Understanding sediment flux in the Mekong River: geomorphology, tropical cyclones, sediment mining and implications for delta stability

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“The sands of time were eroded by the river of constant change” (Genesis, 1973)
The need for sand

GLOBAL SCARCITY
Demand for sand and gravel for construction is rising faster than natural sources can sustain, so prices will soar.

Using crushed stone instead could help.

Bendixen et al., Nature 2019
TODAY:
• Situation so dire in some rivers that ecosystem recovery unlikely
• Discuss the Mekong River as a case example of the magnitude of the issues
Sediment input in the Lower Mekong River

Sediment Extraction Rates

(Bravard et al., 2013)

Study Sites & Suspended Sediment Transport Rates
Quantifying bedload transport on the contemporary Mekong

• Multibeam Echo Sounder surveys
  • Bathymetry at 0.5 m resolution, XY accuracy to ±0.02 m

• Following Nittrouer et al. (2008), bedforms are tracked between repeat surveys (<12 hours apart) to calculate bedload transport rates

• Acoustic Doppler Current Profilers (ADCPs) were deployed to capture in-situ 3D flow fields

• ADCP backscatter intensity used to estimate suspended sediment flux

From Nittrouer et al. (2008) JGR-ES
Quantifying bedload transport on the Mekong

Between 1981 and 2014 bedload
= \(0.18 \text{Mt yr}^{-1} \pm 0.072 \text{Mt yr}^{-1}\)

Combined with a suspended sand load of \(6 \text{Mt yr}^{-1} \pm 2 \text{Mt yr}^{-1}\), total sand flux to the Mekong delta
= \(6.18 \text{Mt yr}^{-1} \pm 2.07 \text{Mt yr}^{-1}\)

Take home: Lower flux now… upstream damming?
Extraction

Estimates of sand mining vary, but the accepted range is between 37 to 62 Mt a\(^{-1}\) (Bravard et al., 2013)

• A central estimate of 50 Mt a\(^{-1}\) has been used in subsequent analysis of sand extraction on the Mekong (Anthony et al., 2015; Schmitt et al., 2017)
• This equates to a 31 M\(\text{m}^3\) a year of sand
• Take home: Extraction now almost \textbf{7} times the natural supply of sand
Physical impact of anthropogenic activity

- Extraction is causing delta-wide incision rates of 0.017 m yr$^{-1}$ (range: 0.012 - 0.022)
- At the reach scale, this can be 0.5 m yr$^{-1}$, and up to 8 m yr$^{-1}$ of instantaneous incision
Impact on river banks

- Modelling results show that at 6 m bed lowering, the majority (63%) of river profiles become seasonally unstable.

- Vegetated banks remain relatively resistant to increasing rates of bank lowering - only 20% of vegetated banks become seasonally unstable with a 6 m lowering.

- The majority of unvegetated banks (57%) become seasonally unstable with a 3 m lowering.
Downstream impact on Mekong Delta

• Downstream sediment flux essential to maintain delta; rice production vital

• Sediment limitation due to sediment mining also exacerbated by: i) upstream damming; ii) changing tropical cyclone tracks that will lower water and sediment delivery to channel; iii) ongoing sea-level rise

• But how do we know what to plan for?
Time is running out for sand

Sand and gravel are being extracted faster than they can be replaced. Mette Bendixen and colleagues argue that global action is needed.
SANDGEM: an agenda for sand

Time is running out for sand

Sand and gravel are being extracted faster than they can be replaced. Bendixen and colleagues report on the resource globally, and on its role as a building material.

Bendixen, Best, Hackney & Iversen, Nature, 2019
SANDGEM: an agenda for sand

Time is running out for sand

Sand and gravel are being extracted faster than they can be replaced. Bendixen and colleagues explore the challenges of managing this resource globally and Metro-Bendixen find solutions.

Bendixen, Best, Hackney & Iversen, Nature, 2019

www.globalsand.org
SANDGEM: an agenda for sand

Time is running out for sand

Sand and gravel are being extracted faster than they can be replaced. Minimize and manage this resource globally with Meta-Sandgem with challenges.

Bendixen, Best, Hackney & Iversen, Nature, 2019

www.globalsand.org
SANDGEM: an agenda for sand

Time is running out for sand

Sand and gravel are being extracted faster than they can be replaced. This paper aims to introduce the novel reuse of sand resources to manage the global sand crisis.

Bendixen, Best, Hackney & Iversen, Nature, 2019

www.globalsand.org
SANDGEM: an agenda for sand

Time is running out for sand

Sand and gravel are being extracted faster than they can be replaced. Bendixen and colleagues call for action to manage this resource globally, with a new agenda for sand.

Bendixen, Best, Hackney & Iversen, Nature, 2019

www.globalsand.org
SANDGEM: an agenda for sand

Time is running out for sand

Sand is gravely being extracted faster than it can be replaced. Bendixen and colleagues urge for rethinking governance, sources, alternatives, design, and novel reuse.


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Time is running out for sand

Sand and gravel are being extracted faster than they can be replaced. Bendixen and colleagues explore how we might manage this resource globally, and Meta-Bendixen's role in achieving that.
SANDGEM: an agenda for sand

Time is running out for sand

Sand and gravel are being extracted faster than they can be replaced. Monitor and manage this resource globally and locally.

Bendixen, Best, Hackney & Iversen, Nature, 2019

www.globalsand.org
The time to act may be too late in some rivers, the time to act for the rest is now.

"The sands of time were eroded by the river of constant change"