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Editorial: The impact of Three Gorges Dam on downstream river-lake system

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Editorial on the Research Topic
The Impact of Three Gorges Dam on Downstream River-Lake System

The Changjiang (Yangtze River) in southern China is third largest river in the world based on discharge. Changjiang headwaters are in the rugged Tibetan highlands in western China and flows eastward for 6,300 km before reaching the sea near Shanghai. The river is generally divided into upper and lower sections based on physiography. In the upper basin in western China the Changjiang and tributaries are deeply incised, mountain bedrock streams. Downstream of the Three Gorges the Changjiang is bounded by broad alluvial valleys with a complex river-lake system that support intensive cultivation. Three Gorges has been considered for a dam site on the Changjiang since the 1930s. Dam construction was approved by the Chinese National People's Congress during 1992. It became fully operational in 2008. The position of leading advocates for the dam focused on hydroelectric power generation, downstream flood control and river navigation. But potential environmental and ecological problems also attracted widespread attention.

Dam operation has altered discharge characteristics and channel sediment load downstream. However, how and to what extent the Three Gorges Dam (TGD) has, and will in the future, affect the physical environment and ecology conditions on the mainstream and adjoining lakes is only now beginning to emerge. We now have 14 years of data since the dam became fully operational and are better able to evaluate the downstream impact. The work presented by experts in this Research Topic of papers gives us a clearer understanding of downstream hydro-geomorphic and ecological changes based on recent data as opposed to model projections and speculation in earlier studies. These studies also provide new insights on hydro-geomorphic changes and how a complex river-lake ecosystem responds to the discharge and sediment modifications caused by the dam.

The Changjiang below the Three Gorges is a highly complex alluvial river system. This is a tectonically active region with areas of uplift and subsidence. Different river segments have either meandering, anabranching, or intermediate channel patterns. Historically, some river

segments had active lateral movement whereas others were relatively stable. The paper by Wang et al. describes how low sediment supply following dam operations affect channel patterns and morphology in meandering reaches of the Changjiang. Their results show that a lower sediment load causes erosion of point bars and concave banks, and formation and development of concave bars, with all affecting meander curvature and channel migration.

Severe floods occurred regularly on the Changjiang affecting millions of people who live in the low-lying alluvial river valleys. One of the major justifications for the TGD was flood control. However, the 2020 flood, that historically ranks among the most severe, occurred when the TGD was operational. Shankman and Lai concluded that the TGD can reduce potential peak discharge but cannot prevent severe floods. This is attributed to both high tributary discharge that is independent of the dam and loss of floodwater storage.

Poyang and Dongting Lakes interacting with the Changjiang are the largest freshwater lakes in China. In recent decades changes in both Changjiang channel morphology and loss of floodwater storge in these lake basins has changed river-lake hydro-interaction. Zhang et al. describe how operation of the TGD has affected water exchange between the Changjiang and Poyang Lake. During unusually dry years river-lake water exchange is low compared to pre-dam conditions, but higher during average and wet years. A second paper focusing on Poyang Lake by Bing Li et al. is complementary to the previous work and describes how lower Changjiang discharge in recent years influence lake stage. Most significantly, it shows that Poyang Lake average water level has decreased during summer and fall months.

Two papers in this Research Topic discuss Changjiang—Dongting Lake interaction. Ge et al. describe how impoundment of the Three Gorges Reservoir during fall lowered Changjiang and Dongting Lake stage. The decrease in water level is most notable near the mouth of the outlet channels and less pronounced with increasing distance from the Changjiang. The work by Yang et al. also working in the Dongting Lake region describe a decrease in sediment volume in outflow channels of the lake and the Changjiang. They describe how lower channel stage during the dry season causes river navigation problems.

TGD affects downstream flow characteristics that directly impact the physical environment and ecological conditions along the main channel and tributaries. The work by Mingzheng Li et al. showed that the fishery yield of Poyang Lake decreased during the past few decades and to a greater extent during recent years. The decline is attributed to water level fluctuations and lower average lake stage during fall. Fang et al. describe decreasing available water supply as a result of the TGD and potential irrigation and water supply problems in the Dongting Lake area.

The papers in this special edition cover a wide range of topics and together significantly advance our understanding of how the TGD affects the downstream physical environment. Clearly, the dam has a direct impact on the flow regime downstream and available water supply, and breaks the dynamic balance of channel flow and morphology. The dam reduces potential peak discharge during floods. It has, however, a limited impact during severe floods because of high discharge of downstream tributaries. Environmental and ecological consequences of the TGD are highly complex, and long-term study of the river-lake system to better understand dam's impact is still needed.

Author contributions

All authors listed have made a substantial, direct, and intellectual contribution to the work and approved it for publication.

Conflict of interest

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