Integrated Flood Forecasting, Warning and Response System

3.1 Defining an Integrated System

Establishing a viable flood forecasting and warning system for communities at risk requires the combination of data, forecast tools, and trained forecasters. A flood-forecast system must provide sufficient lead time for communities to respond. Increasing lead time increases the potential to lower the level of damages and loss of life. Forecasts must be sufficiently accurate to promote confidence so that communities will respond when warned. If forecasts are inaccurate, then credibility of the programme will be questioned and no response actions will occur.

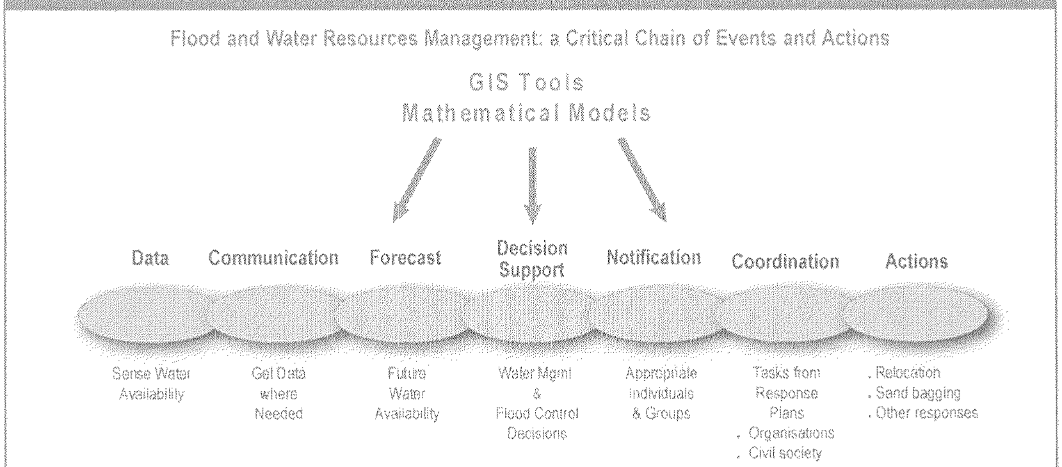
Flood-warning systems must be reliable and designed to operate during the most severe floods. The greatest benefits for an effective flood-warning programme occur when flooding is severe, widespread, and/or sudden, and when communities and organizations are prepared to mitigate impacts.

The implementation of an end-to-end flood forecast, warning and response system consists of many components. These components must be linked for successful operation. The interaction of components of the integrated flood forecast system or programme could be represented as a chain composed of many links. Each link must be present and functional if benefits are to be achieved. Figure 12 shows a schematic representation of the system as links in a chain.

The essential links or components of the integrated flood forecasting, warning and response system consist of a Data Source, Communications, Forecasts, Decision Support, Notification (often referred to as dissemination), Coordination, and Actions (or responses). A flood forecast and warning programme should be designed to mitigate floods, and, as such, it is an asset to overall water management. To achieve this, it is important that all of the components of the system be functional If any component is dysfunctional, then this weak link could break the chain, resulting in an ineffective warning and response process. For example, if critical rainfall or streamflow data are unavailable or if the data are not relayed to a forecast centre for use in forecasting, then the critical lead time required to make decisions, coordinate activities, warn citizens, and take actions is not possible. If a perfect flood forecast is generated but does not reach the population at risk, then the warning system is useless. Equally, should the population at risk receive the warning

Figure 12

Integrated flood forecasting, warning and response system within IWRM



but not know what actions should be taken, then the system again would not have accomplished its purpose.

In the overall design of the integrated system, there are many factors that should be considered. The remainder of this chapter reviews some of these factors.

Basin characteristics

The physical characteristics of the basin, such as surface area, topography, geology, and land surface cover, will help to determine the nature of potential flooding and the basin's susceptibility to related hazards such as landslides and mudflows.

The hydrological response of the basin can be impacted upon by changes in land use associated with urbanization, forestry, agriculture, drainage, or channel modifications. A record of such changes over time is useful in establishing the dynamic relationship between rainfall and runoff. The following also contribute to an understanding of flood hazards: records of climate norms and trends for parameters, such as precipitation and evapotranspiration; and information on the usual effects of ENSO events and extreme events, from synoptic to mesoscale.

Population centres often are adjacent to rivers, and flood plains can be rich agricultural resources. Identification of populations and economic activities at risk should be carried out early in the process, as this will shape the eventual forecast output.

Flood history

Flood history, also known as paleohydrology, can be inferred from study of sediment deposits, tree ring analysis, and examination of a number of other biological indicators. Such analyses will not lead to a determination of flood volumes, but may help put a recent flood into context. Often, such records are of value in defining the flood history in a river basin, particularly when combined with stream gauge records that exist for contemporary periods. Other more recent historical information can be drawn from newspapers, journals and oral histories. Usually there is a perception level associated with flooding at a given location; large events are noted, smaller events are not.

The flood history will identify the portions of a basin subject to flooding, whether flooding is urban or rural or both, seasonal characteristics of flooding, and the feasible warning time. The type of flooding and associated hazards may be significantly different on tributaries compared to the main stem of the river. Knowledge of the factors contributing to or causing the flooding such as meteorological and antecedent conditions should be established for each flood event.

Lake flooding as well as flooding from ocean surge and tsunamis may pose problems quite different from river flooding. These guidelines are oriented to river flooding, but many principles contained herein are also applicable to varying degrees to other water-related disasters.

Environmental factors

Floods can induce major changes in river morphology, mobilize nutrients and contaminants in the soil, release other contaminants from storage depots, and discharge effluents to the river. Deforestation, fires and erosion of materials combined with saturated soils can lead to landslides, mudflows and other threats to human settlements. Sometimes floods are accompanied by strong winds that also can pose threats to human life and property. An analysis of potential environmental risks will help determine flood forecasting and warning needs. This can help to shape future approaches to flood plain management and regulation, and can assist in the design and establishment of response actions.

Economic factors

A flood forecasting, warning and response system comprises an important element of integrated water resources management The benefits of river forecasts for power generation, navigation or irrigated agriculture make implementation of such a system more cost effective and sustainable. Even then, maintaining a system in a state of readiness between floods may be difficult.

An examination of past damages and the potential for future damages will help determine priority areas for flood forecasting, warning and response. Rigorous analysis would call for statistical analysis of flood peaks and the calculation of the present value of costs and benefits of flood forecasting and warning. In most cases, however, the benefits of flood forecasting, warning and response are virtually self-evident. The real questions are the affordability of various options and the desire of society to invoke a more pro-active stance to reducing flood losses.

Communities at risk

While flood losses in rural districts can be devastating to those areas, the most significant losses are usually in urban communities because of the concentration of people and related socio-economic investments. The basin characteristics and flood history of individual communities, combined with damage estimates from previous floods, will give some indication of the type of flood forecasting and warning system that may be most suitable for effective warnings. Once the system is defined, consideration should be given as to how it could benefit rural areas as well.

System identification

Depending on the nature of the basin and the type of event causing the flooding, potential warning times could vary from hours to several days to weeks Communities subject to flash flooding require warnings of meteorological conditions that, when combined with antecedent basin conditions, could lead to flooding. This represents a special case of flood forecasting and warning. The challenge in such cases is rapid depiction of critical flood thresholds and their subsequent communication and emergency response. An analysis of historical rainfall records, including storm transposition and the resulting streamflow would help to identify areas of concern.

Photo: J. Laurie, Las Vegas Review Journal

Las Vegas, July 1999, flash flood meets desert

When warning times are longer than a few hours, full-fledged forecast systems should be contemplated. The degree of desired automation and sophistication must be considered in light of current needs and capabilities. Automation needs can be considered in sub-systems' data acquisition and transmission, data processing; forecast