

Regional Flood Resilience Assessment in Dongting Lake Region of China

Jing LIU

**Academy of Disaster Reduction
and Emergency Management;
Beijing Normal University
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Outline

- ❖ **Resilience Literature Review**
- ❖ **Understanding and Context**
- ❖ **Conceptual Modeling**
- ❖ **Case Study and Assessment**

1.1 Research Background: Why is resilience so important?

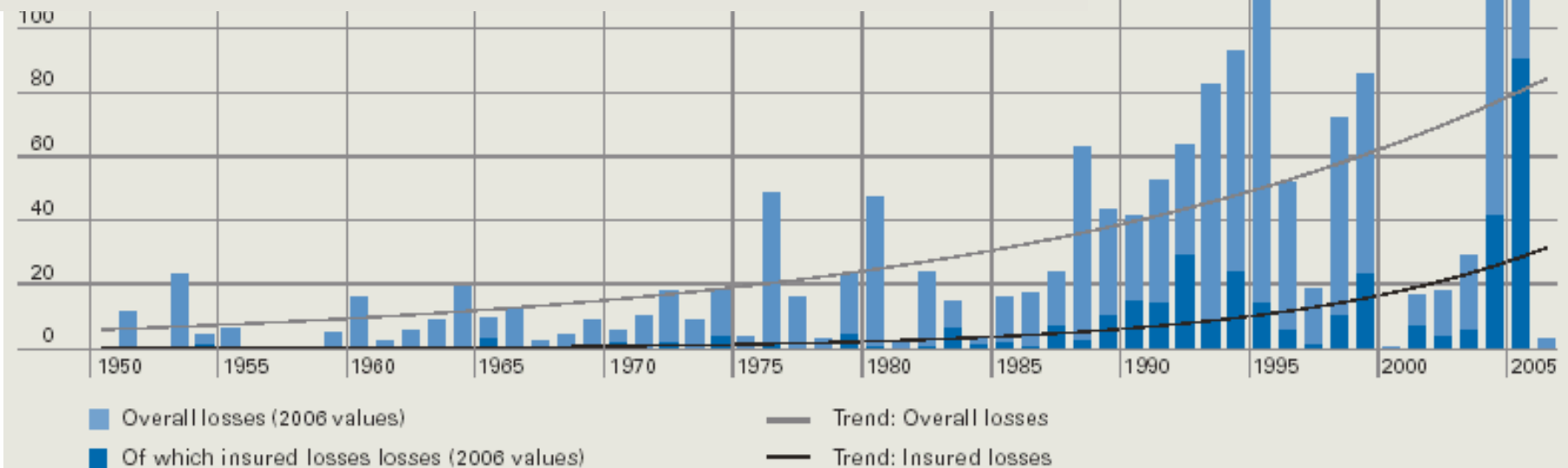
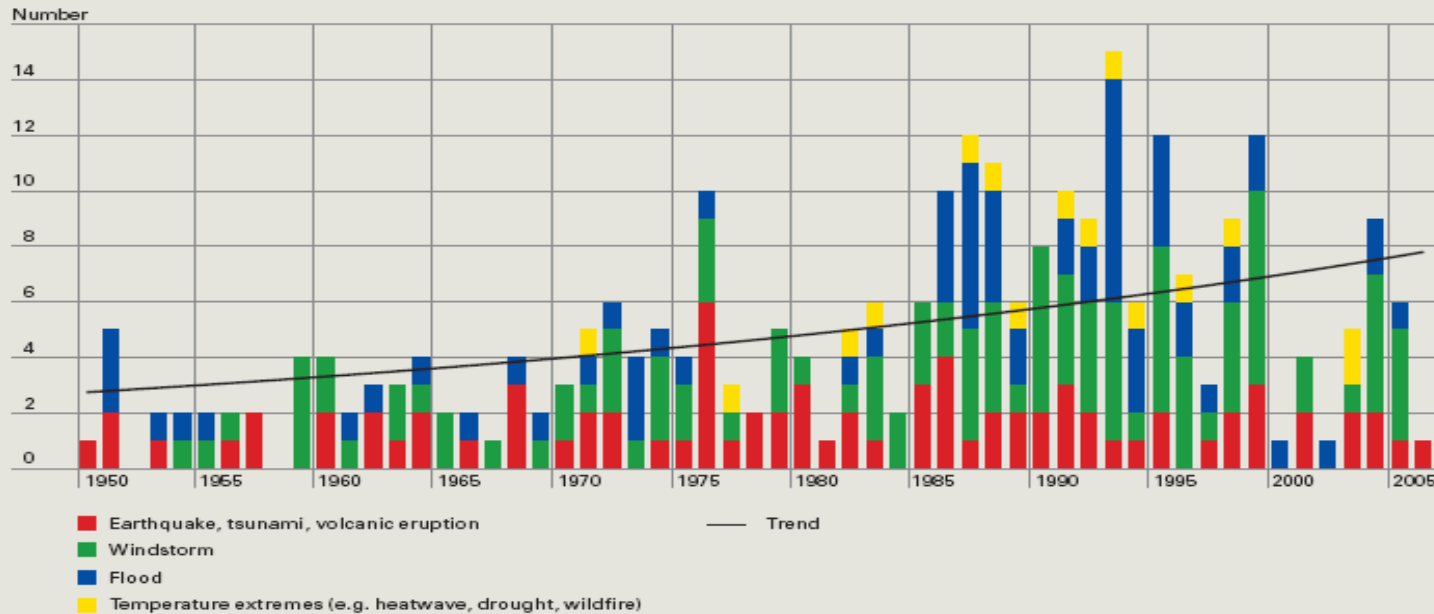
- ❖ **Natural Disaster Losses - all over the world still increasing.**
- ❖ **Mission of International Strategy for Disaster Reduction is to build “disaster-resilient communities” (UN ISDR).**
- ❖ **Broader concepts of Resilience: developed originally in ecosystem context, and later extended to other related complex systems**

Great Natural Catastrophe Loss Trends

(Munich Re, 2007)

Number of events

The chart shows the number of great natural catastrophes for each year, divided according to type of event.



1.2 Resilience Theory: Development of this concept

- ❖ **Origin : from mechanical resilience to ecological resilience**
- ❖ **Development : from ecological resilience to socio-economic resilience**
- ❖ **Reification : from social-economic resilience to disaster resilience**

(1) Origin : From mechanical resilience to ecological resilience

- ❖ **Resilience of a material:** the quality of being able to store strain energy and deflect elastically under a load without breaking or being deformed.
- ❖ **Original ecological concepts:** focus on stable states and transitions between them; a resilient ecosystem can withstand shocks and rebuild itself when necessary.
 - **Ecological Resilience:** ability of a system to maintain its structure and patterns of behavior in the face of disturbance (Holling 1973)
 - **Engineering Resilience:** time for system to return to original state after disturbance (Pimm 1984)
- ❖ **Resilience theory has co-evolved with the development of the theory of Complex Adaptive Systems (CAS)**

Adaptive Cycle

Graphic Metaphor for Dynamism of Resilience

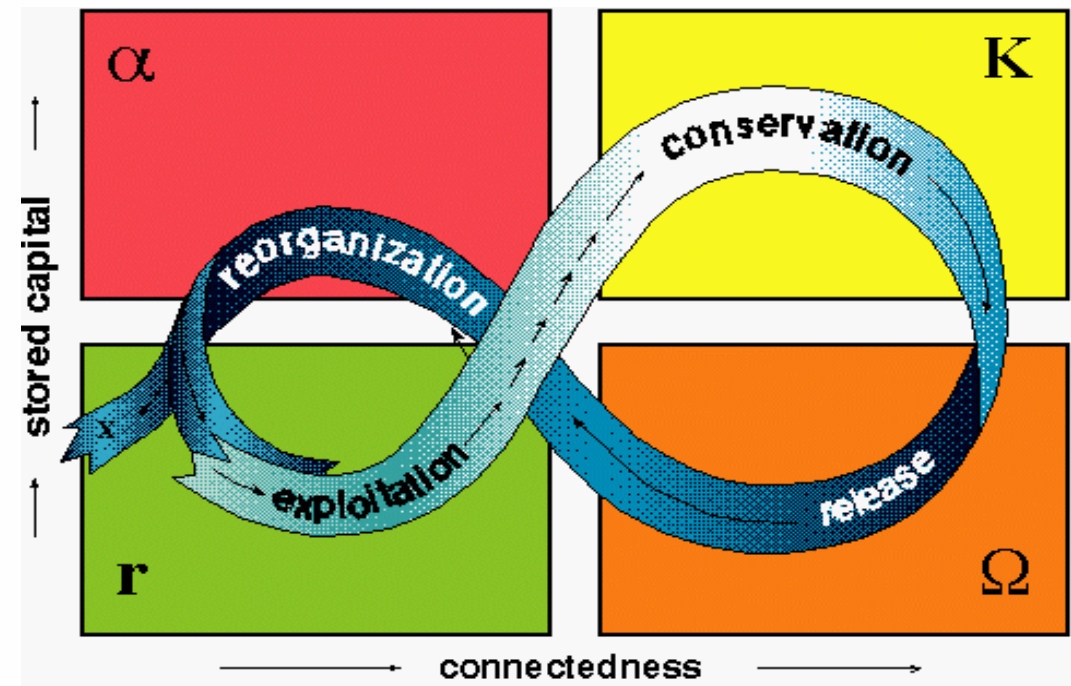
(e.g., Walker et al. 2004)

Slow, cumulative forward loop:

1. Growth or exploitation (r)
2. Conservation (K)
 - ↳ Resources increasingly locked up
 - ↳ System less flexible and responsive to external shocks

Unpredictable back loop:

1. Collapse or release (Ω)
2. Reorganization (α)
 - ↳ Innovation and new opportunities possible



Leads to new (r) phase that may resemble or differ from previous

(2)Development : From ecological resilience to socio-economic resilience

- ❖ **Timmerman(1981): one of the first to discuss the resilience of society to climate change, links resilience to vulnerability.**
- ❖ **Dovers and Handmer: distinguish between the reactive and proactive resilience of society**
- ❖ **Resilience Alliance: "Resilience" as applied to integrated systems of people and the natural environment:**
 - **Capacity to absorb disturbance and stay in same "basin of attraction" (stability)**
 - **Potential for self organization**
 - **Capability for learning and adaptation**

(2)Development : From ecological resilience to socio-economic resilience

- ❖ **“human dimension”** :how the reflects properties of complex adaptive systems, and possibly social influence resilience factors
- ❖ **Enhancing social resilience by:**
 - enhancing the resilience of life-supporting ecosystems
 - spreading risk by diversifying resource use and encouraging alternative livelihood activities and lifestyles
 - building robust institutions and governance systems that underpin our capacity to prepare for and cope with uncertainty and change

(3) Reification : From social-economic resilience to disaster resilience

- ❖ **EMA (Emergency Management Australia, 2001) : a set of guidelines on resilience and vulnerability for application in community risk assessment.**
- ❖ **UN/ISDR(2004): “The capacity of a system, community or society potentially exposed to hazards to adapt, by resisting or changing in order to reach and maintain an acceptable level of functioning and structure.”**
- ❖ **Manyena (2006): the existing definitions refinement of disaster resilience: from more outcome-oriented to more process-oriented.**
- ❖ **MCEER (Multidisciplinary Center for Earthquake Engineering Research): conceptual and measurement of improvements in earthquake resilience of communities, measuring economic resilience, etc.**

“Disaster resilience”

RESEARCH

- ❖ “Resilient communities may bend before the extreme stresses of natural hazards, but they do not break” (Godschalk 2003)
- ❖ Resilience as way of coping with uncertainty
- ❖ “...the ability to survive disasters without significant loss, disruption, and stress” and ability to cope with the consequences, learn, and change (NRC 2006)
- ❖ Conceptual and measurement of improvements in earthquake resilience of communities (MCEER 2003)

PRACTICE

- ❖ Project Impact, with goal of disaster-resilient cities (FEMA)
- ❖ Interest in how post-disaster response practices affect long-term resilience (Red Cross)
- ❖ Mission of International Strategy for Disaster Reduction is to build “disaster-resilient communities” (UN ISDR)

Characteristics of Resilient Communities

- ❖ **Functionally diverse**
- ❖ **Redundant**
- ❖ **Autonomous**
- ❖ **Efficient**
- ❖ **Strong**
- ❖ **Interdependent**
- ❖ **Adaptable**
- ❖ **Collaborative**
- ❖ **Strong social networks**
- ❖ **Inclusive institutional structures**
- ❖ **Well-developed insurance markets**
- ❖ **...**

(Foster 1997, Peacock and Ragsdale 1997, Tobin 1999, Godschalk 2003, Pelling 2003, Berke and Campanella 2006, and others)

MCEER Work

- ❖ Earthquake Resilience: the ability of social units to mitigate hazards, contain the effects of disasters when they occur, and carry out recovery activities in ways that minimize social disruption and mitigate the effects of future earthquakes.
- ❖ A resilient system should demonstrate three characteristics:
 - reduced failure probabilities
 - reduced consequences from failures
 - reduced time to recovery.

MCEER Work



$$R = \int_{t_0}^{t_1} [100 - Q(t)] dt$$

Earthquake resilience measurement framework
(Bruneau et al., 2003)

MCEER Work

❖ Four interrelated dimensions of Resilience:

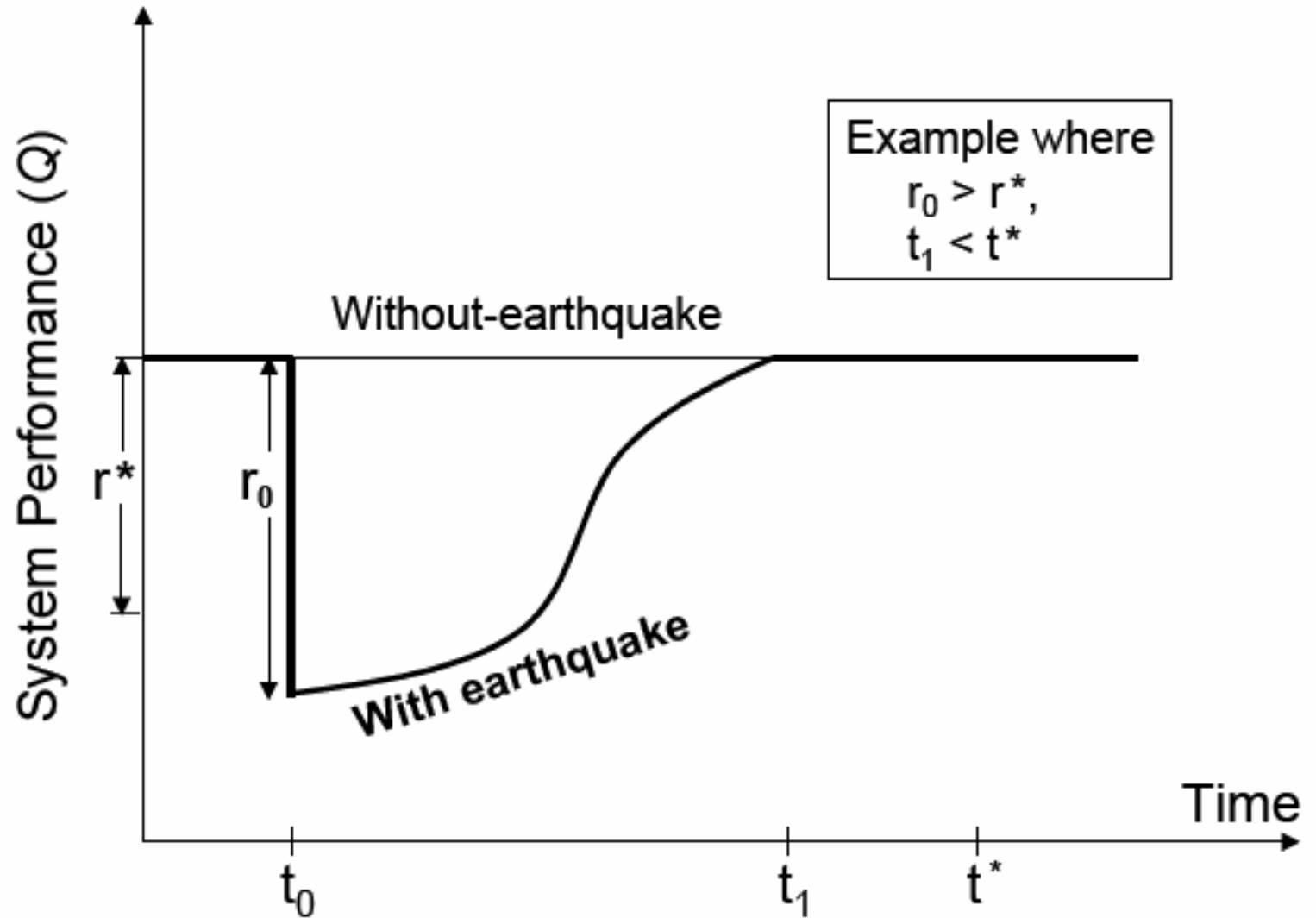
- **Technical** — physical systems perform when subjected to earthquake forces
- **Organizational** — the ability to respond to emergencies and carry out critical functions
- **Social** — the capacity to reduce the negative societal consequences of loss of critical services
- **Economic** — the capacity to reduce both direct and indirect economic losses

❖ Four properties of resilience:

- **Robustness** — strength to withstand a given level of stress without loss of function
- **Rapidity** — the capacity to meet priorities and achieve goals in a timely manner
- **Redundancy** — the extent to which elements, systems that are substitutable
- **Resourcefulness** — the capacity to identify problems, establish priorities, and mobilize resources

MCEER Work

Resilience :
the probability
that the system
of interest will
meet pre-
defined
performance
standards A in
a scenario
seismic event
of magnitude i

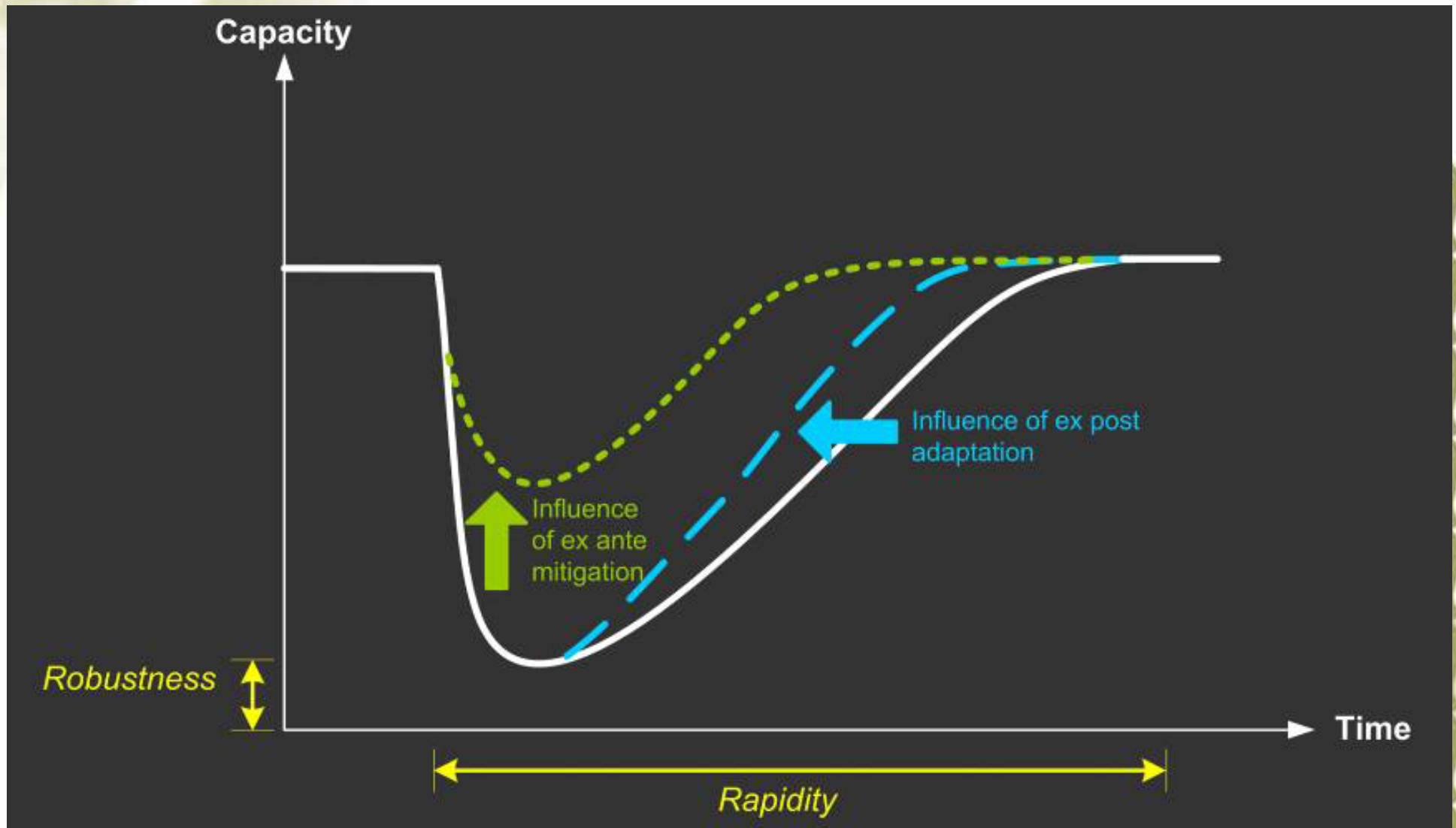


$$\Pr(A|i) = \Pr(r_0 < r^* \text{ and } t_1 < t^*)$$

$$Z_A = \sum_i \Pr(A|i) \cdot \Pr(i)$$

(Chang et al., 2004)

Disaster Recovery and Resilience

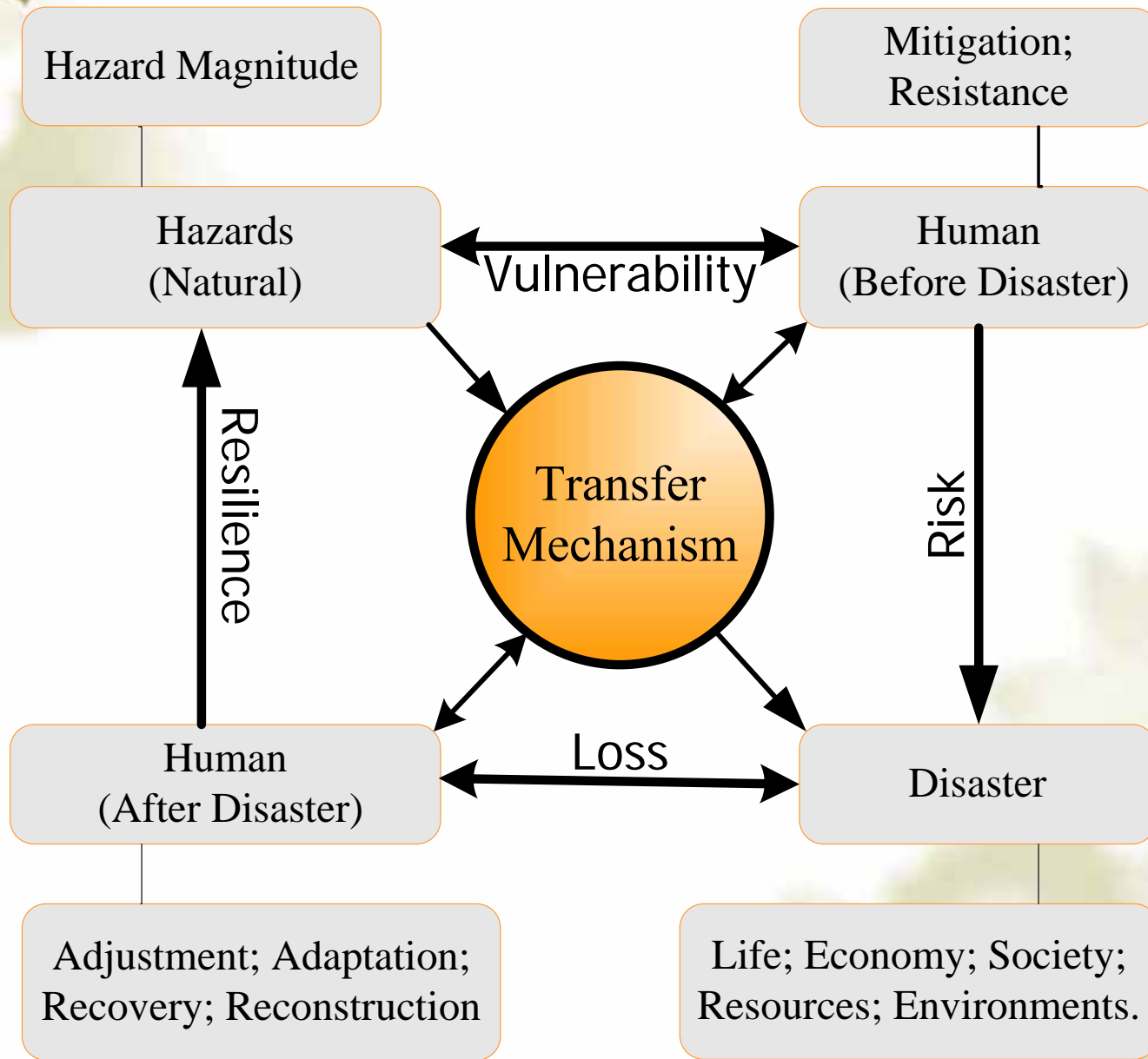


1.2 Conclusion

- ❖ Resilience appeared to be a useful concept that was broadly accepted in both academic, government management and rancher circles.
- ❖ The specifics of any specific system in question (e.g. resilience *of what* factor *to what* disturbance), but it's beneficial for practice development to do some appropriate operational work of resilience in ecological and social context.
- ❖ Disaster Resilience is seen as a comprehensive concept related to many system functions before, during and after disasters, but still at a conceptual research stage with any normative concept.
- ❖ Quantitative measurement helps in understanding how various factors contribute to resilience and why some communities are more resilient than others.

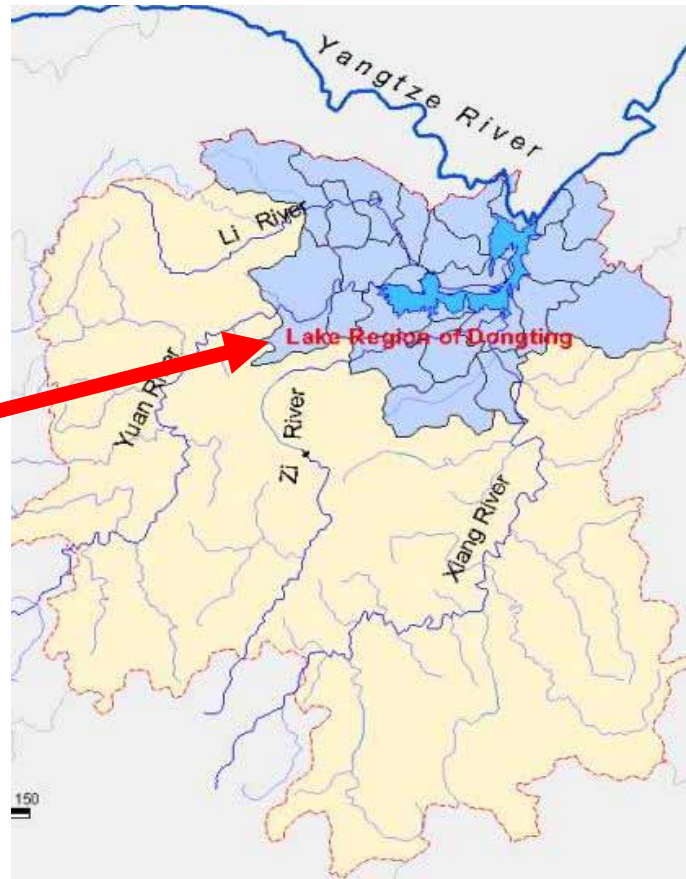
2 Understanding and Context

- ❖ **Metaphor of a balloon:** external shock → shape itself and absorb the external shock → remove of the external point → resume its original shape or a new shape
- ❖ **Related disaster system elements:**
 - Risk — the degree and probability to be confronted with the disaster events,
 - Vulnerability — the possibility and sensitivity to be influenced by the hazards' shock.
 - Resilience — **broad sense** includes the system resistance to hazard (static part) and the post-disaster recoverability (dynamic part); **narrow sense** only includes the latter part of adjustment, adaptation, recovery and reconstruction ability after disaster.



Relationship between disaster system elements

Research Area



**Dongting Lake region
in Hunan Province, China**

Research context

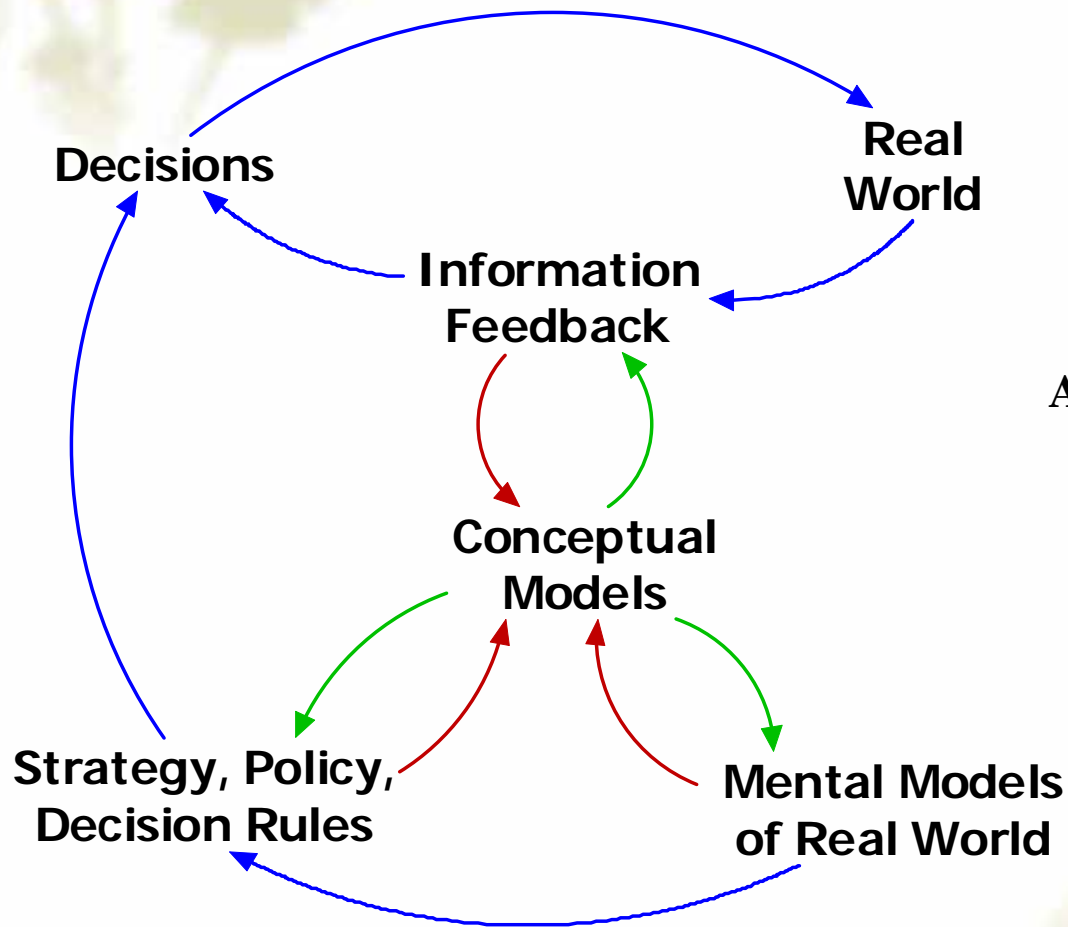
- ❖ Regional flood resilience: the disaster resilience of the influenced people in the Dongting Lake Region to floods.
- ❖ Disaster resilience: the loss minimizing capacity and recovery speed to the desirable socio-economic stable state with the normal functioning and development.
- ❖ Research goal: find out the driving factors of regional flood resilience, and then do some assessment work supporting decision-making.

3 Conceptual Modeling

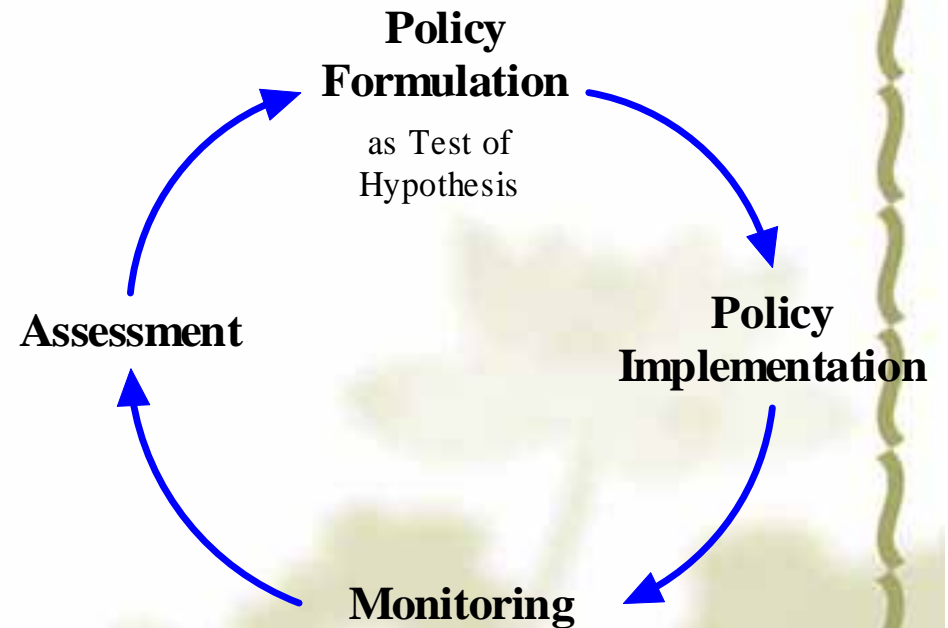
Five-dimension of flood resilience:

- ❖ **social dimension:** human consciousness and activity, such as the disaster and insurance consciousness, in-disaster action ability, social supporting level.
- ❖ **economic dimension:** the system economic resilience, mainly depends on the regional economic level and industry structure diversity, etc.
- ❖ **organizational dimension:** the disaster governance level, including the government disaster management, organization and decision making ability.
- ❖ **technical dimension:** disaster mitigation infrastructures' capacity, including dikes and dams, hospitals, pumping and irrigation machinery, communication and transportation efficiency, etc.
- ❖ **natural dimension:** land and agricultural system recoverability, influenced by agriculture cultivation system, crop types, land use structure and intensity, etc.

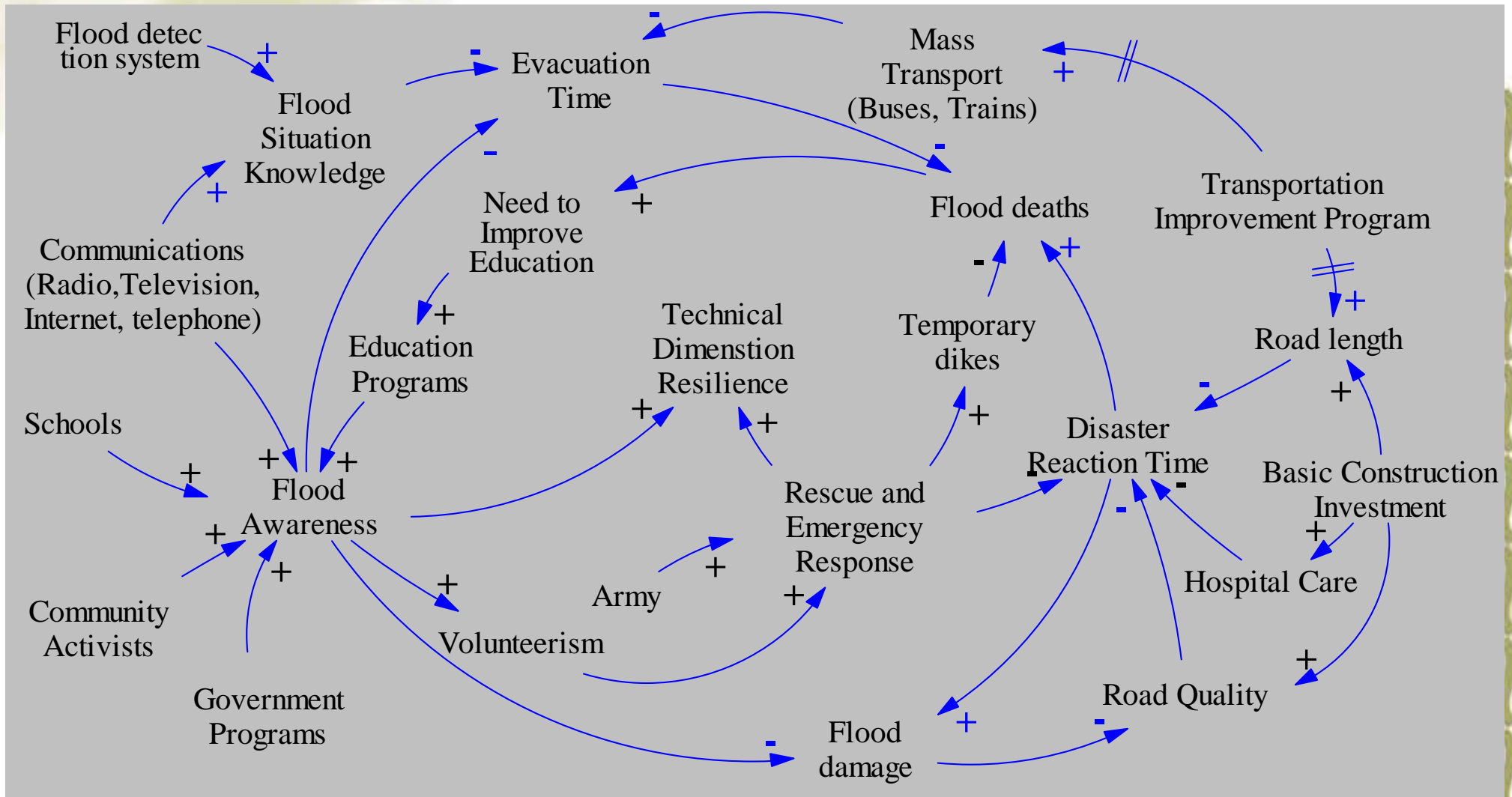
Group Model Building with System Dynamics Models



Adaptive Management Learning Cycle



technical dimension



Comprehensive assessment index system of flood disaster resilience

Social-dimension factors	Economic-dimension factors	Organizational-dimension factors	Technical -dimension factors	Natural-dimension factors
<ul style="list-style-type: none"> ✧ Total population ✧ Urban population proportion (%) ✧ Employed persons' proportion (%) 	<ul style="list-style-type: none"> ✧ GDP ✧ Per capita GDP ✧ Per capita annual net income of rural residents ✧ Primary industry proportion of GDP (%) ✧ Secondary industry proportion of GDP (%) 	<ul style="list-style-type: none"> ✧ Per sq km government revenue ✧ Ratio of revenue and expenditures ✧ Per sq km total investment in fixed assets ✧ Per capita total retail sales of consumer goods 	<ul style="list-style-type: none"> ✧ Per sq km total length of dikes per sq km ✧ Per 10 thousand capita health care institutions ✧ Per 10 thousand capita hospital beds ✧ Per 10 thousand capita personnel in health care institution ✧ Machinery for agriculture drainage and irrigation ✧ Power of agricultural machinery ✧ Capacity of reservoirs ✧ Capacity of power generating sets of the small hydropower station in rural areas 	<ul style="list-style-type: none"> ✧ Cultivated area proportion of total land ✧ Ratio of paddy fields and dry fields ✧ Total sown area ✧ Food production ✧ Aquatic production ✧ Irrigated area proportion of cultivated area (%)

4 Case Study and Assessment

Data:

- ❖ 1990-2005 socio-economic data from regional year book
- ❖ 1998 big flood loss data in Dongting Lake Region from the government department of civil affair

Research Framework:

1. Select two counties for case study, with similar socio-economic condition but quite different flood loss in 1998
- ↓
2. Make semi-quantitative analysis to find out the important indicators influencing post-disaster recovery
- ↓
3. Design a simple resilience index to do further resilience assessment and comparison

4.1 Case Study

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	
1	人均GDP	县	宁乡县	岳阳市区	岳阳县	华容县	湘阴县	平江县	汨罗市	临湘市	武陵区	鼎城区	安乡县	汉寿县	澧县	临澧县	
2	1990	1144	936	4347	1093	1171	1223	634	1048	1159	6647	1269	1232	979	1247	1324	
3	1991	1203	968	4860	1142	1368	1273	659	1112	1159	7109	1279	1275	1023	1140	1375	
4	1992	1422	1165	5450	1296	1469	1486	735	1223	1386	7672	1386	1311	1156	1341	1607	
5	1993	1757	1553	6685	1620	1697	1755	776	1398	1602	8325	1870	1669	1440	1547	1944	
6	1994	3024	2416	9721	2330	2620	2798	1123	1844	2417	7834	2804	2338	2245	2281	3457	
7	1995	4086	2981	13081	2793	3389	3544	1328	3291	2957	9214	3553	3287	2528	3243	4119	
8	1996	5072	3643	15854	3420	3483	4114	2187	3649	3383	10197	3555	3868	2505	3991	4797	
9	1997	5745	4117	15017	3544	4070	4723	2525	3885	3850	9049	4514	3605	3237	3993	5077	
10	1998	6412	4530	14932	3879	4279	4892	2754	4379	4036	Q 桃源县	R 石门县	S 津江市	T 益阳市	U 南县	V 桃江县	W 沅江市
11	1999	6811	4762	7020	4188	4611	4419	3109	4691	4100	1244	843	1502	1862	1238	945	1359
12	2000	6941	4721	17714	4423	5326	4892	2872	5024	4250	1303	858	1481	1888	1296	947	1339
13	2001	7726	5215	8539	4957	5376	5617	3169	5674	4710	1371	932	1634	2350	1443	1149	1405
14	2002	8619	5703	9621.7	5744	6134	6527	3886	6731	6260	1731	1226	2061	3009	1595	1341	1703
15	2003	9870	6795	10048.7	6524	7288	7590	4642	7624	6800	2508	1871	2713	3093	2478	1697	2504
16	2004	11906	8352	11823.3	7358	8392	8538	5385	8648	7950	3085	2485	2993	2772	2934	2053	3370
17	2005	14659	11687	14756.3	7936	9234	9496	5817	8677	7700	3929	2959	3343	3038	2798	2367	2964
											4821	3365	3627	3485	3285	2460	3659
											5313	3621	4006	3988	2960	2510	4035
											5757	3776	4286	4117	3153	2446	4301
											6099	4072	4681	4596	3365	2655	4545
											5991	4572	5386	3980.5	3583	2621	4577
											5620	5038	6125	4293	3794	2896	4983
											7258	6323	7063	4655	4685	3550	6149
											7224	7801	8591	5847.5	6230	4425	6846
											8407	9244	9956	6670	6376	5640	8681

GDP per capita from 1990-2005

号码	县名	Direct Loss in 1998	Flood-affected area	备注
1	望城县	56817.49	10.75	长沙市
2	宁乡县	70949.25	20.72	长沙市
3	岳阳市辖区	98000.00	39.78	岳阳市
4	岳阳县	186410.00	63.20	岳阳市
5	华容县	176600.00	70.80	岳阳市
6	湘阴县	142100.00	77.00	岳阳市
7	平江县	64300.00	50.20	岳阳市
8	汨罗市	111500.00	61.00	岳阳市
9	临湘市	55700.00	45.50	岳阳市
10	常德市辖区	45980.00	40.11	常德市
11	安乡县	280500.00	59.70	常德市
12	汉寿县	38656.00	23.65	常德市
13	澧县	316100.00	125.80	常德市
14	临澧县	34300.00	37.00	常德市
15	桃源县	71250.00	71.07	常德市
16	石门县	86400.00	118.33	常德市
17	津市市	34856.00	18.00	常德市
18	益阳市辖区	185452.80	50.20	益阳市
19	南县	167057.00	24.00	益阳市
20	桃江县	151873.00	33.80	益阳市
21	沅江市	105170.00	74.90	益阳市

Counties for Comparison

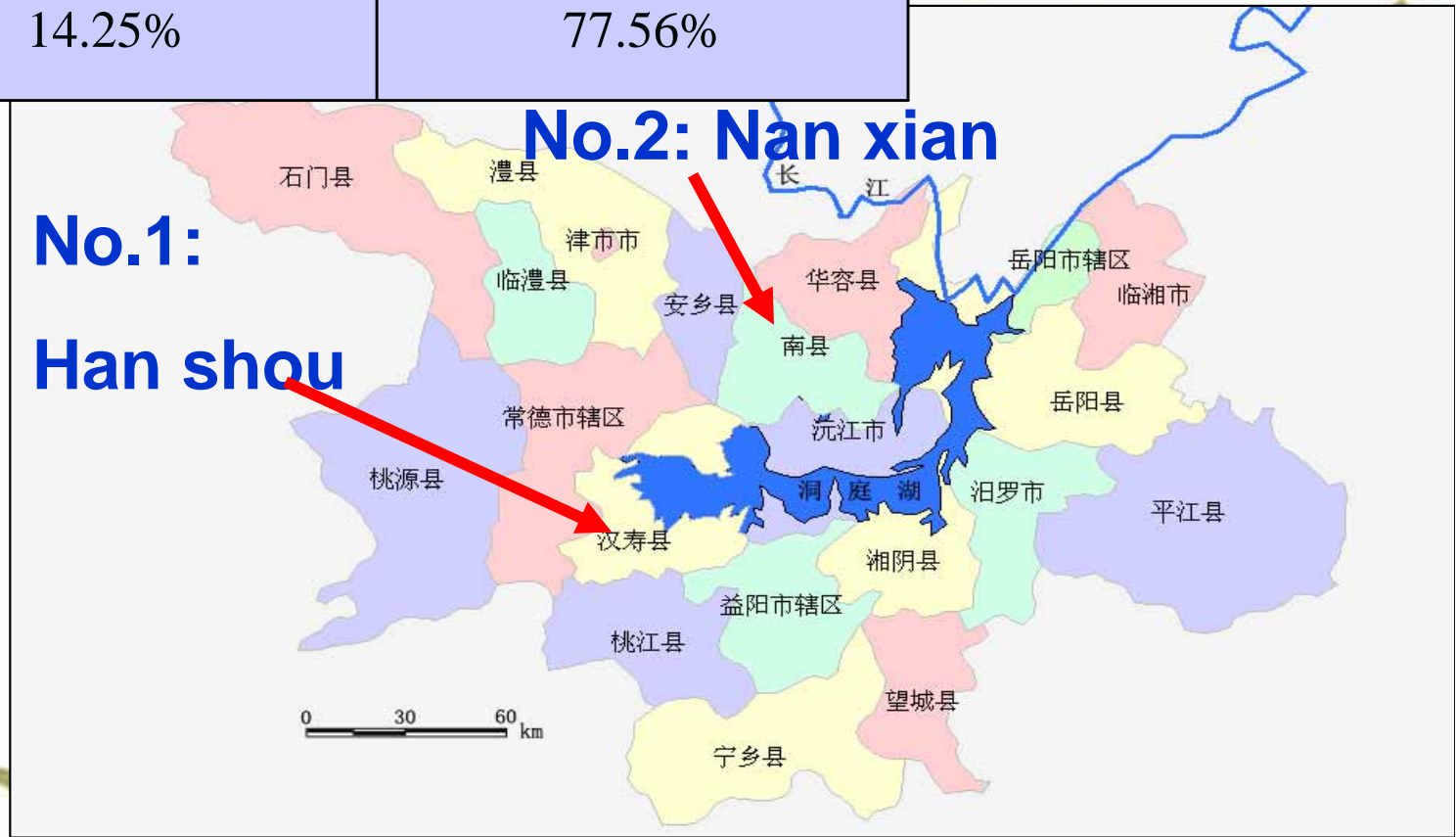
Year	Hanshou County	Nanxian County
1998 GDP (10,000RMB)	271357	215383
1998 Flood Loss (10,000RMB)	38656	167057
1998 Loss/GDP	14.25%	77.56%

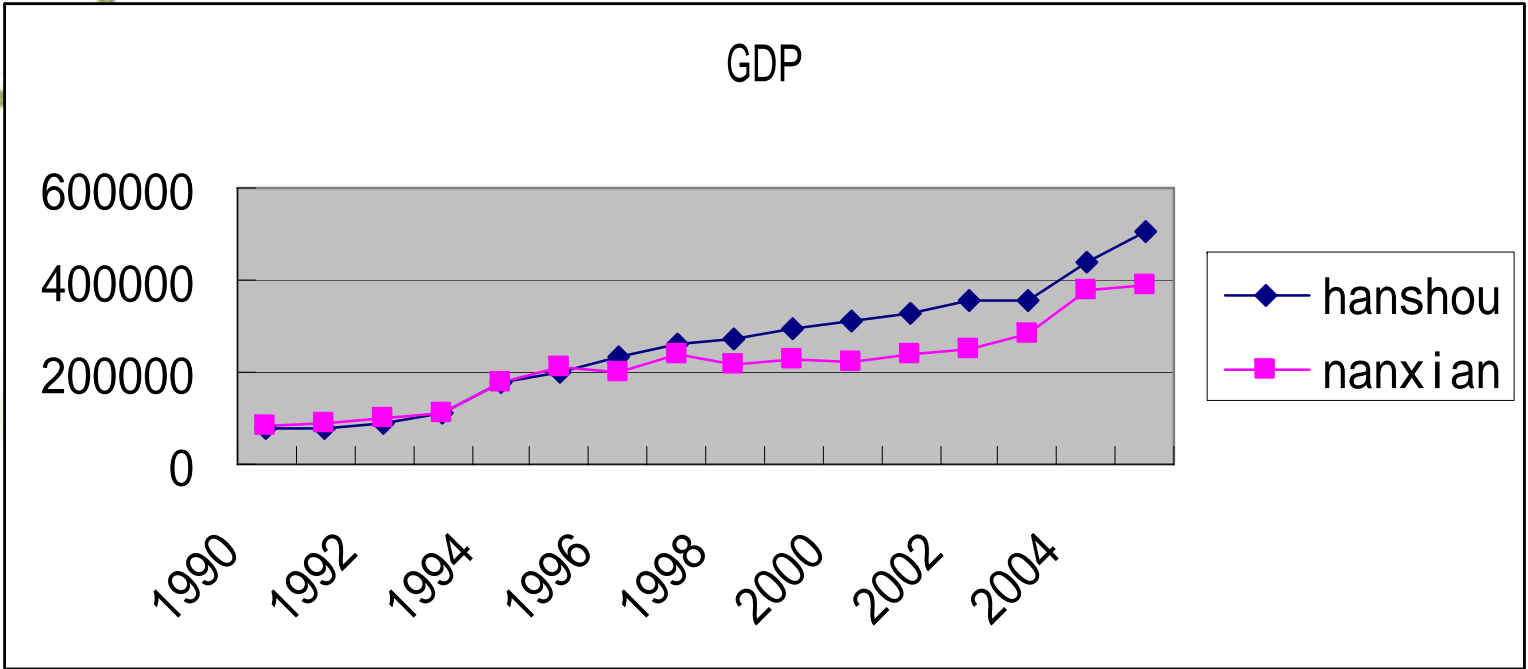
Location

Loss in 1998

No.1:
Han shou

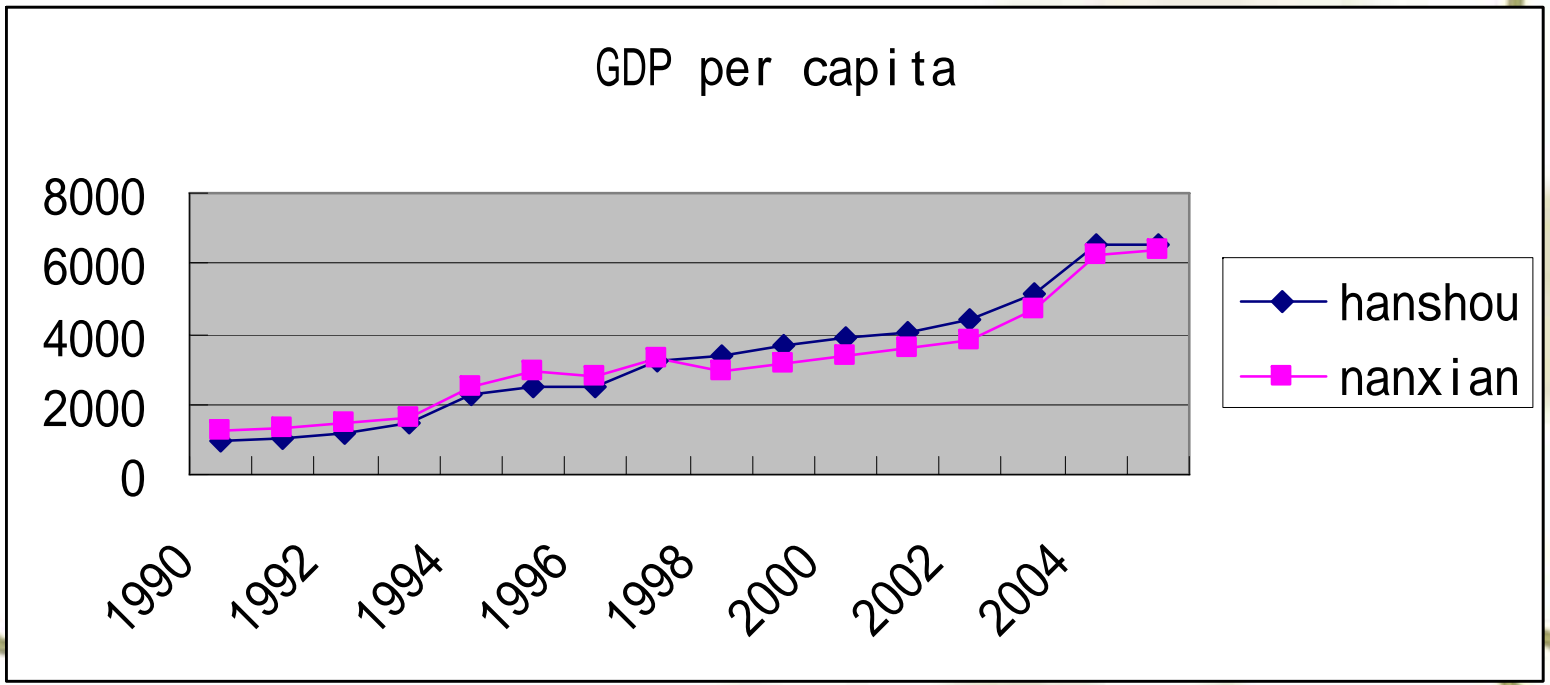
No.2: Nan xian

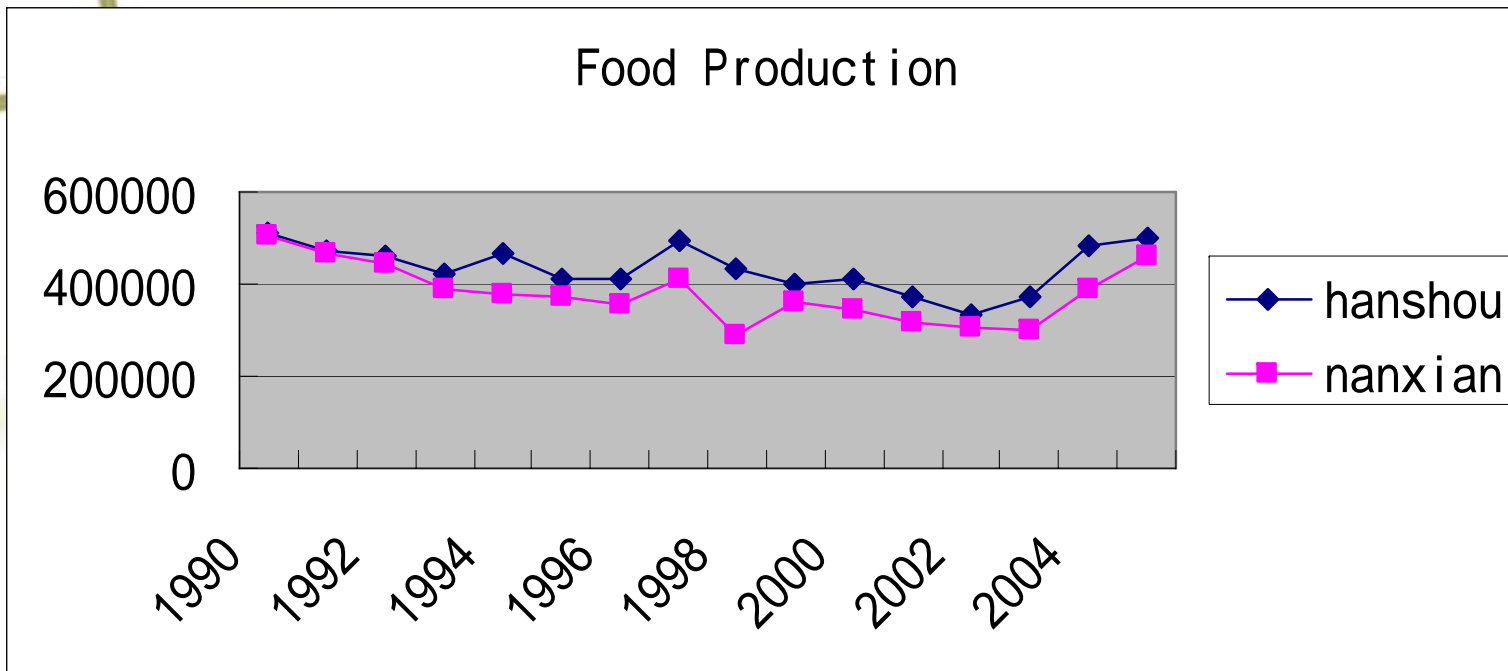




GDP from 1990-2005

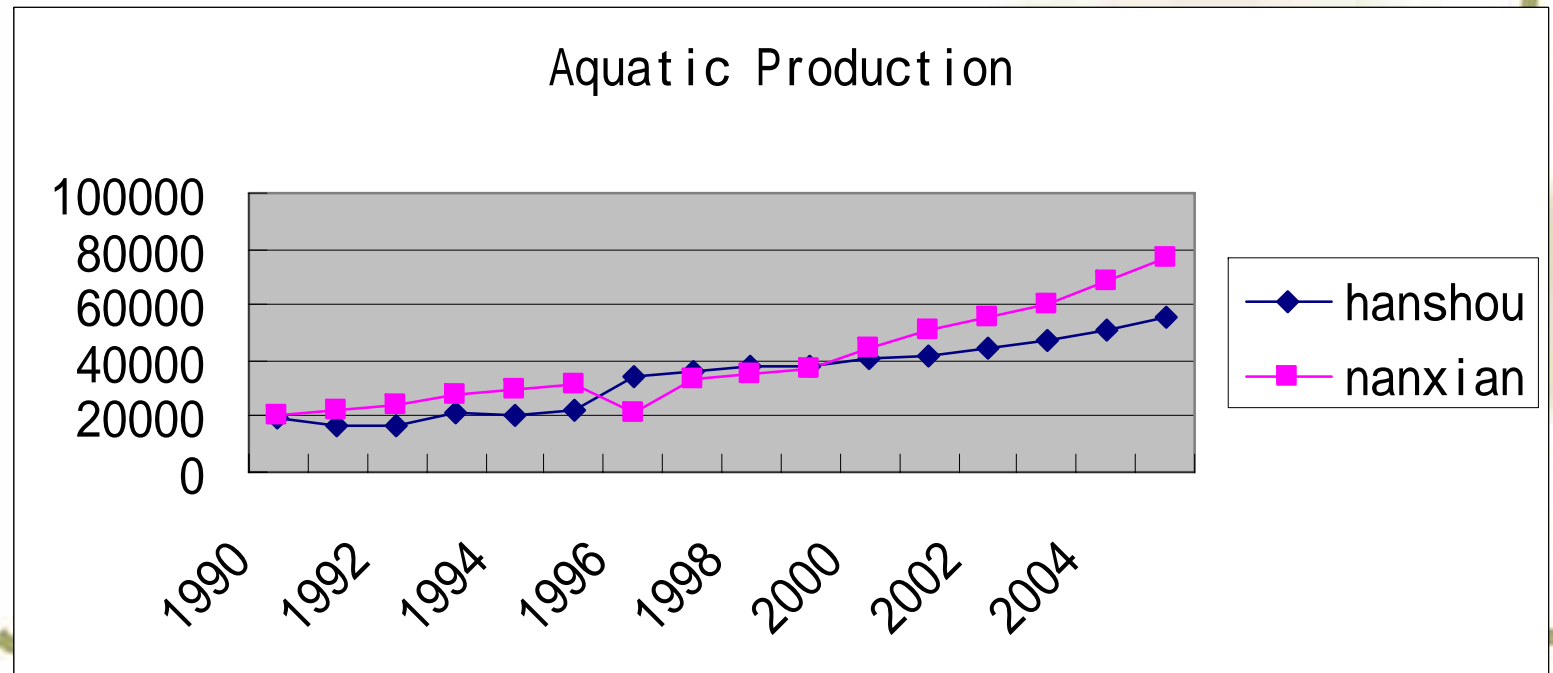
GDP Per Capita from 1990-2005





Food Production from 1990-2005

Aquatic Production from 1990-2005



Important Indicators

26 indicators' development gap comparison:

- ❖ **GDP**
- ❖ **Food production**
- ❖ **Aquatic production**
- ❖ **Total investment in fixed assets**
- ❖ **Public sanitary source (Per 10 thousand capita hospital beds)**

4.2 Resilience Index

1. Introduce the above 5 most important indicators as assessment factors

2. Use Delphi method to deliver weight of the indicators

$$\text{Resilience index} = 0.4 \text{ GDP} + 0.2 \text{ FP} + 0.2 \text{ IFA} + 0.1 \text{ AP} + 0.1 \text{ PSS}$$

3. Design resilience index equation for final calculation, with indicator standardization

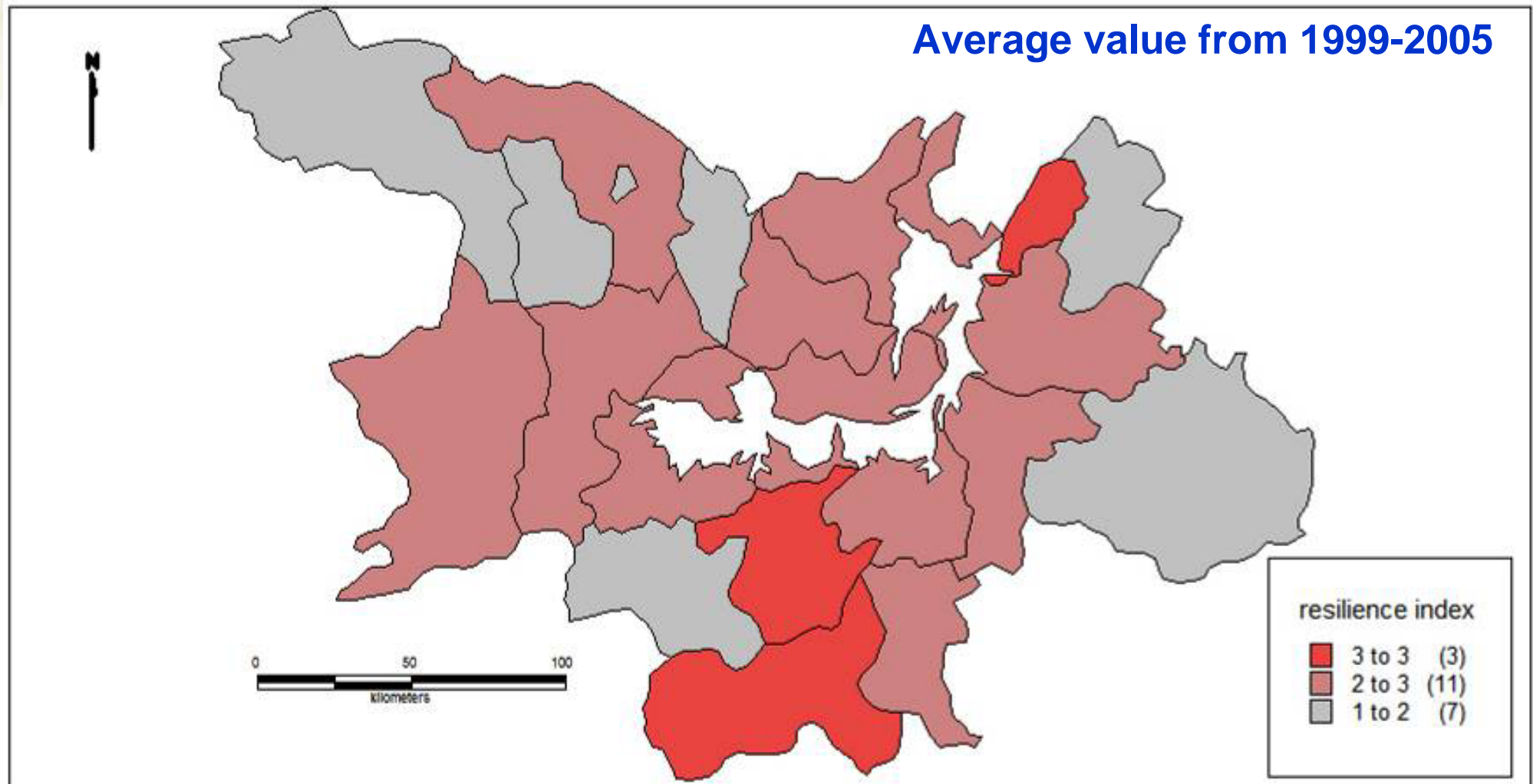
$$R_j = \frac{D_{ij}W_i}{(\max D_{ij}W_i + \min D_{ij}W_i)}$$

- ❖ indicator i , county j , W_i , the weight of i indicator;
- ❖ D_{ij} , the i indicator value of j county;
- ❖ $\max D_{ij}W_i$ & $\min D_{ij}W_i$, maximum and minimum value of the indicator weighted sum.

4. Case study assessment results:

$$R_{\text{hanshou}} = 2.38 < R_{\text{nanxian}} = 2.62$$

4.3 Regional Resilience Assessment of Dongting Lake Region



Inner-part counties are more resilient than outer-part counties

4.4 Policy Suggestion

- ❖ Improve disaster recoverability construction, especially in the lower-level outer areas of the lake region;
- ❖ Pay more attention to disaster reduction and mitigation with rapid economic development;
- ❖ Combine the structural and non-structural measures to reduce disaster risk;
- ❖ Facilitate flood insurance in high-risk region to guarantee people's livelihood.

The background features a light cream color with faint, stylized floral illustrations in a muted greenish-yellow. A decorative border with a wavy, scalloped pattern in the same color runs along the right and bottom edges. The text is centered and rendered in a bold, blue, sans-serif font with a subtle drop shadow.

**Thanks for
your attention!**