Climatic and anthropogenic causes of the reduced sediment in large Chinese rivers

Lu Xi Xi

GIS & Map Resource Unit
Department of Geography
National University of Singapore

Outline

- **The importance of large Chinese rivers**
- **Rapid sediment decline**
- **Main causes**
  - Climate variations/change
  - Human activities (reservoirs construction, reforestation and sand mining)
- **Conclusion**

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High sediment flux from large Chinese rivers

- **High rainfall**
- **Heavily weathered under humid (sub)-tropical climate**
- **Active tectonic activities**
- **High population density and frequent human activities**
- **Rapid alteration of land use/land cover**

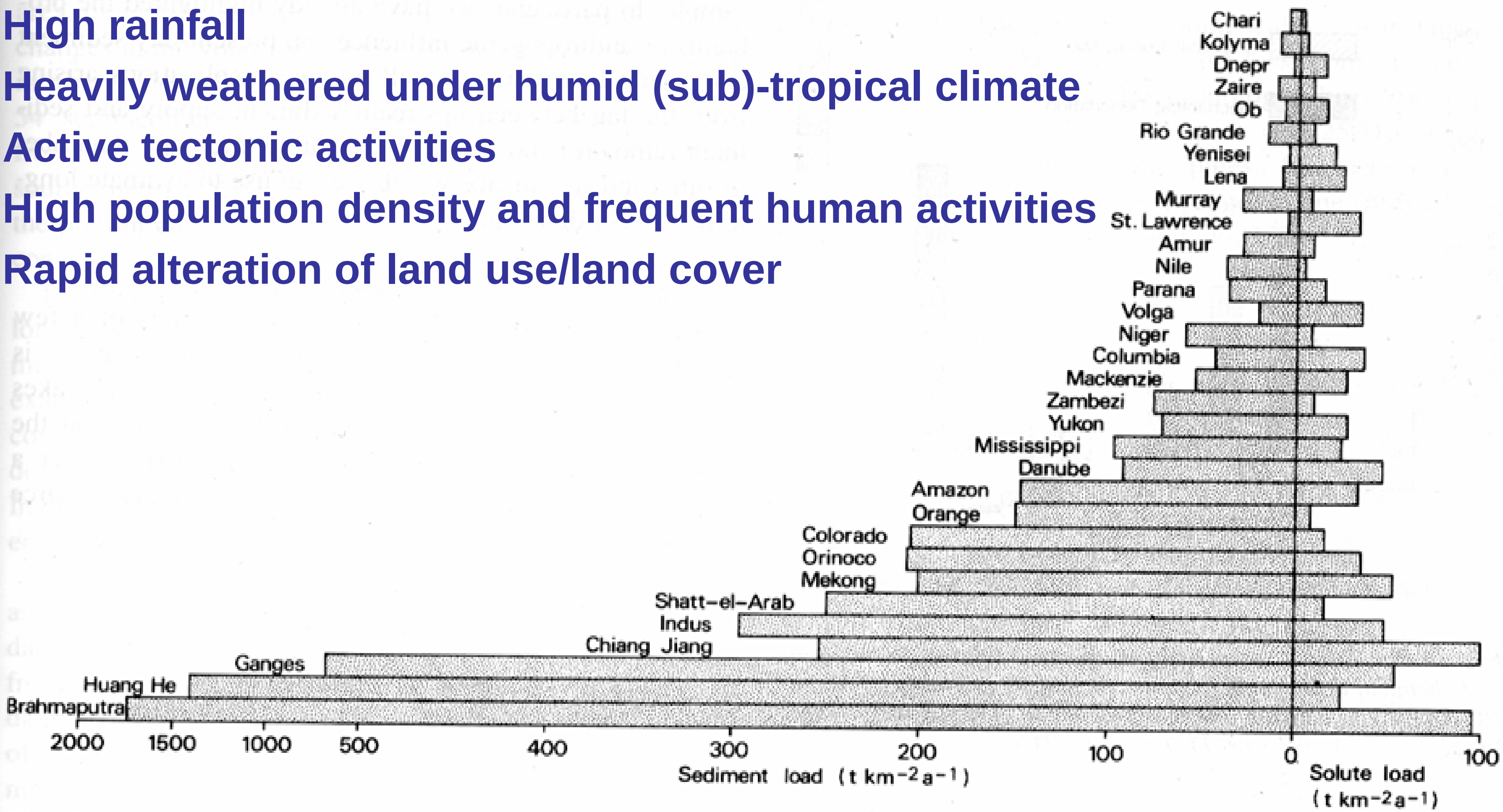
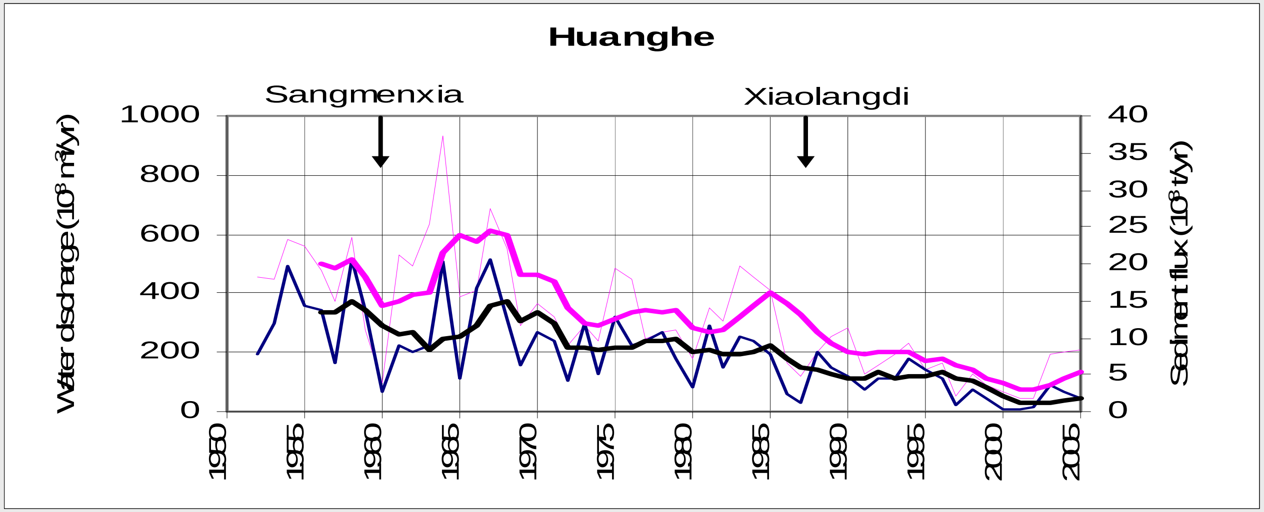
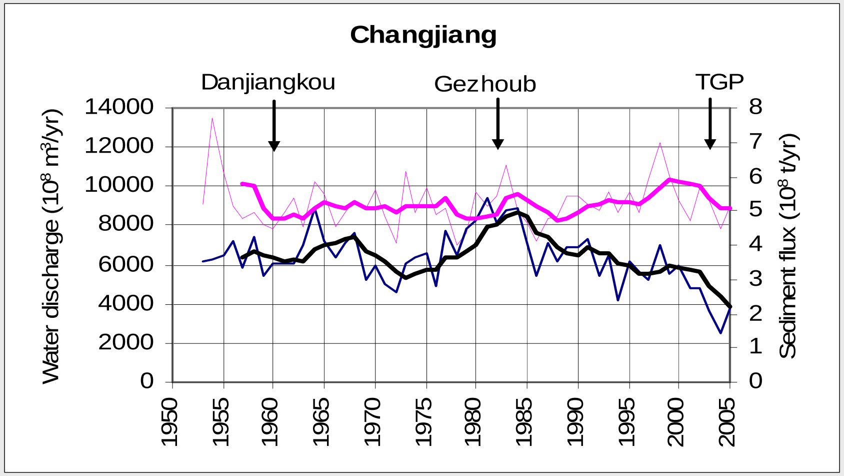


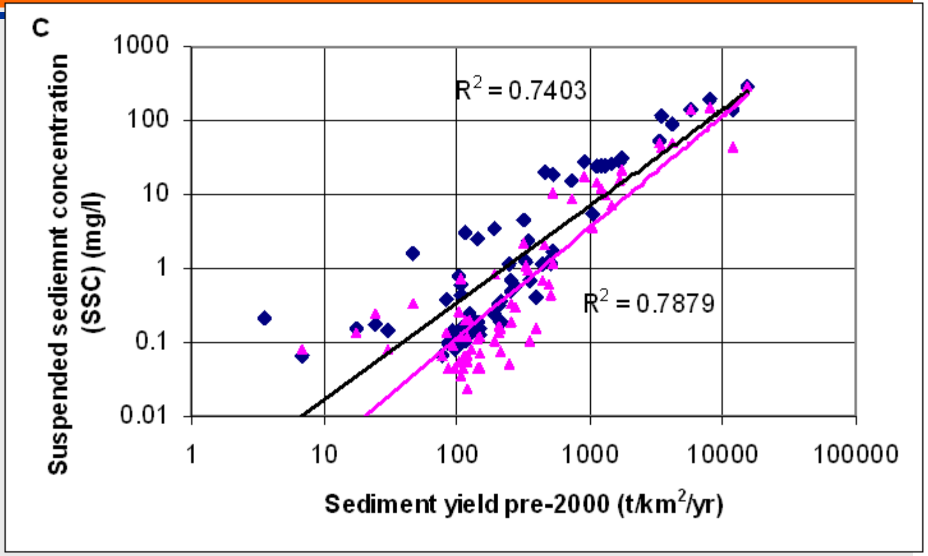
Fig. 15.11 Sediment and solute loads for the world's largest drainage basins. Solute loads represent the estimated denudational component only. Data for the Nelson, Tocantins and São Francisco Basins are not available. (Based primarily on data in M. Meybeck (1976) Hydrological Sciences Bulletin *21, 265–89 and J. D. Milliman and R. H. Meade (1983)* Journal of Geology *91, 1–21.)*

Northern rivers

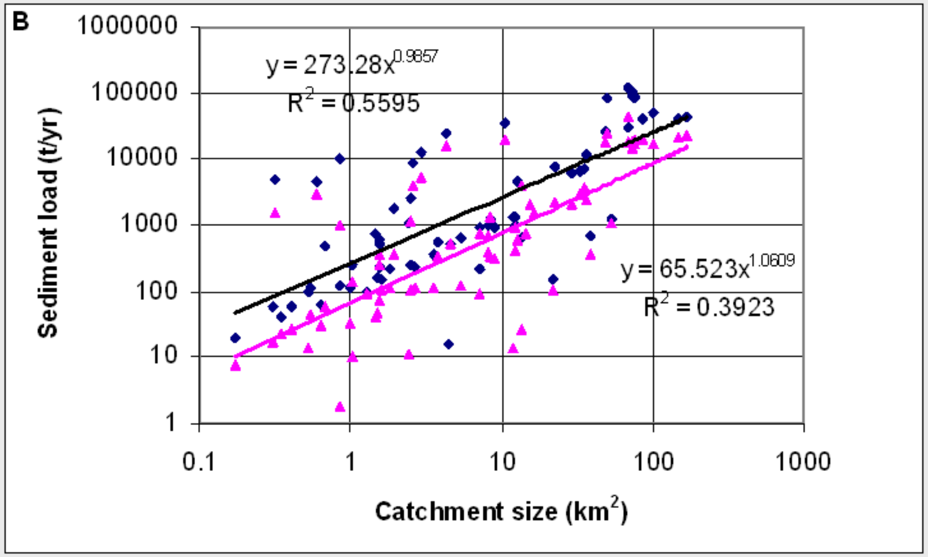


Southern rivers

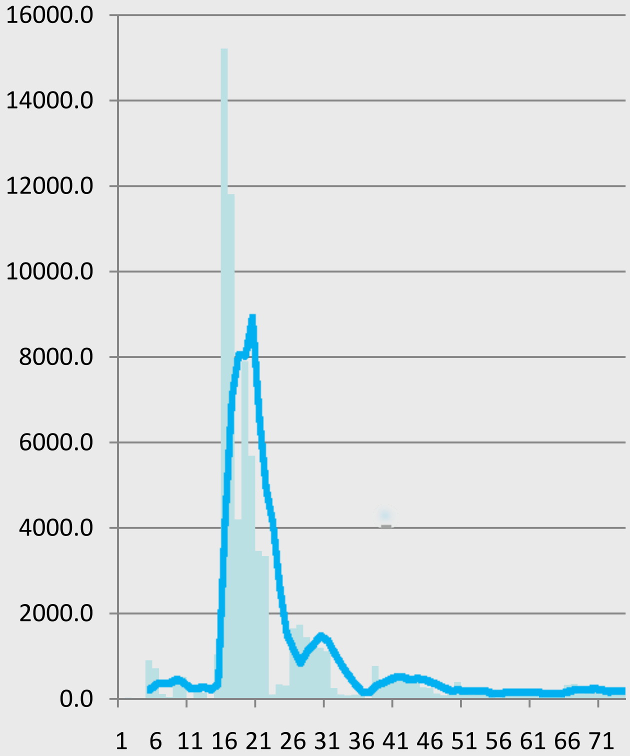


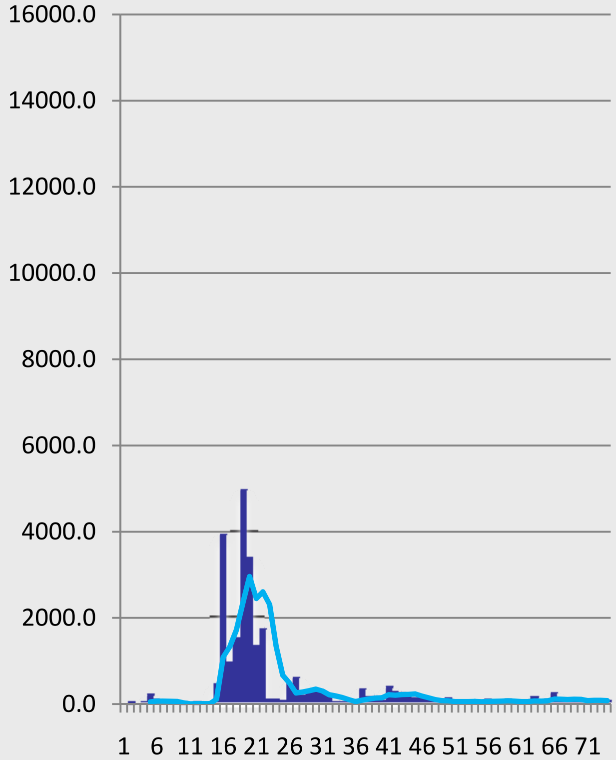


Sediment concentration for the two time periods: the 1950s-2000 (black) and 2001-2005 (pink) against sediment yield of pre-2000, showing suspended sediment concentration (SSC) reduction across the nine large rivers.



Sediment load against catchment sizes of the total 74 gauging stations of the nine large rivers for the two time periods: the 1950s-2000 (black) and 2001-2005 (pink).





Sediment yield vs water discharge of pre-and post-2000 periods: Langbein and Shumm (1958) curve

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Assessment of sediment discharge changes

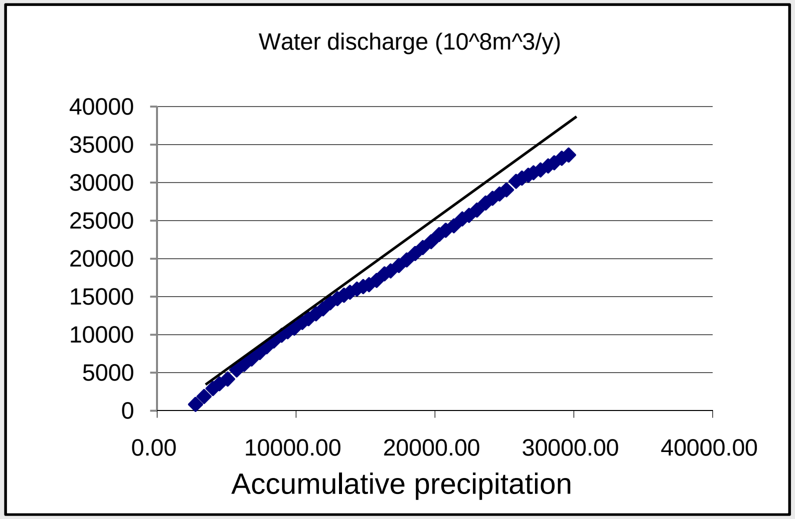
- **Much work on impacts human activities such as reservoirs, land use/cover change, soil conservation and sand mining**

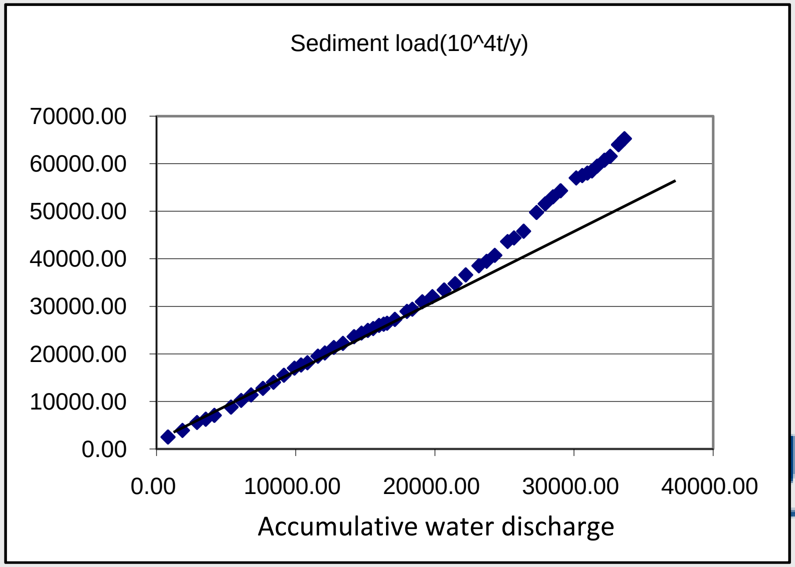
- For example, the terrestrial sediment flux to the global coastal ocean under modern and pre-human conditions, 2.3+/-0.6 BT increase per year through soil erosion, but a simultaneous decrease of 1.4+/-0.3 BT per year because of reservoir retention (Syvistki et al., 2005)

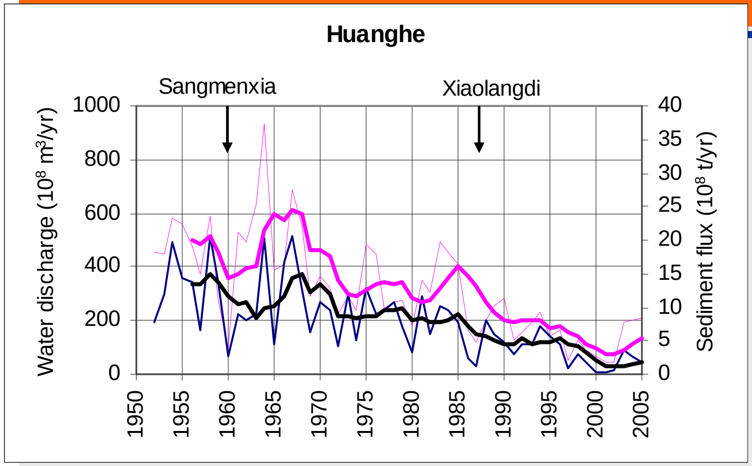
- **"Little work has been done on the expected impacts of climate change on sediment loads in rivers and streams" (IPCC, 2007)**

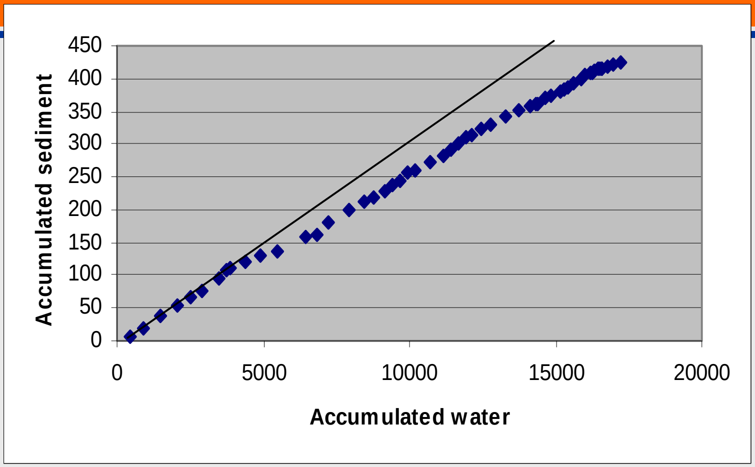
Attempts to evaluate climate change impacts

- Use of double accumulative curves of water discharge vs precipitation, and sediment loads vs water discharge
- The baseline sediment in the 1950s and the 1960s
- The reduction in the water discharge was due to human impacts such as water withdrawal
- To differentiate climate and human activities (a lumped indictor of reservoirs, land use/land cover change, sand mining etc.) only

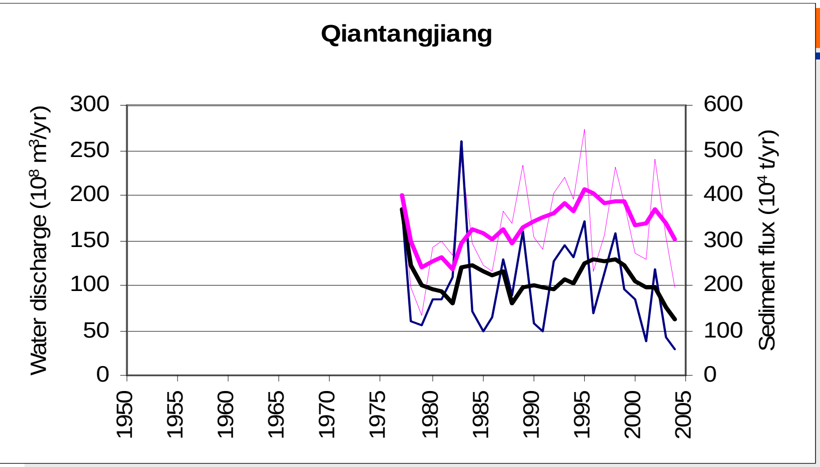


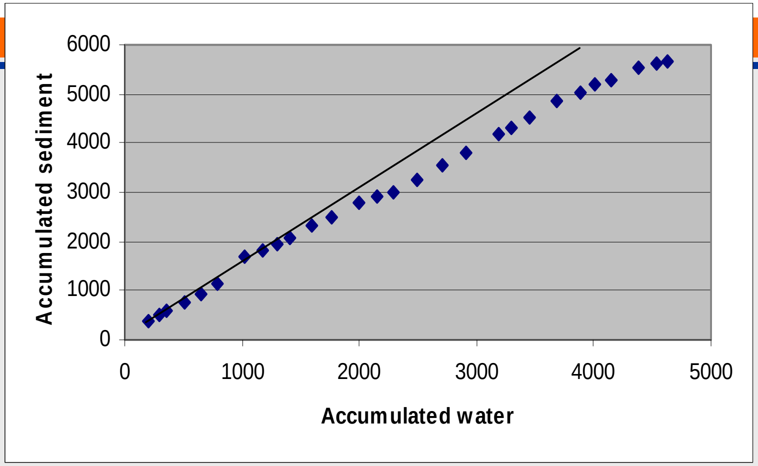






88% decrease from pre-1970 to 2001-05. Climate contributed 75%, human 13%.





No estimation

Impacts of reservoirs construction

- China had built over 85,153 reservoirs by the end of 2003, with a total water storage capacity of $8,658 \times 10^8$ m^3.
- The water storage index: higher in the arid and semi-arid north, e.g. 0.87 for Haihe and 0.60 for Huaihe, but lower in the humid subtropical areas, e.g. 0.11 for Changjiang (pre-TGP) and <0.11 for Zhujiang.
- The total water storage capacity of reservoirs in China has been reduced by 40% because of sediment retention.

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Reservoir retention

- **Use of sedimentation data over 50 mega reservoirs**
- **Total retention by the reservoirs is estimated 1.40 BT per year**
- **The combined 5 reservoirs (Sangmenxia, Xiaolangdi, Danjiangkou, Gezhouba and Three Gorges Reservoir) alone have retained 0.76 BT sediment per year since the TGP's first stage closure in 2003.**

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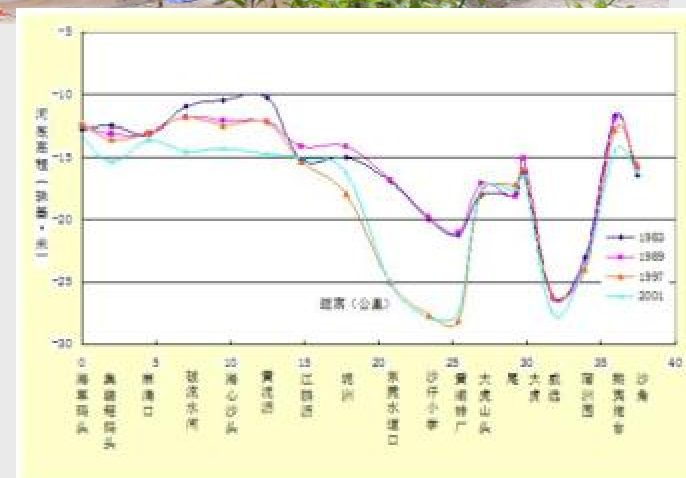
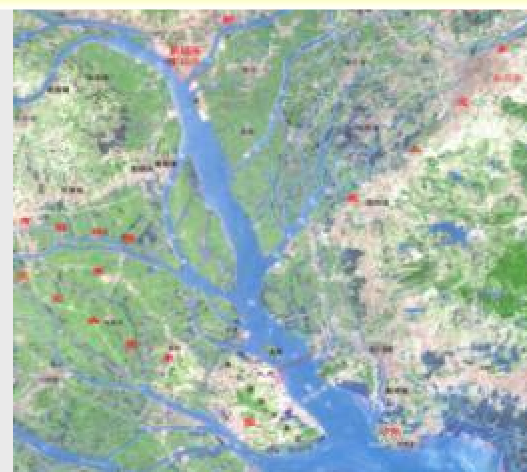
Impacts of sand mining

- **The annual in-channel sediment extraction was 40 MT in the 1980s and increased to 80 MT in the 1990s in the lower Changjiang (Chen et al. 2006).**
- **In the lower Zhujiang the annual sediment extraction was 62.1-71.55 MT during the period 1984-1999. This is almost equivalent to the total annual suspended sediment flux in the entire Zhujiang.**





Impacts of reforestation/afforestation

- Reforestation/afforestation has been implemented nation-wide, and is effective for small catchments, but little information is available for large river basins;
- Soil conservation (including engineering measures) has been effective in the Huanghe basin and has contributed to the decline (Xu, 2005);
- Vegetation recovery and soil conservation have also contributed in the area of upper TGP in the Changjiang basin, especially in the Jialing tributary (around 10-25%).

Conclusions

- Sediment flux from the Chinese Asian rivers to the sea has experienced a dramatic decline over the past decades; such decline has also occurred in a wide range of areas including the upper basins;
- It's difficult to discriminate the contribution from each individual factors;
- In arid and semi-arid environments (e.g. Liaohe, Haihe and Huanghe), climate (mainly rainfall reduction) was primary reason for the decline (contributed to >50%), human activities was secondary reason (<30%);
- In humid environments (e.g. Changjiang, Qiangtangjiang, Minjiang and Zhujiang), human activities were primary reason (contributed to 30-70%), climate was very minor reason (<10%);
- Such massive reduction in sediment flux has a far-reaching impact on the riverine, estuarine, coastal, and shelf area ecosystems;
- The detailed analysis on the cause and effect of such changes requires urgent studies.

Acknowledgments

- Research projects funded by NUS, and National "973" Project (China), and SARCS
- Colleagues: Dr. David Higgitt, Dr. Carl Grundy-Warr, Mr. Uffer Poulsen, Department of Geography, NUS
- Students: Ms Zhu Yunmei, Ms. Zhang Shurong, Ms. Siew Ruyan, Ms. Teo Yen Peng and Mr. Wang J.J, Department of Geography, NUS
- Many other collaborators in China, Canada, UK, Thailand, MRC etc.

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