FLOOD HAZARD ASSESSMENT AND ZONATION

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The context of hazard mapping.

HAZARD EVENT

- MAGNITUDE
- HAZARD MONITORING
- HAZARD DIMENSIONS

FREQUENCY

- STATISTICAL /HISTORICAL FREQUENCY ANALYSIS
- HAZARD MAPPING

LOCATION

ZONATION INTO:
- AREA AFFECTED;
- SIMILAR AREAS NOT YET AFFECTED;
- AREAS UNLIKELY TO BE AFFECTED

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Flood hazard mapping and zonation.

- **Defining:**
  - Location
  - Frequency;
  - Magnitude

- **Resulting in:**
  - Flood Susceptibility maps;
  - Flood hazard Zonation maps.
Basic sciences involved in flood hazard assessment

- **Hydrology**;
- **Meteorology**;
  - e.g. precipitation analysis; quantitative precipitation forecasting using satellite, meteorologic radar and telemetering raingauge networks;
  - linking to rainfall-runoff models
- **Geomorphology**;
- **Soil science**;
- **Vegetation science** incl. land use mapping
Flood hazard assessment and zonation

TYPES OF APPROACHES:

- Hydrologic approach;
- Geomorphologic approach;
- Combined approach.
Hydrological approach.

- Flood assessment using **hydrological techniques and models** (statistical, physical-based, unit hydrograph based)
  - e.g. Simulation models: HEC-1 / HEC-2 / DUFLOW / LISFLOOD.

- Involves using an often incomplete set of information on meteorological, hydrological and catchment conditions.
Hydrologic approach-1

1. Flood estimation;

E.g. calculating peak flood discharges:
- rational method; (yes)
- probability analysis;
- unit hydrograph analysis; yes
- flood routing methods;
Hydrologic approach-2.

2. Flood forecasting (real-time), using a wide range of available data.

- HEC-1; HEC-2 if using real time data;
- River Meuse Simulation model
- Lisflood (time step 5 sec) (JRC) http://natural-hazards.aris.sai.jrc.it/floods/
Frequency analysis of monitoring data.

- Defining frequency of flooding (or recurrence interval);
- A 10 year flood has a 1/10 probability in any one year to occur;
- Needs long-term stream gauge records; basins may have changed considerably!
Frequency analysis example.

Flood frequency curve plotted on logarithmic probability paper.

Tana river at Garissa; 1934-1970.

\[ T = \frac{n+1}{m}; \]

- \( n \) = number of years;
- \( m \) = rank number
Geomorphological approach

- Geomorphological analysis of the landforms and the fluvial system, to be supported wherever possible by information on past floods and detailed topographic information.
Geomorphological approach

Basically the approach is rooted in two facts:

- The micro relief of the floodplain governs the flow of flood water;
- Fact that present landform configuration and distributational pattern of fluvial sediments has been formed by the same rivers that will cause flooding in the future.
Combined approach.

- Analysing records of historic events;
- Analysing monitoring data of diagnostic factors;
- **Geomorphological analysis** of especially landforms & fluvial system in order to
  - deduce former flood events from terrain characteristics;
  - use this knowledge to define:
    - area affected;
    - similar areas not yet affected;
    - areas unlikely to be affected
Steps in Flood Hazard Assessment

1. **Indirect mapping:**
   Detailed geomorphological mapping emphasizing fluvial landforms and processes.
   Basin and network studies.
Steps in Flood Hazard Assessment

2. **Direct mapping:**
   Actual flood mapping (during or just after the flood)
   Emphasizing on diagnostic flood characteristics, fluvial dynamics and basin dynamics, using:
   - AP & RS sequential imagery studies;
   - field studies of flood evidences
   - Lab analysis etc.
Steps in Flood Hazard Assessment

3. **Overlaying (1) and (2):**
   Defining flood susceptibility of each geomorphological unit / subunit
   (consider the scale of mapping)

4. **Improving step 3** by combining this data set with other data sources/sets e.g. hydrological data (frequency analysis etc.) and detailed topographic data.
Steps in Flood Hazard Assessment

5. Combine (1) upto (4) into a FLOOD HAZARD ZONATION

6. Hydrological models.
Survey procedures.

I. Simplest form:
Mapping of the limits of the floodplain and extent of recent major floods using AP & field study;
Common in USA & Canada to supplement maps showing floods of calculated recurrence intervals e.g. 100-yr flood.

Aims: insurance
floodplain management.
Combined map: hydrological map + flood limits.
Floodplain management strategy: prevent flow obstruction.
Flood plain development.
Survey procedures.

II. More sophisticated surveys.
Detailed geomorphological mapping of landforms and the fluvial system.
Followed by investigations on actual floods defining flood characteristics:
- area of inundation;
- depth;
- duration;
- source of floodwater;
- erosion & sedimentation etc.
Survey procedures.

Using AP, RS interpretation field and laboratory studies especially sequential / AP’s and imagery.

**Examples:** Japanese Flood Hazard Maps.
Inundation map of Kuzuryu river basin.
破堤及び欠損地点
AREA WHERE BANKS WERE DESTROYED OR ERODED BY THE FLOOD WATER

洪水流動方向
DIRECTION OF FLOOD CURRENT

排水方向
DIRECTION OF DRAINAGE

最大浸水深
DEPTH OF INUNDATION

堆積物の厚さ
DEPTH OF DEPOSITED LAYER (cm)

潜水源数
PERIOD OF INUNDATION (DAY)

最高水位到達時刻（日時分）
TIME OF THE FLOOD-WATER WHICH SHOWED THE HIGHEST LEVEL

未調査地域
AREA WHERE NOT YET RESEARCHED
Survey procedures.

III. Combining Geomorphological and Hydrological data sets.

1. Updating hydrological data sets (frequency - discharge - relationships) by using geomorphological mapping & lithostratigraphy techniques on fluvial landforms
Survey procedures.

2. Improving the predicting capabilities of susceptibility maps by indicating recurrence intervals of the different units.

By making correlation between hydrology and geomorphic units.

⇒ leading to extrapolation to much larger areas where little or no data exists.
Example: Korean flood susceptibility maps.

Geomorphological map and Flood features of recent flood.
Inundation with ineffective embankment control.

**First inundation stage:**
Warning flood. (T 1-2 yr’s)

**Second inundation stage:**
Dangerous flood based on bankful stage & overbank stage. (T 5-10 yr’s)

**Third inundation stage:**
Emergent flood based on 1972 flood, overbank stage (T=50 year)

**Fourth inundation stage:**
Exceptional flood.

A. Dry river bed
B. Sand bar
E. 2nd river terrace
G. Old river channel
Inundations with effective embankment control.

First inundation stage: applicable to second inundation stage with ineffective control.

Second inundation stage: applicable to third inundation stage with ineffective control.

Third inundation stage: applicable to fourth inundation stage with ineffective control.
Damage map.
Mapping techniques

General remarks:

■ Depending on the aim of the survey, and the location a cost effective mapping approach must be selected;

⇒ this can lead to highly sophisticated approaches in one place and less sophisticated and much cheaper in other areas.
Mapping techniques.

- Availability of data is a constraint;
- Legal status of future maps;

Note: different types of hazards are involved: inundation hazard / sediment load / flow velocities / duration etc.
Tunisia; Wadi Merjerda.

Direction and velocity in m/s; return period after Sidi Salem.

Waterheadight in meters, return period after Sidi Salem.
Conclusions: Geomorphologic Contribution to the flood hazard problem-1.

- Mapping of flood limits using RS, Field survey;
- Predicting the nature of flooding based on an understanding of the causes of flow and the conditions that intensify them (Chapter 1, 2, 6)
- Hydrograph studies (Chapt. 2, Exercises)
- Preparation of flood frequency curves; (chapt. 7A)
Conclusions: Geomorphologic Contribution to the flood hazard problem-2.

- Process maps
  Relationships: form of all channel, the supply, texture, and type of sediment
  (Chapter 3, 4, 5, 6)
- Defining the degree of hazard of flood zones; (integration of all)
- Planning of emergency and relief operations.
  (Chapter 8)
Mapping fluvial geomorphology in Bangladesh.
Flood hazard zonation Bangladesh.

Integration of geomorphic data with direct flood data; gathered from remote sensing sequential imagery, and indirect data from thematic maps and reports etc. using GIS.

(note: depressions within geom units.)
Flood Hazard Zonation map of Bangladesh: regional scale.
Inundation hazard during annual flood.