Critical Processes and Management Issues in Deltas

Updated outcomes of the International Workshop on River Deltas: Evolution, Environmental Challenges and Sustainable Management, jointly organized by the United States Army Corps of Engineers & GEOECOMAR (2006)

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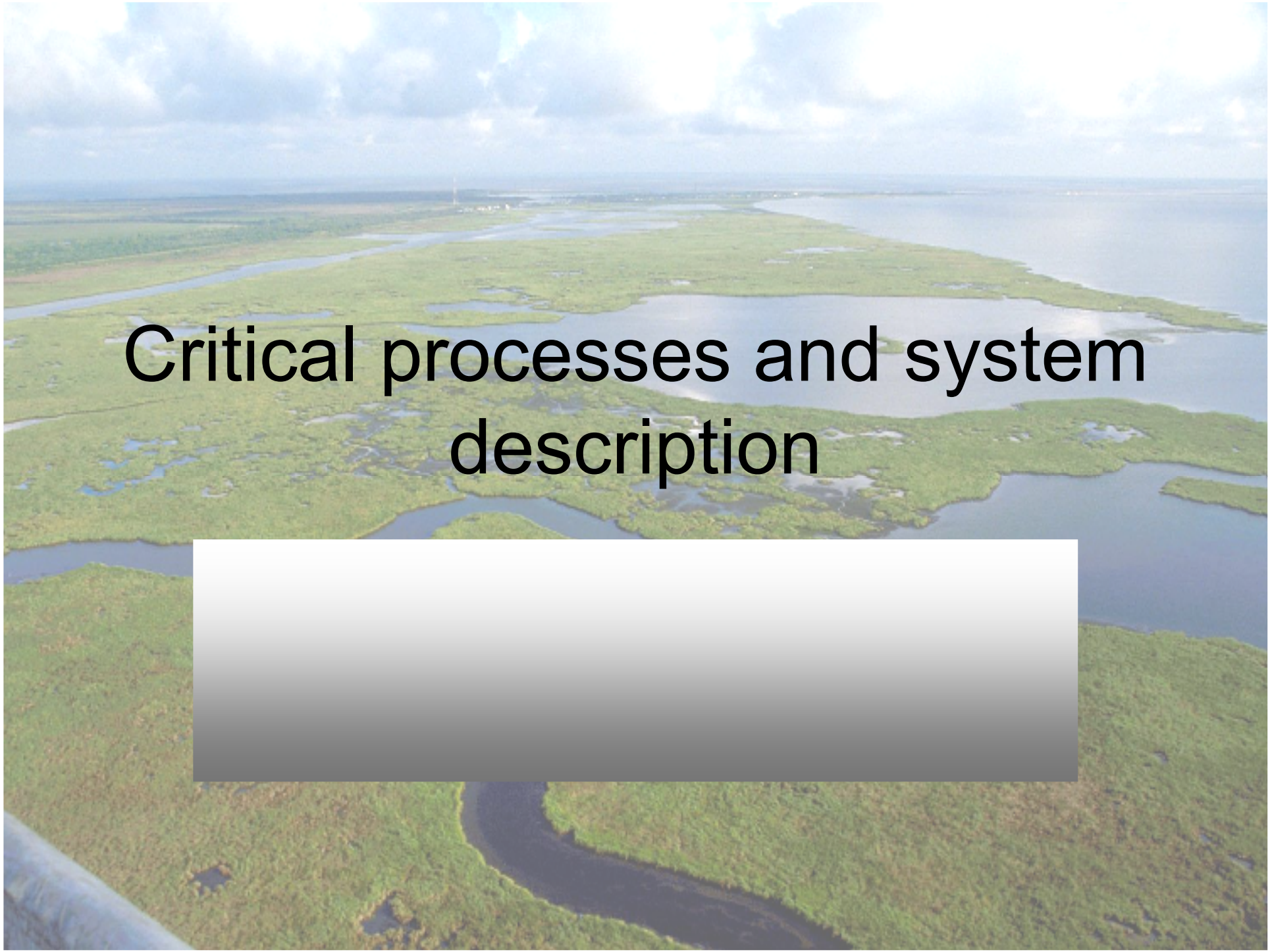
Rationale…

- **Global climate change in combination with human activities will directly affect deltas potentially producing catastrophic change on a decadal scale.**
- **If /when collapse occurs – the effects will be catastrophic.**
- **In a time of real and growing energy scarcity, deltaic ecosystem services provide an enormous subsidy for the global economy**
- **Management – should cope with global climate change; maintain ecosystem services to support the economy and human welfare**



Critical processes and system description

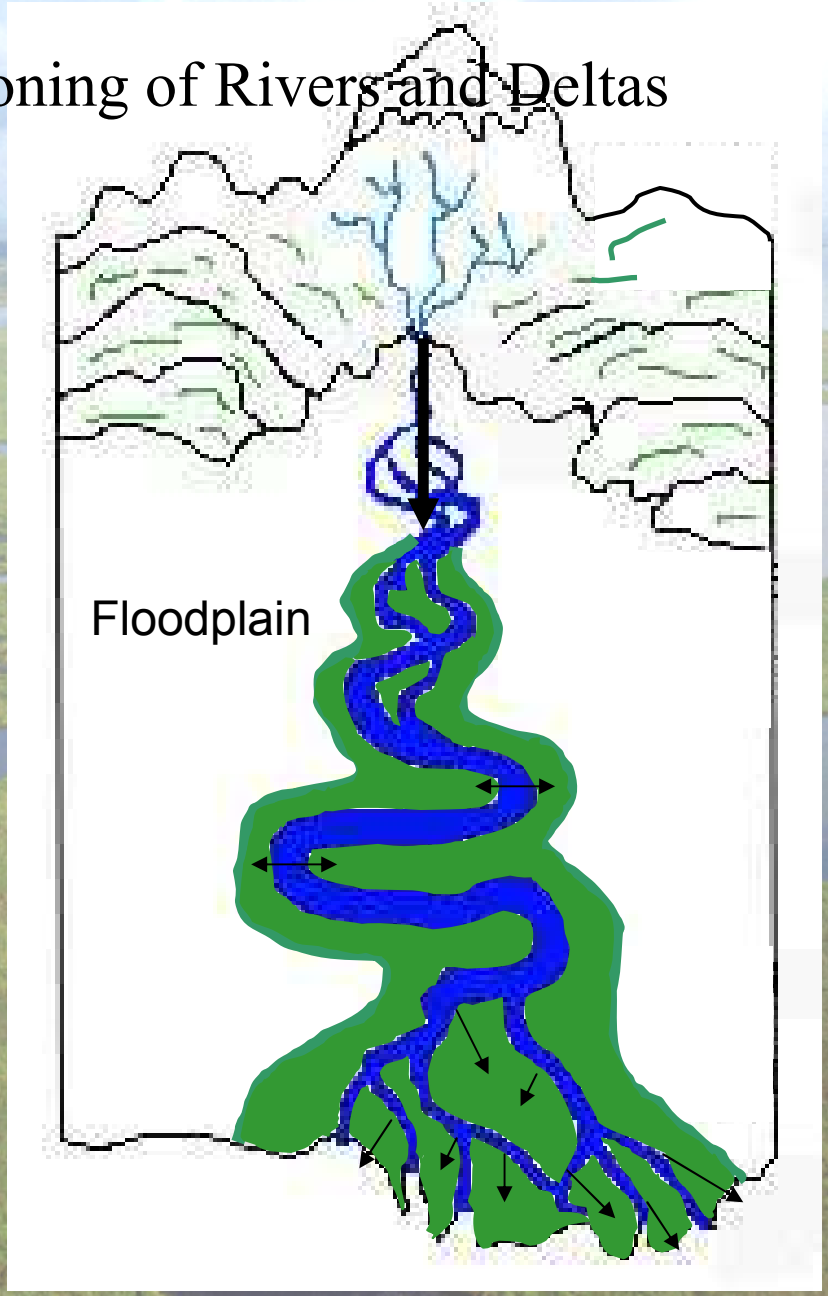
- Deltas are equilibrium landforms – dynamic responding to water and sediment fluxes and characterized by an ability to evolve through time.
- Must identify critical thresholds (and system resilience).
- Lots of system knowledge – most of it formulated in a way that makes it difficult to identify the true inter-relationships.
- How might deltas be affected by temporally varying catchment inputs?
- Must identify inter-relationships between socio-economic processes and the physical / biological system

Concepts of the Functioning of Rivers and Deltas

River Continuum Concept

Flood Pulse Concept

Deltaic Pulsing Concept



Upper River

Lower River

Delta

(John Day, 2006)

Temporal Scale of pulsing events in deltaic systems

Event	Timescale	Impact
River switching	1,000 yrs	**Deltaic lobe formation, Net advance of deltaic landmass, Barrier Island Formation**
Major river floods	50-100 yrs	**Channel switching initiation, Crevasse splay formation, Major deposition**
Major storms	5-20 yrs	**Major deposition, Enhanced production**
Average river floods	Annual	**Enhanced production, Freshening (lower salinity), Nutrient input, Enhanced 1º and 2º production**
Normal storm events (Frontal passage)	Weekly	**Enhanced production, Organism transport, Net material transport**
Tides (where applicable)	Daily	**Drainage/marsh production, Low net transport**

(John Day, 1997)

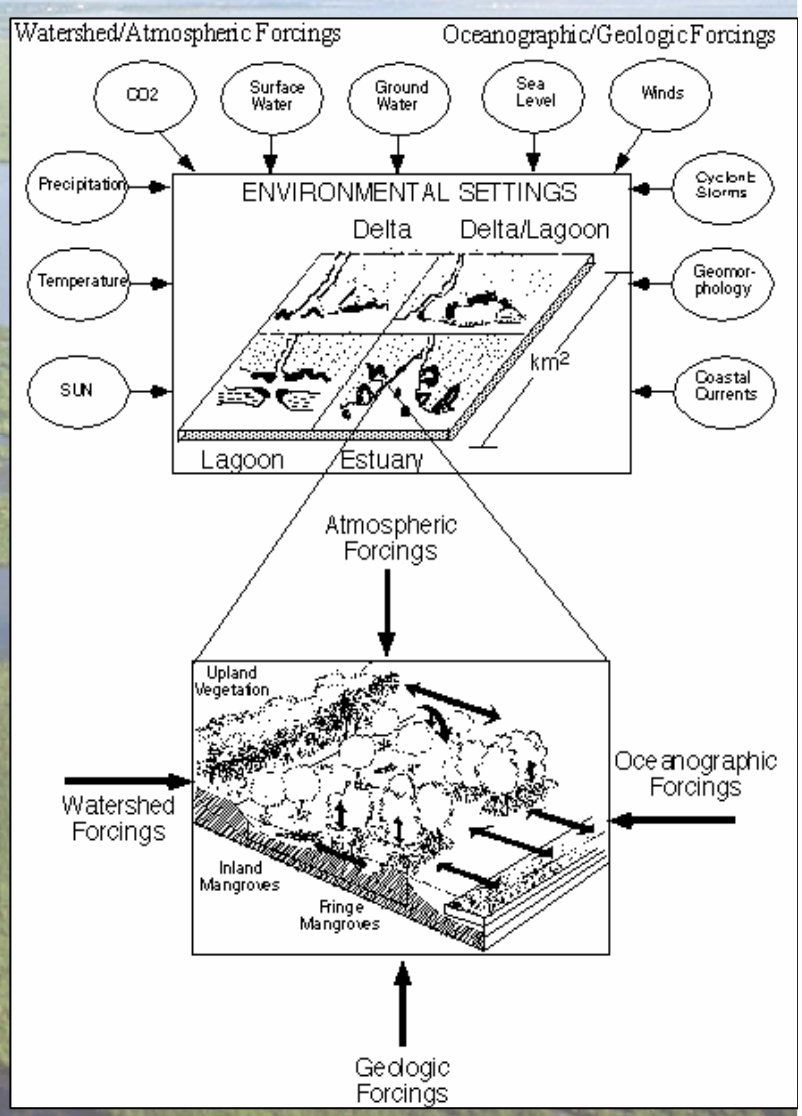
Define System & Subsystems

Watershed

Delta Plain

Delta Front

- Watershed: drainage basin and fluvial system above delta plain



Characterizing Subsystems
Delta Plain

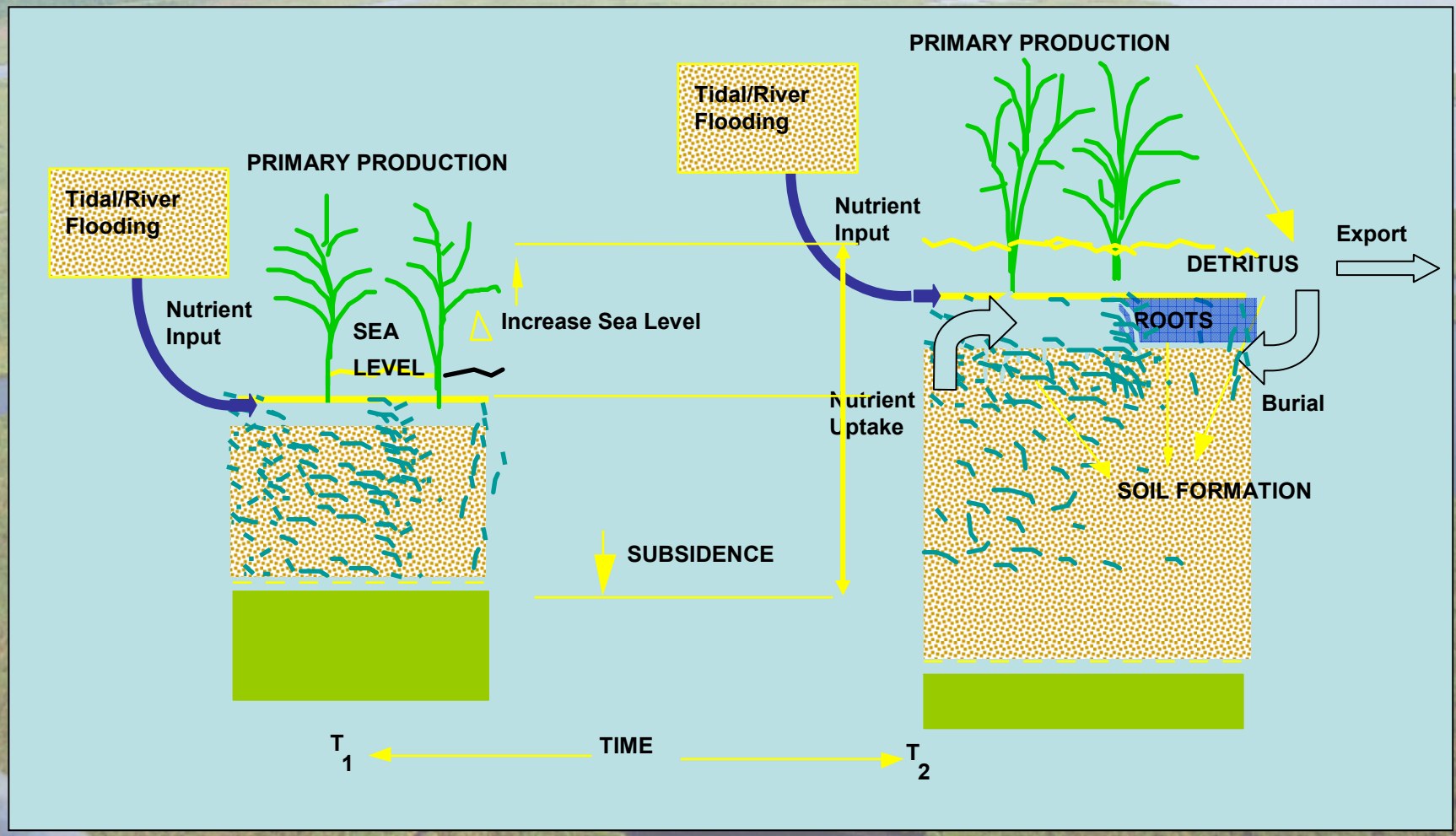
- Subsidence
  - most deltas have a significant rate of natural subsidence, though it may vary between systems
  - Monitoring subsidence (regionally and locally) is an important aspect of characterizing the delta plain
- Relationship between water levels (incl. tidal regime and datums), biological community (incl. vegetation) & soils

Characterizing Subsystems
Delta Plain

- Accretion deficit
- Relationship between surface-soil elevation, below-ground productivity, and riverine input
- Horizontal gradients across the delta plain need to be recognized
- Temporal variations (decades to centuries)
  - problems that occur on the temporal scale
  - background state

Characterizing Subsystems

Delta Plain



Characterizing Subsystems
Delta Front

- Defining seaward boundary/extent of front
- Processes that dominate the front area
  - Marine/coastal
    - **Wave climate**
    - **Currents**
    - **Tidal regime/range**
    - **Sediment transport**
  - Fluvial
  - Ice in glacial areas (wherever appropriate)
  - Aeolian
  - Mixing processes (FW & SW) & density currents

Characterizing Subsystems
Delta Front

- Sediment structure and characteristics
- Coastal erosion
- Shelf boundary, shape, characteristics
- Temporal variations (decades to centuries)
  - problems that occur on the temporal scale
  - Background state

Holistic Understanding of processes

- What are the important gaps in knowledge
- What are the limits of the deltaic pla to survive given projections of global climate change (rslr) and projected human impacts.
- How much sediment and water is needed (and what is the resilience of the system)? Big events are critical ..
- What spectrum of flood pulses do we need– and how often?
- How sensitive are deltas to low flows?
- Must define a conceptual framework – describes the causal process – as a cascading system – incorporates and builds upon existing models such as flood pulse and pulsing


MANAGEMENT CHALLENGES

Overall Focus

- Objective of management is to have a sustainable delta
- Sustainable management should be based on system functioning.
- Understand that deltas develop under sustainable sea levels & sustainable sediment regimes and develop as open systems that we should not try to (over)engineer and restrain
- Management of the delta means management of the entire river basin
- Restoration requires that we define the original condition or define an acceptable end state (restoring function or a critical portion of the function)

General Management of Natural Resources (an approach)

- Look at system as a whole, then look at subsets of the system and focus on each of those
- Identify the pressures that act upon the system and subsystems
  - Internal pressures
  - External pressures
- Resource uses:
  - How do you use this environment?
  - What can be sustainable
  - What will have an adverse effect on the system
  - How do you improve the resource for future use

Pressures and Management Challenges

External pressures

- Processes that act on large spatial and temporal scales
  - Climate change & energy scarcity
  - Watershed
    - Nutrient loading
    - Pesticides & pollutants
    - Fluvial discharge and pulsing
    - Sediment load and pulsing
  - Littoral sediments from beyond delta front
  - Unsustainable use of biological resources within watershed or in marine environment

Pressures and Management Challenges

Internal pressures

- Change in water and sediment regimes due to hydraulic changes within the delta
- Land reclamation / agricultural “improvements” (hydrologic effects, vegetation/habitat loss)
- Unsustainable human activities w/in the delta
  - Towns / villages
  - Agricultural activities, fishing, mining, etc.
  - Harbor activities
  - Pollution
- Sustainable human activities (what level is acceptable)

Management Challenges

Towards resilient systems: response to external pressures

- How capable is the system in terms of sustaining development or other anthropogenic changes
- How much non-natural activity can the system sustain without adverse effects
- How much of a change from the natural condition are we willing to allow

Management Challenges
Big Picture

- Finding a way to sustainability.
  - Geomorphic sustainability
  - Ecological (incl. diversity) sustainability
    - Unique role of deltas for biodiversity and productivity
    - Environmental flows
  - Socioeconomic sustainability.

Management Challenges
Big Picture

- Adaptive management.
  - Respect dynamic nature of deltas, avoid fixed solutions as much as possible, and continually evaluate success
- For a robust scientific program, you need data, models, etc. that will support management objectives (not just for the sake of science).
- Economic quantification of ecosystem services
  (limitations of standard economics in addressing environmental issues)

What should we do? (1)

1 Refine key concepts

- Flood and sediment pulsing (includes accretion deficit issues and internal hydraulics)
- Understand the importance of climate change, energy scarcity & ecosystem services

What should we do? (2)

2. Do not have adequate system descriptions in place for viable decision making processes

- Define and measure the data needed to understand and quantify water and sediment flux
- Understand the relative balance between biomass accretion and fluvial sediment input
- We must maintain deltaic wetlands so that they can deliver the ecosystem services that we increasingly need.

What should we do? (3)

3. Document and quantify Ecosystem Services (and how might these be affected by climate change and energy scarcity).

4. Define and estimate future scenarios – possible decisions and related effects. (How soon could collapse occur, and what can we do to prevent this?)

- Define and map a path to sustainability (includes sea-level rise)
- Develop proper full scale watershed
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(and why not)
Could the International Centre …

- …replicate the activities of the IPCC – but for deltas….to achieve integrated delta management .
- …thus promote a global Intergovernmental Panel on Delta Sustainability (**IPDS**)??