Motivation

- Deltas are landforms with channels that deliver water, sediment and nutrient fluxes from rivers to oceans or inland water bodies via multiple pathways.
- A formal quantitative framework for studying delta channel network connectivity and transport dynamics, and the response to change is lacking.
- The aim is to develop a framework within which a delta channel network can be studied for:
  1. Understanding its connectivity structure and flux transport.
  2. Understanding the response of the system to change: Vulnerability Assessment.

Vulnerability Assessment

Vulnerability is defined in terms of how changes in upstream parts of the system would affect the shoreline fluxes. Questions such as which links of the delta network, if altered, might affect most drastically the distribution of fluxes to the costal outlets, or where an intervention should be imposed to maintain a desired flux to a particular outlet node for land building purposes, are important components of delta management towards sustainability.

We characterize the flux reduction at outlet i with respect to the flux reduction at link (vu) by the local vulnerability:

\[ V_{uv}^i = \frac{p_{uv}^i}{C_{uv}^i} \]

where \( p_{uv}^i \) is the fraction of the steady flux in link (vu) that drains to outlet i and \( C_{uv}^i \) is related to the ratio of the steady flux at the outlet \( F_i \) and the steady flux at the link (vu) \( F_{uv} \).

Vulnerability maps

1. Wax Lake Delta

Each panel highlights the contributing network for a single outlet. Red, yellow, and blue links represent high \( V_{uv} > 0.75 \), medium \( 0.25 < V_{uv} \leq 0.75 \) and low \( V_{uv} \leq 0.25 \) values of the local vulnerability index. Shoreline outlets are shown in black.

Global Vulnerability

The global vulnerability of outlet i is defined as the average of the local vulnerabilities over all links in the subnetwork that drains to outlet i (edges of graph G):

\[ V_i = \frac{1}{|E_i|} \sum V_{uv}^i \]

Where \(|E_i|\) denotes the number of links in the subnetwork that drains to outlet i (contributing network for outlet i).

Spectral Graph theory

From the null space of the proper Laplacian matrix, we can compute:

1) Subnetworks from the apex to each outlet.

2) Contributing network from the apex to any node.

3) Nourishment network from any node to the shoreline.

4) Steady flux partition.

Steady state flux (a,c) and number of outlets (b,d) that a given link contributes to (a,b) Wax Lake delta and (c,d) Niger delta. The distribution of flux among the immediate downstream links is proportional to the channel width.

References:


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