of a particular event and the consequence of that event, be it in terms of lives lost, financial cost and/or environmental impact. Satellite images can be used for hydrological modelling. Remote Sensing and Geographical Information Systems can be used in the assessment of flood risk. Up-to-date information on the development of the landscape is required to assess the flood hazard and to estimate the potential impact of a flood when it occurs. Remotely Sensed data can be used at various stages of the flood forecasting process and the successive risk assessment. The model output, water height and flow velocity distribution at hourly time-steps, can be imported into a GIS and transformed in seven indicator maps that characterise the various aspects of flood hazard: maximum water depth, maximum flow velocity, maximum impulse (amount of moving water), maximum speed of rising of the water level, duration, arrival time of the first floodwaters and sedimentation and erosion.

Remotely sensed images from satellites and aircrafts are often the only source that can provide this information for large areas at acceptable costs. Digital Elevation Models can be constructed quickly e.g. the Aster images. Furthermore all kinds of parameters that are important for hydrological modelling is related to the land cover, e.g. permeability, interception, evapo-transpiration, surface roughness, etc. And since land cover mapping using satellite images is already common practice, the spatial distribution of these values can be easily estimated. However satellite imagery is not only useful to derive input data for the hydrologic models, but offers also good possibilities to validate the output of the models when a flooding disaster has struck. The observed extent of the flood can then be compared with the modelled prediction. Perhaps the most promising application of RS is its use for elements at risk analysis, especially for cities that experience fast and uncontrolled expansion into hazardous areas like floodplains. This offers an opportunity to monitor the increasing risks and impacts and to use it in their decision making process.

Action Plan

The following action plan would directly contribute to the development of a long-term strategy for early warning of floods, but it is acknowledged that to meet the requirements of the action plan a long-term activity must be approached incrementally. A plan to move toward addressing these issues serves as the concluding recommendation.

We must remember first that, while we might expect more flooding as our climate changes, it is not a simple matter to predict the extent of flooding. Modelling of the system can help in risk assessment and in pointing to the key areas where additional capacity or control is best provided to reduce risk. And we are of course talking about reducing risk – not eliminating it.

a) Timely sharing of meteorological and hydrological information so that the information can be used for basin wide early warning and risk assessment.

b) Updated web site of the global basins with meteorological and hydrological data.

c) Seminars/meetings among regional water resource experts and managers.

d) Strengthen cooperation between developed countries and developing countries in technologies relevant for monitoring, forecasting, and risk assessment of floods

e) Better gauging of rivers, collection of meteorological information and mapping of channels is needed.

f) Better and current information about human populations, and infrastructure, elevation and stream channels needs to be incorporated into flood and risk assessment models and to use this information to minimize risks and damages during flood event.

g) Proper training to people to remain self-reliant, proactive and ready before the onset of floods

Conclusion

Through the examples in this presentation I hope to have demonstrated how Remote Sensing and GIS techniques are vital for flood risk assessment studies, especially in areas where data is scarce or outdated. In order to reduce these flood events, communities need non-structural programs that are firmly grounded in information technology within a basinwide program to minimize large-scale flood impacts. The use of spatially distributed flood risk information in urban land use zoning and for flood proofing is particularly important for cities with large areas on floodplains.

New developments within catchments and on alluvial plains can change the flood hazard and the flood risk. The use of flood models can help to prevent undesirable side effects of the developments and can assist in implementing mitigation measures. This could help avoiding a dramatic event like a flood turns into a disaster because of unwise land use. Furthermore, the visualization power of flood simulations will help to bridge the gap between the scientific community and the responsible authorities. For non-experts it is usually hard to imagine what could be the extent of a potential flood. Simulations can be a valuable communication tool to visualise the flood hazard in terms of magnitude, area affected and return intervals. The integration of flood hazard and the vulnerability and value of the various land-use units into a flood risk assessment is crucial but requires still a lot of research work. However it can be safely stated that high resolution images will play a central role in the elements at risk analysis. Further studies are needed and require the cooperation of interdisciplinary experts and responsible authorities. While no individual hurricane can be attributed to global warming the report says, rising global temperatures in the coming decades are likely to cause significant increases in severe weather events, such as hurricanes, floods, hailstorms, wildfires, droughts and heat waves. Unless insurers and their regulators take steps to address this growing challenge, all will suffer even greater financial losses in the future.

Insurers need to: collect more complete data on weather-related losses; incorporate climate modelling into their risk analyses; analyze the implications of climate change on their business and investments and share the results with shareholders; and encourage policy action to reduce greenhouse gas emissions.

Regulators need to: include climate risks in company solvency and consumer-impact analysis; review the "standards of insurability" to identify new challenges, including climate-related hazards in the US and abroad; encourage insurers to collect more comprehensive data on losses; elevate standards for catastrophe modelling ; and assess exposure of insurer investments and adequacy of capital and surplus to extreme weather events.

Government needs to: foster and participate in public-private partnership for insurance risk spreading; comprehensively assess the government's overall financial exposure to weather disasters; reduce vulnerability to disaster losses through improved early warning systems, land use planning and other measures; and take policy action to reduce greenhouse gas emissions. ■

References:

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