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A Tale of Two Deltas: Comparative Study on the Effects of Dam Regulation on Deltaic Hydrological Regime and Morphological Evolution

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Deltas are among the most populous areas and most productive ecosystems on Earth. Despite their critical importance for human society and coastal ecosystems, many of the world's deltas are drowning due to substantial decrease in sediment supply, sea level rise, etc. Previous studies have demonstrated the effects of dam regulation on the hydrological regime and morphological evolution of river deltas. However, past attention was mostly paid to individual deltas or deltas at a global scale, while comparative studies on selected deltas are scarce in the literature. In this study, a comparative study on two wave-influenced deltas, namely, the Volta River Delta in Ghana and the Yellow River Delta in China, was conducted. The trend of change of the annual river discharge and sediment load of the two deltas before and after the construction of the major dams were analyzed, and the resultant effects on deltaic morphological evolution were also examined and compared between the two deltas. The results show that the average annual river discharge and sediment load and their inter-annual variation decreased significantly after the construction of major upstream dams for both deltas. However, presumably due to the differences in reservoir capacity and upstream location of the dams, the sediment load of the Volta River Delta decreased abruptly to <10% of the sediment load in the pre-dam period after the construction of the Akosombo Dam in 1964 and became stable afterwards, whereas the sediment load of the Yellow River Delta decreased substantially to ~10% of pre-dam level but in a more gradual stepwise manner since the 1950s. As a result, after the intense shoreline retreat in the 1960s, the delta area of the Volta River Delta appeared to adjust to the reduced yet stable sediment load and shift to a new quasi-equilibrium with minimal change (maximum 0.53%). On the contrary, the Yellow River Delta still kept prograding at the river mouth given the current sediment load. However, it is foreseeable that if the trend of sediment reduction persists, it may potentially turn net delta progradation to erosion and further into a new quasi-equilibrium like the Volta River Delta. Our study provides a new perspective for understanding the future evolution of the Yellow River Delta as well as other deltas around the world that share similar characteristics and forcing factors.