Lecture-6

EWCE 461

River Engineering and Flood Management

3 Credit Hour

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Lecturer

Department of Environmental, Water Resources and Coastal Engineering

Sec-B: Flood Management- 1.0 Credit

Syllabus of Sec-A: 2.0 Credit

- Behavior of alluvial rivers
- River channel pattern and fluvial processes
- Aggradations and degradation
- Local scours
- River training and bank protection works
- Navigation and dredging of sediment movement in river channels
- Bed form and flow regimes
- Case studies

Syllabus of Sec-B: 1.0 Credit

- Flood and its causes
- Flood process in urban and rural area
- Flood management measures: structural and non-structural measures such as dams, reservoirs
- Diversion channels and floodways
- Improvement of channel capacity by dredging
- Land management, Flood proofing, Flood zoning, Flood hazard mapping
- Flood forecasting and warning, Flood damage assessment

Course Outcome (CO)

CO1	Be able to explain the relationships of river planforms with the river Morphological parameters
CO2	Be proficient in calculating and estimating sediment distribution and sediment load of a river
CO3	Be able to apply different engineering perceptions to estimating the scour depth.
CO4	Be familiar with different bank protection and river training work and understand the dredging and navigation processes
CO5	Apply knowledge of flood processes and management strategies to analyze and assess flood risk

Reference Books

- Any book on Flood Management and Mitigation
- **Water Resources Engineering by R. K. Linsley, J. B. Franzini, D. L. Freyberg and G. Techobanojlous**
- Fluvial Processes in River Engineering (1992) by H. H. Chang
- **Flood Control and Drainage Engineering, Fourth Edition, S.N. Ghosh**
- Urban Flood Management; by Chris Zevenbergen (Author), Adrian Cashman (Author), Niki Evelpidou (Author), Erik Pasche (Author), Stephen Garvin (Author), Richard Ashley (Author)
- Flood Risk: Planning, Design and Management of Flood Defence Infrastructure, By: Paul Sayers
- Vulnerability and Adaptation to Climate Change in Bangladesh: Processes, Assessment and Effects by MD Aboul Fazal Younus

LAND/WATERSHED MANAGEMENT FOR FLOOD MITIGATION

Introduction

- Land management is the process of managing the use and development (in both urban and rural settings) of land resources.
- In the field of environmental engineering, flood mitigation involves the managing and control of flood water movement, such as redirecting flood run-off through the use of floodwalls and flood gates, rather than trying to prevent floods altogether.
- It also involves the management of people, through measures such as evacuation and dry/wet proofing properties for example.

Why land management is important compare to other measures of flood management ?

- Structural flood defenses characteristics
  - Design
  - Construct
  - Maintenance
- Major disadvantages
  - Expensive
  - Time consuming

Analyzing the flood defense system measures in the case studies, it can be concluded that even with significant investment, flood risk can be reduced but not completely eliminated.

As flood safety cannot be reached in most vulnerable areas with the help of structural means only, further flood risk reduction via non-structural measures is usually indispensable and a site-specific mix of structural and non-structural measures seems to be a proper solution. Land management is one of the major parts of non-structural measurement.

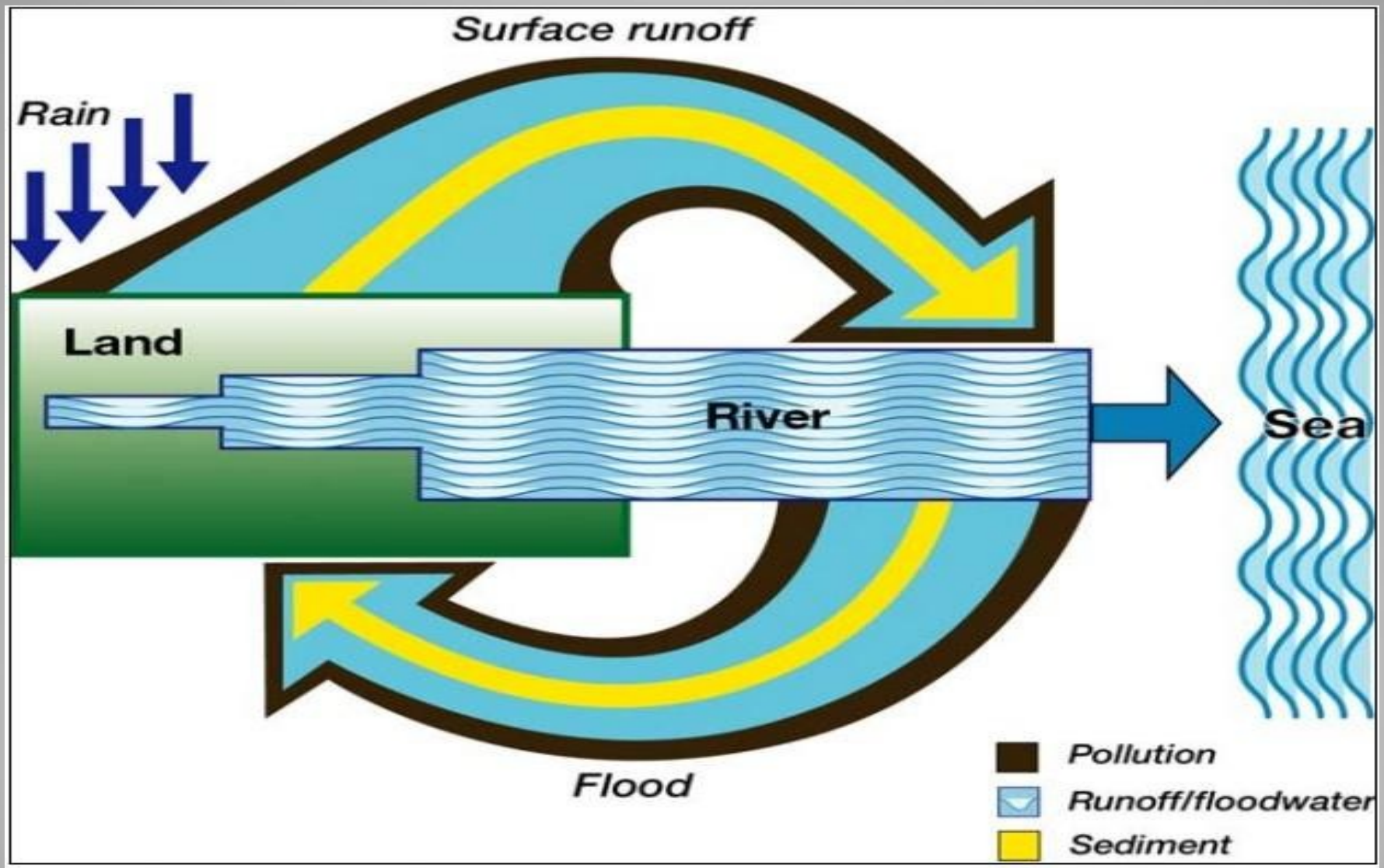
Land use and flood risk

- **Interactions between the land and water environment**

River basins are dynamic systems constituted by a complex arrangement of fluxes between the land and water environment. There are essentially three interconnected fluxes, not only of water but also of sediments/nutrients and pollutants.

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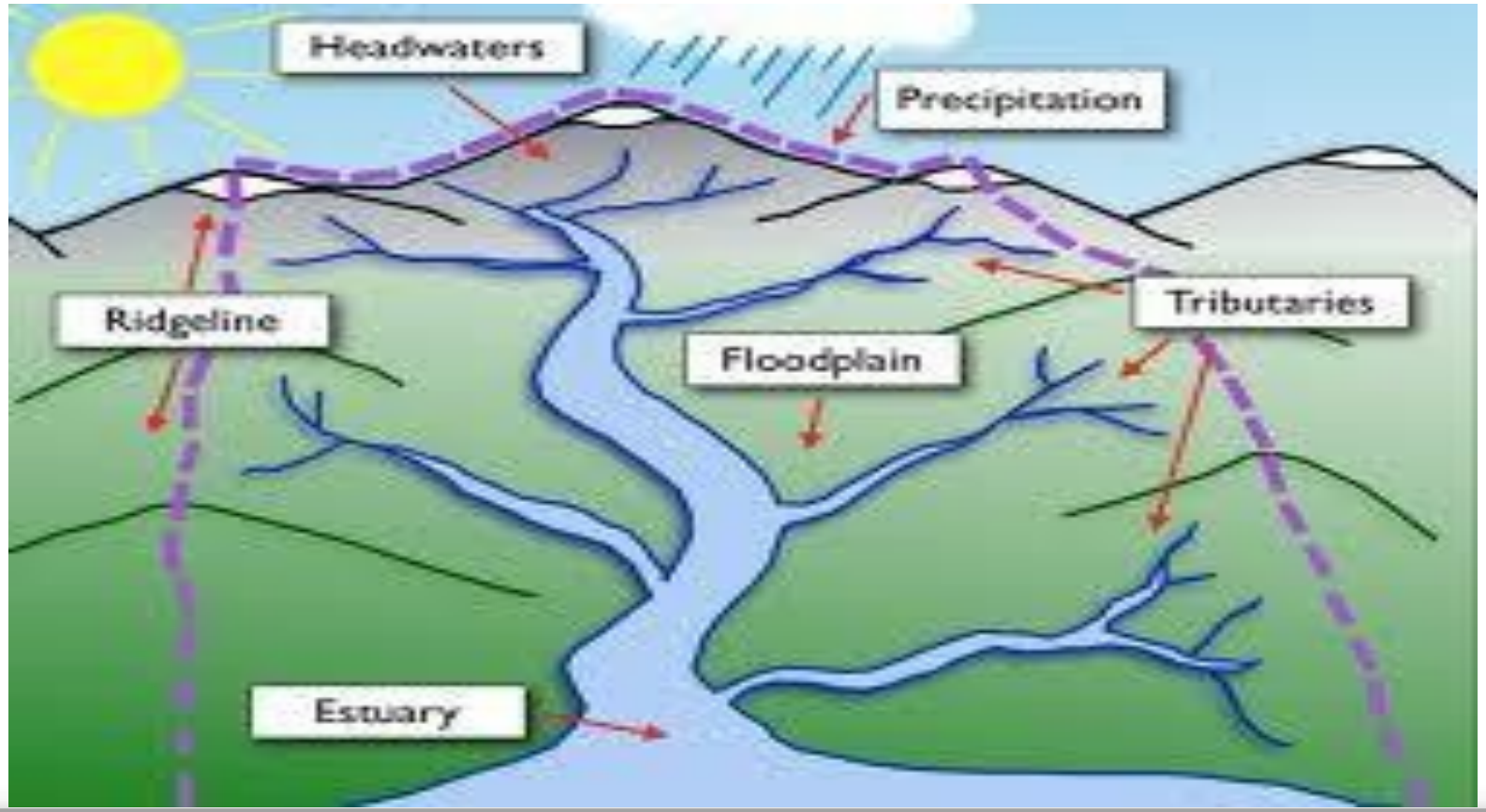
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(Source: APFM, 2004)

WATERSHED

Area bounded by a drainage divide and draining all the water incident upon it through a common outlet (stream or river), or to a common point/place (lake, pond).



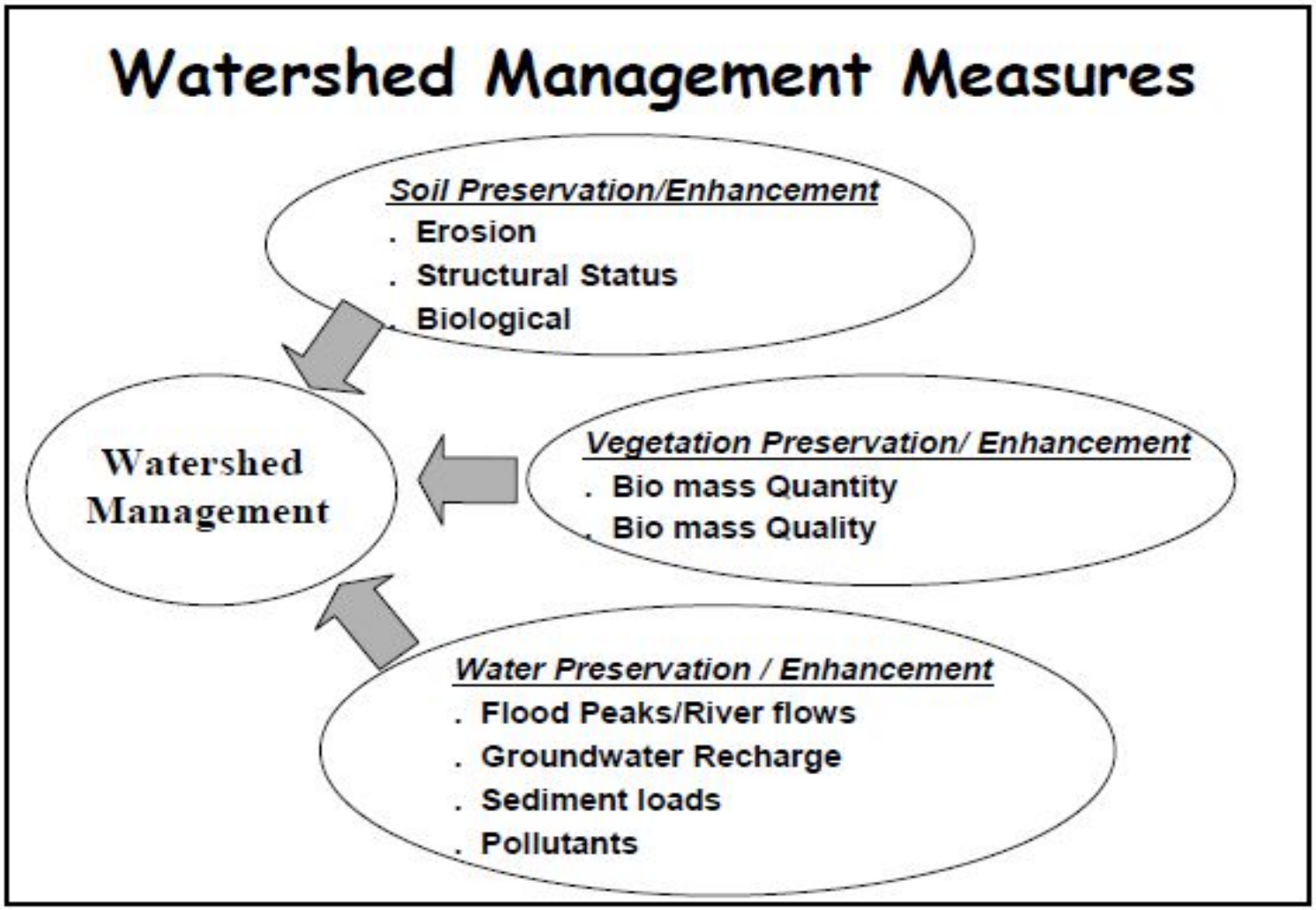
Problems Associated with Watersheds

- Flooding
- Unstable Slopes / Land Slides
- Erosion from Denuded Land
- Deficient Water Supplies
- Energy Shortage
- Food Shortage
- Poor Quality Drinking Water
- Polluted Streams / Reduced Fishing
- Sedimentation of Navigation Tracks.

Watershed management

is the study of the relevant characteristics of a watershed aimed at-

- the sustainable distribution of its resources
- processing of creating and implementing plans, programs, and projects
- enhancing watershed functions that affect the plant, animal, and human communities within a watershed boundary


Watershed Management Measures
Soil Preservation/Enhancement
. Erosion
. Structural Status
. Biological
Watershed Management
Vegetation Preservation/ Enhancement
. Bio mass Quantity
. Bio mass Quality
Water Preservation / Enhancement
. Flood Peaks/River flows
. Groundwater Recharge
. Sediment loads
. Pollutants

Components of Watershed Management

- Entry Point Activity (EPA)
- Land and Water Conservation Practices
- Integrated Pest and Nutrient Management
- Crop Diversification and Intensification
- Use of Multiple Resources
- Capacity Building

Watershed Management Needs Both

- Integrated Approach
  - Consideration of All Measures
- Consortium Approach
  - Consideration of Stakeholders

Program Design Considerations

- How far should the concept of integrated watershed management go?

- Who should be the target (and receive the most benefits) of a watershed program – upstream farmers and rural inhabitants or downstream town and city dwellers?

- Should planning be carried out at the farm level or watershed level?

- Should a watershed program emphasize rehabilitation or prevention?

Program Design Considerations

- What type of protection or rehabilitation should be emphasized: structural or vegetative?
- Should watershed programs include incentive schemes to encourage upstream inhabitants to participate in a watershed program?
- Can market mechanisms help to increase the services that watersheds provide, such as quantity and quality of water?

Watershed Development & Modelling

- Limited water resources,- more demand.
- Watershed is the basic scientific unit.
- Need for proper planning and management.
- Integrated watershed development approach
- Digital revolution
- Recent advances in watershed modelling - use of computer models, remote sensing and GIS.

WATERSHED Development (Cont…)

- Watershed Characteristics.
- Hydrology of watershed.

Watershed (ha)	Classification
50,000-2,00,000	Watershed
10,000-50,000	Sub-watershed
1,000-10,000	Milli- watershed
100-1,000	Micro-watershed
10-100	Mini-watershed

WATERSHED Development (Cont…)

Parameters of Watershed

- Size
- Shape
- Physiography
- Climate
- Drainage
- Land use
- Vegetation
- Geology and Soils
- Hydrology
- Hydrogeology
- Socioeconomics

WATERSHED MODELLING (Cont…)

Watershed modelling steps

- Formulation
- Calibration/verification
- Application

Watershed model constitutes

- Input function
- Output function
- Transform function

WATERSHED MODELLING (Cont…)

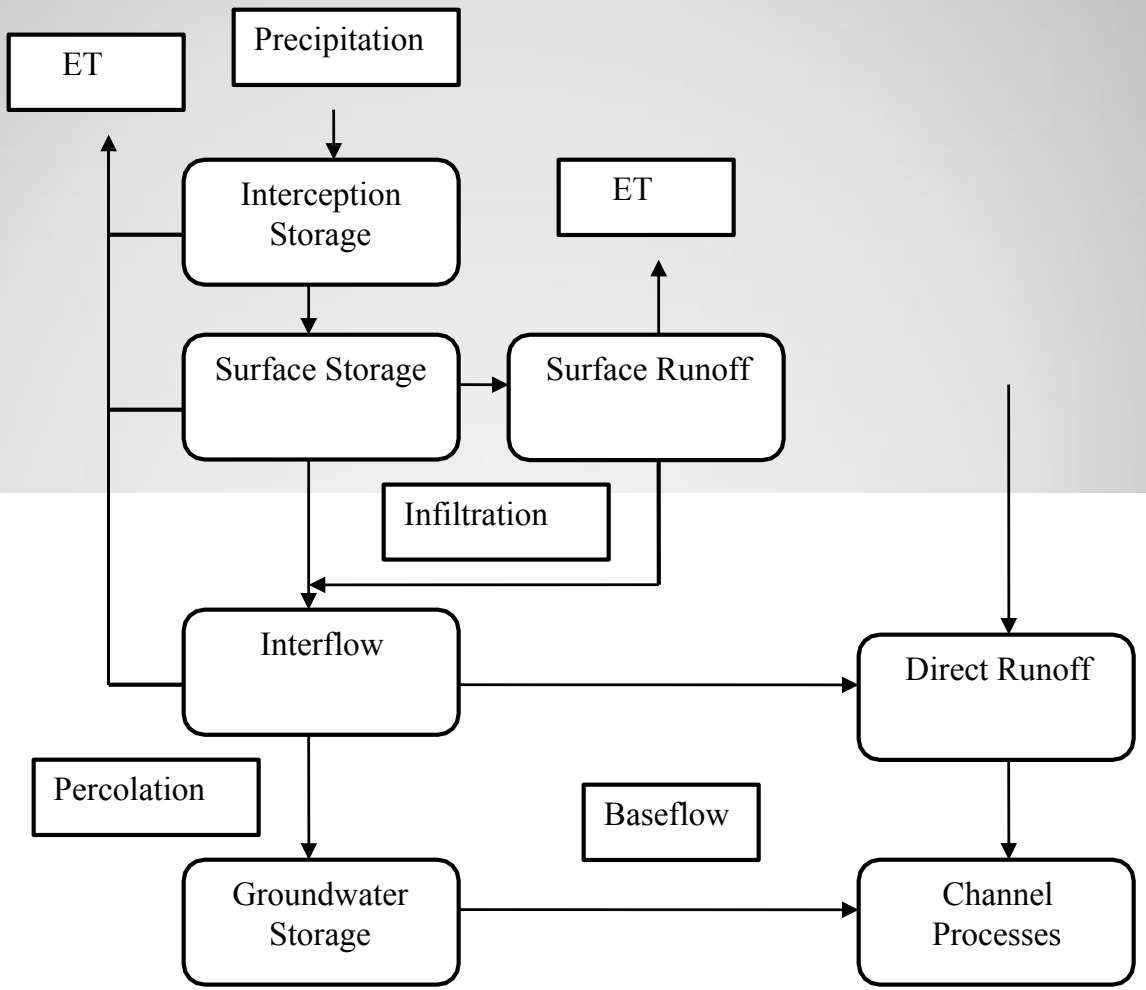


Fig Flowchart of simple watershed model (McCuen, 1989)

WATERSHED MODELLING (Cont…)

General Classification of Models

Broadly classified into three types

Black Box Models:

These models describe mathematically the relation between rainfall and surface runoff without describing the physical process by which they are related.

e.g. *Unit Hydrograph approach*

Lumped models:

These models occupy an intermediate position between the distributed models and Black Box Models.

e.g. *Stanford Watershed Model*

Distributed Models:

These models are based on complex physical theory, i.e. based on the solution of unsteady flow equations.

Concepts and Principles of IWM

Objectives:

- Water has multiples uses and must be managed in an integrated way.
- Water should be managed at the lowest appropriate level.
- Water allocation should take account of the interests of all who are affected.
- Water should be recognised and treated as an economic good.

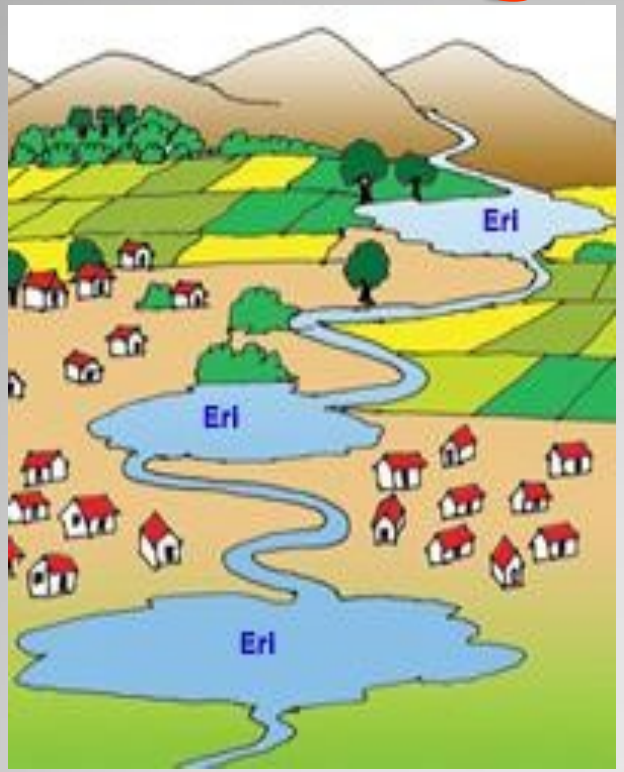
Strategies:

- A long term, viable sustainable future for basin stake holders.
- Equitable access to water resources for water users.
- The application of principles of demand management for efficient utilisation.
- Prevention of further environmental degradation (short term) and the restoration of degraded resources (long term). .

- The four engineering and management tools for effective and sustainable development of water resources in semi- arid rural India:

  - Appropriate technologies
  - Decentralised development system
  - Catchment based water resources planning
  - Management information system

Water Conservation & Harvesting





Total water management for sustainable development?.

Water Conservation

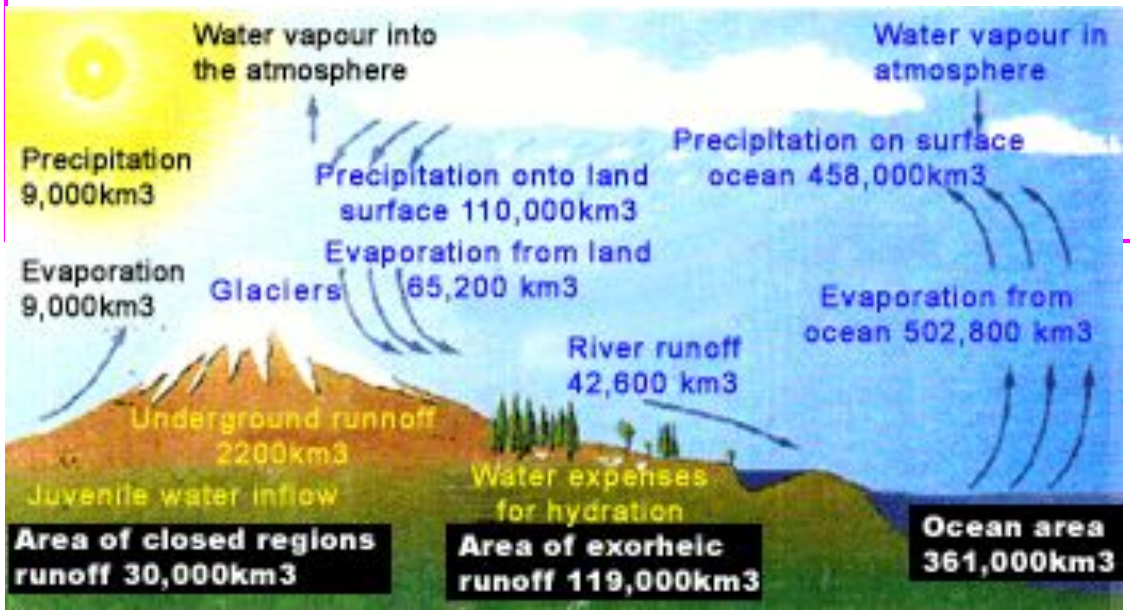
- Important step for solutions to issues of water and environmental conservation is to change people's attitudes and habits
- Conserve water because it is right thing to do!.
- **What you can do to conserve water?**
- Use only as much water as you require. Close the taps well after use. While brushing or other use, do not leave the tap running, open it only when you require it. See that there are no leaking taps.
- Use a washing machine that does not consume too much water. Do not leave the taps running while washing dishes

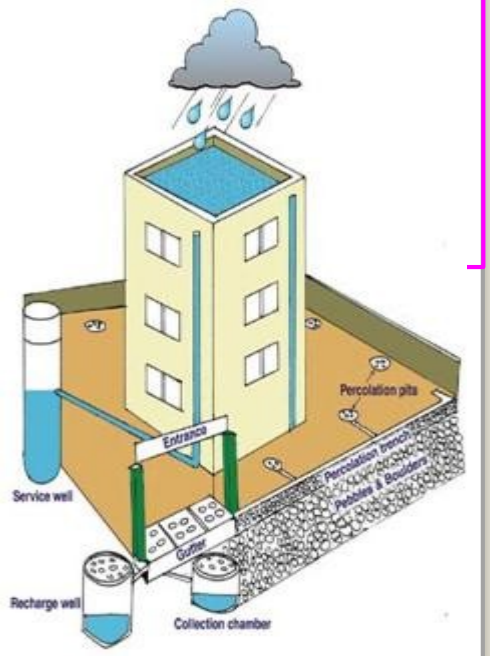
Water Conservation...

- Install small shower heads to reduce the flow of the water. Water in which the vegetables & fruits have been washed - use to water the flowers & plants.
- At the end of the day if you have water left in your water bottle do not throw it away, pour it over some plants.
- Re-use water as much as possible
- Change in attitude & habits for water conservation
- Every drop counts!!!

Rain Water Harvesting?.

- Rain Water Harvesting RWH- process of collecting, conveying & storing water from rainfall in an area – for beneficial use.
- Storage – in tanks, reservoirs, underground storage- groundwater
- Hydrological Cycle

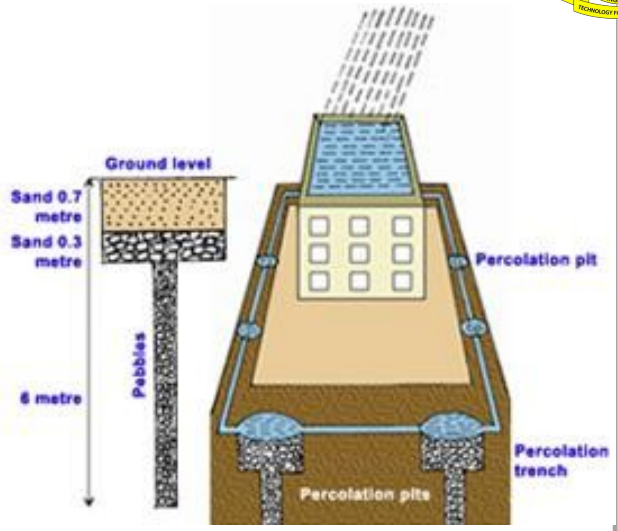




Rain Water Harvesting?.

- RWH - yield copious amounts of water. For an average rainfall of 1,000mm, approximately four million litres of rainwater can be collected in a year in an acre of land (4,047 m^2), post-evaporation.
- As RWH - neither energy-intensive nor labour-intensive
- It can be a cost-effective alternative to other water-accruing methods.
- With the water table falling rapidly, & concrete surfaces and landfill dumps taking the place of water bodies, RWH is the most reliable solution for augmenting groundwater level to attain self-sufficiency

RWH – Methodologies



- Roof Rain Water Harvesting
- Land based Rain Water Harvesting
- Watershed based Rain Water harvesting
- For Urban & Industrial Environment –
  - Roof & Land based RWH
- Public, Private, Office & Industrial building
- Pavements, Lawns, Gardens & other open spaces

Rain Water Harvesting– Advantages

1. Provides self-sufficiency to water supply
2. Reduces the cost for pumping of ground water
3. Provides high quality water, soft and low in minerals
4. Improves the quality of ground water through dilution when recharged
5. Reduces soil erosion & flooding in urban areas
6. The rooftop rain water harvesting is less expensive & easy to construct, operate and maintain
7. In desert, RWH only relief
8. In saline or coastal areas & Islands, rain water provides good quality water

Impacts of land use on flood hazards

With increasing human alteration and development of the catchment area, the runoff generation process is changed, especially through decreasing the infiltration capacity of the soil and the change of soil cover. This has lead to concern over the role human alterations of the catchments play in increasing flood hazards.

Hydrological responses to rainfall strongly depend on local characteristics of soil, such as water storage capacity and infiltration rates. The type and density of vegetation cover and land-use characteristics are also important to understand hydrologic response to rainfall. Environmental degradation coupled with uncontrolled urban development in high-risk zones, such as historical inundation plains and at the base of mountain ranges, leads to an increased vulnerability of those communities on the floodplains to catastrophic events.

Effect of specific development intervention on flood hazards

Large scale earthworks within the floodplain such as for water resources development barrages or dams may be constructed in the upper reaches of a water course. Depending on the topography of the area this in case leads to the diversion of water into a neighboring catchment and may increase the flood hazard there.

Construction of transport infrastructure and cross drainage works

The development of transport infrastructures such as highways and railroads on floodplains and in various parts of the world floodplains are used to develop such infrastructure. Those roads are usually elevated above the adjacent land to minimize risk from flooding to the transport system. Under flood conditions those works can serve as embankments, i.e. an obstruction to the water.

If such work is aligned parallel to flood flows and too close to the river channel, it may cut off a substantial part of the floodplain and therefore reduce the conveyance or storage capacity of the river under flood conditions. This can lead to increased flood hazards both upstream and downstream of such artificial 'bottleneck'.

Similarly, if an elevated road traverses a floodplain it can substantially obstruct the flow of floodwaters, depending on the size of the river and expected flood flows usually bridges or culverts are constructed to traverse the river channel and the immediately adjacent floodplain. This particularly becomes a problem where parallel river channels form during flood conditions that have not been accounted for in the design of such cross drainage works.

Effect of land use change processes on flood hazards

- **Urbanization**

Urbanization disrupts natural drainage patterns natural watercourses are destroyed and the natural retention of runoff by plants and soil is removed. By changing pervious natural surfaces to less- or non-pervious artificial surfaces, the storm water runoff rates and the total runoff volumes will increase as a result of a declining natural water storage capacity of the soil. All these factors are leading to an increased risk of urban flooding.





Agricultural Practice

- **Soil drainage system**: the availability and design of trenches, ditches or pipes in the soil which are utilized to control the soil water content and groundwater levels on agricultural land,
- **Soil tillage**: especially the compaction of the topsoil and the orientation of the furrow,
- **Choice of crops planted and cropping patterns**: each crop but also the amount of crop residues available on the soil has on influence on the runoff and erosion process.
- **Slope of the field**: terraced soils in steeply sloping areas can to a certain extent slow down runoff





Impact of land use on flood damage potential

- **Flood damage potential**

Flood damage potential can be defined as the extent of possible damage in a given flood hazard area. This means that the benefits derived from the floodplains are provided at a risk, i.e. the risk of having to bear flood damage. This flood damage can come in various forms to buildings, goods, crops, infrastructure, or the environment. In modern flood management approaches land-use planning and regulation plays a vital role in controlling the flood damage potential to acceptable levels.

The overall flood management policy should therefore point in a direction where implicit and explicit choices are possible under the awareness of prevailing flood risks and where those risks must be considered in the decision-making process.

- the benefits that the use of floodplain areas provides to society
- the possible lack of less risk-prone alternatives
- the level of protection that existing flood defenses and flood-proofing measures provide

Land use planning and flood management

- **Land use Planning**
  - Regional planning,
  - Town and country planning,
  - Urban planning
  - Spatial planning

Flood Management

Flood Management explicitly aims at maximizing the efficient use of floodplains while minimizing losses of life from flooding.

Flood risk management, while not having a uniform definition in literature, lays emphasis on reducing the overall flood risk.

Planning processes

Land use planning processes

- At the highest administrative levels such as federal or national level in form of land use policy or (strategic) plans that specify general aims, objectives and measures for future land use that are binding for all development authorities concerned.
- At the state, district or similar level in form of plans specifying development ambitions and required land uses under its jurisdiction.
- At the local or municipal level in form of local land use plans with detailed allocations of particular land parcels to specific uses or specific planning application procedures to be followed for different zones.

Flood management planning processes

These include:

- Basin or Catchment Flood Management Strategy
- Basin or Catchment Flood Management Plan
- Local Floodplain Management Plan
- Project Plan

Planning permits

Changes of land-use type or intensification of land use

- Buildings and structural works: dwellings, commercial and industrial buildings, levees, fences, roads, embankments, etc
- Earthworks, resulting in: land forming, lanes, tracks, aqueducts, laser grading, surface and subsurface drains, etc
- Subdivision: the splitting of an existing land parcel into several pieces owned by different owners

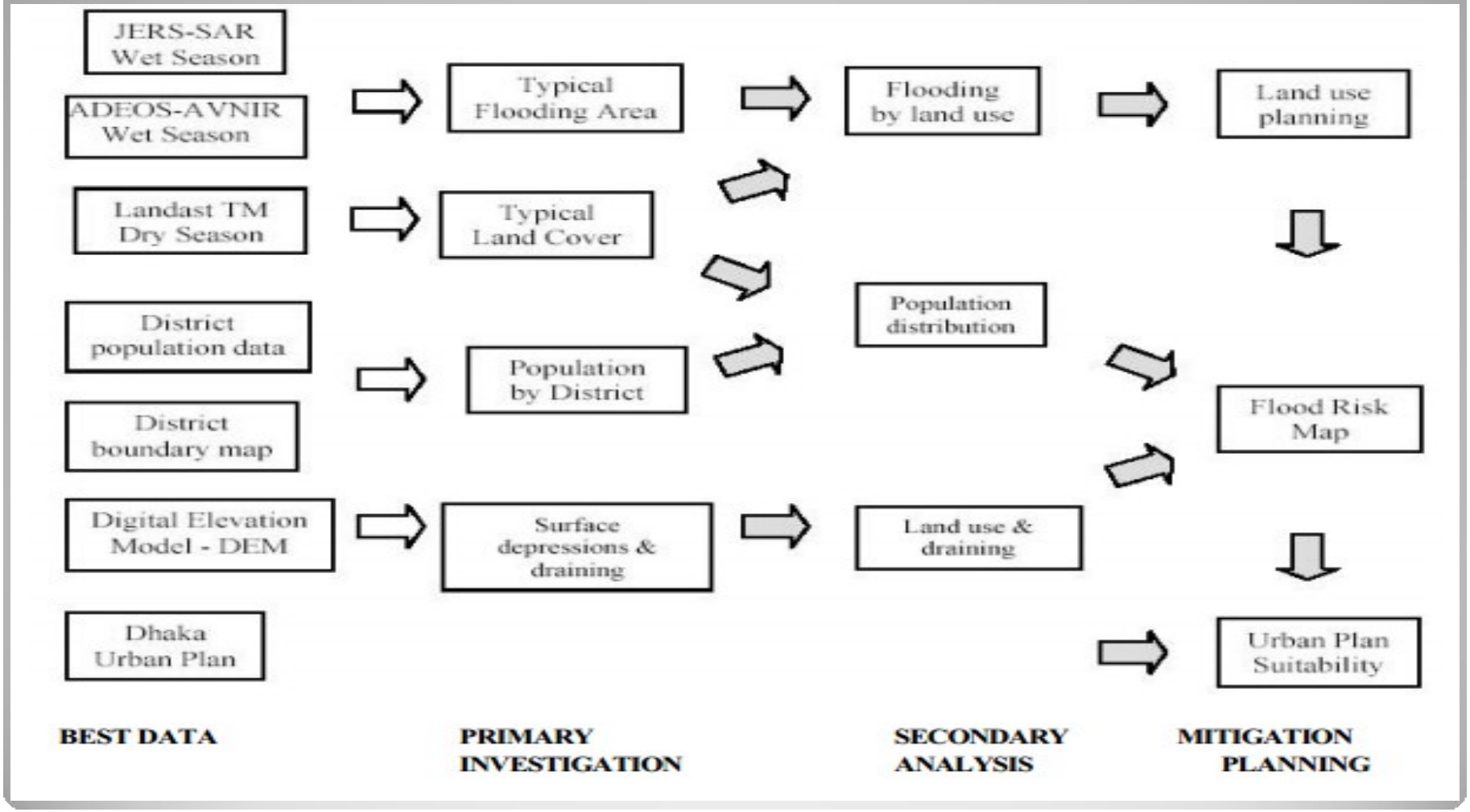
Certain developments may be permitted under certain conditions, relating for example to the:

- Location and extent of building and works;
- Incorporation of various flood proofing measures into the design of the development;
- Restriction on storage and goods and materials that may create pollution or become a floating hazard during floods;
- Land drainage and effluent disposal requirements;
- Requirements for access roads or tracks;
- Maximum height and extent of landfill and earthworks, including levees;

Building standards and codes

- Freeboards above base flood elevation for buildings and essential infrastructure (access roads etc.)
- Protection against foundation erosion
- Limit enclosure for parts of the building below the regulatory flood level (e.g. put houses on stilts)
- Orientation of the building to least obstruct flood flows
- Various measures of wet and dry flood proofing
- Compensation for storage losses due to land fill

Land use management in Dhaka city





Conclusion

Flood control is a combination of flood defense and flood mitigation. Land management is not the major part of flood defense but a primary step for flood mitigation. Flood control can be fulfilled by taking flood mitigation alongside constructing flood defense structures. In geologic point of view, Bangladesh is a flood prone area. So, it is unrealistic to control flood fully rather we can focus on better land management system for flood mitigation.