Working togther toward sustainable sand mining and management.

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IKI INTERNATIONAL CLIMATE INITIATIVE

SUMMARY REPORT
Sand Budget for Viet Nam Mekong Delta

August 2023

Deltas worldwide are under significant climatic stress and any response must address the local drivers of change. A holistic and systemic understanding of both the challenges and opportunities of these vulnerable yet productive, populous and ever-

urbanising ecosystems is fundamental to informing policy makers possible climate adaptation interventions and how to integrate them into wider socio-economic development considerations.

The Viet Nam Mekong Delta (VMD), one of the world's most rapidly transforming and lowest-lying deltas relative to mean sea level, is under stress from various climatic and anthropogenic drivers and, consequently, facing an existential threat over the coming three decades if no large-scale transformative action is undertaken. Land subsidence, reduction of fluvial sediment from upstream, riverbed, riverbank, and coastal erosion, tidalamplification, salt intrusion, urban (predominantly) flooding and biodiversity loss, all threaten Viet Nam's food security and sustainable development of the delta. Recent scientific findings demonstrate that riverbed-, riverbank- and coastal erosion, tidal amplification and salt intrusion are mainly driven by anthropogenic sediment starvation of the delta (Bravard et al., 2013; Brunier et al., 2014; Anthony et al., 2015; Eslami et al., 2019b). For example, Eslami et al., 2019b, 2021a, b,&2022b showed that salt intrusion in the VMD has only been marginally influenced by climate change, but mostly driven by riverbed erosion due to sediment starvation, which can be classified under two categories: A) fine sediment shortage due to hydropower developments in the upper Mekong Basin, and

B) coarse sediment (sand, gravel) declined due to sand mining within the VMD and in Cambodia, Laos and Thailand.

In the context of global climate change and the increasing relative threats of relative sea level rise (Eslami et al., 2021a; Minderhoud et al., 2020), considering the role of sand in preserving the morphological integrity and resilience of both the emerged and subaqueous delta (riverbed and near coast continental shelf being integral components of the morphologically active parts of the delta) becomes an existential priority to protect people, biodiversity and other assets supporting the economy.

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Sediment starvation

is the main driver

threatening the resilience

of the Mekong Delta

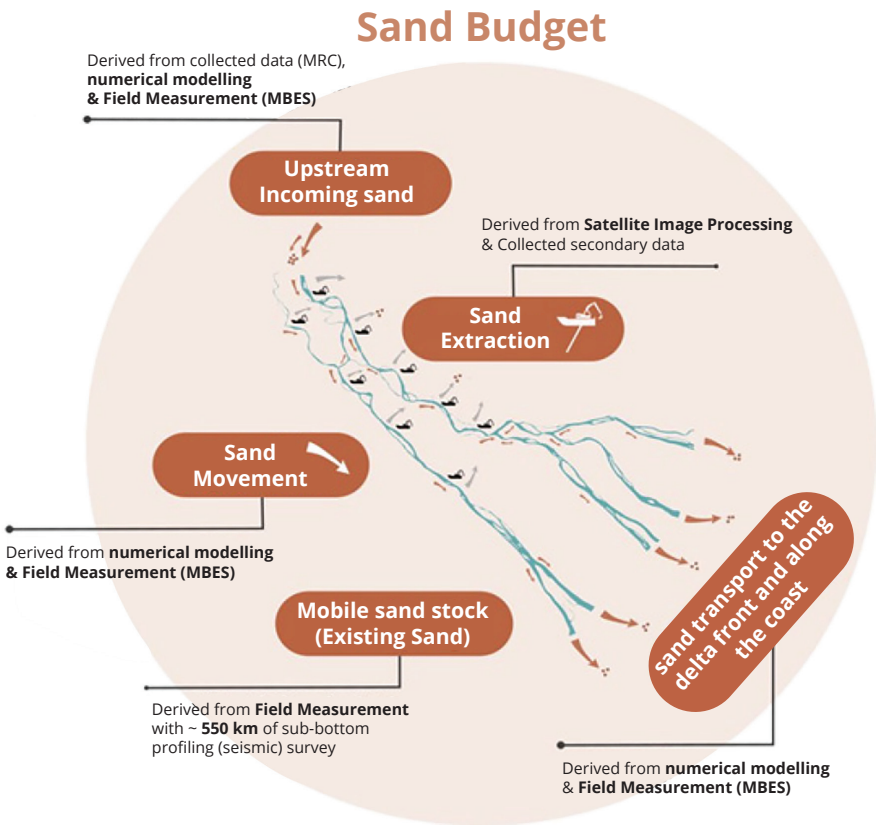

Figure 1. An overview of contributions from different activities leading to the VMD sand budget

While climate change threatens the VMD, anthropogenic drivers, largely reflected in sediment starvation and hydrological regime shifts, seem to outpace climate change in the first half of the 21st century. Factoring existing and planned hydropower plants on both the Mekong mainstream and its tributaries, the aggregate sediment trapping of the reservoirs are predicted to reduce sediment supply by 36% (moderate) to 95% (worst case) (Manh et al., 2015), and a recent study measured 75% reduction in suspended sediment supply to the VMD (Thi Ha et al., 2018). Based on a range of studies in the past decade (Brunier et al., 2014; Bravard et al., 2013; Jordan et al., 2019; Eslami et al., 2019, the sand budget study, 2023), total sand extraction in the delta is in the range of 35-55 Mm^3/yr, which exceeds the total of the pristine fluvial sediment supply to the delta, making the delta significantly short of sediment with a negative budget.

35-55

Mm^3 of sand

extracted per year

exceeds

total sediment supply to the delta

Sand Budget for Viet Nam Mekong Delta

The VMD-wide sand budget was developed by the "Drifting Sands: Mitigating the impacts of climate change in the Mekong Delta through public and private sector engagement in the sand industry" project, which is implemented by WWF in partnership with Viet Nam's Ministry of Agriculture and Rural Development and other national and provincial stakeholders, carried out by Deltares JV, with financial support from the German government.

The project aims to provide decision makers with an accurate account of the exploitable mobile sand stocks, replenishment, and extraction rates, and the volume of sand discharged to the sea. The study's approach combined available and new data, state-of-the art numerical modelling, and national and provincial VMD stakeholder consultations. The analyses included an estimation of the volumes of sand entering the VMD from Cambodia, an updated estimate of sand extraction within the delta, the distribution and movement of sand within the major channels of the estuarine system and an estimation of the exploitable sand reserves in the delta in the year of 2022, with a vision to 2030, 2040. The results from this project can serve as the basis for developing a mitigation plan that addresses the VMD's vulnerability to climate change and anthropogenic influence. To derive a robust sand budget, four factors needed to be determined;

1) the inflow sand to the head of the Viet Nam Mekong Delta, 2) sand transport to the delta front and along the coast, 3) extracted sand in main channels of Tien and Hau river within delta and 4) the existing mobile sand stock under riverbed of the VMD.

The study measured sand volumes entering the delta in the order of 2-4 Mm^3/yr and negligible volumes transported to the delta front and along the coast (0-0.6 Mm^3/yr). The estimation of existing mobile sand stock (mostly mobile sand) amounts to~367-550 Mm^3 within the channels of the VN delta, while the sand extraction rate is in the order of 35-55 Mm^3 per year. **Based on those figures, given the limited supply from upstream, and if the current extraction rates remain unchanged, we expect that the existing mobile sand stock under the riverbed, which is critical to the delta's resilience, can only last as far as a decade.** It is now clear that the resources are extremely limited and, according to a number of scientific publications, the impact of exploiting those last reserves on the resilience of the people, biodiversity and economy of the VMD could be significant enough that socio-economic plans, including major infrastructures, would need to be re-assessed. Extraction management and decisions must be based on a sand budget, not the exploitable mobile sand stock. Any further loss of mobile sand stock is a loss of the delta's resilience.

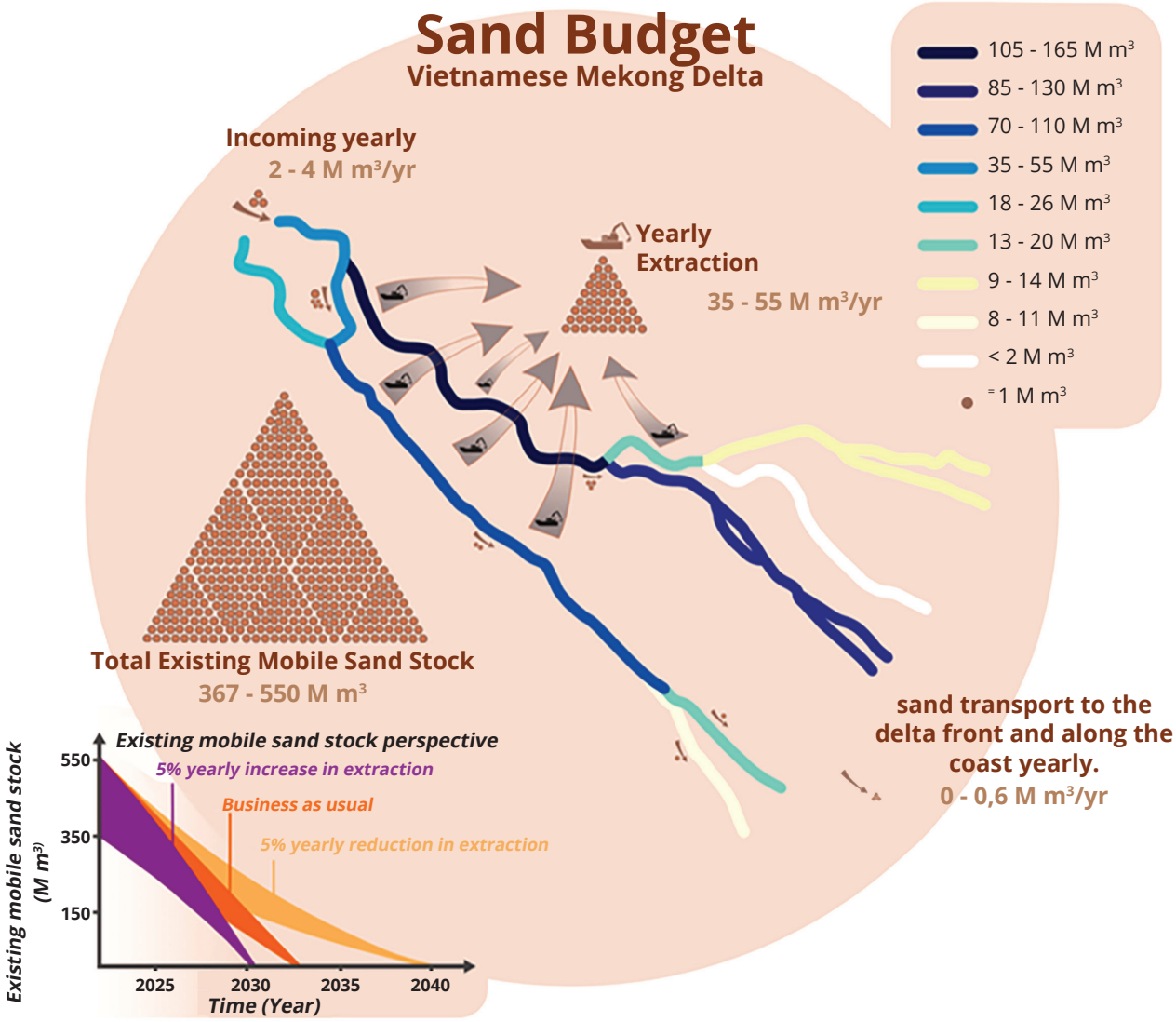

Figure 2. Sand budget of the Mekong Delta with a perspective of sand availability towards mid-century.

Climate Resilience and Environmental Implications

The reduction of the mobile sand stock of deltas has various and fundamental hydrological, hydrodynamic, morphological and ecological impacts on both the fluvial and coastal systems. Other deltas around the world have either experienced similar trends in the past century or have limited the practices to mitigate the grave environmental impacts.

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Noting that in the case of the VMD, those changes were concentrated in a shorter period, i.e. in the past two to three decades, when the impacts in many other deltas, if they happened earlier, were prolonged over five to ten decades or more. For example, the Netherlands, along with other upstream countries of the Rhine-Meuse Delta, banned river sand mining in the early 20th century when it realised sand stock were no longer naturally replenished by the rivers that had built the delta. Most Western countries (France, UK, US) and China have banned in-channel sand mining from rivers and coasts and now source sand from quarries. They also recognize that if they had understood and assessed the impacts of sand mining on the resilience of their delta, they would have taken actions earlier, as some of the impacts were irreversible and required hard infrastructure to mitigate them, and this infrastructure was expensive to build and maintain.

Delaying action within the VMD will likely lead to further riverbank instability (riverbank collapse) as well as coastal erosion, and this will also further exacerbate water risks, including exposure to floods and typhoons and freshwater supply. Based on the projections of salinity in the delta (Eslami et al., 2021), a loss of half a billion m3 of sediment from the VMD tidal riverbed system can lead to an additional 10-15% increase in areas affected by salt intrusion within the VMD. The observed rapid riverbed degradation rates of 10-20 cm yr-1 (Eslami et al., 2019; Vasilopoulos et al., 2021) over the past two decades drives tidal amplification (2 cm/yr) and saline water intrusion (0.2-0.5 PSU/yr) with further implications for city flooding and riverbank erosion.

Trans-provincial and transboundary nature of sediment resources

The mobile sand stock in river and coastal systems is dynamic, it moves with river flows, and is reshaped by sea surges and storms. The impacts of sand mining are felt in downstream channels and along the coast, sometimes very far from the place where sand is extracted. Thus, the management of sand resources in the VMD are by nature transboundary: actions in countries upstream in the basin affect the VMD. They are also trans-provincial: actions in one province of the delta can have consequences on the available stocks of mobile sand, the exposure to climate and water risks, economic development, livelihoods and the biodiversity of other provinces.

Therefore, a VMD-wide 'sand budget approach' that monitors and takes into consideration all inputs and outputs of sand at the scale of the entire VMD to make up a comprehensive budget is necessary to advise sustainable management of sand resources and the socio-economic and environmental impact on the delta and its people. But, in order to address the whole dimension of the system, it needs to be complemented by a basin-wide sand budget, to equip the Mekong riparian countries with understanding and a monitoring tool to make joint decisions regarding the management of this valuable shared resource. Such a Mekong basin-wide sand budget could be hosted by the Mekong River Commission Secretariat, whose mandate is to manage river related resources shared by its four member countries and the upstream Greater Mekong countries.

RECOMMENDATIONS

1. It is necessary to develop a comprehensive sand resource management plan based on scientific research, taking in account socio-economic aspects and public benefit.

2. In addition, a Sand Budget for the whole delta has great potential to help manage river sand more sustainably, especially during the gradual transition from total dependence on river sand to other sustainable alternative materials in Viet Nam. Specifically, (i) sand mining licensing and management plans should consider both existing riverbed reserves and upstream sand inflows, and (ii) river sand management should be coordinated by a regional body instead of being administered by individual provinces/City along administrative boundaries.

3. Research shows river sand is scarce and completely dependent on the inputs from upstream Mekong River basin, but plays a very critical role in maintaining the stability and resilience of the Mekong Delta, therefore, it is crucial to recognise river sand as an important resource, not a common construction material, in relevant legal and policy documents.

4. The Government and Ministries should take in account sand scarcity as well as the consequences of the depletion of the existing sand reserves under riverbed, in order to support localities and businesses that can implement initiatives to mitigate river sand extraction, such as (i) supporting research, development and the use of sustainable alternative sources, especially for public investment infrastructure (e.g., m-sand) (ii) promote resource-efficient and sustainable designed construction, e.g. building highway with pile foundation will reduce the negative impacts on water and sediment exchange from river to floodplain, reduce a large amount of road levelling materials, avoid Delta fragmentation, and separation of the existing residential communities.

5. Viet Nam National Mekong Committee needs to collaborate with MRC and riparian countries to develop a basin-wide Sand Budget to ensure the sustainable management of this regional shared valuable resource.

REFERENCES

Anthony, E. J., Brunier, G., Besset, M., Goichot, M., Dussouillez, P., and Nguyen, V. L.: Linking rapid erosion of the Mekong River delta to human activities, Sci. Rep., 5, https://doi.org/10.1038/srep14745, 2015.

Bravard, J.-P., Goichot, M., and Gaillot, S.: Geography of Sand and Gravel Mining in the Lower Mekong River, 26, https:// doi.org/10.4000/echogeo.13659, 2013.

Brunier, G., Anthony, E. J., Goichot, M., Provansal, M., and Dussouillez, P.: Recent morphological changes in the Mekong and Bassac river channels , Mekong delta : The marked impact of river-bed mining and implications for delta destabilisation, 224, 177–191, https://doi.org/10.1016/j.geomorph.2014.07.009, 2014.

Eslami, S.: Environmental change in a mega-delta, dynamics of salt intrusion in the Vietnamese Mekong Delta, Utrecht University, https://doi.org/10.33540/1367, 2022.

Eslami, S., Hoekstra, P., Nguyen Trung, N., Ahmed Kantoush, S., Van Binh, D., Duc Dung, D., Tran Quang, T., and van der Vegt, M.: Tidal amplification and salt intrusion in the Mekong Delta driven by anthropogenic sediment starvation, Sci. Rep., 9, 18746, https://doi.org/10.1038/s41598-019-55018-9, 2019.

Eslami, S., Hoekstra, P., Kernkamp, H. W. J., Nguyen Trung, N., Do Duc, D., Nguyen Nghia, H., Tran Quang, T., van Dam, A., Darby, S. E., Parsons, D. R., Vasilopoulos, G., Braat, L., and van der Vegt, M.: Dynamics of salt intrusion in the Mekong Delta: results of field observations and integrated coastal--inland modelling, Earth Surf. Dyn., 9, 953–976, https://doi.org/10.5194/ esurf-9-953-2021, 2021a.

Eslami, S., Hoekstra, P., Minderhoud, P. S. J. ., Trung, N. N., Hoch, J. M. ., H.Sutanudjaja, E., Dung, D. D., TranQuang, T., Voepel, H. E. ., Woillez, M.-N., and Vegt, M. van der; Projections of salt intrusion in a mega-delta under climatic and anthropogenic stressors, Nat. Commun. Earth Environ. (accepted Publ., https://doi.org/10.1038/ s43247-021-00208-5, 2021b. Jordan, C., Tiede, J., Lojek, O., Visscher, J., Apel, H., Nguyen, H. Q., Quang, C. N. X., and Schlurmann, T.: Sand mining in the Mekong Delta revisited - current scales of local sediment deficits, Sci. Rep., 9, 17823, https://doi.org/10.1038/s41598- 019-53804-z, 2019.

Milliman, J. D. and Farnsworth, K. L.: River Discharge to the Coastal Ocean: A Global Synthesis, 384 pp., https:// doi. org/10.5670/oceanog.2011.108, 2011.

Milliman, J. D. and Fransworth, K. L.: River Discharge to the Coastal Ocean: A Global Synthesis, Cambridge University Press, Cambridge, 392 pp., 2011.

Vasilopoulos, G., Quan, Q. L., Parsons, D. R., Darby, S. E., Tri, V. P. D., Hung, N. N., Haigh, I. D., Voepel, H. E., Nicholas, A. P., and Aalto, R.: Establishing sustainable sediment budgets is critical for climate-resilient mega-deltas, Environ. Res. Lett., 16, 064089, https://doi.org/10.1088/1748-9326/ac06fc, 2021a.

Vasilopoulos, G., Quan, Q. L., Parsons, D. R., Darby, S. E., Tri, V. P. D., Hung, N. N., Haigh, I. D., Voepel, H. E., Nicholas, A. P., and Aalto, R.: Establishing sustainable sediment budgets is critical for climate-resilient mega-deltas, Environ. Res. Lett., 16, 64089, https://doi.org/10.1088/1748-9326/ac06fc, 2021b.

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WORKING TOGETHER TOWARDS SUSTAINABLE SAND MINING AND MANAGEMENT

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