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Evidence of natural hazards in the lower Yellow River: A close look at bank collapses

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outline

1. Introduction
2. Methods and materials
3. Results and discussion
4. Conclusions

1.Introduction

INTRODUCTION

Bank collapses: a close look at natural hazards

Riverbank erosion is geomorphologically important in effecting changes in the river channel course and in the development of the floodplain, which affects infrastructure and stream-side properties, in-stream habitat and water quality. It is also a natural process participating in river morphodynamics and related ecosystems

Recent damages caused by bank collapses have been frequently reported in the Yellow River, China.

INTRODUCTION

Bank collapses: a close look at natural hazards

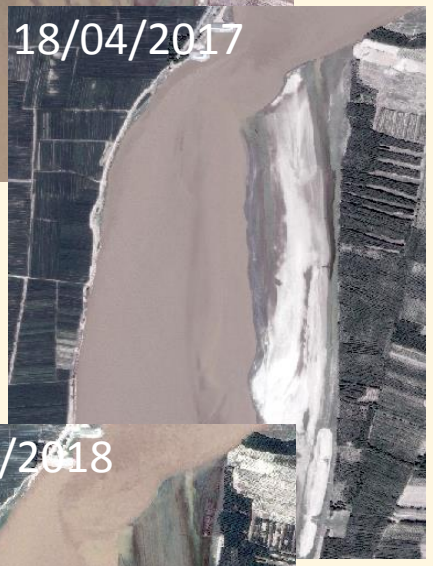
Presently **ecological protection and high-quality development in the Yellow River Basin** have been a hot issue since the idea was presented by **Jinping Xi** last summer.

Hence, in the face of the risk of flooding as the biggest threat, the implementing comprehensive improvement and management projects for the basin to **reduce downstream sedimentation and ensure riparian safety** is **a key task to improve water and soil conservation in the lower Yellow River**.

2.Methods and materials

Field investigation and satellite remote-sensing

- A variety of on-the-spot-**investigations** in the **Shandong Reach of the lower Yellow River (Dongming and Jiyang Reach)** were initiated in July 2018 and April 2019.
- Then, the observed cross-sectional profiles data and the Google Earth were used in the analysis of this paper.
- Finally, the software programs ArcGIS 10.2 and AutoCAD 2014 were used to process and analyze.



The lateral variation of the bank lines

The **lateral dynamic displacement**, B_{La}, and the **maximum lateral dynamic displacement** of the bank line, B_{pm}, that can reflect the strength against the bank failure were defined in detail in this paper.

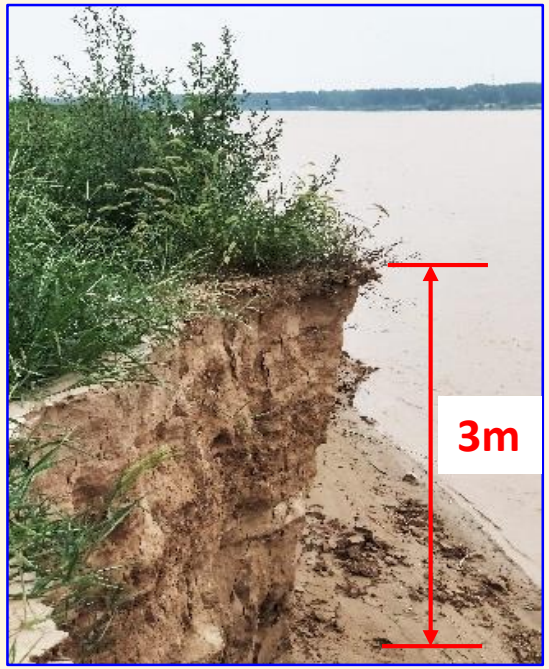
$$B_{\mathrm{La}} = \frac{A_R + A_D}{L} \qquad |B_{\mathrm{pm}}| = Max|B_{\mathrm{p}i}|$$

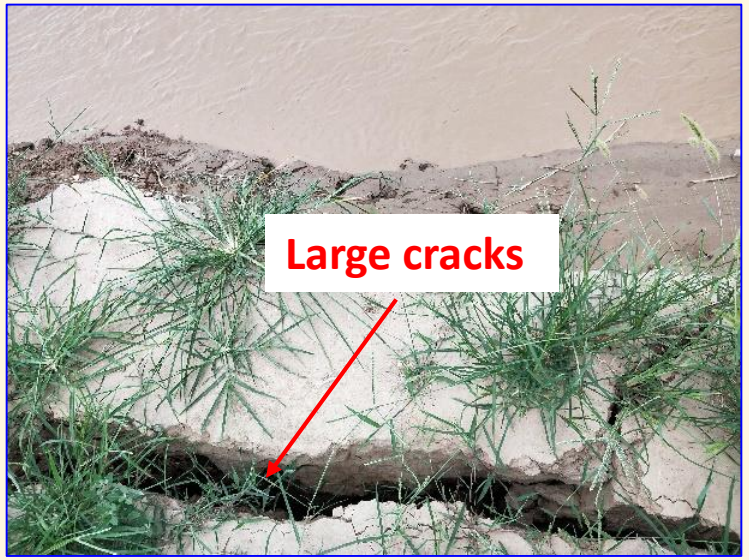
where A_R means the area of the emerging river because of the bank retreat, m^2. A_D means the area of the deposited bank, m^2. L is the distance between the two endpoints A and B of the shoreline in the original shoreline, m. $B_{\mathrm{p}i}$ refers to the minimum distance from any point of the original shoreline to the existing shoreline, m. The values of B_{pi} and A_R are positive when the bank line is scoured while the values of B_{pi} and A_D are negative when the bank line is deposited.

3.Results and discussion

Event damage

Figures show the Dongming Reach with **wandering characteristics**. **Planar failures** were probably the main types of riverbank failure that occurred in this reach. Some **deposits** were clearly observed at the foot of the slope, which could protect the near-shore riverbed. It is also found that **the riverbank was unstable** and the bank may collapse at any time due to the presence of **large cracks** in the riverbank.



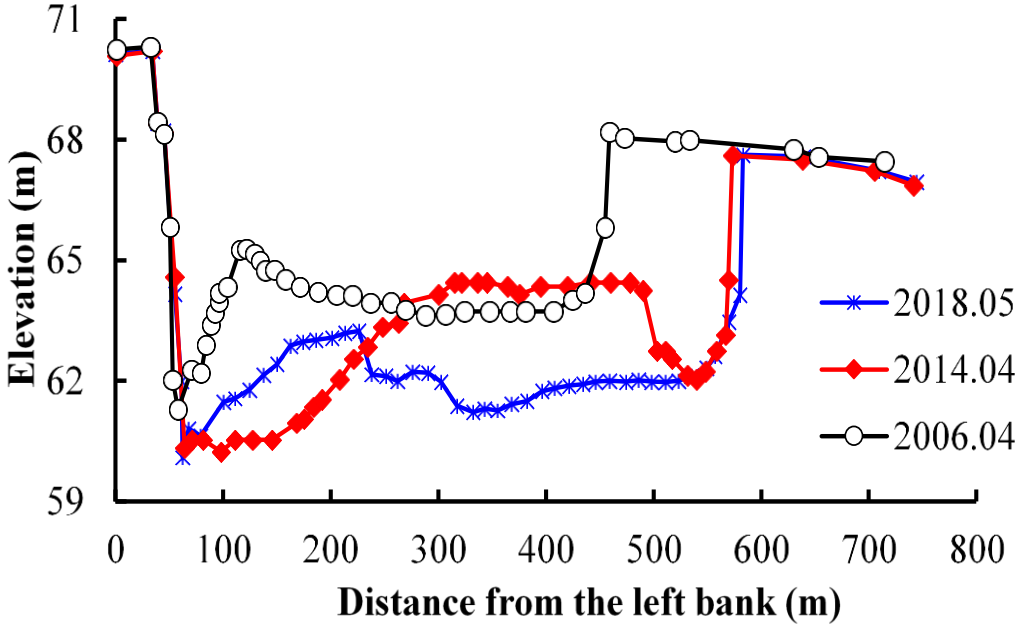


RESULTS & DISCUSSION

Event damage

We obtained the changes of cross-sectional profiles at the **Zhulin section near the investigation** in Dongming Reach. During the period 2006-2018, the **right bank** has retreated **124 m** in the past 12 years, especially its lateral displacement reached **114 m during the period 2006-2014**, while the annual-lateral displacement was **10.3 m/a**.

The shoreline is at an angle to the flow direction in the channels. Coincidentally, the bank collapse of Dongming section has been affected for this reason. In fact, **there are no protective measures on the riverbank** and the upstream water directly scours the riverbank, which causes serious problems.



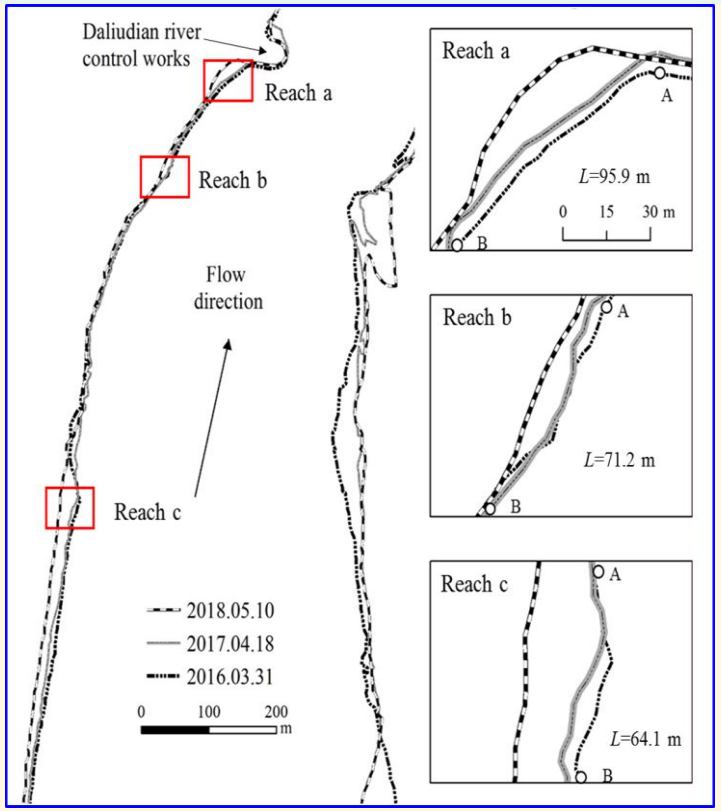
Event damage

The Jiyang Reach is a **narrow reach**. In the river reach and adjacent downstream, the Daliudian river-control works were scoured extensively because of the significant changes in the local flow regime. Similarly, many cracks were also observed on the bank slope, and the failure type was the **upward-concave collapse**.

The erosional process still remains active to the present.

Event damage

The bank lines we got from the satellite images show that the degrees of collapse on the left bank were different during the phase of 2016-2018. We further studied the bank collapses of the **Reaches a, b and c**.



Reach	Characteristics	Duration		
		3/31/2016-4/18/2017	4/18/2017-5/10/2018	3/31/2016-5/10/2018
Reach a	L (m)	95.9	95.9	95.9
	A_R (m^2)	419.0	801.3	1220.4
	A_D (m^2)	0.0	-13.8	-13.8
	$\overline{B_{La}}$ (m)	4.4	8.2	12.6
	B_{pm} (m/a)	5.8	15.5	15.5
Reach b	L (m)	71.2	71.2	71.2
	A_R (m^2)	87.1	415.9	502.9
	A_D (m^2)	-52.8	0.0	-52.8
	$\overline{B_{La}}$ (m)	0.5	5.8	6.3
	B_{pm} (m/a)	4.2	9.7	9.7
Reach c	L (m)	64.1	64.1	64.1
	A_R (m^2)	240.2	1287.9	1528.1
	A_D (m^2)	-4.8	0.0	-4.8
	$\overline{B_{La}}$ (m)	3.7	20.1	23.8
	B_{pm} (m/a)	7.4	26.0	26.0
Average	L (m)	77.1	77.1	77.1
	A_R (m^2)	248.8	835.0	1083.8
	A_D (m^2)	-19.2	-4.6	-23.8
	$\overline{B_{La}}$ (m)	2.8	11.4	14.2
Maximum	B_{pm} (m/a)	7.4	26.0	26.0

Event damage

Based on the characteristics of the wandering river reach, a change of the upstream flow direction will make the mainstream directly scour the left bank due to the upstream river-control works and bridge piers. Therefore, for a long time, the riverbank has been **attacked by the mainstream** and **scoured by the backflow** due to the downstream control works.

Defense scenario

Presently, a combined management solution of riprap and gabions is popularly used in the bank-restoration projects in the lower Yellow River.

Shortcoming:

- High price
- An insufficient amount of material
- Low number of skillful stonemasons

Discussion-1: Is there any substitute material?

Building materials

Defense scenario

Discussion-2: How to develop the ecological environment?

In the lower Yellow River, the **proportion of hard revetment is still high**. The hard revetment is not conducive to the development of an ecological environment and also undesirable as a basin-wide solution in the future.

A two-pronged approach is envisaged to **establish an ecological bank protection work**, which can realize the function of protecting the riverbank, improve the ecological environment, and even construct a waterside pavilion. **Looking for such ecological construction measures has become a hot topic in river management research.**

4. Conclusions

CONCLUSIONS

The riverbank collapse is a kind of serious and frequent disaster in the lower Yellow River.

- The average retreat area of three representative segments in the Jiyang section were **1083.8** m^2 during the study period of 3/31/2016-5/10/2018.
- The average lateral dynamic displacements were **2.8** and **11.4** m during the periods 3/31/2016–4/18/2017 and 04/18/2017–5/10/2018, respectively.
- In the near future, **an effective, low-cost and ecological construction practice is expected** to replace the work with a combination of riprap and gabions in the lower Yellow River.


Thank you for your
attention!