RECENT TECHNOLOGICAL ADVANCEMENT AND SUSTAINABLE SOLUTIONS FOR FLOOD ISSUES IN NORTH BIHAR
Murlidhar Singh
B.E (Civil) M.E (Roorkee), Ph.D.
Professor (Environment and Drainage)

WATER AND LAND MANAGEMENT INSTITUTE, PHULWARISHARIF, PATNA, BIHAR, INDIA
My Journey as a CIVIL ENGINEER

• Graduated from VNIT NAGPUR in 1981
• Railway Bridge----AFCONS—1981
• Tower Foundation in River- 1982
• Gopalpur Port Project—Orissa-1983-85
• Jawahar Lal Nehru Port Trust-1985-87 July
• WRD govt Bihar—1987-----2015( Subernrekha project, Kitanala Dam, canal system , etc)
• WALMI- Training and Research on flood management, River Engineering, Water Management
Bihar flood Issues

- Perennial Rivers
- Catchment is trans boundary.
- Alluvial and unstable.
- Meandering features.
- Carries a lot of sediment.
- Discharge - Minimum and Maximum has got a big gap.

- Storage Reservoirs – Not possible
  - Flood embankments 3430 km on Gandak, Burhi Gandak, Bagmati, Kamla, Kosi & Mahananda etc. to protect an area of 2.916 Million Ha.
    - only out of total flood affected area of 6.88 Million Ha. Bihar is a major flood affected area in India
  - Bihar’s total flood affected area is 68.80 Lac Ha
  - It is 73% of its total geographical area.
  - It is 17.20% of countries total flood affected area which is 400 Lac Ha
Landslides occur in the catchment area
BIHAR
The ancient land of Buddha

NORTH BIHAR
KOSHI BASIN

SOUTH BIHAR

CATCHMENT OF RIVERS ARE OUTSIDE BORDER
AN IDEA ABOUT NORTH BIHAR

• PEAKS

Himalayan catchment area

NEPAL KOSHI

NORTH PART OF BIHAR

GANDAK

ADHWARA GROUPS OF RIVER

BREACH
Flood affected Districts of Bihar - 2004

DAMAGE DETAILS

- No. of Districts affected: 18
- No. of Blocks affected: 172
- No. of Panchayats affected: 2225
- No. of Villages affected: 7090
- Population affected: 19.87 million
- No. of Human lives lost: 163
- No. of Cattle lives lost: 993
- Flood affected Area: 4.8 million Hect.
- Crop damaged: 1.298 million Hectare.
Bihar is a state in East India. It is the 13th largest state, with an area of 94,163 km² and the 3rd largest by population; its population is the fastest-growing of any state.

**Population:**
99.02 million (2012)

**Capital:**
Patna

**Area:**
36,357 mi²
HIMALAYAN SNOW CATCHMENTS

Map Showing overview of Bihar Rivers & waterbodies
Based on MODIS Terra Image dated 6 Sep 2015 (10:30 AM)
FLOOD HISTORY

• Bihar is India’s most flood-prone State, with 76 percent of the population, in the North Bihar living under the recurring threat of flood devastation. About 68800 sq Km out of total geographical area of 94160 sq Km comprising 73.06 percent is flood affected.
Drainage System of Bihar

- The plains of Bihar, adjoining Nepal, are drained by a number of rivers that have their catchments in the steep and geologically nascent Himalayas. Kosi, Gandak, Burhi Gandak, Bagmati, Kamla Balan, Mahananda and Adhwara Group of rivers originates in Nepal, carry high discharge and very high sediment load and drops it down in the plains of Bihar. About 65% of catchments area of these rivers falls in Nepal/Tibet and only 35% of catchments area lies in Bihar. A review by Kale (1997) indicated that the plains of north Bihar have recorded the highest number of floods during the last 30 years. In the years 1978, 1987, 1998, 2004 and 2007 Bihar witnessed high magnitudes of flood.
2008 Koshi breach

- **2008** :- an appreciable amount of rainfall was received on very first day of monsoon season i.e. 15th June (160mm at Chanpatia, 141 mm at Sikanderpur and 92.2 mm at Khagaria). July was the wettest month having maximum rainy days followed by August-08. There was an unprecedented flood due to breach near 12.9km of Eastern Kosi Afflux Embankment near Kussha village in Nepal on 18th August 2008 that took a shape of a catastrophe leading to miseries to lakhs of people in Sunsari and Saptari districts of Nepal and Supaul, Madhepura, Araria, Saharsa, Katihar and purnea districts of Bihar. River Kosi entirely changed its course from earlier one which was again tamed to its original course by Water Resources Department after a tremendous effort keeping in line with the advice of Kosi Breach Closure Advisory Committee (KBCAT).
Koshi Breach
18th Aug 2008
BRB : Braiding river classified by ILMSimage

As a result of uncontrolled management and geotectonic activity the channel system is continuously braiding.
A FLOOD SCENE AFTER KOSHI BREACH IN D/S AREA
RECENT TECHNOLOGICAL ADVANCEMENT IN RIVER TRAINING
USE OF RIVER TRAINING TECHNIQUES

Management of stream bank erosion,

Flood control,

Fairway development for Inland navigation
RIVER TRAINING STRUCTURES

Cost effective river training techniques

- Bandalling
- Porcupine
- Steel Jack Jetty system (Presently used with trial and error approach with element of conjecture in USA)
RIVER TRAINING STRUCTURES

Conventional river training techniques

- Spurs
- Groynes
- Bank revetments
Expensive and less cost effective Due to

- Rising costs of labour
- Rising costs of the construction material such as boulders, wire nets etc.

- Costly both in terms of capital cost as well as with regard to high yearly maintenance cost

- Practically unaffordable for large river network
Before monsoon period anti-erosion works and during the monsoon, flood fighting works are done at vulnerable sites by State Water Resources Department.

The joint committee seeing the river regime after the flood, erosion, vulnerable sites are suggested and proposed for anti-erosion schemes.

On the basis of the committee’s report, field Executive Engineers measure the damages, frame scheme as per relevant design and prepare estimate. They put it before Technical Advisory committee (TAC).
After recommendation by TAC, the scheme are sent to Scheme Review Committee(SRC)

With concurrence of Principal Secretary, the agenda are sent to State Flood Control Board.

The State Flood Control Board is headed by State Chief Minister.

In the board other members are Minister Water Resources Department, Principal Secretary W.R.D, Principal Secretary Finance & Engineer in Chief (North)

AGENDA GETS APPROVED AND FUND MADE AVAILABLE.
Channelization of a stream may be undertaken for several reasons.

To make a stream more suitable for navigation or for navigation by larger vessels with deep draughts.

To restrict water to a certain area of a stream's natural bottom lands so that the bulk of such lands can be made available for agriculture.

For flood control, with the idea of giving a stream a sufficiently large and deep channel so that flooding beyond those limits will be minimal or nonexistent.

To reduce natural erosion; as a natural waterway curves back and forth, it usually deposits sand and gravel on the inside of the corners where the water flows slowly, and cuts sand, gravel, subsoil, and precious topsoil from the outside corners where it flows rapidly due to a change in direction.

It simply washes away. Channelization of a waterway by straightening it prevents the water from changing directions randomly, and net erosion is greatly reduced. (Gray D. Harding, Schumm. S & Kahn H)
Types of Channelisation

1. Resectioning by Widening and Deepening: - Widening and deepening increase the channel cross section; therefore, channel capacity to contain flows is increased and floodplain is inundated less frequently (flood control and agricultural purposes).

2. Straightening:- Straightening implies the cut of river bends (meander cutoff in the case of a meandering river); it produces shortening of the river channel, increasing of the gradient, and increasing of the flow velocity. The purpose is to reduce flood heights.

3. Levees (or Embankments):- The aim of levees is to increase channel capacity so that flood flows are confined and do not inundate the areas adjacent to the channels (floodplains), which would be inundated under normal conditions.

4. Flood Walls and Lined Channels: - This type of method is commonly used in urban areas where other kinds of channelization are limited or where access for maintenance is restricted.

5. Bank Protection Structures: - Groynes are structures built transverse to the river flow and extending from the banks into the channel. The aim of these structures, which deflect the direction of the flow, is to protect the banks from erosion processes.

6. Diversion Channels: - New channels can be constructed to divert flows out of the existing channel.

7. Culverts: - This type of channelization has often been used for urban streams, but also for small rural/mountain streams.
### Some River Channelised

<table>
<thead>
<tr>
<th>No</th>
<th>Name of River</th>
<th>Country</th>
<th>Type of River</th>
<th>River Training work</th>
<th>Remark</th>
<th>Year</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Los Angeles River</td>
<td>United State</td>
<td>Alluvial</td>
<td>Concrete embankment, Earthen embankment, slope lined</td>
<td>City area balance</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Danube river</td>
<td>Austria</td>
<td>Alluvial</td>
<td>Embankment slope Lined Earthen embankment</td>
<td>City area balance</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Rhone river</td>
<td>France</td>
<td>Alluvial</td>
<td>Embankment slope Lined Earthen embankment</td>
<td>City area balance</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Wolf river, Tennessee</td>
<td>United State</td>
<td>Alluvial</td>
<td>Earthen embankment</td>
<td>complete</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>Kissimmee river, Florida</td>
<td>United State</td>
<td>Alluvial</td>
<td>Earthen embankment</td>
<td>complete</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>Salt river, Arizona</td>
<td>United State</td>
<td>Alluvial</td>
<td>Earthen embankment</td>
<td></td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>Garonne river</td>
<td>France</td>
<td>Alluvial</td>
<td>Embankment slope Lined Earthen embankment</td>
<td>City area balance</td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>The Lower Mississippi River basin</td>
<td>United State</td>
<td>Alluvial</td>
<td>Earthen embankment</td>
<td>complete</td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>Odra river,</td>
<td>Poland</td>
<td>Alluvial</td>
<td>Embankment slope Lined Earthen embankment</td>
<td>City area balance</td>
<td></td>
</tr>
</tbody>
</table>

**Note:** In India channelisation of SWAN RIVER and BATA RIVER is in progress
Channelisation of Rhone river, France
The Lower Mississippi River basin

Note:- The river is constrained by levees and dikes for flood control and to maintain a safe navigation channel for the towing industry.
For a well-balanced Design of River works
Channelisation Methods

- channelized with concrete embankments
- channelized with earthen embankments
- channelized with riprap
- channelized with earthen embankments
### Effect of Channelisation

**Table 1** Examples of studies documenting the effects of channelization

<table>
<thead>
<tr>
<th>Location</th>
<th>Effects (channel morphology, ecology, structures, etc.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Danube River, Austria</td>
<td>Ecology</td>
</tr>
<tr>
<td>Rhone River, France</td>
<td>Incision; destabilization of infrastructures; lowering of water table</td>
</tr>
<tr>
<td>Garonne River, France</td>
<td>Ecology</td>
</tr>
<tr>
<td>England and Wales</td>
<td>Channel adjustments</td>
</tr>
<tr>
<td>Main River, Ireland</td>
<td>Flows</td>
</tr>
<tr>
<td>Skawa and Wisloka Rivers, Poland</td>
<td>Incision; decrease of overbank flow and deposition</td>
</tr>
<tr>
<td>Raba River, Poland</td>
<td>Increased flood magnitude</td>
</tr>
<tr>
<td>Denmark</td>
<td>Channel adjustments</td>
</tr>
<tr>
<td>Italy</td>
<td>Channel adjustments</td>
</tr>
<tr>
<td>Spoon River, Illinois</td>
<td>Channel aggradation; good ecological effects</td>
</tr>
<tr>
<td>Wolf River, Tennesse</td>
<td>Incision; habitat destruction; increase earthquake risk</td>
</tr>
<tr>
<td>Iowa</td>
<td>Degradation; loss of land; damage to infrastructures</td>
</tr>
<tr>
<td>Several Rivers in Tennessee</td>
<td>Incision; aggradation; riparian vegetation</td>
</tr>
<tr>
<td>Kissimmee River, Florida</td>
<td>Ecology</td>
</tr>
<tr>
<td>Salt River, Arizona</td>
<td>Channel changes</td>
</tr>
<tr>
<td>Rio Puerto Nueva, Puerto Rico</td>
<td>Groundwater changes</td>
</tr>
<tr>
<td>Kuchoro River, Japan</td>
<td>Aggradation; vegetation change in wetlands</td>
</tr>
<tr>
<td>New Zealand</td>
<td>Riparian ecology; channel morphology</td>
</tr>
<tr>
<td>Australia</td>
<td>Aquatic habitat</td>
</tr>
</tbody>
</table>
Six Member Porcupine Front elevation of typical 3m size
New Nine Member Porcupine
Trapezoidal vanes with and without collar installed in Solani river
Sediment deposited on vanes after flood in Solani river
RCC Jack Jetty of 3m length and 15cm thickness with 15cm x 15cm haunch at junction mesh with 4mm GI wire
United States Department of the International Bureau of Reclamation. Control of Alluvial Rivers by Steel Jetties
SUSTAINABLE SOLUTIONS OF NORTH BIHAR FLOODS
Himalaya
High Slope Fragile soil, heavy rainfall, discharge & velocity

Flat terrain, high silt load
Low velocity, plenty saucer terrain

Flooding, Drainage congestion, waterlogging, river shifting, Bank erosion, Failure of FPW, GW pollution

Flash Flood, Draught,

Rainfed rivers, water scarce

Ghaghara
Gandak
Gandak
Kosi
Ganga
Sone
Chotanagpur Plateau

Vindhayan
Yamuna

Fl档 terrain, high silt load
Low velocity, plenty saucer terrain

Draught, drainage congestion at outfall during monsoon

Rainfed rivers, water scarce

Draught, drainage congestion at outfall during monsoon

Rainfed rivers, water scarce

Draught, drainage congestion

Draught, drainage congestion at outfall during monsoon

Rainfed rivers, water scarce

Rainfed rivers, water scarce
In India, the river Ganga travels through the State of Himachal, Uttrakhand, Uttar Pradesh, Bihar, West Bengal. The tributaries of river Ganga have coverage of Haryana, Rajasthan, Madhya Pradesh, Jharkhand, Chattisgarh, NCT of Delhi.
Hydrological Problems

• Basins of Himalayan Origin

– Drainage area in Nepal and Tibet.
– Gradient 10-5m/km in upper catchment.
– Rainfall in hilly terrain is about 1.75 times more than the plains.
– In downstream, flatter topography results in blockage of water due to substantial loss of velocity causing flood and deposition of silt.
– River shifting and Chaur formation. Kosi shift 113km in last 200 years. Silt deposition 0.23 billion tonne per year.
– Blockage of water due to network of Road, Rail system, inadequate opening of bridges and culverts further causes flood hazards.
– Waterlogging and drainage congestion are of grave concern.
– Water pollution in the river system endangering the ecological front.
Hydrological Problems of the Region (Contd...)

- **Basins of Vindhayan Origin**
  - Rivers are rainfed, therefore seasonal in nature and mostly go dry during rainless months.
  - Hilly terrain receives about 1.25 times more rain than the plain areas during monsoon months.
  - About 80% rainfall rainfall during monsoon months.
  - Problem of erosion in the upper terrain and siltation in the constructed structures are common as Himalayan basin.
  - Problem of scarcity of water.
Hydrological Problems of the Region (Contd…)

• Basins of Chotanagpur Plateau origin
  – Similar problem as Vindhayan origin.
  – Flash flood usual phenomena.
  – Secondary porosity more pronounced.
  – Groundwater mostly in confined condition.
<table>
<thead>
<tr>
<th>Name of the basin</th>
<th>Catchment area (km²)</th>
<th>Annual rainfall (mm)</th>
<th>Hydrological Problems</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ghaghra</td>
<td>1,27,950 (total)</td>
<td>970-1560</td>
<td>1. flood,</td>
</tr>
<tr>
<td></td>
<td>57,647 (in India)</td>
<td>1127 (north Bihar)</td>
<td>2. erosion,</td>
</tr>
<tr>
<td></td>
<td>54,417 (U.P),</td>
<td></td>
<td>3. water logging &amp; drainage,</td>
</tr>
<tr>
<td></td>
<td>3,230 (Bihar)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sone</td>
<td>47,656 (in M.P)</td>
<td>990-1620</td>
<td>1. flood in lower stretches,</td>
</tr>
<tr>
<td></td>
<td>5,952 (in U.P)</td>
<td></td>
<td>2. drainage,</td>
</tr>
<tr>
<td></td>
<td>17,651 (Bihar)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Name of the basin</td>
<td>Catchment area (km²)</td>
<td>Annual rainfall (mm)</td>
<td>Hydrological Problems</td>
</tr>
<tr>
<td>-------------------------------------------</td>
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<td>---------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Sone (South Bihar) (Kanhar &amp; N. Koel are tributaries)</td>
<td>10,57.44 (N.Koel)</td>
<td>990</td>
<td>1. bank spilling, 2. drainage congestions, 3. drought in North Koel basin.</td>
</tr>
<tr>
<td>Gandak (North Bihar)</td>
<td>46,300 (total) 7,620 (Bihar)</td>
<td>1120</td>
<td>1. river course shifting &amp; erosion, 2. flood, 3. water logging &amp; drainage,</td>
</tr>
<tr>
<td>Buri Gandak (North Bihar)</td>
<td>12,500 (total) 10,150 (Bihar)</td>
<td>1180-1390</td>
<td>1. flood, 2. erosion, 3. drainage congestion,</td>
</tr>
<tr>
<td>Bagmati &amp; Adhwara (North Bihar) (Tributaries of the Kosi)</td>
<td>13,400 (total) 6320 (Bihar) 3720 (Bagmati) 2600 (Adhwara)</td>
<td>1180</td>
<td>i) severe flood, ii) Drainage congestion</td>
</tr>
<tr>
<td>Name of the basin</td>
<td>Catchment area (km²)</td>
<td>A/rainfall (mm)</td>
<td>Hydrological Problems</td>
</tr>
<tr>
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<td>---------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Kamala-Balan (N/Bihar tributary of Kosi)</td>
<td>5445 (total) 2980 (Bihar)</td>
<td>1210-1380</td>
<td>1. flood, 2. river course shifting, 3. drainage congestion, 4. flood, 5. waterlogging due to rise of ground water table,</td>
</tr>
<tr>
<td>Kosi (North Bihar)</td>
<td>70,409 (total) 11,070 (Bihar)</td>
<td>1590-1380 3500 (in hilly area, mm)</td>
<td>1. enormous siltation, 2. river shifting 3. drainage congestion, 4. flood, 5. waterlogging due to rise of ground water table,</td>
</tr>
<tr>
<td>Mahananda</td>
<td>25,043 (total) 17,440 (India) 6,340 (Bihar)</td>
<td>6000 in u/catchment and 1000 in plains</td>
<td>1. flood due to spilling of banks, 2. landslides during monsoon in upper stretches, 3. drainage congestion,</td>
</tr>
<tr>
<td></td>
<td>11,100 (West Bangal)</td>
<td>6000 in u/catchment and 1000 in plains</td>
<td></td>
</tr>
<tr>
<td>Name of the basin</td>
<td>Catchment area (km²)</td>
<td>A/rainfall (mm)</td>
<td>Hydrological Problems</td>
</tr>
<tr>
<td>-----------------------------------</td>
<td>----------------------</td>
<td>----------------</td>
<td>--------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Karamnasa (South Bihar)</td>
<td>5,127 (Bihar)</td>
<td></td>
<td>1. drought</td>
</tr>
<tr>
<td>Punpun (South Bihar)</td>
<td>8,530</td>
<td>990-1340</td>
<td>1. flood de to bank spilling,</td>
</tr>
<tr>
<td>Kiul-Harohar (South Bihar) (Harohar is a tributary of Kiul)</td>
<td>16,580</td>
<td>990-1260</td>
<td>1. water logging &amp; drainage (Tal), 2. Flood due to backwater from Ganga,</td>
</tr>
<tr>
<td>Belharna (South Bihar)</td>
<td>2,215</td>
<td>1040-1370.</td>
<td>1. drainage congestion,</td>
</tr>
<tr>
<td>Badua-Bilasi-Chandan (South Bihar) (Bilasi &amp; Chandan are tributaries of Badua)</td>
<td>4,093</td>
<td>1040-1370</td>
<td>1. flash floods in plains of Badua system in Bhagalpur &amp; Mongher district and also the drought problems, 2. Flood in Chandan river system.</td>
</tr>
<tr>
<td>Name of the basin</td>
<td>Catchment area (km²)</td>
<td>A/rainfall (mm)</td>
<td>Hydrological Problems</td>
</tr>
<tr>
<td>-------------------</td>
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<td>-----------------------</td>
</tr>
<tr>
<td>Gumani (South Bihar)</td>
<td>4,286</td>
<td>1470</td>
<td>1. drought</td>
</tr>
<tr>
<td>Mayurakshi (South Bihar)</td>
<td>8,530 (total)</td>
<td>1280-1380</td>
<td>1. sedimentation, 2. drought,</td>
</tr>
<tr>
<td></td>
<td>2,070 (Bihar)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>6,460 (Bengal)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ajay</td>
<td>6,050 (total)</td>
<td>1280-1380</td>
<td>1. drought in Deoghar area,</td>
</tr>
<tr>
<td></td>
<td>2,798 (Bihar)</td>
<td>1380 mm.</td>
<td>1. flash floods in some pockets, 2. drought,</td>
</tr>
<tr>
<td></td>
<td>3,252 (Bengal)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sankh (South Bihar)</td>
<td>4,027.43</td>
<td>1430</td>
<td>1. drought,</td>
</tr>
<tr>
<td>South Koel (South Bihar)</td>
<td>10,588.56</td>
<td>1280</td>
<td>1. drought,</td>
</tr>
<tr>
<td>Barakar (S.Bihar tributary of Damodar)</td>
<td>7,026</td>
<td>1300</td>
<td>1. soil erosion &amp; sedimentation, 2. drought,</td>
</tr>
<tr>
<td>Name of the basin</td>
<td>Catchment area (km²)</td>
<td>A/rainfall (mm)</td>
<td>Hydrological Problems</td>
</tr>
<tr>
<td>-------------------</td>
<td>----------------------</td>
<td>----------------</td>
<td>----------------------</td>
</tr>
<tr>
<td>Damodar</td>
<td>31,228 (total i/c Barakar) 20,570 (Bihar)</td>
<td>1250-1480</td>
<td>1. soil erosion in u/catchment, and ii) sedimentation in the reservoirs site. 2. WQ due to coal mines and industrial pollution, 3. drought in some areas,</td>
</tr>
<tr>
<td></td>
<td>10,650 (Bengal)</td>
<td>1300 -1520 mm.</td>
<td>1. erosion &amp; sedimentation, 2. flood in the right bank of the river,</td>
</tr>
<tr>
<td>Subarnarekha (S. Bihar)</td>
<td>8591.46</td>
<td>1338 -1372 mm.</td>
<td>1. drought,</td>
</tr>
<tr>
<td>Jalangi</td>
<td>5,640</td>
<td>1280-1340</td>
<td>1. drainage congestion, 2. siltation,</td>
</tr>
<tr>
<td>Rupnarayan</td>
<td>10,930</td>
<td>1320</td>
<td>1. drainage due to the tide, 2. siltation,</td>
</tr>
<tr>
<td>Haldi</td>
<td>10,210 (total) 2,070 (Bihar) 8,138 (Bengal)</td>
<td>1270-1470</td>
<td>1. deterioration of river stretches due to the siltation,</td>
</tr>
</tbody>
</table>
Flood Mitigation/Control Measures

Aims at

✓ Modifying the flood
✓ Modifying the susceptibility to flood damage
✓ Living with flood

Flood Control Measures aim at avoiding damages from floods by

✓ Structural Measures
✓ Non-Structural Measures
Structural Mitigation Measures

✓ Storage reservoirs – Multipurpose

✓ Confining river flow by embankments
  – Surrounding area is protected from flooding

✓ Channel improvement works
  – Includes increase in size of X-section and excavation of stream bed - to increase discharge or velocity

✓ Diversion Works
  - Form the u/s side of the flood affected area a diversion channel is excavated to connect the river at the d/s area

✓ Flood Wall
  – when no space is available or site condition is not suitable
Structural Measures……

✓ Flood Ways
  – A portion of the flood water is diverted in the low lying areas along the course of the river through a natural or artificial channel

✓ Runoff reduction by watershed management – an indirect method applied to the watershed which has long term effect on flood disaster mitigation
  – Includes Afforestation, Contour farming, Contour bunds, Check bunds, Gully plugging, Bank protection, Diversion drains, Strip cropping
Non-Structural Mitigation Measures

Include modifying the susceptibility to flood damage by

✓ Flood plain management
✓ Flood proofing including disaster preparedness
✓ Response planning
✓ Flood forecasting and warning

Include modifying the loss burden by

✓ Disaster relief
✓ Flood fighting including public awareness
✓ Flood insurance
Non-Structural Mitigation Measures……

Flood Plain Zoning

✓ Area near the river are the most vulnerable to flood hazards if not upland
✓ Therefore, no dwelling in these flood prone areas
✓ Places below HFL should not be recommended for inhabitation
✓ These areas may be used as parks, recreation ground etc.
Thrust Areas of Research

Based on the hydrological problems of the region the thrust areas of research can be categorised as follows

1. Flood estimation
2. Flood forecasting.
3. Mathematical modelling of river flows
4. Water logging and drainage congestion
5. Failures analysis of dams/ embankments
6. Watershed management for flood control
7. Flood plain zoning
8. Erosion and Sedimentation,
9. Water assessment and availability,
10. Hydrological Network design and data management
Non-Structural Mitigation Measures

Flood Forecasting

- Data observation, quick transmission, analysis and dissemination
- Temporary evacuation of persons and properties to safer places before flood arrives

Flood Proofing

Mathematical Modelling

- Can predict flood intensity in d/s, area of inundation and depth of flooding
1. Development of hydrologic response modelling for the trans-boundary watershed for simulation of discharge dynamics driven by season monsoon rains complemented by snow and glacier melt water runoff along with sediment yield. The above will provide the required hydrological information on runoff generation from the watershed pertaining to water and sediment on spatial and temporal basis, which are responsible for shaping the river behaviour. Latest modelling software will be used supplemented with high resolution multispectral satellite data for assessment of Land Use Land Cover (LULC) characteristics, and identify zones for required implementation of watershed management measures.

2. Assessment of river plan form changes using multi-spectral multi-date satellite imageries to identify & prioritize the vulnerable locations, as well as monitor the behaviour / hazard of spur protected bank-line.

3. Development of flow simulation computerized river model of
3. the Koshi, Gandak, Bagmati, Kamala and all other rivers which should be calibrated with surveyed river cross-sections & other hydrological data.

The above model will be helpful for flood forecasting, planning for channel improvement programme etc. of North Bihar Rivers

4. Development of robust, sustainable and cost effective river training system for Koshi all the rivers for channelization & imparting hydraulically efficient sediment transport capacity, desired flow conveyance.

5. Assessment of confluence zone of all north Bihar rivers with the Ganga near their meeting points with Ganga from the standpoint of fluvial behaviour and evolve suitable measures.

Thank You