WMO

UNITED NATIONS UNIVERSITY UNW-DPC

UN WATER UN-Water Decade Programme on Capacity Development

RCUWM TEHRAN

Training Workshop on Integrated Flood Management for countries in Western Asia and the Arab region

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FLOOD MANAGEMENT AND ECOSYSTEM

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FLOOD PLAINS

Positive aspects:

Preferred places for socio-economic activity due to development potentials

- Easy access to natural resources
- Fertile land for agriculture
- Services provided by ecosystems

Negative aspects:

Areas frequently affected by flooding

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Adoption of flood control and protection works (e.g., dams, embankments, diversion works, etc.)

CONSEQUENCES OF STRUCTURAL MEASURES

Natural environment of the rivers is altered :

- **River shape is fixed**
- **River channels are separated from their flood plains**
- **Natural morphological and ecological processes are impeded**

⇩

Resulting in spatially homogeneous ecosystems:

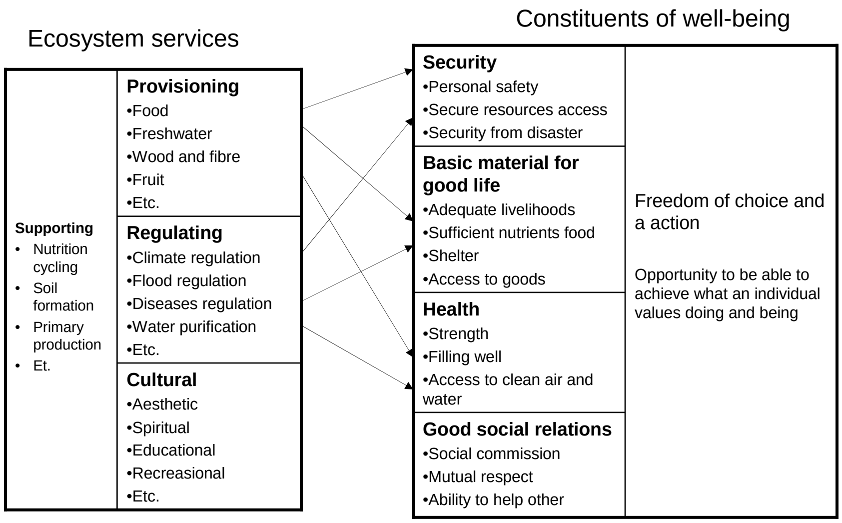
- **Loss of habitat**
- **Loss of biological diversity**
- **Loss of ecosystem productivity**
- **Loss of services provided by such ecosystems**

INTEGRATED FLOOD MANAGEMENT

Objectives

- **Maximizing net benefits from flood plains**
- **Reducing loss of life from flooding**
- **Reducing flood vulnerability and risks**
- **Preserving ecosystems and their associated biodiversity**

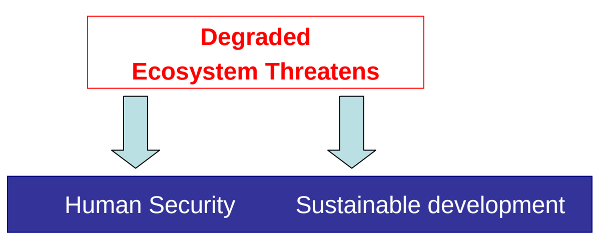
ECOSYSTEM SERVICES AND WELL-BEING



ENVIRONMENT AND SUSTAINABLE DEVELOPMENT

Environmental degradation has the potential to threaten human security:

- **Life**
- **Livelihoods**
- **Food**
- **Health**



DRIVERS OF ENVIRONMENTAL DEGRADATION

- **Population growth**
- **Urbanization**
- **Industrialization**
- **Agriculture development**
- **Transportation**
- **Tourism**

DEVELOPMENT DILEMMA

- **Development Imperatives**
  - Poverty alleviation
  - Improving livelihood and human security
    - ⇨Need for interference in fluvial Ecosystem
- **Preservation of Fluvial ecosystem**

Harmonizing conflicting objectives

UNDERSTANDING ECOSYSTEMS

What should Flood Managers know?

1. **Basic concepts of river morphology and ecology**
2. **Flood processes and ecosystem services: inter-relationship**
3. **Impact of flood management interventions on ecosystems**
4. **Mitigation Measures**

BASIC CONCEPTS OF MORPHOLOGY AND ECOLOGY

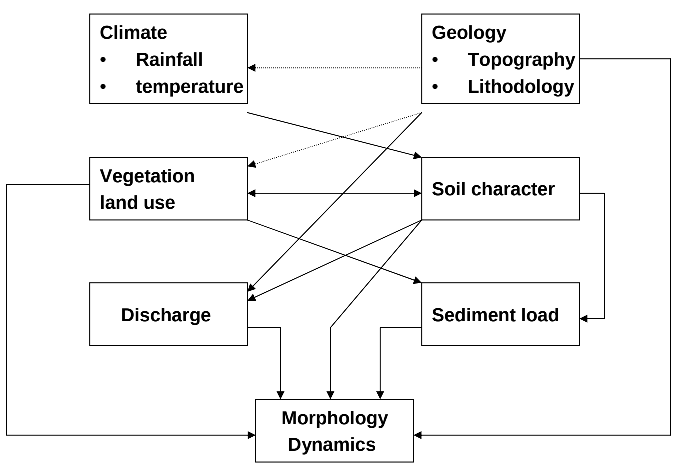
- **Fluvial processes and flood plains**
- **Morphological and ecological connectivity**
- **Morphological regime**
- **River corridors and Biological diversity**

FLUVIAL PROCESSES AND FLOOD PLAINS

Floods

- Simply a part of the natural variation of hydrological processes, allowing water to flow over the banks and inundating the adjacent lands
- Play a key role in determining the level of biological productivity and diversity of rivers and their flood plains

FLUVIAL PROCESSES AND FLOOD PLAINS



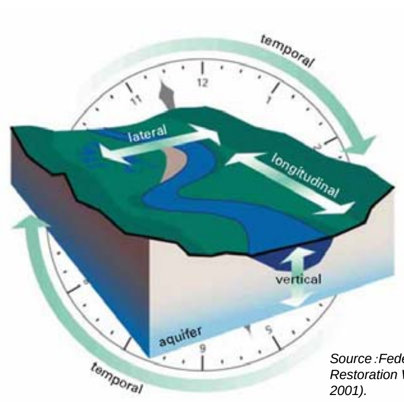
The fluvial systems

SPATIAL AND TEMPORAL HIERARCHY OF FLOOD PLAIN COMPONENTS

	Geomorphic Unit		Vegetation Unit	Turn over time (years)	Spatial Scale (km)	Flood Frequency (years)
i.	Point bars, channel edge sediment, and recently cut off meanders		Herbaceous vegetation and early succession tree species	Upto 1	Upto 1 km	1 to 5
ii.	Various topographical features like natural levees and ox-bow lakes	a)	Flood plain grass lands	1-5	Upto 5 km	5 to 500
		b)	Early succession woodlands	5-100		
iii.	Higher parts of flood plain		Established forest >1 generation	>100	>10 km	50 to 1000
iv.	Post glaciated flood plain		Established forest >1 generation	>500	>100 km	500 to 10,000

Morphological and Ecological Connectivity

Basic concepts of morphology and ecology

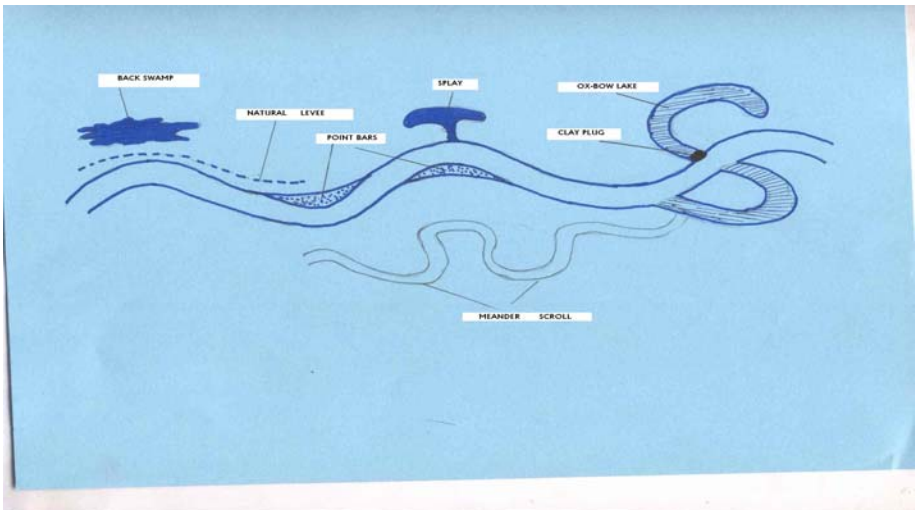


Source :Federal Interagency Stream Restoration Working Group, 1998 (revised 2001).

Spatial and temporal dimensions of a river corridor

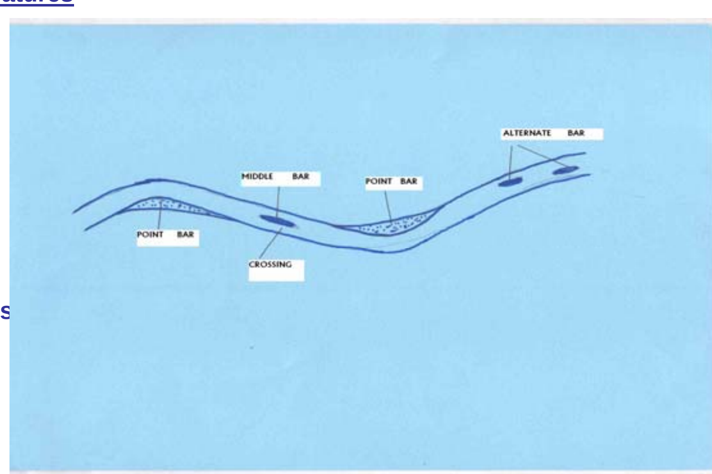
MORPHOLOGICAL REGIME

TYPICAL MORPHOLOGICAL FEATURES OF A RIVER



MEANDERING RIVER

Morphological Features



i. **Meander belt**

ii. **Point bars**

iii. **Middle bars**

iv. **Alternate bars**

v. **Crossings.**

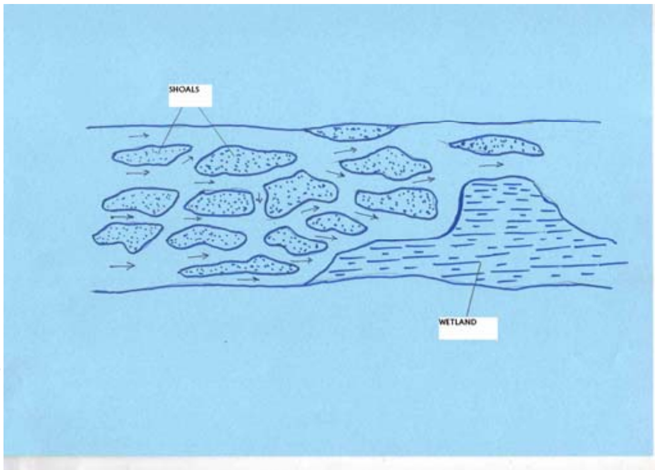
BRAIDED RIVER

Morphological Features

i. **Shoals**

ii. **Islands**
(Relatively more stable)

iii. **Braided channels**



FEATURES OF RIVER CORRIDOR

A) **River Channel**

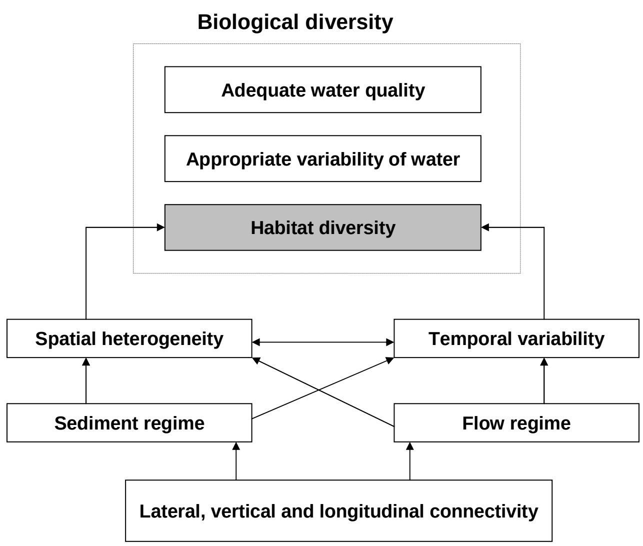
B) **Alluvial flood plains (including Natural levees, Backswamps, splays, ox-bow lakes, alluvial fans etc.)**

C) **River deltas**

D) **Wetlands**

  i. **Marsh**
  ii. **Fen**
  iii. **Peatland (organic-soil flats)**
  iv. **Lakes**
  v. **Ponds.**

RIVER CORRIDORS AND BIO-DIVERSITY



FLOOD MANAGEMENT INTERVENTIONS AND THEIR IMPACT ON ECOSYSTEMS

DAMS AND RESERVOIRS

i) Store flood waters and sediment	* Submerge large areas upstream	* Destroy forests and other vegetation. * Destroy or disturb habitat of terrestrial fauna and micro-organism. * Prevent seasonal fish migration. ➢ Loss of fish species.
	* Modify flow regime in the downstream and reduce sediment discharge.	* Changes in morphologic features ➢Drastic changes in habitat for flora and fauna
	* Water quality changes	* Eutrophication * Toxic algal growth. * Adverse impact on downstream food web.

FLOOD EMBANKMENTS/ DYKES/ LEVEES

* Increased flow velocities	
* Changes in sediment transport	* Reduction in habitat heterogeneity
* Disrupt lateral hydrological connectivity	
* Reduction in flood plain inundation	

DETENTION AND RETENTION BASINS

* Reduce peak floods downstream	* These basins can act as wetlands or permanent ponds ➢Create habitat for aquatic and semi-aquatic species

BYPASS AND DIVERSION CHANNELS

Reduce flood discharge in bypassed reach.

* Change in morphologic features
* Drastic change in habitat for flora and fauna.

CHANNALIZATION

* Simplifies channel form and flood plain
* Disconnects the channel from side channel features
* Changes sediments transport and deposition process

* Reduces habitat diversity

RIVER MORPHOLOGICAL CONSIDERATIONS FOR PLANNING AND DESIGN OF FLOOD MANAGEMENT WORKS

Variables Influencing River Systems

* **Structure:**
  - Effect of various kinds of rocks
    - ➢Erosional characteristics
    - ➢Sediment yield potential
  - Faults, joints, fractures, shear zones etc.
* **Stage:**
  - Stage of land form development
    - ➢Youthful
    - ➢Mature
    - ➢Old
* **Process:**
  - Distinctive characteristics of river flows

THESE AFFORD A GENERAL QUALITATIVE UNDERSTANDING OF A RIVER AND ITS BEHAVIOUR.

CONCEPT OF MORPHOLOGICAL TIME SCALE

Geological Time Scale

* Millions of years:
  - River is an open system
  - Undergoing continuous
    - ➢ No definite relation between variables
    - ➢ All variables are time dependent

Steady Time Scale

* Few days or weeks
  - River may be in a "Steady State"
    - No significant change in channel morphology or flood plain

CAUSE-EFFECT RELATIONSHIP IN THE TWO CASES ARE QUITE DIFFERENT

Graded Time Scale

Few hundred years - River in dynamic equilibrium
- Variables change in cyclic manner

THIS IS RELEVANT FOR RIVER ENGINEER

Hydrology (mean discharge of water and sediment)	- Independent variables
Channel morphology	- Dependent variable
Hydraulics of flow	- Indeterminate

* Close Empirical relationship
  - Discharge ~ Channel morphology

APPROACH FOR PLANNING AND DESIGN

1. **Empirical** : For Initial Planning & Design
2. **Analytical** : For firming up
   - Mathematical modelling.
   - Physical modelling

HYDROLOGICAL STUDIES

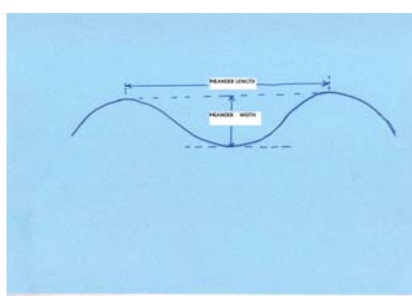
Objective: **Understanding River Mechanics**

- Structural analysis of flow series
  - * High flows
  - * Low flows
  - * Mean annual flow
  - * Integrated effect of all flows

  (High flows, Low flows, Mean annual flow: Channel parameters)
- Assessment of dominant discharge
  - * Average annual or
  - * Bankful
  - * Any other
- Analysis of sediment load
  - * Suspended
  - * Bed load
- Sediment size (d) and silt factor (f)

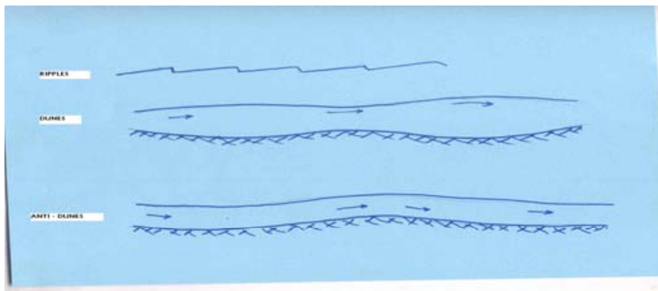
MORPHOLOGICAL RELATIONSHIPS

- **Lane and Handerson: S~f(Q, d)**
- **Meander (Length and Width) ~ f(Dominant Q)**
- **Channel Parameters (W,R,v) ~ f(Q,silt factor)**
- **Channel factor ~ slope roughness factor (Delicately balanced for a given Q)**
- **Sediment Load at a given site ~ f(V, Stream Power)**
- **Annual Sediment Load ~ f(drainage area, Ann precip, Ann runoff)**



BED FORMS AND FLOW REGIMES

Flow regime	Bed form	Mode of sediment transport	Type of roughness
Lower regime	Ripples Dunes	Discrete steps	Form roughness Predominates
Transition	Washed-out dunes		Variable
Upper regime	Plane beds Antidunes chutes and pools	Continuous	Grain Roughness Predominates



AGGRADATION AND DEGRADATION

Sediment Deposition – Rising of bed
Sediment erosion – Lowering of bed

Change in discharge and sediment load
Increase in QS (Q unchanged)
OR Decrease in Q (QS unchanged) - Aggradation

Aggradation or degradation in a tributary channel is also caused by lateral movement of the channnel

POSSIBLE MITIGATION MEASURES

i) **Dams and Reservoirs**

* **Regulated releases to ensure seasonal variability**
* **Multiple and / or depth-selective intake structures to maintain natural seasonal temperature**
* **Providing fish passages**
* **Bypassing devices for sediment and wood debris**

POSSIBLE MITIGATION MEASURES cont…

ii) **Embankments/dykes/levees**

* **To be planned in conjunction with other structural measures like dam, detention basins and non-structural measures**

* **Adequate spacing between embankments to allow lateral movement of river and lateral connectivity between river channel and other morphologic units.**

POSSIBLE MITIGATION MEASURES cont…

iii) Detention/retention basins

* **Develop them as artificial wetlands or permanent ponds to create new habitat for aquatic and terrestrial species.**

iv) Bypass and diversion channels

* **Flow regulation to ensure new dynamic equilibrium**
* **Bypass channel to be planned in conjunction with detention basin in its downstream**

iv) Canalization

* **Use of natural and permeable material – for soft revetment**
* **Maintaining coarse woody debris flows in the channel.**