A STUDY ON FLOOD FORECASTING AND MANAGEMENT

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ABSTRACT

Hydrologic hazards are severe events caused by either excess or lack of water. Floods are the most common hydrological disaster in India. Floods have caused lots of harm in terms of lives lost, people affected, property damaged and frequency. Floods are caused when water overflows its normal range because of an excessive rise in the water level. The rise in water level can result from heavy rain, the rapid thawing of snow or ice, when ocean waves come on shore, or when dams or levees break. There are several types of flooding, with riverine flooding being the most common phenomena. River flooding can be divided into slow rising, and abrupt flash floods result from heavy rainfall or rapid snowmelt, and the Flashfloods are caused primarily by intense thunderstorms. Flashfloods are extreme and short-lived, and can result in heavy damage. Given the proper conditions, every river has the potential for flooding. Flood management and control are necessary not only because floods impose a curse on the society, but also because the optimal exploitation of land and proper management and control of water resources is of vital importance. There is a need for an integrated approach to reduce flood hazards and thereby lessen the potential disaster. This chapter discusses the nature of flood plains, causes of floods and flood protection measures including river diversions and embankments.

Keywords: *Flood plains, River Embankments, Flash Flood Forecasting, Main-stem Flood Forecasting, Integrated Flood Management.*

Introduction:

Societies, communities and households seek to make the best use of the natural resources and assets available to them in order to improve their quality of life. However, they are subject to a variety of natural and manmade disturbances such as floods, droughts, economic recessions and civil strife. These disturbances adversely impact their assets or the multipliers that build their capacity to increase their incomes. Since not all sections of society have equal opportunities to improve their quality of life – with respect to access to resources, information and power to participate in the planning process and implementation of development policies – these disturbances have varying effects on different social groups. Natural disasters cause much misery, especially in developing countries where low- income economies are greatly stressed by their recurrence. Statistics show that around 70 percent of all global disasters are linked to hydro-meteorological events. Flooding is one of greatest natural disasters known to humankind. Flood losses reduce the asset base of households, communities and societies by destroying standing crops, dwellings, infrastructure, machinery and buildings. In some cases, the effect of flooding is dramatic, not only at the individual household level but on the nation as a whole.

Floodplains:

. Floodplains are low-lying areas adjacent to rivers, lakes, and oceans that are periodically inundated by floodwater. It includes the floodway, which consists of a stream channel and adjacent areas and the flood fringe, which are areas covered by the flood, but which do not experience a strong current. A large percentage of the world population and tangible property is concentrated in flood-prone areas. These areas are comprised of floodplain land and thin coastal strips. The floodplains are formed of sediment deposits or removal

accompanying the natural, intermittent overflow of the steam above its ordinary bed. The floodplain acts as a natural reservoir and temporary channel for the excess water.

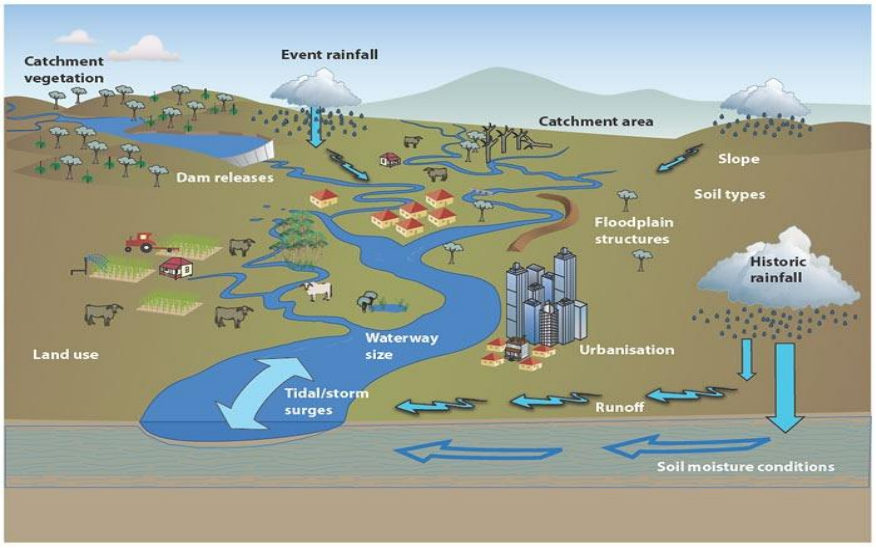
Floodplains and the Society:

Historically, many towns, homes and other buildings have been built on floodplains where they are highly susceptible to flooding. There are several reasons for it:

- This is where water is easily available;
- Floodplains are usually very fertile for farming;
- Rivers act as cheap sources of transportation in the floodplains are often where railroads are located; and
- Floodplains also have a dense network of railway lines;
- Plains are easier to develop than hilly land.

Causes of Floods:

- **Tropical storms:** Heavy rains followed by tropical storms are one of the most common causes of floods. Such form over the warm waters of the tropics, so they are full of moisture. Under the right conditions these giant storms move towards the land, causing a heavy rainfall. This heavy precipitation causes the streams and rivers to overflow leading to inland floods.
- **Seasonal Flooding:** During the Monsoons, heavy rains cause floods in various parts of the Indian peninsula. Other seasonal and weather conditions may also cause floods for example, cyclones, ice melting in the Himalayas or landslides in floodplains.
- **Coastal Flooding:** The earth comprises of seven oceans that cover almost three-fourths of its surface. Heavy, winds and other events cause the ocean water to sometimes overflow. This leads to flooding on the shores. Ocean storms can carry a lot of water on coast, raising the sea level in that area. These are known as storm surges, either tropical or winter storms. Ocean waves intensify on the open ocean, and these storms make surface water much choppier and fierce than normal. Raging winds can create huge waves that crash on unprotected beaches.
- **Tsunamis:** Coastal flooding can also be caused by long, low sea waves caused by volcanoes, landslides, earthquakes, or explosions. These waves are caused tsunamis. These giant tidal waves are difficult to detect on the open sea, so seismologists must keep track of seafloor movements that warn of possible tsunamis. These waves are extremely dangerous because of their high speeds. Deep waters create fast travelling waves. When the sea floor is several miles deep, waves can travel more than 600 miles an hour. As they come near shallow water, they slow down, but build in height. Some tsunamis can be 50 to 100 feet high when they hit the shore.



Types of flooding in Urban Areas:

- **Localised flooding** occurs many times a year usually in the slum areas. As there are few drains and most of the ground is highly compacted the pathways between dwellings turn into streams heavy rainfalls. Such drains and culverts are often blocked by waste and debris.
- **Small streams in urban areas** rise quickly after heavy rainfall, but often pass through small culverts under the roads. Although, adequate when designed, changes in the urban area and rise in storm intensity produces higher flows that exceed their capacity. Channels may also be blocked by debris which has made them narrows as compared to two decade ago.
- **Major rivers** flowing through urban areas are affected by land use changes and engineering works. Dams can trap sediment, causing rivers to erode their banks downstream. Dam operation may lead to high flows when stored water is released suddenly. Often, urban growth has expanded over some parts of the floodplain, making parts of the city below flood level and reducing the area into which floods can naturally overflow. Levees have been raised artificially, but with the risk that they may be breached and cause devastating urban flooding.
- **Wet seasons flooding** affects lowland and coastal cities for two or more months. Both rain and river water combine to raise the levels of water in swamps that would have naturally been inundated at certain times of the year. Dumping of waste beneath dwellings in these areas tends to raise water levels further. Storm waves can also bring flooding to such areas.

River Embankments:

Embankments protect low-lying land from high tides. Embankments is a long artificial mound of stone or earth, built to hold back water or to support a road or as protection.

A natural or artificial slope which can be made out of earth, stones or bricks, or a combination of these. The purpose of this could be to prevent or direct flooding by water e.g. levee and dyke;

Hill or a mound-like structure consisting of an artificial heap or bank usually of earth or stones;

Bulwark, rampart or a wall can be embankment built around a space for defensive purposes;

Revetment a stone facing (usually masonry) that supports an embankment;

Embankment dam – a dam made of mounded earth and rock.

Flood Warnings:

- **Minor Flooding:** Causes inconvenience, closing minor roads and low-level bridges.
- **Moderate Flooding**: Low-lying areas inundated, requiring removal of stock, equipment and evacuation of isolated homes: Main road and rail bridges may be covered.
- **Major flooding:** Higher areas inundated, towns/properties isolated, and extensive damage.
- **Local flooding:** Intense rainfall, some high run-off, but usually no flooding in main streams.
- **Significant river rises:** This warning is issued if it is not certain that the initial flood levels will be exceeded in the main streams. It lets people know that appreciable rises are expected.

Flash Flood:

A **flash flood** is a rapid flooding of geomorphic low-lying areas: washes, rivers, dry lakes and basins. It may be caused by heavy rain associated with a severe thunderstorm, hurricane, tropical storm, or meltwater from ice or snow flowing over ice sheets or snowfields. Flash floods may occur after the collapse of a natural ice or debris dam, or a human structure such as a man-made dam. Flash floods are distinguished from a regular flood by a

timescale of less than six hours. The temporary availability of water is often utilized by foliage with rapid germination and short growth cycle, and by specially adapted animal life.

Flash Flood Forecasting:

1. The spatial distribution of rail fall is an important predictor of flash floods, and
2. The law of diminishing gains does apply to complexity of hydrologic models.

The following obstacles are faced in flash flood forecasting:

a. Even a relatively dense rain gauge network [one gauge per 20km] may be insufficient to detect convective rainfall and estimate its spatial coverage and depth
b. Without rainfall predictions, the reliability and lead time of warnings are severely constrained.

Main-stem Flood Forecasting:

Streamflow Models:

The system consists of three conceptual models to forecast stream flow in headwater basins:

A] A spatially lumped soil moisture accounting model, which is a modified version of the Sacramento model, and

B] A channel routing model in the form of a cascade of nonlinear reservoirs.

In routine operation, streamflow forecast is computed once a day for upto ten days into the future. During floods, updated forecasts are produced more frequently.

Integrated flood Management:

Integrated flood management integrates land and water resources development in a river basin under the integrated water resources management, with a view to maximise the efficient use of floodplains and minimize the loss of life. Thus, occasional flood losses can be accepted in favour of a long-term increase in the efficient use of floodplains.

The aim of IFM is to purpose well-functioning integrated measures for flood management. As a result, the linkages between various relevant sectors become very important. Thus, the most important step will be cooperation and co-ordination across institutional boundaries, noting that the mandates of many institutions will either cover only part of the river basin or extend well beyond the basin boundary. At the core of integration is effective communication across institutional and disciplinary boundaries, which can take place only if there is a perception of common interest. Emphasis should be place on the adoption of flexible strategies tailored to each flood-prone region [characterised by their various physical, social, cultural and economic aspects] recognizing the importance of evaluating differing options and their relative advantage and disadvantages.

A participatory and transparent approach which includes a representative range of stakeholders in the decision-maker process is another key component of IFM. The degree of public participation can differ from region to region. However, it should not be assumed that such stakeholder involvement will necessarily result in a consensus. Therefore, a methodology for managing conflicts, possibly a formal system of conflict resolution, needs to be developed. Thus, a major challenge in this context will be the development of a consensus on the question of funding of overall activities when flood management is one of the main objectives, and to do this through a dialogue among stakeholders particularly in places where such practises are not commonplace.

Elements of Integrated Flood Management (IFM)

- Maximise the positive aspects of water cycle

- Integrate land and water management
- Adopts best mix of strategies
- Ensure participatory approach
- Adopts integrated hazards management.

Integrated Land and Water Management:

Integrated Assessments of Land and Water Resources for Sustainable Joint Management

On the basis of the premise that a coupled systems approach to land and water management would reduce costs and increase benefits for humans and nature, further research questions will be developed that need to be addressed in order to move towards a deeper understanding of the complex dynamics of land and water systems:

Status Quo:
We need to work on a deeper understanding of the dynamics within and between land and water systems to be able to map geographical hot spots for future research as well as to broaden the appreciation of potential issues for improved joint management of the resources. This will include the development of scale-appropriate landscape models...

Steps Forward:
To make a joint management of land and water work on large scale, we need to identify which social, economic, institutional, technical and environmental factors support or constrain an integrated management of land and water resources and how they interact

- Social:
  Analysis of social, political and cultural aspects that effect on and are affected by the management of land and water resources at different scales (historical perspective on land and water management, political ecology of a region)
- Economic:
  Analysis of existing economic instruments (subsidies, taxes, markets) and their effects on land and water resources ...
- Institutional factors:
  Comprehensive multi-level assessment of existing institutional arrangements for ILWM to identify common factors that enable integrated management approaches at global, regional, national, sub-national and local level
- Technical:
  Examination of ILWM measures: which are known to work in which areas, both to prevent and to rehabilitate degradations of land and water resources in a joint manner? What traditional and indigenous techniques exist, what are recent innovations?
- Environmental: Global satellite and remote sensed data to map, more active use of mobile phone technologies and networks.

The Challenges for Flood Management:

- Population growth, the need for enhanced economic activity for livelihood and food security, and the construction of infrastructure exert considerable pressure on the natural system and increase the damage potential on flood plains.

- Climate change tends to intensify the hydrological cycle, potentially resulting in increase in magnitude and frequency of extreme flood events or changes in the seasonality of floods. Sea level rise affects the flood risk of coastal areas and estuaries.

- Absolute protection from flooding is neither technically feasible nor economically and environmentally viable.

- The poorest and most vulnerable people are the ones that are exposed to flooding as they have no other choice but to settle in the most exposed areas.

- The shortage of alternative land for economic activities in many countries, means for those countries that abandoning flood-prone areas cannot be a sustainable option for flood management.

- Rapid urbanization and large-scale urban sprawl with ever more impervious surfaces leading to accelerated runoff and accentuate downstream flood peaks.

- Need to preserve or restore riverine ecosystems that provide many services such as: water purification, food, flood mitigation and recreational benefits.

- Large-scale deforestation driven by farming, mining or urbanization results in larger sediment yields which reduce the discharge capacity of the conveyance system.

- Decision making is increasingly becoming multi-dimensional and concerned with resolving multiple, often conflicting, objectives.

Flood Management Measures:

Floods are the most common and widespread of all natural disasters. India is one of the highly flood prone countries in the world. Around 40 million hectares of land in India is prone to floods as per National Flood Commission report. Floods cause damage to houses, industries, public utilities and property resulting in huge economic losses, apart from loss of lives. Though it is not possible to control the flood disaster totally, by adopting suitable structural and non-structural measures the flood damages can be minimised. For planning any flood management measure latest, reliable, accurate and timely information is required. In this context satellite remote sensing plays an important role.

Rescue & Evacuation

Evacuation is a pre-emptive move to protect life and property, where as rescue is a post-disaster phenomenon of helping people to move from areas that have been hit by disaster to a safer place. However, the situation of evacuation and rescue comes along with numerous unanswered queries in mind. Very often, due to lack of information or in haste, living during evacuation and rescue becomes difficult and painful. However, during such the situations, following precautionary norms should be kept in mind.

Preparing for a Flood

Here are some basic steps to take to prepare for the flood:

- Contact the local geologist or town planning department or meteorology department to find out if your home is located in a flash-flood-prone area or landslide-prone area.

- Learn about your community's emergency plans, warning signals, evacuation routes, and locations of emergency shelters.

- Plan and practice a flood evacuation route with your family. Ask an out-of-state relative or friend to be the "family contact" in case your family is separated during a flood. Make sure everyone in your family knows the name, address, and phone number of this contact person.

- Post emergency phone numbers at every phone.
- Inform local authorities about any special needs, i.e., elderly or bedridden people, or anyone with a disability.
- Identify potential home hazards and know how to secure or protect them before the flood strikes. Be prepared to turn off electrical power when there is standing water, fallen power lines etc. Turn off gas and water supplies before you evacuate. Secure structurally unstable building materials.
- Buy a fire extinguisher and make sure your family knows where it is and how to use it.
- Buy and install sump pumps with back-up power.
- Have a licensed electrician to raise electric components (switches, sockets, circuit breakers and wiring) at least 12" above your home's projected flood elevation.
- For drains, toilets, and other sewer connections, install backflow valves or plugs to prevent floodwaters from entering.
- Anchor fuel tanks which can contaminate your basement if torn free. An unanchored tank outside can be swept downstream and damage other houses.

If you are under a flood watch or warning:

- Gather the emergency supplies you previously stocked in your home and stay tuned to local radio or television station for updates.
- Turn off all utilities at the main power switch and close the main gas valve if evacuation appears necessary.
- Have your immunization records handy or be aware of your last tetanus shot, in case you should receive a puncture wound or a wound becomes contaminated during or after the flood.
- Fill bathtubs, sinks and plastic soda bottles with clean water. Sanitize the sinks and tubs first by using bleach. Rinse and fill with clean water.
- Bring outdoor possessions, such as lawn furniture, grills and trash cans inside or tie them down securely.

Emergency Supplies You Will Need

You should stock your home with supplies that may be needed during the emergency period. At a minimum, these supplies should include:

- Several clean containers for water, large enough for a 3-5 day supply of water (about five gallons for each person).
- A 3-5 day supply of non-perishable food and a non-electric can opener.
- A first aid kit and manual and prescription medicines and special medical needs.
- A battery-powered radio, flashlights, and extra batteries.
- Sleeping bags or extra blankets.

- Water-purifying supplies, such as chlorine or iodine tablets or unscented, ordinary household chlorine bleach.
- Baby food and/or prepared formula, diapers, and other baby supplies.
- Disposable cleaning cloths, such as "baby wipes" for the whole family to use in case bathing facilities are not available.
- Personal hygiene supplies, such as soap, toothpaste, sanitary napkins, etc.
- An emergency kit for your car with food, flares, booster cables, maps, tools, a first aid kit, fire extinguisher, sleeping bags, etc.
- Rubber boots, sturdy shoes, and waterproof gloves.
- Insect repellent containing DEET, screens, or long-sleeved and long-legged clothing for protection from mosquitoes which may gather in pooled water remaining after the flood.

Preparing to Evacuate

Expect the need to evacuate and prepare for it. When a flood watch is issued, you should:

- Fill your vehicle's gas tank and make sure the emergency kit for your car is ready.
- If no vehicle is available, make arrangements with friends or family for transportation.
- Fill your clean water containers.
- Review your emergency plans and supplies, checking to see if any items are missing.
- Tune in the radio or television for weather updates.
- Listen for disaster sirens and warning signals.
- Put livestock and family pets in a safe area. Due to food and sanitation requirements, emergency shelters cannot accept animals.
- Adjust the thermostat on refrigerators and freezers to the coolest possible temperature.

If You Are Ordered to Evacuate

You should never ignore an evacuation order. Authorities will direct you to leave if you are in a low-lying area, or within the greatest potential path of the rising waters. If a flood warning is issued for your area or you are directed by authorities to evacuate the area, follow the below mentioned checklists:

- Take only essential items with you.
- If you have time, turn off the gas, electricity, and water.
- Disconnect appliances to prevent electrical shock when power is restored.
- Follow the designated evacuation routes and expect heavy traffic.
- Do not attempt to drive or walk across creeks or flooded roads.

If You Are Ordered NOT to Evacuate

To get through the storm in the safest possible manner:

- Monitor the radio or television for weather updates.
- Prepare to evacuate to a shelter or to a neighbour's home if your home is damaged, or if you are instructed to do so by emergency personnel

Safety and Security

Any natural calamities espouse itself with serious devastation to transportation, communication channel, supply of electricity etc. Hence, in the immediate aftermath of any calamity, the surrounding environment becomes dangerous and unsafe due to it's exposure to toxic and harmful objects. This becomes more important for children as they are usually overlooked by the parents during the calamity or in the immediate aftermath of it.

Conclusion:

The impacts of natural disasters are becoming increasingly costly and devastating. Experts believe that the statistics on disaster losses continue to rise worldwide due to a combination of factors that include a rise in the number of hazardous events due to global climate change or natural cyclical trends, and an increase in human exposure to such disasters. Over the years, progress has been made in reducing hazard impacts through better predictions, forecasts and warnings, particularly for natural disasters such as cyclones and floods. A major area of interest in disaster management is that of disaster risk and vulnerability assessment. Maps delineating disaster-prone areas are made to provide a more comprehensive hazards assessment for a variety of natural phenomena, including cyclones, floods, earthquake, tsunamis, landslides, and drought. Better methodologies and models are needed for conducting hazard vulnerability assessments that can incorporate highly variable local conditions and characteristics. Other advances needed in risk and vulnerability assessment include the ability to identify potential social, economic and environmental losses. Application of new technologies such as computer-based geographic information systems are being used analyse hazards information and provide national risk assessment data to state and local governments in a quick and easy manner. Increased attention is being given to reduce disaster losses by engineering and structural applications. Land use planning is an effective method for mitigating the impacts of natural hazards.

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