Trajectory of changes in river management and channel geometry: the case study of middle and lower Han River in Central China

Trajectoire des changements dans la gestion des cours d'eau et la géométrie des lits de rivière : l'étude de cas du cours moyen et inférieur du fleuve Han en Chine centrale

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RÉSUMÉ

Le cours moyen et inférieur du fleuve Han (Chine centrale) a fait l'objet depuis plus de 3000 ans d'une gestion de son cours. Du 11ème siècle avant JC aux années 1960, la gestion du fleuve consistait principalement à construire des canaux et des digues. Au cours des cinq dernières décennies, la partie moyenne et inférieure du fleuve Han a subi d'importantes modifications de la main de l'homme, y compris des barrages en cascade, le placement d'épis, l'extraction de sable, des projets de transfert entre bassins et des changements d'utilisation des terres. Le changement de chenal dans cette portion moyenne et inférieure de 652 km de long du fleuve Han est abordé sous forme d'une analyse multi-temporelle, superposant les caractéristiques des chenaux à différents moments. Les caractéristiques des chenaux avant les années 1960 ont été reconstituées par géocodage des informations textuelles historiques et les caractéristiques détaillées des chenaux des 50 dernières années sont tirées de 12 images de télédétection (1960, 1978, 1985, 1992, 1995, 2002, 2004, 2006, 2009, 2012, 2014, 2016). Avant la mise en eau du premier grand barrage en 1967, le changement de chenal était caractérisé par une baisse du taux de migration des tronçons inférieurs. Au cours des cinq dernières décennies, les changements dans le chenal comprennent l'incision du lit, le rétrécissement du chenal, le déplacement du profil des chenaux vers un fil unique et les bancs de sable colonisés par la végétation. En associant le changement historique du chenal à l'historique de la gestion du fleuve, nous avons analysé la trajectoire de coévolution de la gestion du fleuve et de la géométrie du chenal dans la partie moyenne et inférieure du fleuve Han.

ABSTRACT

The middle and lower Han River (Central China) has a history of river management longer than 3000 years. From 11th century BC to 1960s, the river management was mainly construction of canals and levees. In the last 5 decades, middle and lower Han River experienced extensive human alterations, including cascade dams, groynes placement, sand mining, inter-basin water transfer projects and land use change. Channel change in this 652-km long middle and lower Han River is approached by multi-temporal analysis, overlaying channel features at different time. Channel features before 1960s have been reconstructed by geo-coding historical text information and detailed channel features in last 50 years are derived from 12 remote sensing images (1960s, 1978,1985, 1992, 1995, 2002, 2004, 2006, 2009, 2012, 2014, 2016). Before the first large dam impounded in 1967, channel change was characterized with declining migration rate of lower reaches. In the last 5 decades, channel changes include bed incision, channel narrowing, channel pattern shifting toward single-thread, and vegetation colonizing sand bars. By associating historical channel change with river management history, we analysed the co-evolution trajectory of river management and channel geometry in middle and lower Han River.

KEYWORDS

Channel change; Human alterations; Hydromorphology; River Management; Temporary trajectory

1 INTRODUCTION

Over the last few hundred years, many large river system have been extensively affected by different means of human river management. One of the responses of rivers to human alterations has been change of channel geomorphology (Gurnell el al., 2016). Channel change can produce a range of environmental and social damage, such as loss of habitat diversity, undermining of structures, bank erosion, and decreased flood-carrying capacity (Rinaldi et al., 2017). A better understanding of historical channel change is essential for predicting future channel evolution, understanding the implication for river management, and thus preventing damage.

This study investigates the co-evolution trajectory of river management and channel geometry in middle and lower Han River, by associating historical channel change with river management history. The Han River has a history of river management longer than 3000 years and undertakes extensive human alteration over last few decades. Correspondingly, the channel of middle and lower Han River has experienced dramatic change over this long history and the change is extremely rapid in the last 30 years.

2 METHODS

2.1 Study Area

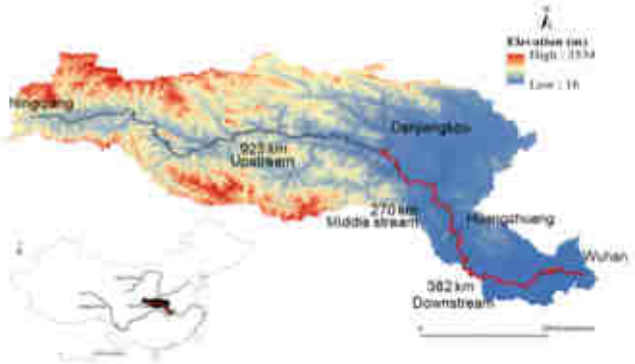

Fig.1 Location and geographical setting of Han River basin

The Han River is a large perennial river in central China draining 159,000 km2. It is the largest tributary of the Yangtze River, China's largest river. The Han River has 1577 km of its total channel length in subtropical monsoon climate region.

This research focuses on middle and lower reaches of the Han River flowing into an alluvial plain. The middle reach is 270 km long from Danjiangkou Reservoir to Huangzhuang Township. It owned a wandering channel pattern, which is characterized with wide and shallow cross section, mid-channel bars and highly migrating thalweg. The lower reach was a typical meandering channel with a length of 382 km from Huangzhuang Township to Wuhan City, being sinuous and without mid-channel bars.

2.2 Reconstruction of river management history

The history of river management is reconstructed by compiling information from secondary data, manual mapping from Google Earth images, land use change analysis from multi-spectral remote sensing data and field observation. Secondary data included historical documents, papers and books, published reports, government documents and newspapers. Manual mapping from Google Earth images detected the location of constructed structures and dynamic human activities. We analysed the land use change metrics in catchment scale with GLCC 1-km resolution land cover class data from U.S. Geological Survey website. For the land use change of riparian corridor in reach scale, we classified the multi-spectral remote sensing images (Landsat and ASTER) into land cover class maps. Field observation helped identify the structures and uncleared features from mapping and modify land cover classification.

2.3 Quantitative analysis of temporal channel change

The temporal channel change is approached by overlaying channel features at different time. Channel features before 1960s have been extracted by geo-coding historical text information. Detailed channel features in last 50 years are derived from 12 remote sensing images (1960s, 1978,1985, 1992, 1995, 2002, 2004, 2006, 2009, 2012, 2014, 2016). Each image is a mosaic image from 4 remote sensing scenes.

In each image, active channel boundary was defined as the limit of vegetation and bare soil with low water level in winter (Gurnell et al., 1994). After manually delineating the active channel boundary, we extracted in-channel features by classifying the active channel area into water, vegetation and bare

land. The indicators describing channel cross section, channel pattern, bed profile and bed particle size were defined according to REFORM framework (Gurnell el al., 2016). Most of the indicators were measured from delineated channel boundary and in-channel features. Those indicators that cannot be measured with historical maps were supplemented by secondary data.

3 RESULTS AND DISCUSSION

3.1 History of river management

Before 1960s, the river management was mainly the increasing length and connectivity of levee in lower reaches and increasing amount of irrigation canals.

After the first dam impounded in 1967, middle and lower Han River experienced extensive human alterations, including cascade dams, groynes placement, sand mining, inter-basin water transfer projects and land use change in the last 30 years.

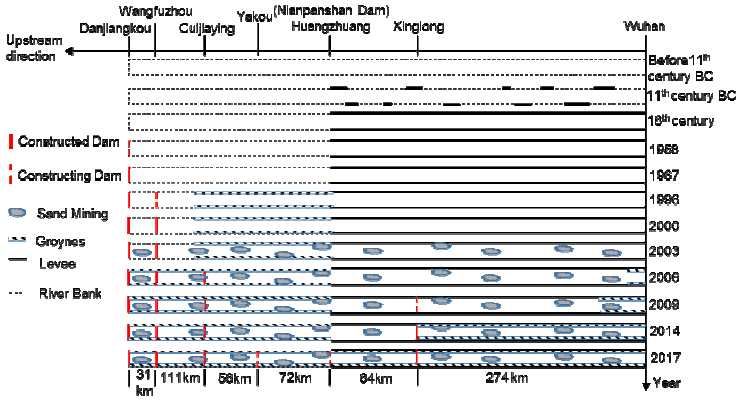

Fig.2 A brief history of major river management means in middle and lower Han River

3.2 Historical channel change

River management history and natural river condition result in five major phenomena of channel change: 1) decrease in lateral migration rate in lower reaches from 11th century BC to 16th century; 2) channel aggradation in lower reaches from 16th century to 1960s; 3) channel deepening since 1967; 4) channel narrowing, loss of mid-channel bars, vegetation colonizing marginal bars, channel pattern shifting to single-thread in middle reaches since mid-1990s; 5) channel narrowing and increasing sinuosity in lower reaches since mid-1990s.

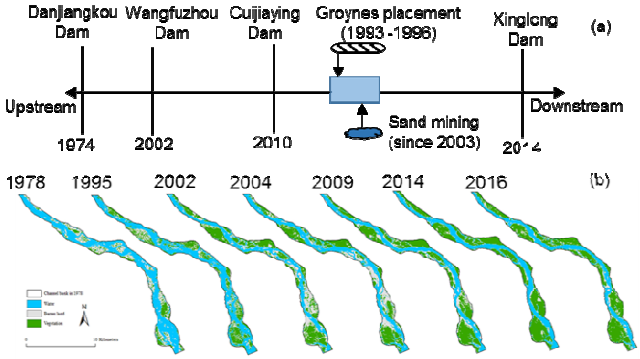

Fig.3 An example of changes in river management(a) and channel features (b) of a small section in middle Han River

4 CONCLUSION

Other than local water supply, the purpose of river management has shifted from flood control (levee construction) towards multiple uses, including flood control, hydropower, inter-water transfer, navigation, sand extraction and opportunistic land reclamation. The consequent channel change was deliberate before. However, without integrated river management plan, multiple utilizations of rivers make channel change incidental to some extent.

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