

# ENVIRONMENTAL ASPECTS OF INTEGRATED FLOOD MANAGEMENT



## WMO/GWP ASSOCIATED PROGRAMME ON FLOOD MANAGEMENT (APFM)



World Meteorological  
Organization



Global Water  
Partnership

# Flood Plains

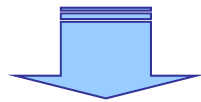
## Positive aspects:

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 recurrently affected by flooding



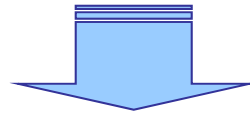
Adoption of flood control and protection works  
(e.g. dams, embankments, diversion works, etc.)



# Consequences

## Altered natural environment of the rivers:

- Fixed river shape
- Separated river channels from their flood plains
- Impeded natural morphological and ecological processes



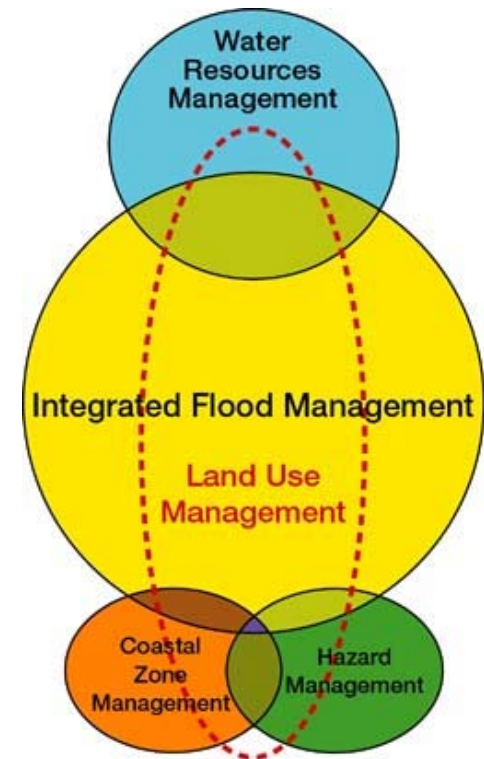
## Resulting in spatially homogeneous ecosystems:

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

# Flood Control to Integrated Flood Management

## Integrated Flood Management (IFM):

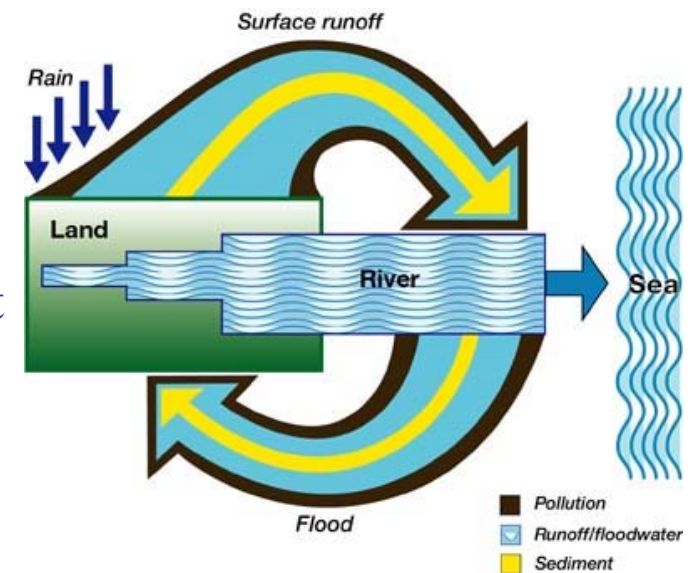
- Maximizing the net benefits from flood plains
- Reduce loss of life from flooding
- Reduce flood vulnerability and risks
- Preserve ecosystems and their associated biodiversity



# Elements of IFM

## Five key elements of IFM:

- Managing the land plan of water cycle as a whole
- Integrating land and water management
- Using an appropriate mix of strategies
- Ensuring a participatory approach
- Adopting multi-hazard approach



## These elements can be put together through:

- Adopting a basin approach to flood management
- Bringing a multi-disciplinarity in flood management
- Reducing vulnerability and risks due to flooding; and
- Preserving ecosystems services.



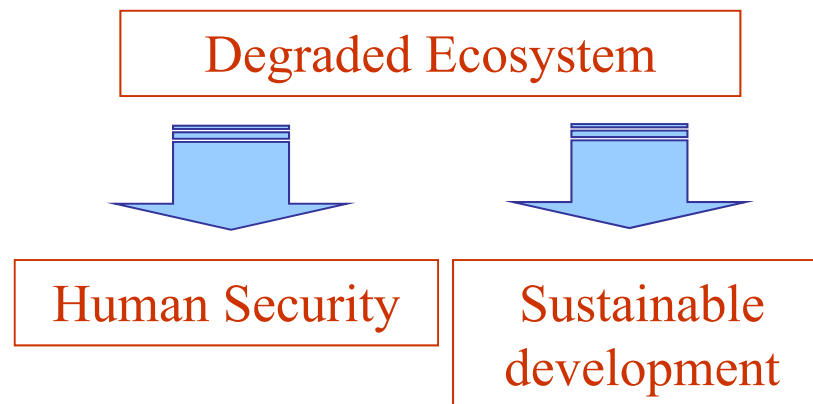
# Environmental Degradation and Sustainable Development

Environmental degradation has the potential to threaten human security:

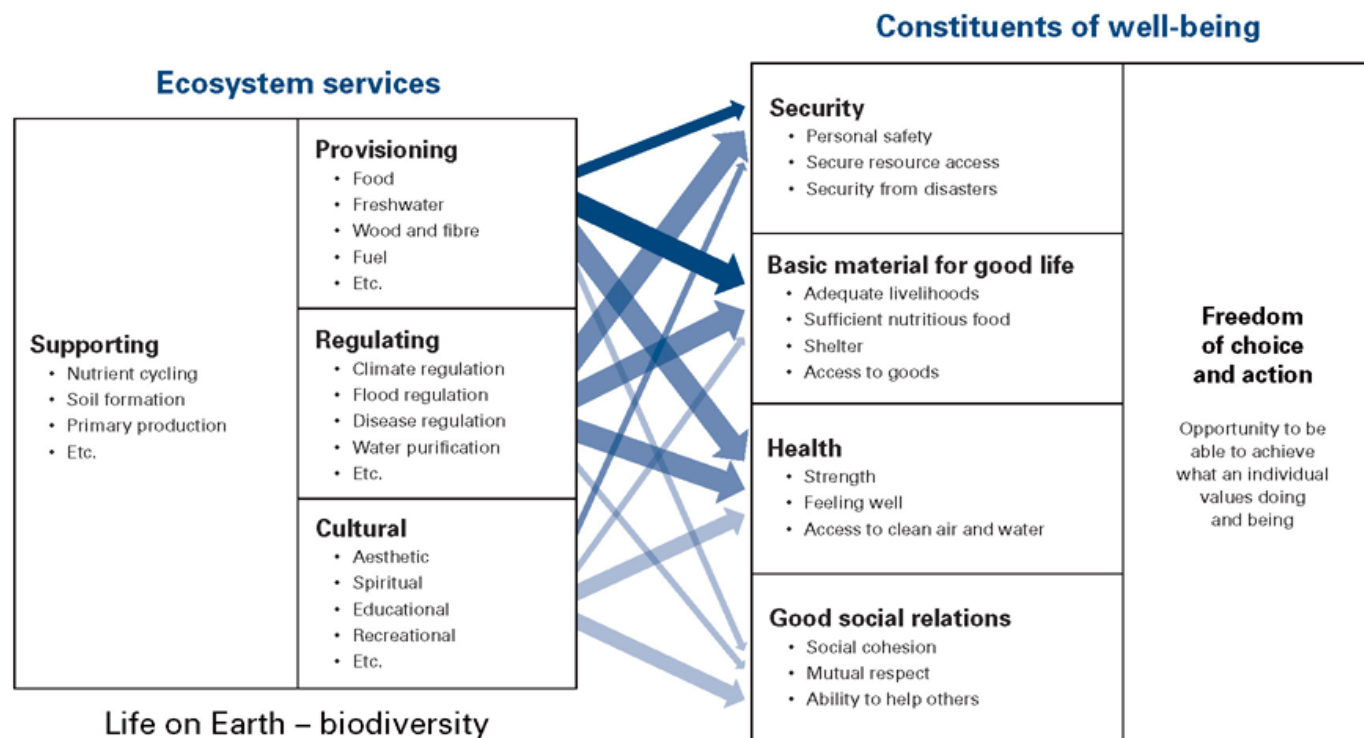
- Life
- Livelihoods
- Food
- Health



**If resources are changed...**






# Ecosystem Services






## Arrow's colour

Potential for mediation by socio-economic factors

-  Low
-  Medium
-  High

## Arrow's width

Intensity of linkages between ecosystem services and human well-being

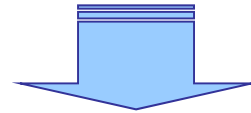
-  Weak
-  Medium
-  Strong

Source: Millennium Ecosystem Assessment, 2005.  
Ecosystems and Human Well-being: synthesis,  
Island Press, Washington, DC.

# Dilemma of Human-Being

## Drivers of environmental degradation:

- Poverty and consumerism
- Agricultural development
- Industrialization
- Urbanization
- Transportation
- Tourisms
- Population growth

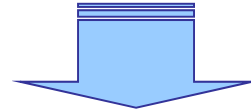


- Poverty alleviation measures
- Activity for improving livelihoods and human security



# Development Imperatives and Preservation of Ecosystems

- Protection from a natural disaster for the benefit of people
- Disaster mitigation by restricting the occupation of flood plains



## Importance of balancing between:

- Development imperatives:  
flood risks, their relation to socio-economic vulnerability and sustainable development
- Preservation of ecosystem services

# Understanding Ecosystems:

## What should Flood Managers know?

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

# Understanding Ecosystems:

## What should Flood Managers know?

### Understanding of:

#### 1. Basic concepts of morphology and ecology

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

#### 2. Flood processes and ecosystem services: inter-relationship

#### 3. Impact of flood management interventions on ecosystems

# Fluvial processes and flood plains

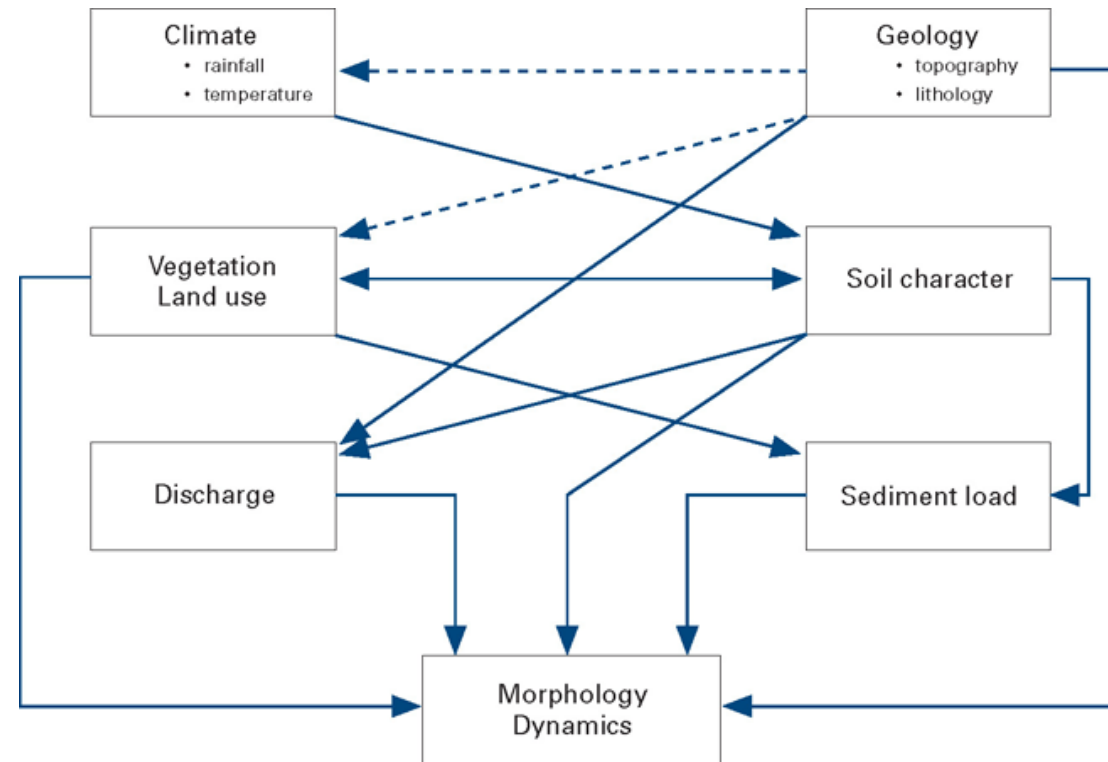
## Floods

- 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



Church, M., 2002. Geomorphic thresholds in riverine landscapes, *Freshwater Biology*, 47: 541–557.

# Fluvial processes and flood plains

## Defining flood plain

### Ecologists:

Areas that are periodically inundated (usually annually) by lateral overflow of rivers or lakes, or by direct precipitation or even by a rise in groundwater levels

### Hydrologists:

Areas on both banks of a river inundated by a flood event with a recurrent interval of 100 years

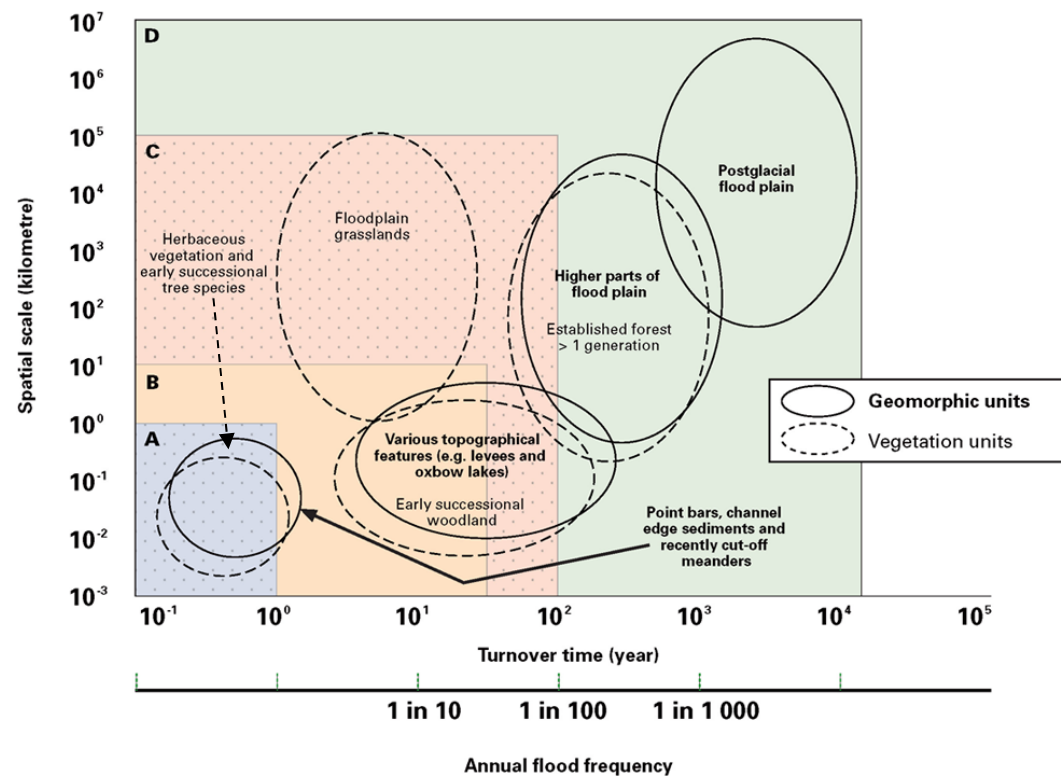
**The extend of a flood plain can gets defined by:**

- **the specific geomorphic and vegetation characteristics; and**
- **the objectives of floodplain management**



# Fluvial processes and flood plains

## What are the flood plains we are discussing?



### *Region A:*

the flood plain flooded every year

### *Region B and C:*

the flood plain flooded on an average every 100 years

# Fluvial processes and flood plains

## Flood plains

- Highly heterogeneous ecosystems
- A complex assemblage of: small channels, depressions, backwaters, hillocks, ridges, etc.

## Depression wetlands within flood plains

- Connected to rivers
- Flood water bring fine sediment and nutrients
- Allowing migration of fish providing habitats for birds

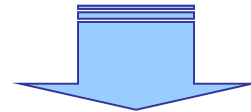


Meandering of the Yellow River, China

# Morphological Regime

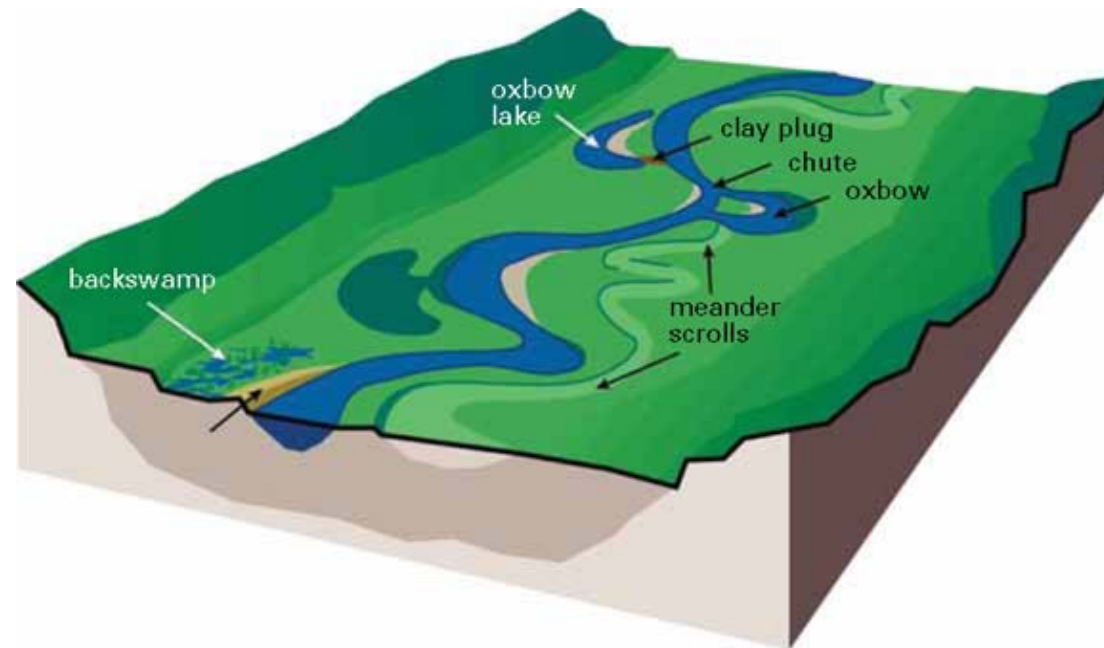
## River landscape

- Determined by the interactions among:
  - water in hydrological regime,
  - sediment load and calibre,
  - coarse woody debris,
  - bed and bank materials and vegetation, etc.



- Modifying movable sediment boundary
- Creating a range of channel style or patterns (meandering, anastomosing, single-thread sinuous, wandering or braided patterns)

# Morphological Regime



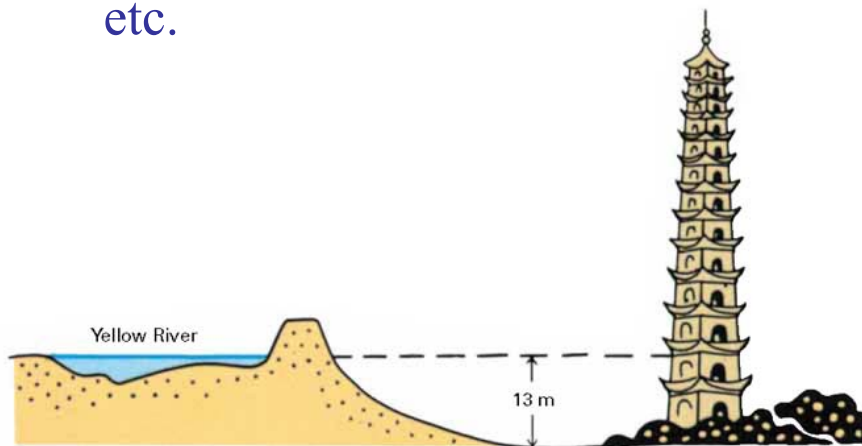
**An example of an alluvial river corridor with meandering pattern**

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

# Morphological Regime

## Aggradation

Under natural conditions or due to human induced land use change, deforestation, etc.



Sketch map of the “hanging river”  
near Kaifeng, China

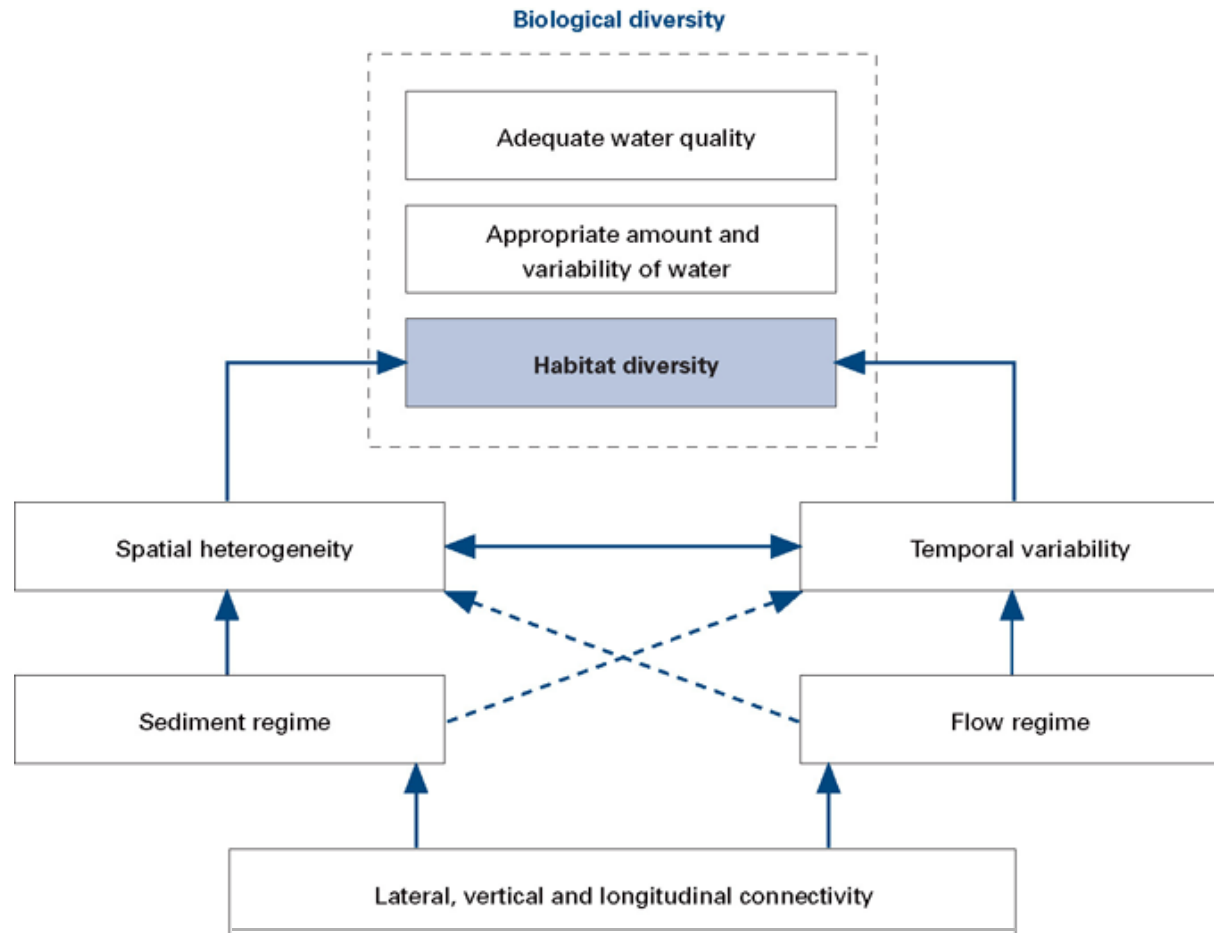
## Degradation

Under natural conditions or due to dam construction, soil protection, reforestation, etc.



Kerr dam on the Flathead river,  
U.S.A.

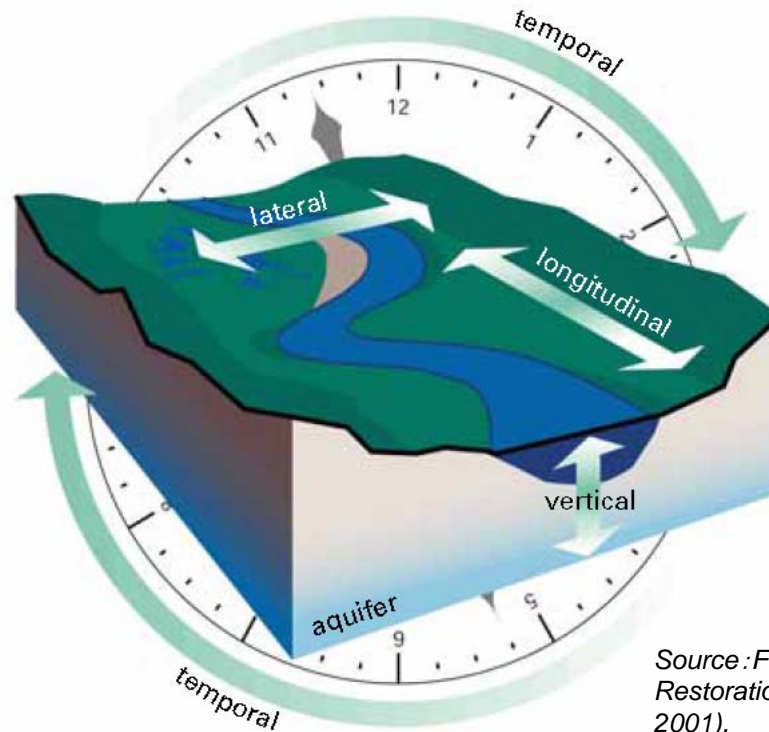
# Biological diversity



Various components in formulating biological diversity



# Morphological and Ecological Connectivity



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

**Spatial and temporal dimensions of a river corridor**

# Understanding Ecosystems:

## What should Flood Managers know?

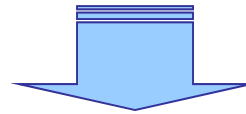
### Understanding of:

1. Basic concepts of morphology and ecology
2. Flood processes and ecosystem services:  
inter-relationship
  - Roles of various ecosystems in the hydrological processes and response
  - How ecosystems interact with flow regimes including flood events
  - Opportunities and limitations of ecosystems as flood alleviation service provider
3. Impact of flood management interventions on ecosystems

# Flood processes and ecosystem services: inter-relationship

## Various ecosystems:

- Forests
- Tree root
- Ponds and lakes
- Wetlands



- Roles of various ecosystems in the hydrological processes and response
- How ecosystems interact with flow regimes including flood events
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# Understanding Ecosystems:

## What should Flood Managers know?

### Understanding of:

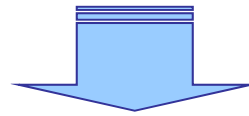
1. Basic concepts of morphology and ecology
2. Flood processes and ecosystem services:  
inter-relationship
3. Impact of flood management interventions on  
ecosystems
  - Flow regime
  - Sediment transport and balance
  - Water quality
  - Biological diversity

# Impact of flood management interventions on ecosystems

## Structural flood control and protection works:

- Dam and reservoirs
- Detention and retention basins
- Bypass and diversion channels
- Embankments
- Channelization

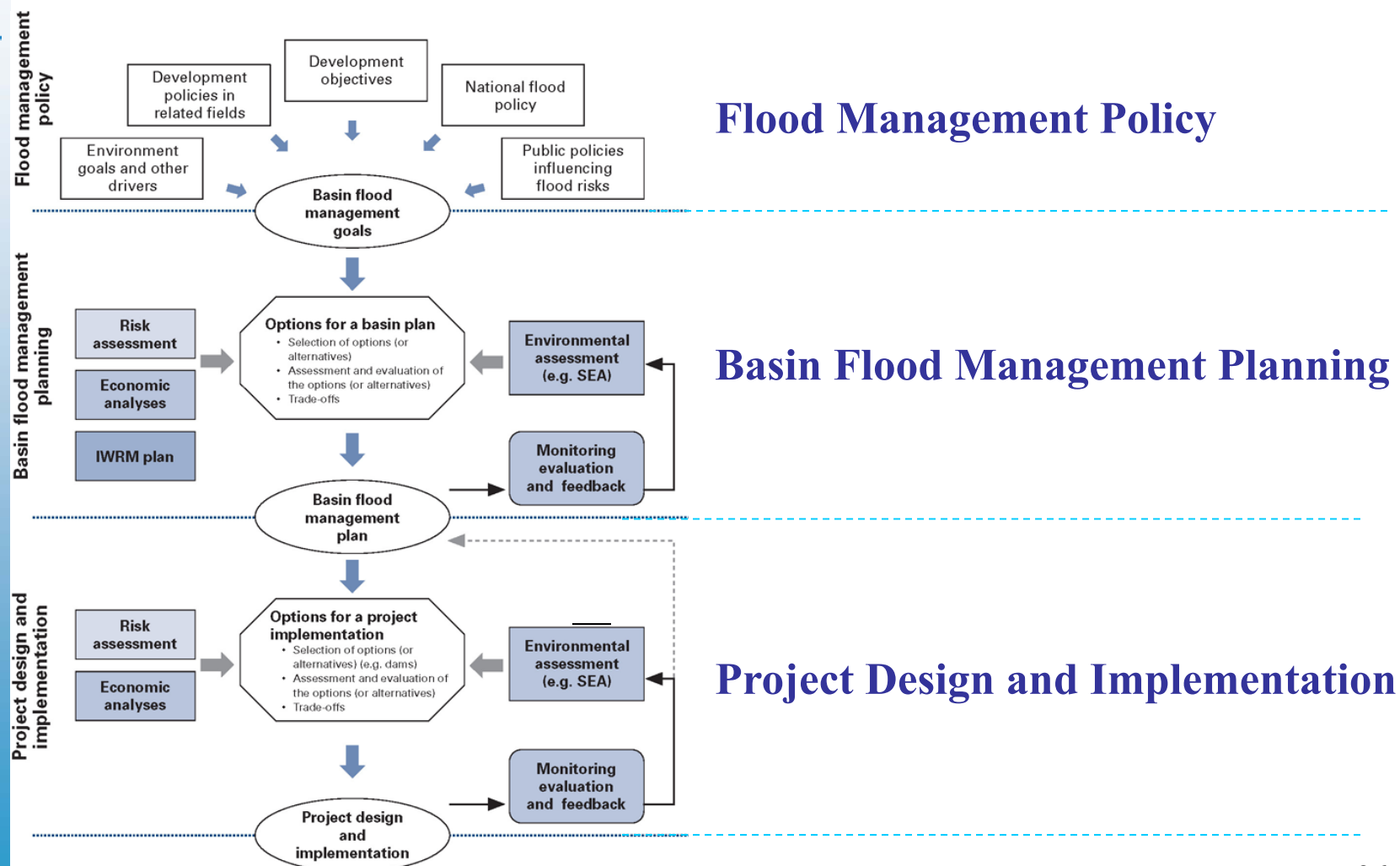
- Environmentally sensitive operation
- Lateral disconnection kept to a minimum, removal and setting back
- Avoiding channelization and using environment friendly materials



### can help:

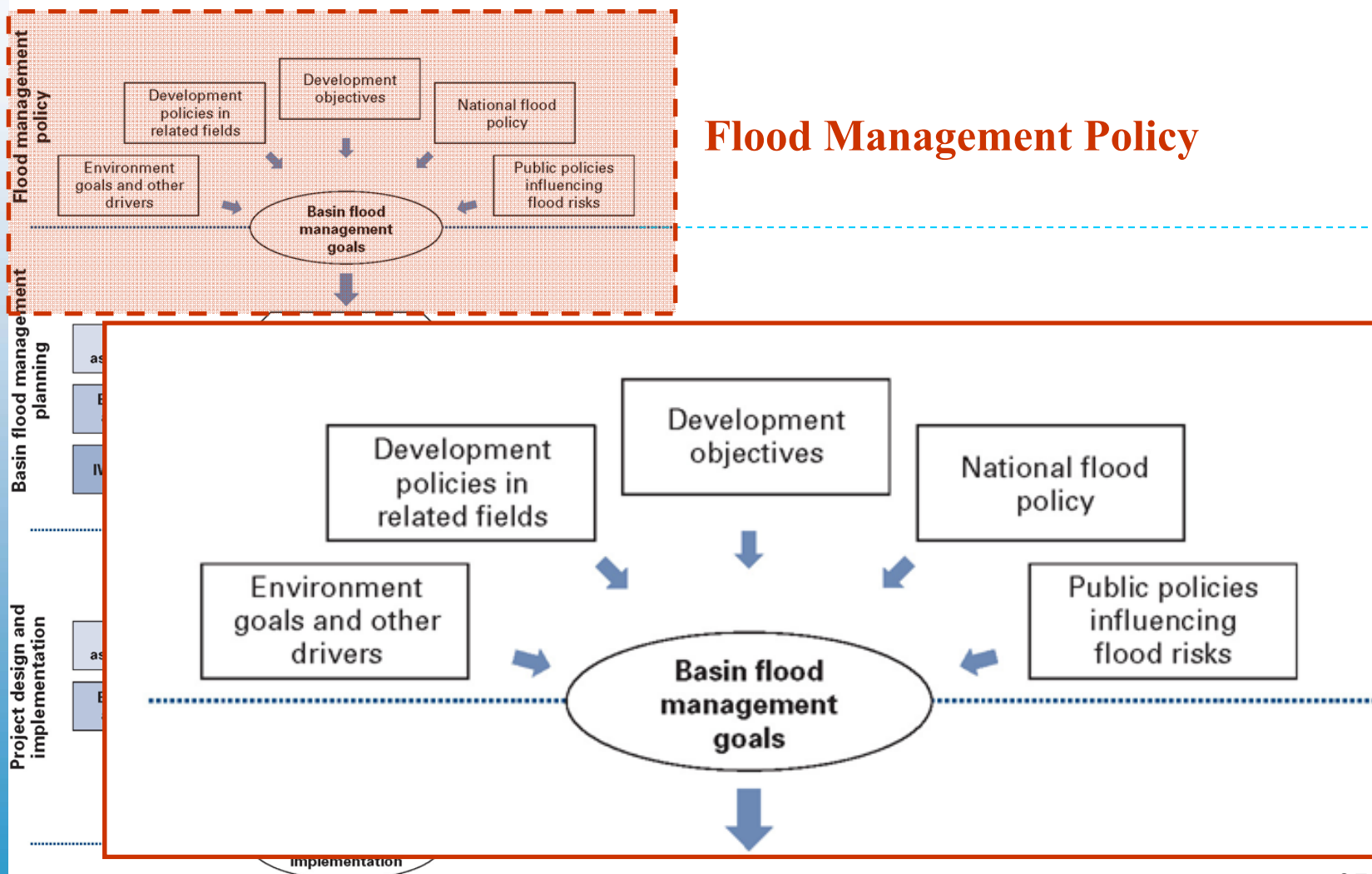
- Maintain ecological health of riverine ecosystems
- Keep the environmental impacts to a minimum

# Framework for Environment friendly flood management

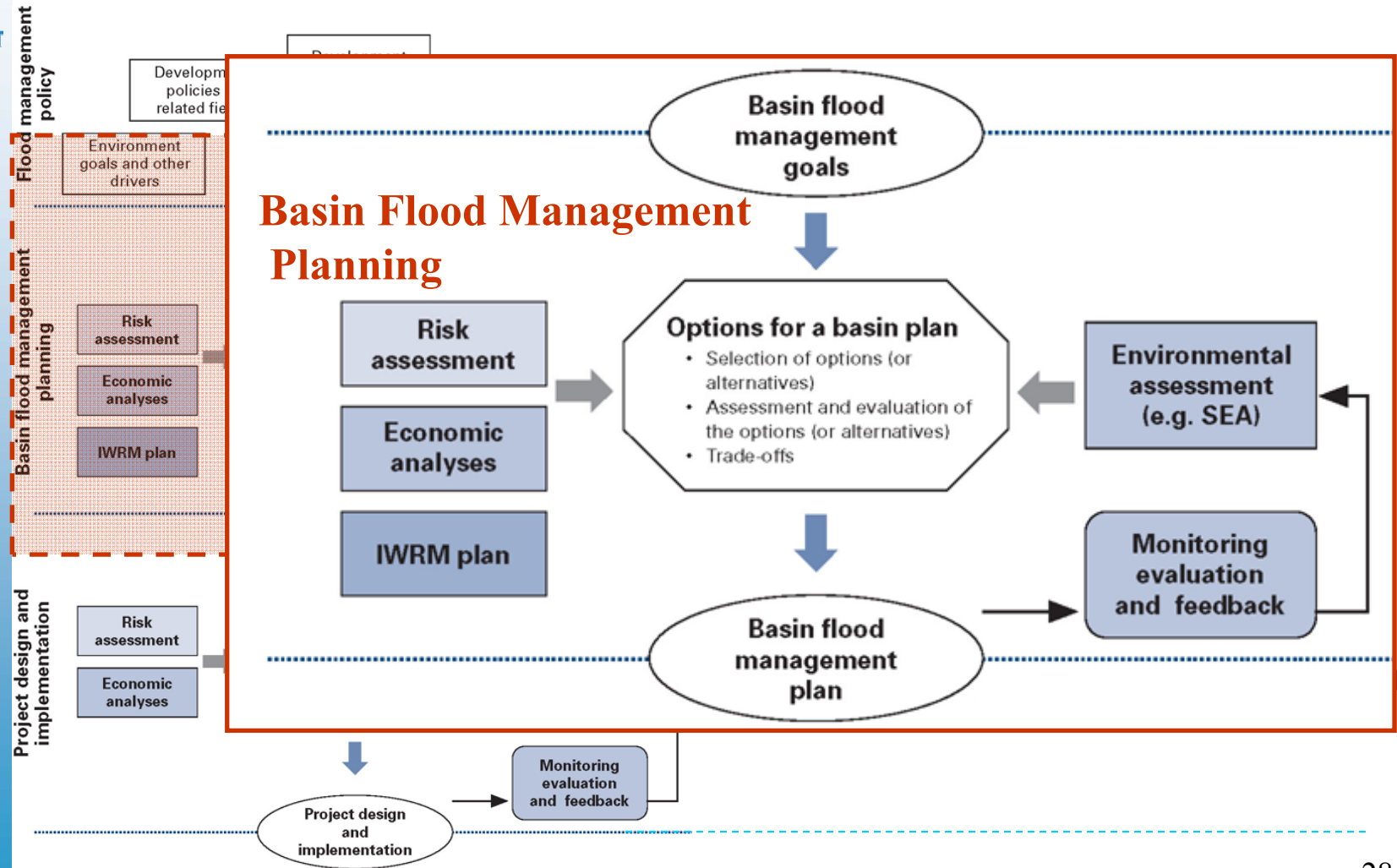




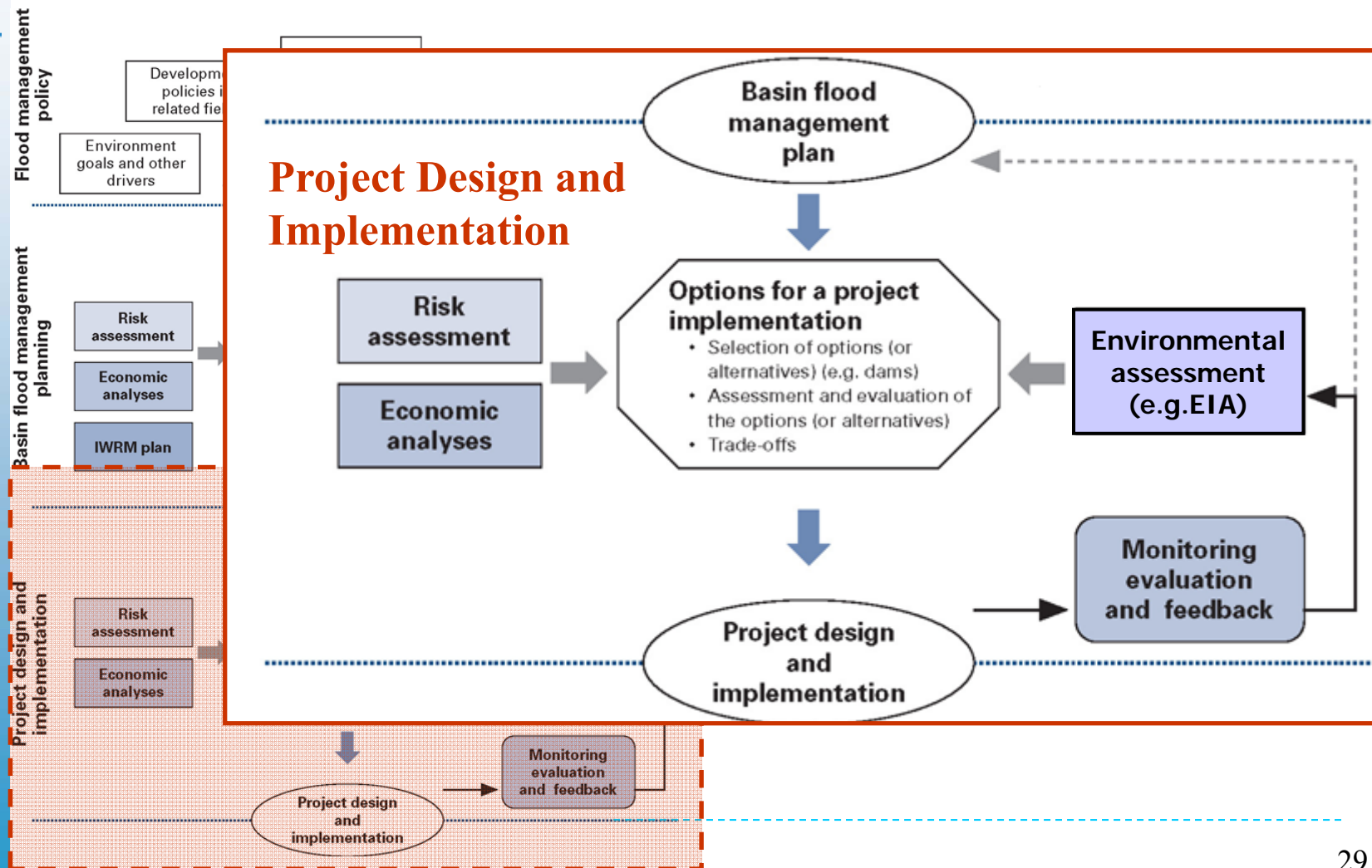
# Framework for Environment friendly flood management



# Framework for Environment friendly flood management



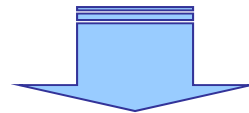
# Framework for Environment friendly flood management



# Framework for Environment friendly flood management

## Elements:

- Scientific understanding and analysis
- Environmental assessment
- Environmentally sensitive economic analysis
- Stakeholder participation
- Adaptive management approach
- Monitoring
- Enabling mechanism



## Approach:

Adopting a threefold approach of

- 1) avoiding
- 2) reducing, and
- 3) mitigating adverse impact on the environment

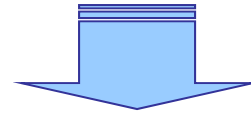
# Environmental Assessment

## Strategic Environmental Assessment (SEA):

- Applied at policy and planning level

## Environmental Impact Assessment (EIA):

- Applied at the project design and implementation level



## What are the similarities and differences?

- Levels of detail to be assessed
- Option (s) or alternative (s) to be considered
- Procedures: screening; scoping; identification, prediction and evaluation of impacts; monitoring, etc.
- Interaction and consultation with stakeholders

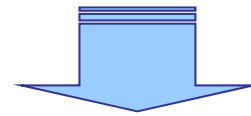
# Environmentally sensitive economic analysis

## Cost-Benefit Analysis (CBA):

- Compares costs versus benefits in monetary terms
- Limitation in evaluating the costs and benefits from environmental and societal perspective
- Useful in detailed appraisal

## Multi Criteria Analysis (MCA):

- Judges the expected performance of each development option against a number of criteria and objectives
- Useful in ranking options, short-listing a limited number of options



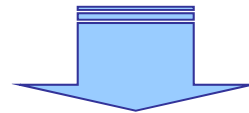
**A complementary approach between CBA and MCA involving various stakeholders is useful**



# Adaptive Management (1/2)

## Scientific uncertainties

- Existing conditions of ecosystems
- Impact of human interventions on environment and ecosystems



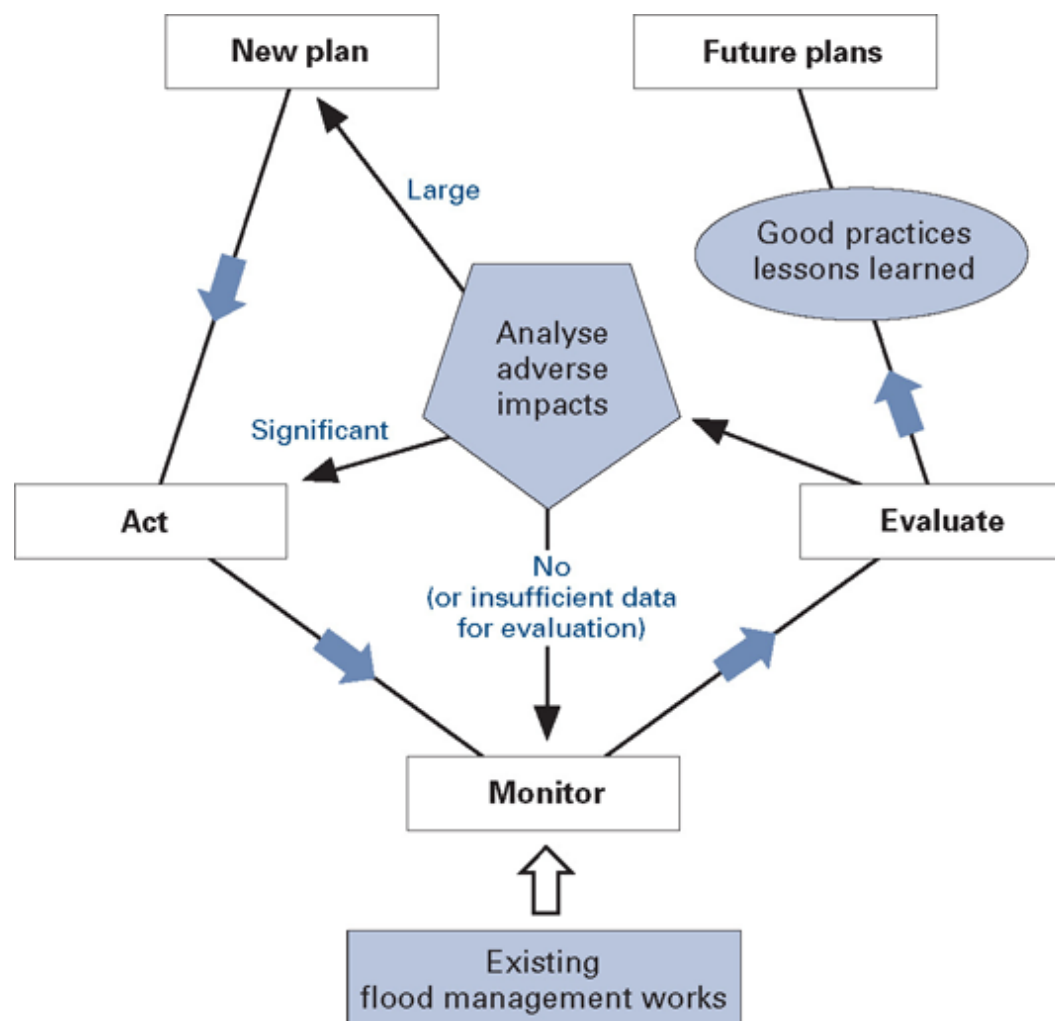
## Precautionary principle:

**“Where there are threats of serious or irreversible damage, lack of full scientific certainty shall not be used as a reason for postponing cost-effective measures to prevent environmental degradation.”.**

## Adaptive management:

**An approach to dealing with scientific uncertainties, wherein, decisions are made as part of an ongoing science-based process.**

## Adaptive Management (2/2)



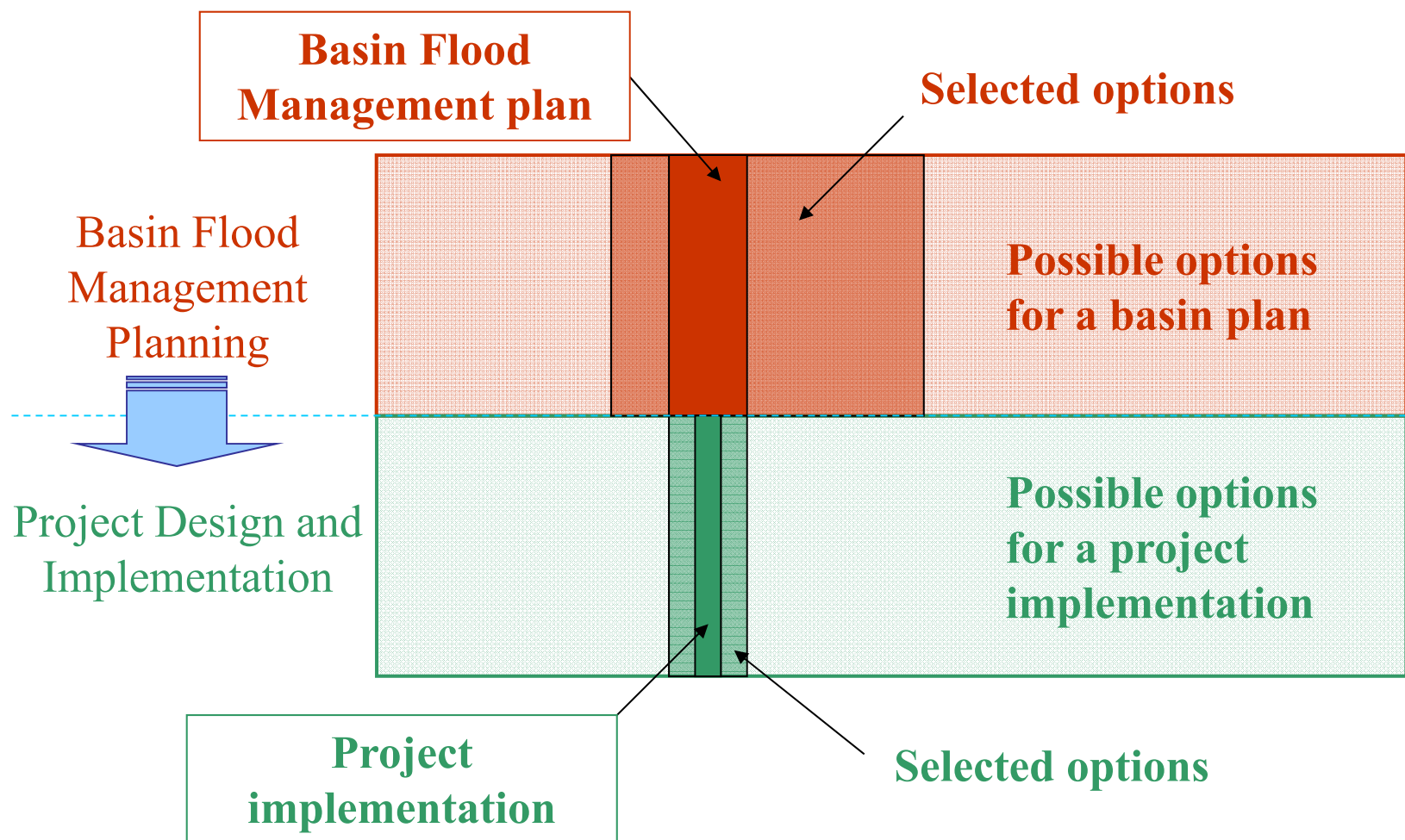
## For More Information

Visit the APFM website at:

**[www.apfm.info](http://www.apfm.info)**

**THANK YOU!**

# Decision-making processes at different levels



# Monitoring

## At the development planning level

- Are objectives of the plan are achieved?
- Are the actions taken appropriately based on the plan?

## During- and post-implementation at the project level

- Has the flood management measure met the desired objectives?
- Are the extent of the impacts foreseen being manifested?
- Are the measures taken to prevent them are effective and to what extent?