Disturbed Sediment Continuum of the Mekong: Its impacts and Proposed Mitigation Measures

G Mathias Kondolf[1,2]

[1]University of California, Berkeley USA
[2]Collegium – Institute for Advanced Studies, Lyon FR

Phone: +33-(6)-14382907
E-mail: kondolf@berkeley.edu

Introduction: The Mekong River's natural sediment load of 160 MT/y [1] was sufficient to drive progradation of the delta over 250km from what is now Phnom Penh over the past 7 ka. However, the fluvial sediment supplied to the delta is being reduced by sand mining, dam construction, and changes in monsoon patterns driving sediment transport. Recent studies report lower sediment yields, such as 87 MT/y [2], reflecting new measurement/calculation techniques and reductions in sediment transport already evident in the river. Reversing its 7-ka Holocene trend, the Mekong Delta is now retreating, attributable in large part to reduced sediment supply due to upstream sand mining [3]. Sediment loads will be reduced further as new dams trap sediment and the effects of these reductions in sediment supply propagate downstream.

Methods: Using predictions of cumulative sediment trapping by planned dams in the river basin [4], we created a simplified sediment budget for the lower Mekong River and Delta based on historical sediment loads, estimates of sand mining [5], and projected future sediment supply from upstream after trapping by planned dams. We assessed the sustainability of the delta in light of the combined effects of reduced sediment supply to the delta, accelerated subsidence from groundwater pumping, accelerated sea level rise, and the inability of sediment-laden waters to spread out over the delta plain, due to dikes and other water control infrastructure in the delta [6].

Results & Discussion: Surveys of active mines indicated extraction of at least 54 MT/y of sand from the Mekong [3], 1/3 to over half of the total load. If we assume that sand constitutes no more than 10% of the load, that would imply that mining removes about 5-10 times the annual sand load. immediately, this cuts off the supply of sand to the delta. Over the long term, if the proposed hydroelectric dams are built as planned, they will trap 96% of the natural sediment load of the Mekong before it reaches the Delta. The implications are sobering: without big changes in management, the delta landform itself will likely be half submerged by 2100, and the highly productive ecosystem and fishery may collapse due to loss of the nutrient load that maintained them [6].

For dams now in the planning stage, modifications to locations, designs, and operations have the potential to improve the flows of sediment, nutrients, and fish through and around dams. Dams can be strategically sited to minimize disruption to the sediment budget, yielding dam portfolios with lower environmental impacts than the current ad-hoc approach to building dams, without strategic oversight [7].

Reservoir operational techniques such as drawdown flushing, sluicing, and sediment bypassing could improve sediment passage through Mekong dams [8]. Large dams are generally unsuitable for reservoir sediment management methods like flushing and sluicing, but in many cases, a series of smaller dams could substitute for a larger dam and route sediment more easily. If more fundamental modifications are not possible, simply including bottom and mid-level outlets in new dam designs would create flexibility for future reservoir re-operation for sediment passage, which can help mitigate downstream geomorphic impacts of dams and increase the operational lifespan of these projects.

Although the technologies for passing sediment through and around dams work well in certain contexts, they are rarely implemented where they could be, and thus opportunities are lost to extend reservoir life and reduce downstream impacts [9]. Coordinated reservoir operations would require multi-national cooperation, and cooperation of many individual private developers in different countries, who may not find sustainable sediment management practices to be in their short-term interest.

References: [1] Walling (2008) *Ambio* **37:**150–157; [2] Darby et al (2016) *Nature* **536**:276-279; [3] Anthony et al. (2015) *Sci. Rep.* **5**:14745; [4] Kondolf et al. *Water Resour. Res*. **50**:5158–5169; [5] Bravard et al. (2013) *EchoGéo*: 13659; [6] Kondolf et al. (2018) *Science of Total Env*. **625**:114-134; [7] Schmitt et al. (2018) *Nature Sustainability* **1**:96–104; Wild & Loucks (2014) *Water Resour. Res.* **50**:5141–5157; Annandale et al. (2016) *Extending the Life of Reservoirs,* The World Bank Group, Washington DC.