IRTCES, ISI, DATABASE OF SEDIMENT AND ISI CASE STUDIES

Cheng Liu
International Research and Training Center on Erosion and Sedimentation, Beijing, China
International Sediment Initiative (ISI-IHP-UNESCO)
Oct. 26, 2016
IRTCES: International Research and Training Center on Erosion and Sedimentation

ISI: International Sediment Initiative
Content

1. IRTCES

2. ISI

3. DATABASE OF SEDIMENT

4. ISI CASE STUDIES

5. POSSIBLE COLLABRATION
1. IRTCES
First Water-related Category II Center

IRTCES is the first established Category II water-related centers under auspices of UNESCO, it was established in 1984 under:

- Resolution of the 22nd Session of UNESCO’s General Conference (1983, Paris)
- The Ministry of Water Resources is the governmental executive agency.
Inauguration Ceremony of IRTCES (1984, China)

Mr. Amadou Mahtar M’Bow, the DG of UNESCO and Ms. Qian Zhengying, the Chinese Minister of Water Resources, attending the Inauguration Ceremony of IRTCES
Renewal Agreement Signing Ceremony (2005, China)

- The renewed Agreement on IRTCES was signed in Beijing on Nov. 30, 2005.
Vision of IRTCES

Vision:

IRTCES aims at the promotion of international exchange of knowledge and cooperation in the studies of erosion and sedimentation problems. IRTCES provides technical services in sediment information exchange, training of sediment engineers and consultation on sediment management, erosion control and environmental and ecological protection of watersheds.
IRTCES Routine Work

1 Training: Sediment related training workshop

1 Prize: Qian Ning Prize for Erosion and Sedimentation Technology

1 Database: Global Data of Erosion and sedimentation

3 Conferences:
- International Symposia on River Sedimentation
- WASWAC World Conferences
- International Conferences on Estuaries and Coasts

3 Secretariats:
- World Association for Sedimentation and Erosion Research (WASER)
- World Association of Soil and Water Conservation (WASWAC)
- UNESCO’s International Sediment Initiative (ISI)

3 Publications:
- International Journal of Sediment Research
- International Soil and Water Conservation Research
- China Gazette of River Sedimentation

4 Websites: IRTCES, WASER, WASWAC and UNESCO-ISI

also conduct many research projects, consulting programs and national issues.
Recent Activities
The 13th International Symposium on River Sedimentation held in Stuttgart, Germany

- Stuttgart, Germany on September 19-22, 2016
- 300 participants from 51 countries and regions
The Third WASWAC World Conference held in Belgrade, Serbia

- Belgrade, Serbia, Aug. 22-26, 2016
- 200 participants from 33 countries and regions
The Fifth International Conference on Estuaries and Coasts held in Muscat, Oman

- Muscat, Oman on November 2-4, 2015
- 150 participants from more than 20 countries and regions
The International Youth Forum of Soil and Water Conservation held in Nanchang

- Nanchang, China, October 16 -18, 2015
- than 150 participants from 20 countries
The UNESCO – IHP - International Sediment Initiative 'Programme Planning Workshop' held in Beijing

- Beijing, China from 25-28 May 2015
- The workshop brought together members of the ISI advisory and expert groups, representatives of relevant UNESCO Category II Centres and Chairs and other partner organizations, as well as other stakeholders to discuss the action plan for the future ISI programme, set priorities, and explore opportunities for collaborative projects with partner agencies within the framework of the ISI objectives.
Training Workshop on River Basin Management Strategies and Technologies of Water and Soil Conservation

- Beijing, China, Oct. 9-15, 2016
- 26 participants from 11 countries and regions
International Workshop on Sediment Management in Water Resources and Hydropower Projects

- Beijing, August 18 – 22, 2014
- 42 participants from 13 countries and the World Bank
- Trainers Dr. Gregory L. Morris, Dr. George Annandale, and Dr. Zhao-Yin Wang delivered lectures
- IRTCES expert, Tsinghua University PhD students made presentations.
- Trainees presented case studies their home countries
2015

- Over 20 research projects from National Natural Science Foundation, Ministry of Water Resources and Ministry of Science and Technology……
- Finished 10 research projects
- Finished 12 research reports
- Published 20 technical journal and conference papers
Published 4 issues of International Journal of Sediment Research
SCI Impact Factor for 2015 is 1.388
New journal International Soil and Water Conservation Research stared in 2013
Published annual China Gazette of River Sedimentation (in Chinese) since 2000
2. UNESCO – IHP – ISI
**International Sediment Initiative (ISI)**

- The International Sediment Initiative (ISI) was recommended to be launched in the 15th session of the IHP Intergovernmental Council in Paris in June, 2002.
- The Technical Secretariat for the ISI is provided by the IRTCES in Beijing, China in 2005.

---

**RESOLUTION XV-8**

**International Sedimentation Initiative (ISI)**

The Intergovernmental Council of the International Hydrological Programme of UNESCO

Noting

a) that erosion and sedimentation processes and management in catchments, river systems and reservoirs are increasingly important in all parts of the world,

b) that erosion and sedimentation processes have significant socio-
Objectives of ISI

ISI contributes to the 8th phase of the IHP (2014-2021) with the title “Water security: responses to local, regional and global challenges” by addressing the wide-ranging social, economic and environmental impacts of erosion, sediment transport and sedimentation processes with due consideration of gender perspectives. ISI addresses both sediment quantity and quality within the context of global change. The objectives of ISI are to:

- Support the global agenda for sustainable integrated land and water resources management through sound sediment management;
- Link science with policy and management needs at the local, regional and global scale, as well as in transboundary settings;
- Promote the development of an improved understanding of sediment mobilization, transport and storage and sediment budgets at local, regional and global scales, to support effective sediment management;
- Strengthen the capacity for sediment management, through education, training and the promotion of cooperation among stakeholders;
- Communicate the importance of sediment management to decision makers and the public.
ISI’s governing structure

The ISI’s governing structure was reorganized in 2014 in order to ensure the continued efficient coordination of the initiative. Two bodies, Advisory Group and Expert Group, has been established since 2014.

Advisory Group
- Manfred Spreafico (Chairperson)
- Cheng Liu (Representatives of Secretariat / IRTCES)
- Anil Mishra (Representative of UNESCO)
- Desmond E. Walling (Expert on sediment and erosion)

Expert Group
- 10 experts worldwide:
  - Abdalla Abdelsalam Ahmed (Sudan)
  - Farhad Yazdandoost (Iran)
  - Gerrit Bason (South Africa)
  - Giampaolo Di Silvio (Italy)
  - Gil Mahé (FRIEND Network)
  - Helmut Habersack (Austria)
  - Johannes Cullman (Germany)
  - Valentin Golosov (Russia)
  - Zhao-Yin Wang (China)
  - Rollin H. Hotchkiss (USA)
Global Evaluation of Sediment Transport (GEST Project):
The GEST Project entails the development of a global repository for data, information and documentation on soil erosion and sediment transport which will serve as the basis for global assessment of erosion and sedimentation problems, and their social and economic implications. The data and information base will be developed in existing international institutions, such as the IRTCES in Beijing, China, GEMS-Water in Canada, ISIDE Observatory in Italy, etc..

The ISI Information System provides:

- **Information access:** through the creation of a global information resource portal;
- **Information repository:** through the establishment of a sediment database and the collection of other information;
- **Information development:** through the implementation of strategic training activities.
**Case Studies for River Basins as Demonstration Projects:**

Case studies are an effective means of raising awareness about erosion and sedimentation problems in different regions. These will provide examples of monitoring and data processing techniques, procedures and methodologies for analysis of environmental, economic and social impacts, and evaluation of management practices. Case studies on the Mississippi, Nile, Rhine, Volga, Yellow, Liaohe and Haihe river basins have been prepared. Other case studies will follow. The data available from the case studies will be incorporated into the global database.

**Review of Erosion and Sedimentation-Related Research**

A survey of ongoing research is an important contribution to the operation of databases and information systems, given the lack of knowledge about certain aspects of erosion and sediment phenomena needed to address key sedimentation problems. Associations such as the International Coordinating Committee on Reservoir Sedimentation (ICCORES) and the newly created World Association for Sedimentation and Erosion Research (WASER) could play substantial roles in this endeavor.
**Education and Capacity Building for Sustainable Sediment Management**

ISI scientific conferences conduct workshops and seminars focusing on the most important issues of erosion, transport and sediment deposits. International and local experts discuss local problems at these conferences and develop proposals for solving them.

Within the medium term, the initiative will focus on identifying the modes of education at all levels while also taking into account regional priorities and interests in different socio-economic and eco-hydrological settings. This activity should take into account the findings of the GEST Project and the updated survey of sedimentation-related research. In line with its commitment to education and capacity building, ISI will encourage young scientists to become involved in its activities.

**Networking**

ISI is open to collaboration with all interested institutions – international, regional or national associations – in the interest of promoting sound and sustainable sediment management policies. ISI is eager to establish close working relationships with international, regional, and national projects, programmes and networks, such as IAHS, WASER, ICCORES, ICOLD, GEMS WATER, IAHR, GEOSS, SedNet among others.
ISI Achievements since 2004

- Global Repository for Information - ISI Information System
- Research Reviews
- Support for Conferences and Workshops – Published Proceedings
- Training Courses – Sava River Basin Commission, Zagreb, September, 2012
ISI Website: http://www.irtces.org/isi/
ISI Information System

- INFO DEVELOPMENT
- INFO REPOSITORY
- NEWSLETTERS
- DATABASE LINKS
- OTHER LINKS
- UNESCO WATER CENTERS

ISI Information System:  
http://www.irtces.org/isi/info.asp
3. Database of Sediment
Eg. "Basic Data" Section

- includes five sub-sections of "River Data", "Soil Erosion", "Engineering Sediment", "River Erosion & Deposition" and "Gazette".

- "River Data" sub-section is used to release numerical data related to sediment of global rivers, mainly including runoff, sediment load, sediment concentration, sediment median size etc.

Daily Sediment Concentration of Columbus Station on the Colorado River During 1960 - 1974
中国长江流域大通站1952-2005年输沙量过程线

### 中国长江流域大通站1952-2005年输沙数据表

<table>
<thead>
<tr>
<th>年份</th>
<th>年径流量（亿m³）</th>
<th>年平均含沙量（t/km²）</th>
<th>年度输沙量（t）</th>
<th>年平均输沙量（t/km²）</th>
<th>年平均输沙率（t/km²）</th>
</tr>
</thead>
<tbody>
<tr>
<td>1952</td>
<td>3370.0</td>
<td>10700.0</td>
<td>3370.0</td>
<td>0.431</td>
<td>40375.0</td>
</tr>
<tr>
<td>1953</td>
<td>3200.0</td>
<td>9950.0</td>
<td>3200.0</td>
<td>0.399</td>
<td>40600.0</td>
</tr>
<tr>
<td>1954</td>
<td>3210.0</td>
<td>13900.0</td>
<td>3210.0</td>
<td>0.530</td>
<td>47650.0</td>
</tr>
<tr>
<td>1955</td>
<td>3010.0</td>
<td>10900.0</td>
<td>3010.0</td>
<td>0.562</td>
<td>54900.0</td>
</tr>
<tr>
<td>1956</td>
<td>2870.0</td>
<td>9450.0</td>
<td>2870.0</td>
<td>0.525</td>
<td>52320.0</td>
</tr>
<tr>
<td>1957</td>
<td>2710.0</td>
<td>9220.0</td>
<td>2710.0</td>
<td>0.559</td>
<td>54700.0</td>
</tr>
<tr>
<td>1958</td>
<td>2850.0</td>
<td>9730.0</td>
<td>2850.0</td>
<td>0.522</td>
<td>48640.0</td>
</tr>
<tr>
<td>1959</td>
<td>2460.0</td>
<td>7875.0</td>
<td>2460.0</td>
<td>0.535</td>
<td>41000.0</td>
</tr>
<tr>
<td>1960</td>
<td>2550.0</td>
<td>8915.0</td>
<td>2550.0</td>
<td>0.527</td>
<td>45950.0</td>
</tr>
<tr>
<td>1961</td>
<td>2560.0</td>
<td>9490.0</td>
<td>2560.0</td>
<td>0.487</td>
<td>47750.0</td>
</tr>
<tr>
<td>1962</td>
<td>2460.0</td>
<td>7760.0</td>
<td>2460.0</td>
<td>0.697</td>
<td>58600.0</td>
</tr>
<tr>
<td>1963</td>
<td>2320.0</td>
<td>10790.0</td>
<td>2320.0</td>
<td>0.682</td>
<td>67800.0</td>
</tr>
<tr>
<td>1964</td>
<td>2780.0</td>
<td>9750.0</td>
<td>2780.0</td>
<td>0.694</td>
<td>59416.0</td>
</tr>
<tr>
<td>1965</td>
<td>2460.0</td>
<td>7740.0</td>
<td>2460.0</td>
<td>0.618</td>
<td>47900.0</td>
</tr>
<tr>
<td>1966</td>
<td>2320.0</td>
<td>8820.0</td>
<td>2320.0</td>
<td>0.621</td>
<td>55100.0</td>
</tr>
<tr>
<td>1967</td>
<td>2590.0</td>
<td>9440.0</td>
<td>2590.0</td>
<td>0.619</td>
<td>53400.0</td>
</tr>
<tr>
<td>1968</td>
<td>2770.0</td>
<td>8720.0</td>
<td>2770.0</td>
<td>0.484</td>
<td>39000.0</td>
</tr>
<tr>
<td>1969</td>
<td>3140.0</td>
<td>9950.0</td>
<td>3140.0</td>
<td>0.447</td>
<td>40600.0</td>
</tr>
<tr>
<td>1970</td>
<td>3320.0</td>
<td>7385.0</td>
<td>3320.0</td>
<td>0.547</td>
<td>37850.0</td>
</tr>
<tr>
<td>1971</td>
<td>3320.0</td>
<td>6770.0</td>
<td>3320.0</td>
<td>0.549</td>
<td>34500.0</td>
</tr>
<tr>
<td>1972</td>
<td>3410.0</td>
<td>10740.0</td>
<td>3410.0</td>
<td>0.526</td>
<td>44100.0</td>
</tr>
<tr>
<td>1973</td>
<td>3320.0</td>
<td>9350.0</td>
<td>3320.0</td>
<td>0.517</td>
<td>47800.0</td>
</tr>
<tr>
<td>1974</td>
<td>3190.0</td>
<td>10890.0</td>
<td>3190.0</td>
<td>0.508</td>
<td>50700.0</td>
</tr>
<tr>
<td>1975</td>
<td>3360.0</td>
<td>9242.0</td>
<td>3360.0</td>
<td>0.432</td>
<td>38300.0</td>
</tr>
<tr>
<td>1976</td>
<td>2900.0</td>
<td>9460.0</td>
<td>2900.0</td>
<td>0.48</td>
<td>41400.0</td>
</tr>
<tr>
<td>1977</td>
<td>2450.0</td>
<td>6760.0</td>
<td>2450.0</td>
<td>0.55</td>
<td>37000.0</td>
</tr>
<tr>
<td>1978</td>
<td>2340.0</td>
<td>7330.0</td>
<td>2340.0</td>
<td>0.46</td>
<td>44900.0</td>
</tr>
<tr>
<td>1979</td>
<td>2340.0</td>
<td>9720.0</td>
<td>2340.0</td>
<td>0.48</td>
<td>47400.0</td>
</tr>
<tr>
<td>1980</td>
<td>1650.0</td>
<td>9970.0</td>
<td>1650.0</td>
<td>0.41</td>
<td>53700.0</td>
</tr>
<tr>
<td>1981</td>
<td>2790.0</td>
<td>9710.0</td>
<td>2790.0</td>
<td>0.41</td>
<td>53700.0</td>
</tr>
<tr>
<td>1982</td>
<td>2030.0</td>
<td>9770.0</td>
<td>2030.0</td>
<td>0.49</td>
<td>46750.0</td>
</tr>
</tbody>
</table>
"Documents" Section

<table>
<thead>
<tr>
<th>序号</th>
<th>研究者名称</th>
<th>作者</th>
<th>发表时间</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Pierre Julien, Samsun (France)</td>
<td>Pierre Y. Julien and Chad N. Inman</td>
<td>2000-11</td>
</tr>
<tr>
<td>2</td>
<td>UNEP/UTD: The Impact of Sedimentation on the Mississippi River Delta</td>
<td>UNEP/UTD: The Impact of Sedimentation on the Mississippi River Delta</td>
<td>2001-11</td>
</tr>
<tr>
<td>4</td>
<td>Sedimentation Issues of the Haine and Liame Rivers in China</td>
<td>INTERNATIONAL RESEARCH AND TRAINING CENTER ON ENVIRONMENT AND SEDIMENTATION</td>
<td>2000-12</td>
</tr>
<tr>
<td>5</td>
<td>Report on National Sedimentation Initiative (ISU) Case Study on Yellow River Basin Sedimentation</td>
<td>UNIOP</td>
<td>2006</td>
</tr>
<tr>
<td>6</td>
<td>Field Methods for Measurement of Fluvial Sediment</td>
<td>Thomas E. Edwins and G. Douglas Hooven</td>
<td>1990</td>
</tr>
<tr>
<td>7</td>
<td>Sediment delivery in a high sediment stream of the Ok River, central Japan</td>
<td>Mikihl Bala</td>
<td>1990</td>
</tr>
</tbody>
</table>

"Simulation Technology" Section

[Image 96x466 to 298x708]

[Image 334x128 to 568x424]

[Image 93x115 to 300x430]
4. ISI Case Studies
Location of the river basins

A range of basins in different areas of the world that provided examples of rivers:

- with both high and low sediment loads
- with different climatic, physiographic socio-economic conditions, and
- with different sets of sediment problems and therefore requiring different sediment management strategies

- Nile River Basin
- Mississippi River Basin
- Rhine River Basin
- Volga River Basin
- Yellow River Basin
- Haihe and Liaohe River Basins
What we find?

-- Sediment Issues
(1) Decrease of sediment yield and load after management projects

- The sediment regimes of each of the ISI case study river basins have been significantly influenced by urban development, river regulation, and land use practices.
- These factors have caused changes in soil erosion rates and sediment yields within each of these basins, as well as the associated sediment load of the rivers.

### Comparison of sediment yields and trends in sediment discharge

<table>
<thead>
<tr>
<th>River Basin</th>
<th>Mean Sediment Load (x10^6/t)</th>
<th>Annual Specific Sediment Yield (t/km²)</th>
<th>Annual Mean Runoff (volume - km²)</th>
<th>Mean Annual Runoff (depth - mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Haihe</td>
<td>150</td>
<td>569.5</td>
<td>27</td>
<td>103</td>
</tr>
<tr>
<td>Liaohe</td>
<td>Pre Dam 46.4</td>
<td>384</td>
<td>5.8</td>
<td>48</td>
</tr>
<tr>
<td></td>
<td>Post Dam 7.9</td>
<td>65</td>
<td>1.7</td>
<td>14</td>
</tr>
<tr>
<td>Yellow</td>
<td>Pre Dam 1243</td>
<td>1653</td>
<td>50</td>
<td>66</td>
</tr>
<tr>
<td></td>
<td>Post Dam 149</td>
<td>198</td>
<td>10</td>
<td>13</td>
</tr>
<tr>
<td>Mississippi</td>
<td>Pre Dam 400</td>
<td>134.2</td>
<td>490</td>
<td>158</td>
</tr>
<tr>
<td></td>
<td>Post Dam 145</td>
<td>48.6</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nile</td>
<td>Pre Dam 120</td>
<td>38.6</td>
<td>80</td>
<td>26</td>
</tr>
<tr>
<td></td>
<td>Post Dam 0.2</td>
<td>0.1</td>
<td>30</td>
<td>10</td>
</tr>
<tr>
<td>Rhine</td>
<td>Pre Dam 7.3</td>
<td>39.5</td>
<td>74</td>
<td>389</td>
</tr>
<tr>
<td></td>
<td>Post Dam 0.2</td>
<td>0.1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Volga</td>
<td>Pre Dam 26</td>
<td>18.8</td>
<td>254</td>
<td>179</td>
</tr>
<tr>
<td></td>
<td>Post Dam 8</td>
<td>5.8</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
The Yellow River Basin has been recognized as having the highest specific sediment yield of all the world’s large river basins.

- Prior to both the construction of reservoirs and the implementation of extensive soil conservation measures within the Loess Plateau: the mean annual specific sediment yield -- 1243 t/km²
- The specific sediment yield of some sub-basins -- 10,000 t/km²
- Measures including the construction of terraces and sediment retaining dams, reforestation and planting of grasses since the late 1950s: the mean annual sediment yield of the basin -- 198 t/km²·yr
Volga and Nile Rivers

Volga River

- under natural conditions, the Volga River exported large amounts of sediment to the Caspian Sea
  - sediment load - 26 Mt/yr / specific sediment yield - 18.8 t/km².yr
- At present, the trapping of sediment by large reservoirs
  - sediment load - 8 Mt/yr / specific sediment yield - 5 t/km².yr

Nile River

- Aswan High Dam
Accelerated soil erosion is a major cause of sediment problems. The main activities leading to increased soil erosion include unsustainable agricultural practices and deforestation. mechanized agriculture / farming on steep slopes / use of pesticides and chemical fertilizers / row cropping / use of surface irrigation.

Mississippi River Basin

intensive land use was historically responsible for significant increases in the sediment load.

Extensive soil conservation programs were initiated in the 1930s. These included:

contour ploughing / replanting trees and grasses / constructing sediment retention dams / stabilizing stream banks.
(3) Sedimentation in reservoirs and the downstream impacts

- A number of reservoirs suffer from severe sediment problems posing significant management issues.

Nile River Basin

- Reservoirs: play a significant role in the economic development and water security of the riparian countries within the basin.

- Khashm El-Girba reservoir in Sudan was constructed in 1964, but by 1977, the reservoir had lost half of its original capacity due to sedimentation.
Khashm ElGirba Reservoir Storage
Loss Rate at Different Levels
Yellow River Basin

- The amount of sediment deposited in reservoirs reached 10.9 billion tonnes by 1989, accounting for 21% of the total storage capacity of all reservoirs.
- Sanmenxia Reservoir, problems with severe sediment accumulation became evident immediately after water impounding commenced.
Sanmenxia Reservoir, Yellow River

- Before the reconstruction program in June 1970, the sediment accumulated in the reservoir totaled 5.3 billion m³, equivalent to an average annual loss of storage capacity of 0.54 billion m³.
Liao/Haihe Rivers Basin

Hongshan Reservoir in the Liaohe River Basin

- From 1962 to 1999, the available storage capacity declined by 36.8%

Guanting Reservoir in the Haihe River Basin

- Due to the large amount of sediment deposited in this reservoir, extensive reconstruction has been required to increase storage capacity.
Downstream impact associated with reservoir sedimentation

**Downstream impact**: generally result from a shortage of sediment and the resulting impacts on the equilibrium of the fluvial system and the environment.

- **Wetland areas**: reliant on sediment to maintain their ecological functioning and biological diversity
- **Estuary environments**: depend on the deposition of nutrient-rich sediment to support fish breeding
- **When sediment is trapped**, these ecological assets may eventually cease to function as wetland ecosystems.

*Nile Delta: Coast line at Rosetta retreated at rate of 120-240 m/yr since 1964.*
Marsh deterioration in the Mississippi River delta region

Mississippi River

- Dam construction during the 1950s and 1960s significantly reduced the suspended sediment load reaching the Mississippi River Delta and the Gulf of Mexico.
- Estimates of the magnitude of the reduction range from 50% to as much as 70%.
- While wetlands throughout the basin have been affected by this decline in sediment supply, the impact has been especially severe in the marshes and estuaries of the Mississippi Delta.
Downstream impact relates to infrastructure

Rhine River Basin

- River training and bed load excavation have significantly changed the sediment budget and morphology of the river.
- Increased erosion has also been observed downstream of reservoirs, endangering the stability of bridges and water diversion structures.
- In the 1950s through to the 1970s, a series of hydroelectric dams were constructed on the border between France and Germany.
- lead to severe sediment deficit problems downstream and associated impacts on infrastructure in the river channel.

The bridge Buchs-Schaan collapsed in 1972 because of the erosion of the river bed. After the collapse numerous bed load excavations were stopped (Landesarchiv Vaduz) (Zarn 2005)
What we learn?

-- Management strategies
Sustainable sediment management should seek to balance sediment inflow and outflow within the impounded reach, while maximizing long-term benefits.

### Measures against reservoir sedimentation

- **In the catchment area**
  - Soil conservation
  - Setting basins
  - Slope and bank protection
  - Bypassing structure
  - Off-stream storage reservoir

- **In the reservoir**
  - Dredging
  - Dead storage
  - Flushing
  - Hydrosuction, air lift
  - Avoiding setting of fine sediments
  - Controlling the turbidity currents

- **At the dam**
  - Sluicing
  - Turbidity current venting
  - Turbining suspended sediments
  - Dam heightening
  - Heightening of intake and bottom outlet structures

(from: Rhine River Basin Report)
Sediment flushing

Xiaolangdi Reservoir on the Lower Yellow River

- Two sediment flushing trials were conducted in July 2002 and September 2003: 66.4 Mt and 120.7 Mt were flushed downstream to the sea
- 13 sediment flushing till 2015. Total sediment flushed to the sea 762 Mt, average elevation in the Lower Yellow River channel decreased 2.03 m.
Underwater dredging or dry excavation management

- Removing sediments by underwater dredging or dry excavation of the deposited material. **high operating costs**
- In some areas, such as the Roseires Reservoir in the Nile River Basin, dredging is necessary as flushing and sluicing are insufficient to control sedimentation in this reservoir.
Prevent or reduce the settling of sediments in the reservoir

Lake Grimsel in Switzerland

- To prevent sediment deposition, submerged dams that block the flow and deflect a major part of the turbidity current were constructed away from the dam wall.
- Larger amounts of sediment was deposited upstream of the obstacles, and away from the dam wall and intake and outlet structures of the reservoir.
- The retention of sediments behind these obstacles should continue for at least 20 to 50 years.
(2) Land management and soil conservation techniques

- The management of soil erosion: construction of terraces, check dams and settling basins, forest planting, increasing vegetation cover and improving land management practices

Yellow River Basin

- Extensive engineering measures have been implemented, particularly in the Loess Plateau

- Construction of terraces for agriculture: In the Loess Plateau over 20% of all agricultural land is now located on such terraces, equivalent to an area of 380,000 ha.

- Construction of ‘check’ or ‘warping’ dams: functions: 1) stabilizing gullies by preventing gully expansion by retrogressive erosion, bank collapse and scouring, 2) reduction of muddy flood peaks by detaining sediment and 3) trapping sediment to create new agricultural land. Now more than 110,000 check dams have been constructed, and more than 300,000 ha of new agricultural land have been created.
Terracing the farmland
Constructing sediment check dams
Revegetating the loess hills
(3) Bed load management

Rhine River Basin

- Where the natural transport of bed load has been interrupted by engineering works, scouring of the river channel can occur.
- In order to counteract the effects of scouring, artificial supply of bed load material is often adopted as a management strategy.
- Approximately 260,000 tonnes of sediment is transported annually by barges and dumped into certain reaches of the Rhine River to compensate for the deficit of bed load material.
What we will do next?

-- Update Guidelines

-- New case studies
5. Possible Collaboration
Possible collaboration with G-WADI

- **Capacity building:** A training workshop is proposed to be organized in Beijing by the ISI, and future workshops.

- **Case studies:** more case studies are proposed, case studies in arid lands in the future.

- **Data sharing:** ISI Information System; Global Data of Erosion and Sedimentation.

- **Co-organize international conferences:** The 14th International Symposium on River Sedimentation will be held in Chengdu, China in 2019.

- **Publications**