Informing Long Term Planning Decisions – Scenario Analysis for Future Flood Management in Taihu Basin, China

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Taihu Basin

- East China, delta region of Yangtze, 37,000km², >40million people, includes Shanghai
- Rapidly developing, 80% low lying (3-4m), Taihu lake, hills in west
- Major basin-wide flooding: 1991 & 1999. Taihu lake level in 1991 @ 4.79m leading to heavy damages and loss of life. In 1999 Taihu lake 5.08m, >$1billion damages
Aims and scope

• **Project aims**
  – How might risks of flooding change in Taihu Basin over next 50 years?
  – What are best options for Government and other stakeholders for responding to future challenges?

• **Scope**
  – Explore impacts of:
    • rapid urbanization and economic development
    • development of flood control system
    • climate change
Conceptual model of flooding
Scenarios @ 2030 and 2050 → 2 pairs giving contrasting futures

- IPCC SRES A2 climate change + A2 socio-economic
- IPCC SRES B2 climate change + Chinese government National Plan (NP)
### Qualitative assessment:
#### Example ranking of drivers and responses

<table>
<thead>
<tr>
<th>Tab1-4 Ranking of Importance of Drivers in the Future Scenarios</th>
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<tbody>
<tr>
<td>2020S</td>
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</table>
Quantified Risk Assessment System

Hydrology model
\[ \downarrow \]
Broad scale hydraulic model
\[ \downarrow \]
Flood risk calculator

Hydrological Models

1999 rainfall and temperature
(rainfall scaled to represent range of return periods, T)

SCS CN models → Effective rainfall
(time series for each T)

VIC models → Mountain runoff
(time series for each T)

Sluice rules

Flood cell pump capacities

Volume entering each flood cell (for each T)

Maximum channel water levels around each flood cell (for each T)

Yangtze levels (1999 observed)
Initial Taihu lake level
Coastal levels (1999 observed)

TBRAS (GIS-based)
Calculate expected breach inflow volumes as function of WL (for each T)

Convert flood volumes to depths (add local polder effects) (for each T)

Calculate damages values (for each T and annualised)
Calculate other indicators (inundated areas etc for each T)

Outputs (maps and tables)
- Economic flood damage by land use type and district (for each T & annualised)
- Affected population (for each T)
- Inundated areas by land use type and district (for each T)
Hydrology: VIC model

9 sub-catchments

Upland areas
VIC model calibration

<table>
<thead>
<tr>
<th>Period scale</th>
<th>$E_r$ (%)</th>
<th>$R^2$</th>
<th>Ens</th>
</tr>
</thead>
<tbody>
<tr>
<td>year</td>
<td>0.77</td>
<td>0.760</td>
<td>0.826</td>
</tr>
<tr>
<td>month</td>
<td>0.759</td>
<td>0.809</td>
<td></td>
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</tbody>
</table>

Xitiaoxi Basin

discharge (m$^3$/s) vs. time (month)
Broad scale hydraulic model

- Wide-area, sparse-data model, fast enough to run many cases needed for scenario analysis, reproduces at a sufficient level of accuracy the broad features of flooding and approximate flood levels and extents
- Selected ISIS as the most appropriate modelling software ([www.ch2m.com/isis](http://www.ch2m.com/isis))
- Model elements:
  - Inflows from hills
  - Inflow/outflow exchange with the Yangtze at N
  - Tidal boundary effects E & S
  - Direct rainfall in ‘plains’ area
  - Channel system in ‘plains’ area
  - Taihu lake storage/level
  - Gates / other major control structures
  - Main flood embankments/dikes
  - Internal polders and pumping
Hydrological inflow nodes from hilly areas

Taihu lake storage unit

Yangtze water level boundaries

Key/aggregated sluices/pumps represented

ISIS model contained:
- 2400 river sections
- 22 inflow boundaries
- 42 water level boundaries
- 200 flood cells

90 day simulation in 30 mins.

Direct net rainfall into lakes & local ‘storage’ as fn(P, ET, land cover)

Simplified (aggregated) channel links
Recorded & modelled water levels 1999
Quantified Risk Assessment System

Hydrology model
↓
Broad scale hydraulic model
↓
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TBRAS

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### Sample Results - future damages

<table>
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<tr>
<th>Baseline 1999</th>
<th>Baseline 2005</th>
<th>2050 socio-economic change only</th>
<th>2050 climate change only</th>
<th>A2 (CC) / A2 (SE)</th>
<th>B2 (CC) / NP (SE)</th>
</tr>
</thead>
</table>

#### Socioeconomic change → 5x increase in damages
Sample Results - future damages

Climate change → 5x increase in damages
Sample Results - future damages

CC + socioeconomic $\rightarrow$ 15x to 20x
Subsequent work looked at responses

- Improving the flood defences
- Reserving flood pathways
- Flood risk mapping
- Land-use and flood-management planning
- Flood insurance
- Improving mitigation and coping capacities
Key points:

• **Able to provide strong messages of the need for adaptation** (under range of futures)

• **Initial qualitative approach** – identify most significant processes that need including in modelling. Also helps with team working and stakeholder buy-in.

• **Modular approach & automation.** Nested models working at different scales. Intermediate results available for scrutiny (not ‘black box’).

• **Hydrodynamic model at regional scale** – ISIS model of some 4500km of channel and 30,000km$^2$ – unusual but successful & necessary because flat system driven by hydraulics.
Summary

- **Scenario-based analysis** (not ‘what will happen’, but what could happen under range of potential futures, let the *decision makers* decide which futures they plan for)
- Qualitative analysis of drivers and responses
- Set up & run broad-scale hydrology/hydraulics models for flood risk scenario analysis
- Quantitative impact analysis of drivers and responses
- **Communicating → messages & policy options**
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