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# Interactions between hydrological changes and geomorphological responses in the Yellow River basin from the perspective of basin system integrity

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Water and sediment are the main transport materials transported by rivers to the ocean, playing a crucial role in the evolution of river-delta-estuary-coast topography. Strong anthropogenic activities and climate change have led to distinct hydrological changes and geomorphological responses in river systems worldwide. However, previous studies usually considered the changes of streamflow and sediment load and the evolution of river channel and delta separately, and the understanding of the interactions between hydrological changes and geomorphological responses from the perspective of basin system integrity remains limited. In this study, using the Mann-Kendall trend test, normalized anomalies analyses and sediment budget analyses, the basin-wide streamflow and sediment load changes stretching from the headwater to the delta in the Yellow River basin (YRB) during 1956-2019 were examined, and the coupling relationships of water-sediment variations with channel erosion and delta evolution across the basin were explored. The results indicate that the streamflow and sediment load in the YRB decreased significantly over the past six decades except the headwater, and the decrease rate increased along the downstream continuum with the whole basin. However, the streamflow increased significantly and the sediment load tended to be gradually stabilizing since 2000. The reduction of sediment load mainly occurred in the middle-lower river downstream. The sediment yield coefficient in the middle reach decreased linearly with the reservoir capacity and exponentially with the vegetation coverage and number of check dams ($p < 0.01$), and the sediment reduction rate increased exponentially with the increase of terraces proportion, and gradually approached the limit value of 96.20% ($p < 0.01$). The ratio of sediment load at the outlet of the upper reach over that exporting from the middle reach was stable before 2000, but it increased and fluctuated sharply after 2000 as a result of ecological restoration campaign in the middle reach. The sediment load at the outlet of the middle basin was about 1.99 times of that transporting to the ocean before 2002, but their ratio decreased to be 0.69 after 2002 due to the operation of water-sediment regulation project. The construction of reservoirs gradually reduced the erosion in the headwater to near zero, and the river sediment deposition in the middle reach increased linearly with the reservoir capacity, whereas the sediment deposition in the lower reach depended on the sediment concentration exporting from the middle reach. The decreasing sediment supply also resulted in the gradual erosion of delta land since 2000 with combination of tidal waves. This study provides a synthesis of the relationships among water, sediment, channel and delta from the entire river system in the

YRB, and it can shed light on integrated basin management adapting to anthropogenic activities and climate change.