Functioning adjustment of a braided river to different human activities in the Qinghai-Tibet Plateau

Ajustement fonctionnel d'un fleuve tressé aux différentes activités humaines dans le plateau du Qinghai-Tibet

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RÉSUMÉ

Cette étude vise à explorer les mécanismes de réponse du fonctionnement des rivières en tresses aux perturbations humaines complexes en portant l'exemple d'une rivière en tresses située sur le plateau Qinghai-Tibet. Ce travail est basé sur : (1) l'analyse temporelle des changements morphologiques et du fonctionnement de cette rivière au cours des quatre dernières décennies sur la base de l'analyse des archives Landsat et d'images récentes Sentinel-2 traitées à l'aide de Google Earth Engine, ainsi que d'autres images haute résolution ; (2) l'analyse des modalités de fonctionnement de la rivière Lhasa en réponse à la dynamique hydrologique et aux changements des activités anthropiques. Pour ce faire, Le réseau des chenaux en tresses est distingué en (i) chenaux coulants, qui désignent des bras connectés en permanence et (ii) des chenaux non coulants, qui sont partiellement connectés au réseau coulant durant certaines périodes et les bras isolés. L'analyse de deux métriques morphologiques, la largeur de la bande active et l'intensité du tressage, au cours des quatre dernières décennies permettra de révéler non seulement les tendances temporelles de l'interaction entre les eaux souterraines et les eaux de surface, mais aussi les effets humains sur le régime d'écoulement et le fonctionnement de cette rivière. Sur la base de ces résultats, nous expliquerons pourquoi le fonctionnement de la rivière Lhasa semble encore résilient aux perturbations d'origine anthropique.

ABSTRACT

This study aims to explore mechanisms of river functioning response to intensive and complex human disturbances in a braided river located on the Qinghai-Tibet Plateau by focusing on (1) revealing temporal trends of river functioning characteristics in the past four decades based on analysis of a large amount of Landsat and recent Sentinel-2 images processed using Google Earth Engine, as well as other high-resolution images; and (2) linking the discovered river functioning patterns to hydrological dynamics and temporally variable intensities of human activities. The braided channels are distinguished as (i) flowing channels that denote river branches having constant flow all year round and (ii) non-flowing channels, representing those that have discontinuous water flows or isolated water bodies. Exploring two morphological metrics, active channel width and braiding intensity, over the past four decades will allow for revealing not only temporal trends of the interaction between groundwater and surface water, but also human effects on the flow regime and river functioning. Based on these results, we will explain why the Lhasa River functioning is still resilient to human disturbances.

KEYWORDS

River functioning, Active channel width, Braided river, Braiding intensity, Human disturbance

FUNCTIONING ADJUSTMENT OF A BRAIDED RIVER TO DIFFERENT HUMAN ACTIVITIES IN THE QINGHAI-TIBET PLATEAU

1 Study area and challenges

The middle and lower reach of the Lhasa River, which is the largest tributary of the Yarlung Tsangpo River in the southern Qinghai-Tibet Plateau, is characterized by a typical braided river developed in the valley with elevations above 3500m. It has been heavily impacted by different types of anthropogenic activities, including cascade dams in the upstream reach, land use/cover changes along the reach, urban sprawling, sediment mining, and channel diversion (You et al., 2021). The goal of this study is to explore the response of river functioning to different types of human activities for understanding why this river has been apparently resilient to continuous and intensive human disturbance.

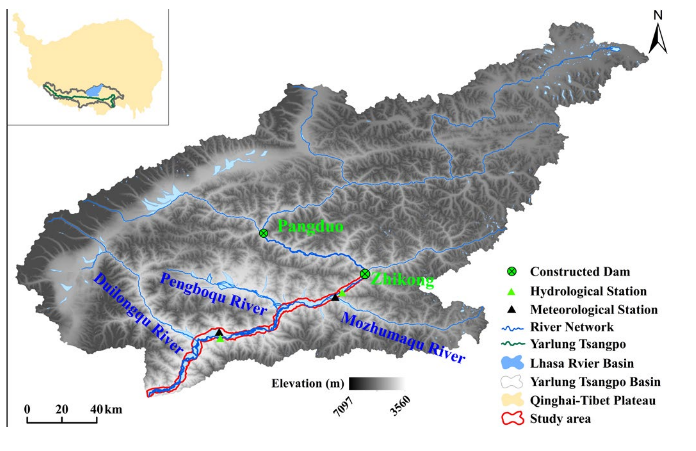

Fig. 1 Location of the Lhasa River

2 Methods and expected results

The studied reach is divided into four sub-reaches based on dominant human pressure. A big challenge for studying rivers in such remote regions is lack of data for use to achieve the proposed research goal and then propose appropriate management actions. In this study, we process 40 years of Landsat images and 3 years of Sentinel-2 images on Google Earth Engine, as well as a number of high-resolution images from Chinese satellites (Gaofen) and in situ Unmanned Aerial Vehicle survey. Using these data, we calculate two fundamental morphological metrics that characterize the braided pattern, i.e., the active channel width and the braiding intensity (Piégay et al., 2009; Belletti et al., 2013). We also compute the normalized difference water index (NDWI) to extract water areas and estimate water discharges in years only limited measured data are available. To obtain the braiding intensity, we characterize the braided channel structure of the four sub-reaches by distinguishing between flowing and non-flowing channels, the former denoting river branches that have continuous flows all year round, while the latter representing those that have discontinuous water flows or isolated water bodies.

By examining the temporal trends of the active channel width and the braiding intensity for flowing channels and their correlation with the estimated peak discharges, we reveal the key morphological processes (e.g., avulsion and/or asymmetric bifurcation; channel widening/narrowing) that drive the temporal changes of the braided pattern. Quantitative investigation for non-flowing channels exposes patterns of groundwater upwelling and downwelling during different time periods along the studied reach. Then, we quantify temporal changes of each type of human activities at local and catchment scales using obtained hydrological data and processed images (i.e. dam building, land use changes, urban development, sediment mining, and channel diversion). Finally, we compare these changes in each classified sub-reach to develop quantitative relationships and explain the temporal adjustments of river functioning according to the dominant human activities. Based on these results, we propose appropriate strategies for future river management.

List of references

You, Y.C., Li, Z.W., Gao, P., and Hu, T.S. 2022. Impacts of dams and land-use changes on hydromorphology of braided channels in the Lhasa River of the Qinghai-Tibet Plateau, China. *International Journal of Sediment Research,* 37: 214-228.

Piégay, H., Alber, A., Slater, L., Bourdin, L., 2009. Census and typology of braided rivers in the French Alps. *Aquatic Sciences*, 71: 371–388.

Belletti, B., Dufour, S., Piegay, H., 2013. Regional variability of aquatic pattern in braided reaches (example of the French Rhone basin). *Hydrobiologia*, 712: 25–41.