清華大學
Tsinghua University

ESCAPE/WMO Typhoon Committee Roving Seminar, Vientiane, LAO PDR, Nov 4-6, 2015

Topic B: Part 3
Strategies and practice of flash flood hazard mitigation in Mainland China

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Nov 5, 2015

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Outline

1. Flash flood disasters in mainland China
2. National strategies of hazard mitigation
3. Practices at the county level
4. Future development: National platform

1. Flash flood disasters in the mainland

1. Overview

What is flash flood?

Short-duration flood due to heavy rainfall in mountain streams. In China also included its induced debris flows and landslides, leading to heavy losses of economy and human life.

1. Overview

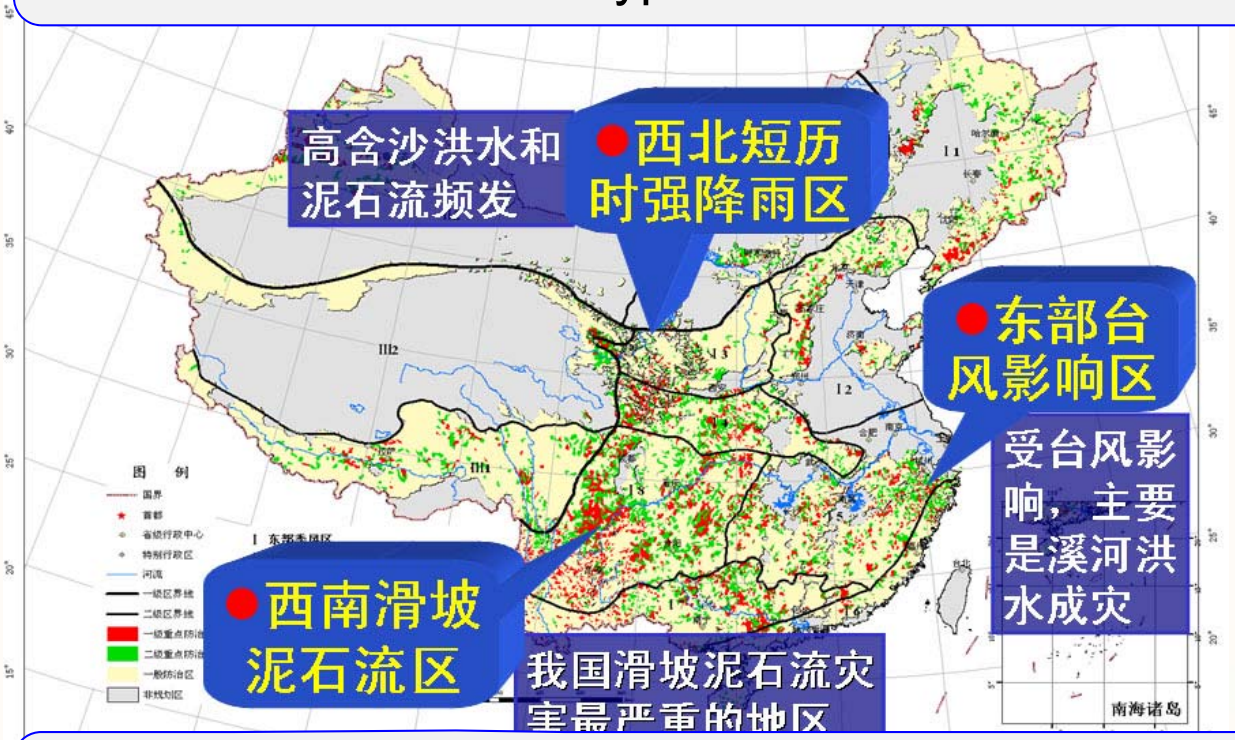
Features of flash flood

- Sudden & quick
- Energetic & destructive
- Hard to monitor and forecast accurately

1. Overview

Three patterns of flash flood

Northwestern China: short-duration rainstorms,
hyperconcentrated floods or muddy flows



Eastern China:
Typhoon
Water-stony flood

Southwestern China: Heavy rainstorms,
Landslides and debris flows

1. Overview

Distribution of flash flood-prone area

- ❖ Mountainous area: 2/3 of the land
- ❖ Complex hydro-meteorological and topological conditions: multiple patterns
- ❖ Large population and concentrated inhabitants: prone to flood disasters

- ❖ **Widespread in space**
- ❖ **Frequent in time**

1. Overview

Distribution of flash flood-prone area

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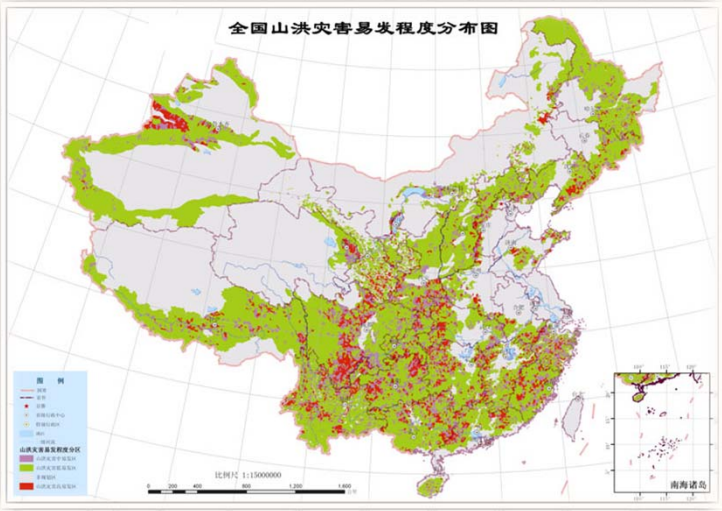
- ❖ Complex hydro-meteorological and topological conditions: multiple patterns
- ❖ Large population and concentrated inhabitants: prone to flood disasters

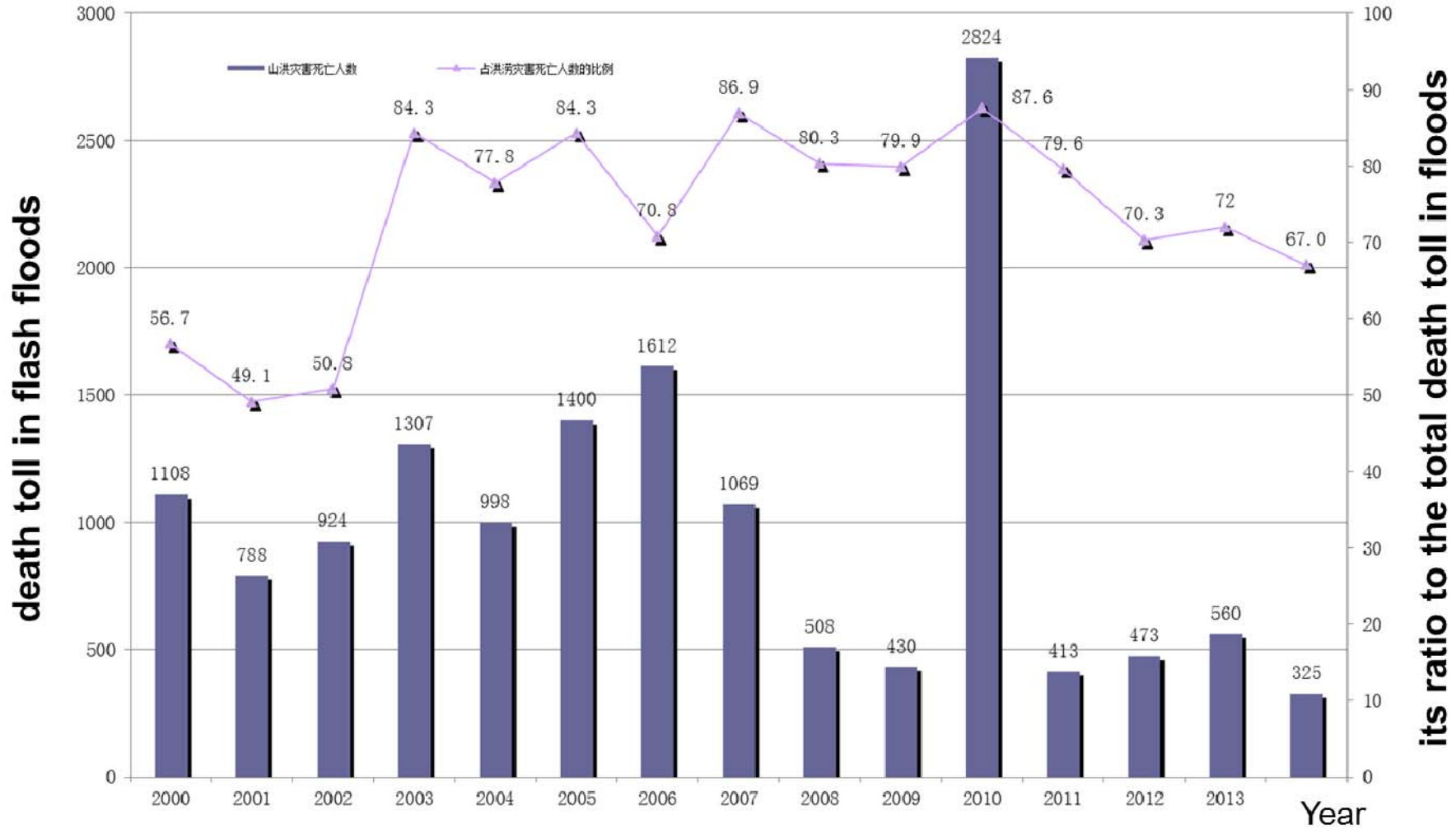


Wide range and large population:

- ❖ **274/643 prefecture-level city (>2/5)**
- ❖ **560 million people influenced**
- ❖ **74 million inhabitants under direct threat**

1. Overview

Death toll in flash floods from 2000 to 2014



However, flash flood hazard has usually been neglected for a long time.

1. Overview

Overall challenges in hazard mitigation and disaster control

Comprehensive detailed survey has not been performed yet in some flood-prone areas.

Monitoring network was coarse and **warning devices were in serious shortage**; the warning information was hard to transmit.

Ambiguous responsibility in organizing flash flood control activities.

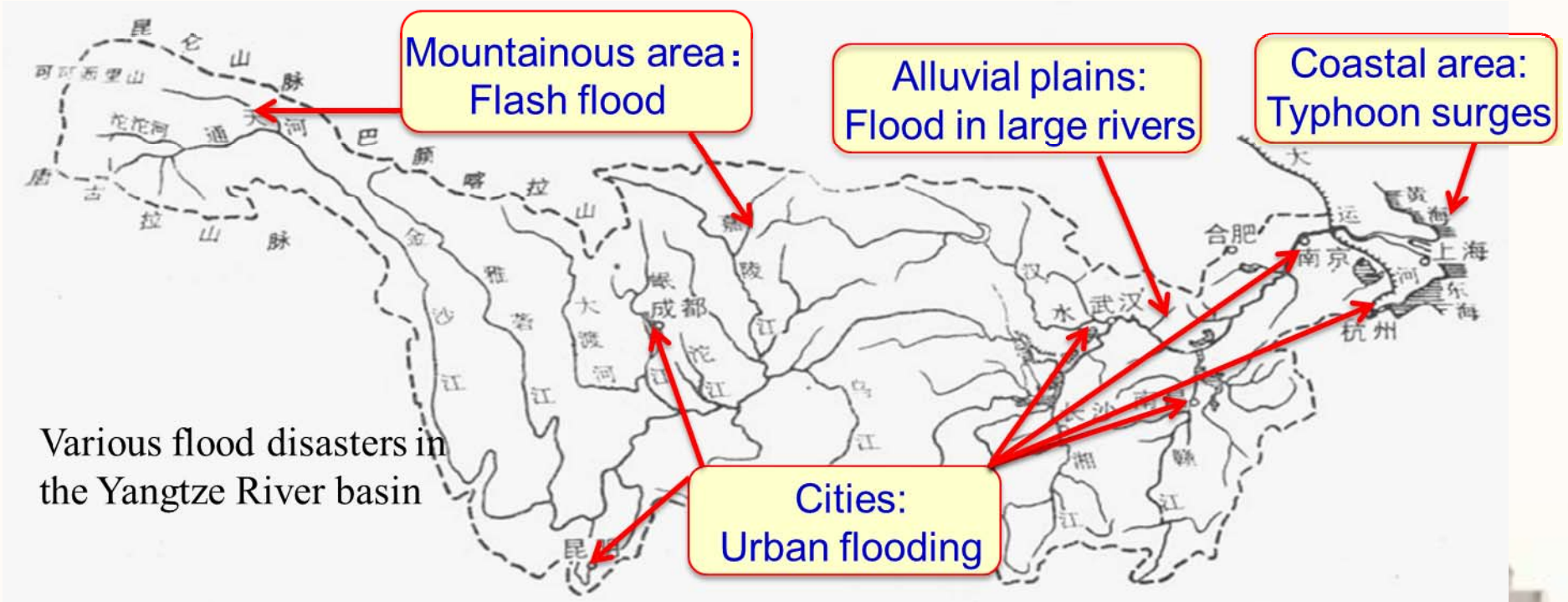
Poor feasibility of mitigation plan.

Public awareness needed be improved.

2. National strategies for flash flood hazard mitigation

2. National strategies

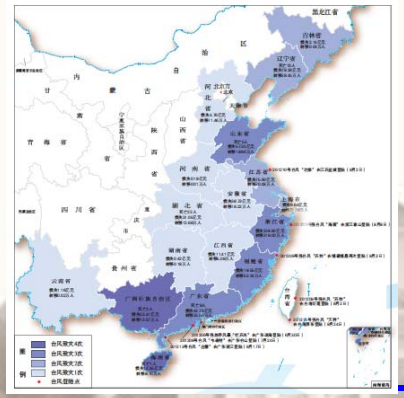
❖ **Floods in the mainland: 4 types in general**



Various flood disasters in the Yangtze River basin

2. National strategies

- **Large rivers have been given first priority in flood control**
- Seven large rivers: Yangtze, Yellow, Zhujiang, Huai…
- River basin authorities: Yangtze Conservancy commission….



2. National strategies

National planning was approved in 2006

The State Council approved the *National Flash Flood Control Planning* (NFFCP) in 2006

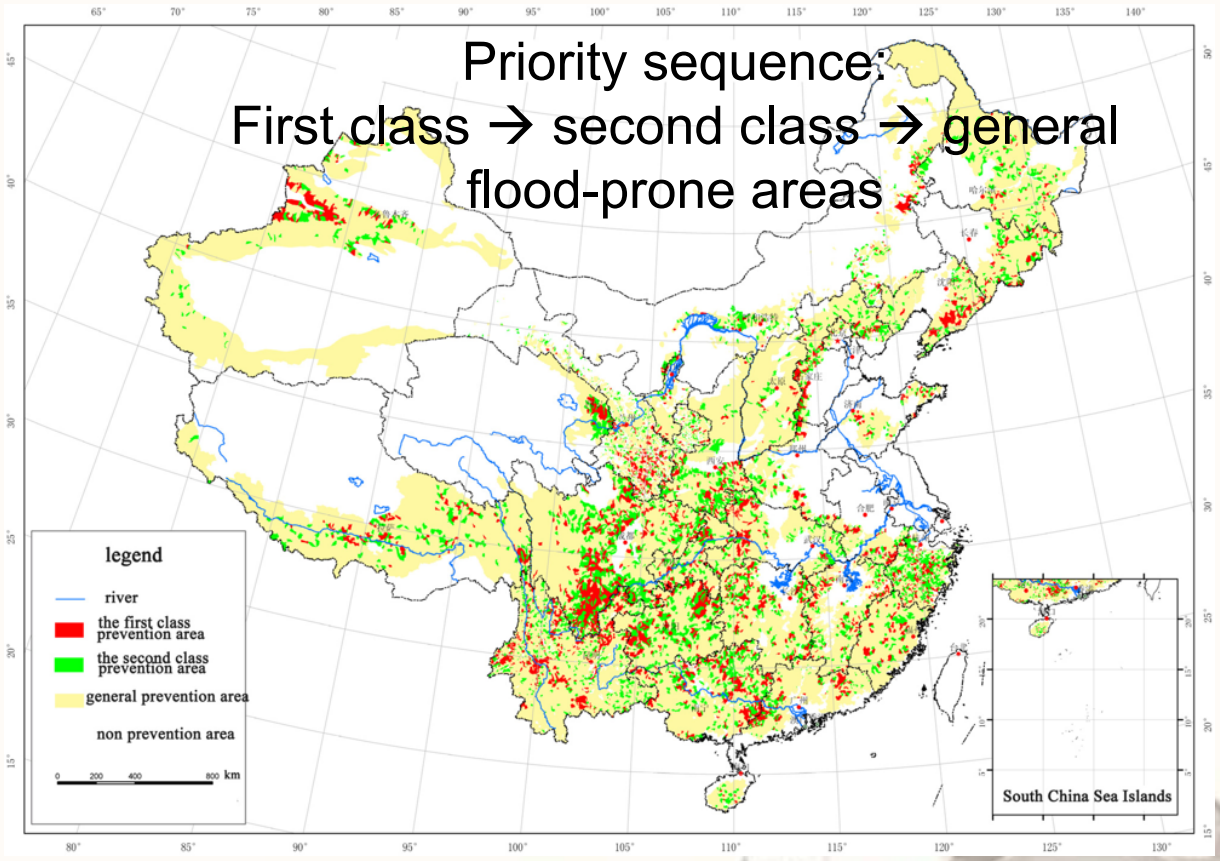
- **Investigation**: detailed survey & analysis
- **Region:** 4.63 million km^2
- **Population:** 560 million people
- **Investment:** total budget of ￥187 billion
- **Implementation:** non-structural measures at the first step

In 2005, the Ministry of Water Resources, together with the Ministry of Land and Resources, China Meteorological Administration, the former Ministry of Construction and the former State Environmental Administration, compiled the *National Flash Flood Control Planning* (NFFCP).

2. National strategies

National planning was approved in 2006

2006



Sun et al. Framework of national non-structural measures for flash flood disaster prevention in China, Water, 2012, 4(1), 272-282

2. National strategies

The Ministry of Water Resources asked the local authorities to conduct studies in pilot counties.

Pilot counties started in Feb 2009

- First 103 pilot counties specified to explore practical measures.
- Subsidization from the central government: ￥200 million.

Central government → Province → Prefecture → County
County → Town → Village → Group → Family

2. National strategies

2010

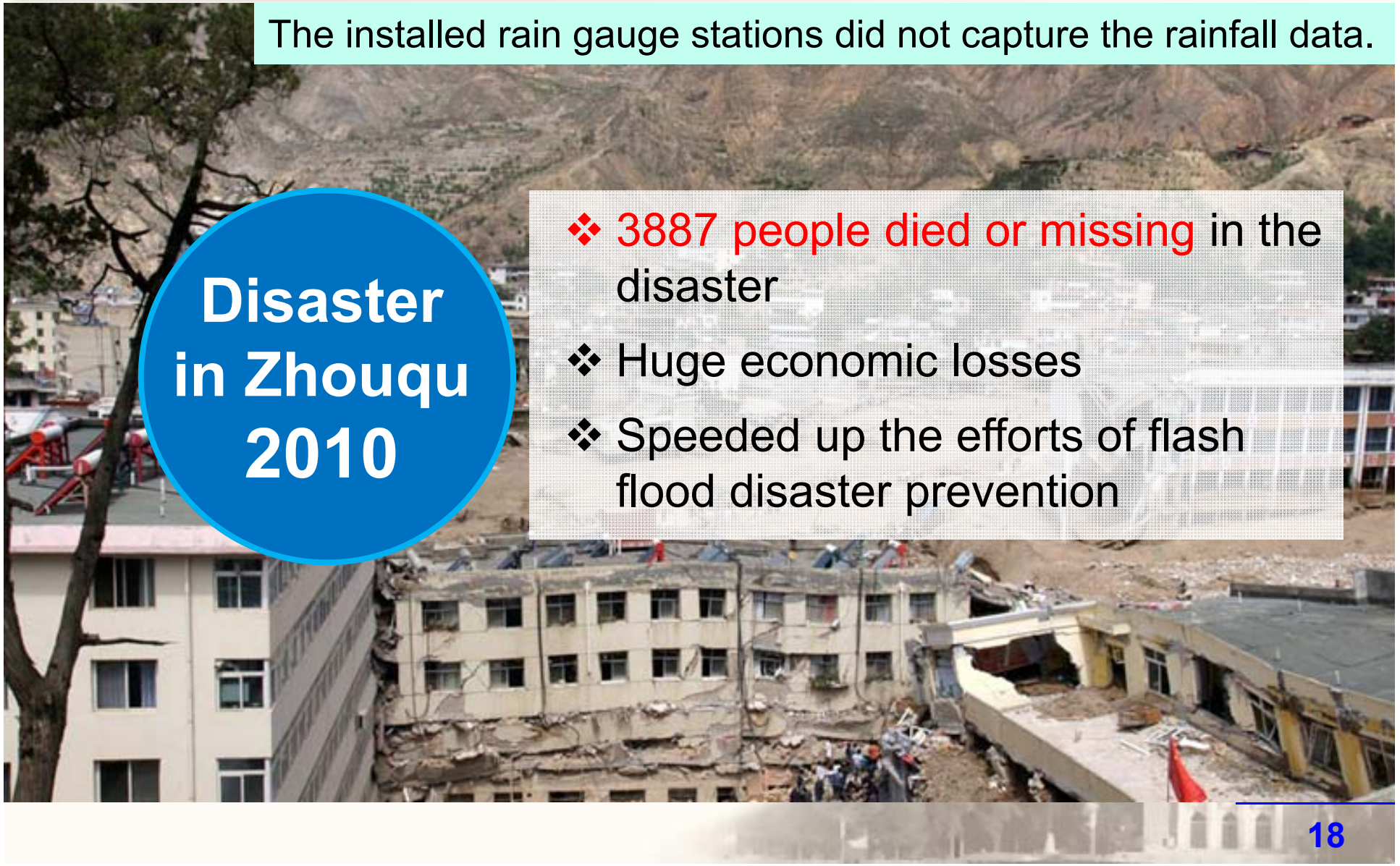
1836 counties initiated in 2010

Based on the experience from these pilot counties, the construction of non-structural measures on flash flood disaster prevention for 1836 counties was officially initiated in 2010.

Central government ➔ Province ➔ Prefecture ➔ County
County ➔ Town ➔ Village ➔ Group ➔ Family

2. National strategies

The installed rain gauge stations did not capture the rainfall data.



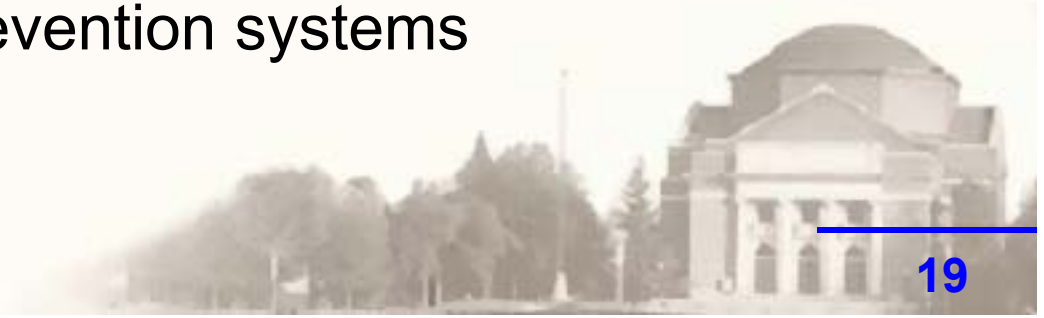
Disaster in Zhouqu 2010

- ❖ 3887 people died or missing in the disaster
- ❖ Huge economic losses
- ❖ Speeded up the efforts of flash flood disaster prevention

2. National strategies

2012

- 2058 counties were specified to construct the prevention plan.
- Initiate non-structural measures at the county level
- Build up monitoring, forecasting, warning, and other disaster prevention systems



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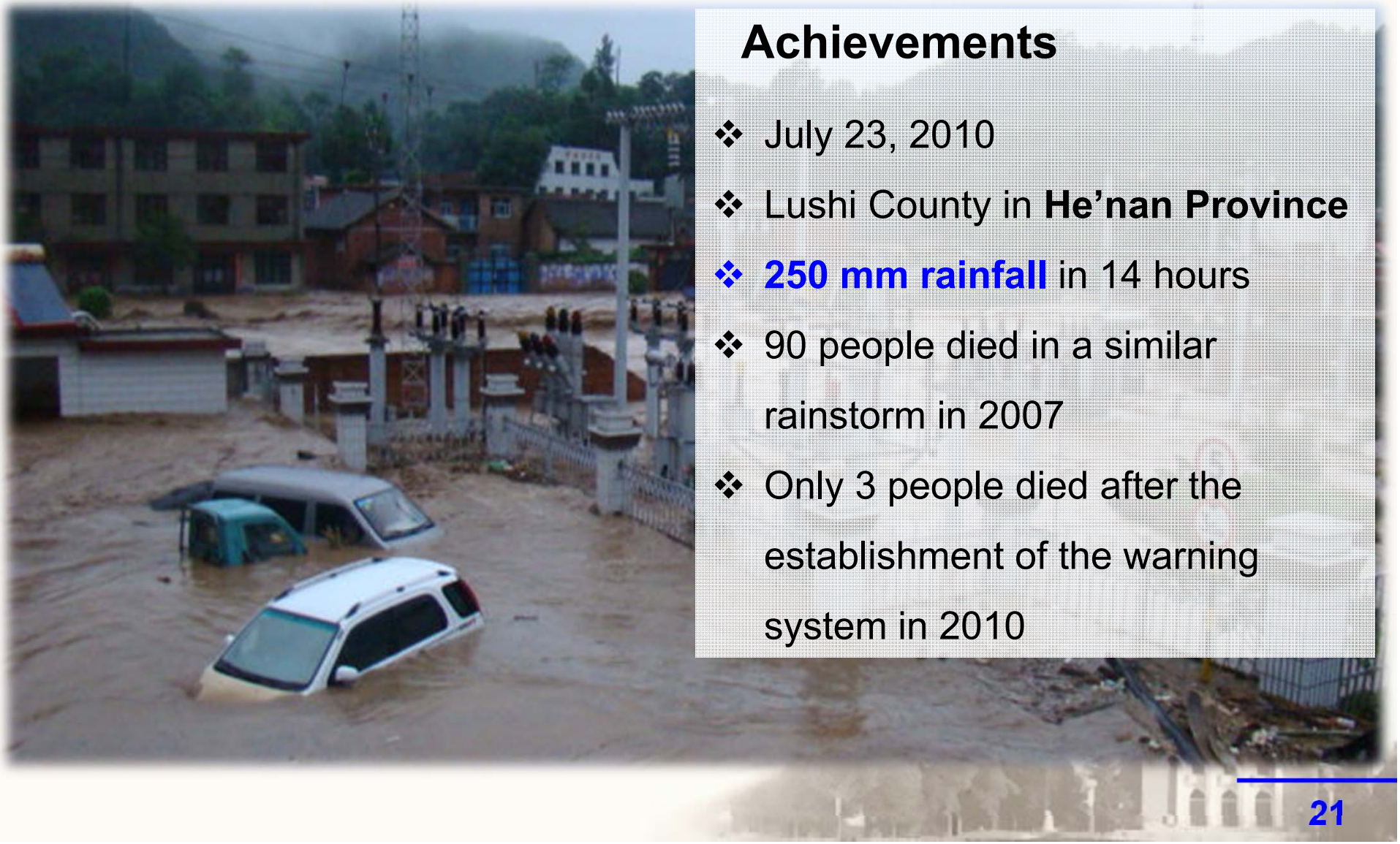
2. National strategies

Achievements

- June 18, 2010
- Lichuan County in **Jiangxi Province**
- **148 mm** averaged rainfall in 6 hours
- Evacuating **30,000 people**
- No death

2. National strategies



Achievements

- July 23, 2010
- Lushi County in **He'nan Province**
- **250 mm rainfall** in 14 hours
- 90 people died in a similar rainstorm in 2007
- Only 3 people died after the establishment of the warning system in 2010

2. National strategies

Achievements

- May 18, 2010
- Anhua County in **Hu'nan Province**
- **over 100 mm daily rainfall**
- **93,000 people evacuated**
- No one died.

2. National strategies

Statistics of implementation of non-structural measures

32,000,000	155,000	18,830,000
Warning messages	Warning broadcast	Evacuated people

3. Practices at the county level

3. County-level practices

Central government

➔ **Province**

➔ **Prefecture**

➔ **County**

➔ Town

➔ Village

➔ Group

➔ Family

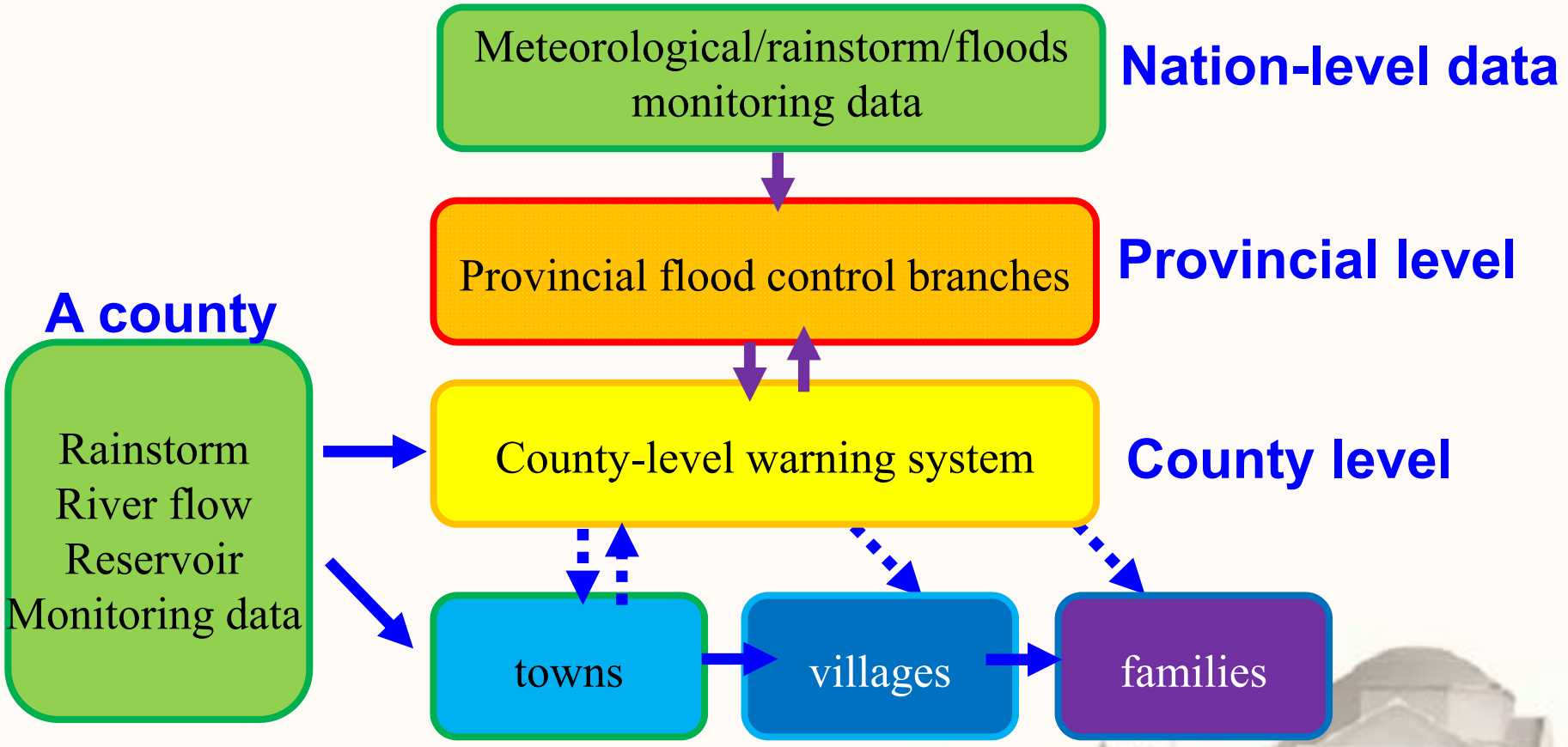
A county: A fourth-level government in the mainland

- ❖ local authority in charge of 10^3 km^2
- ❖ Responsible for flood control and disaster prevention
- ❖ Basic unit in national strategy

2862 counties in the mainland

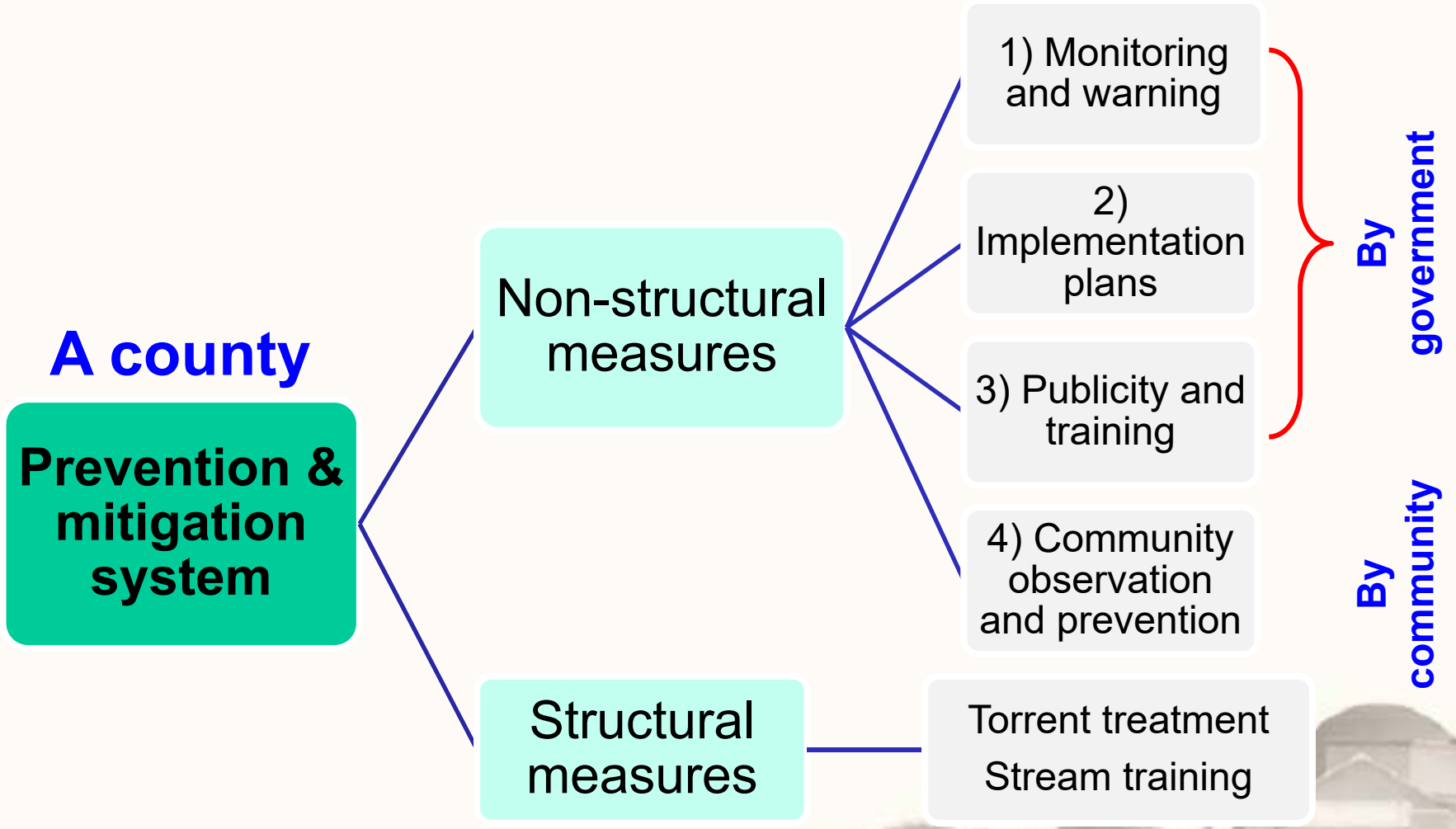
3. County-level practices

Basic unit and role in the national strategy



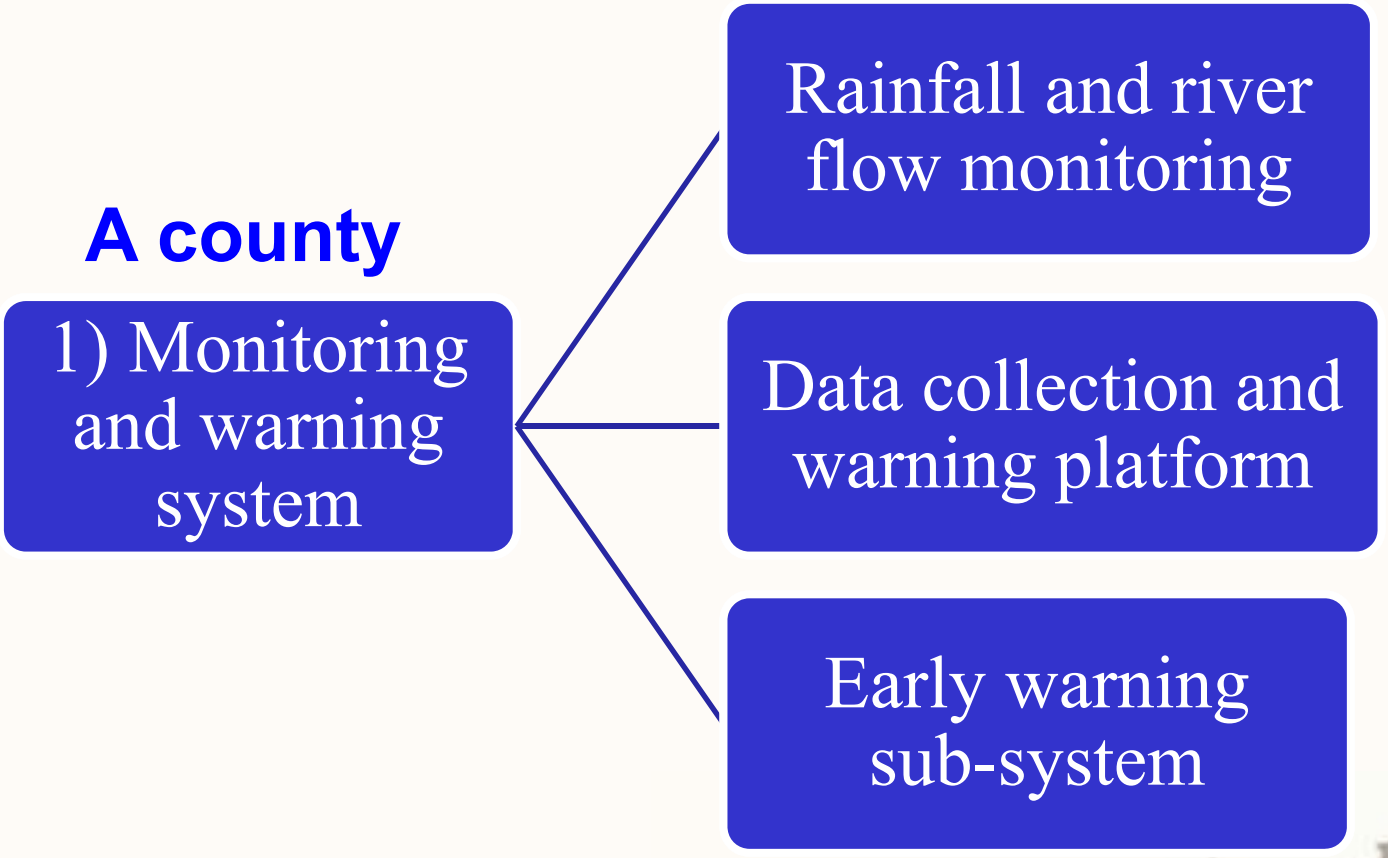
监测信息由县级平台汇集，预警信息由县级平台发布，群防群治作为补充。

3. County-level practices



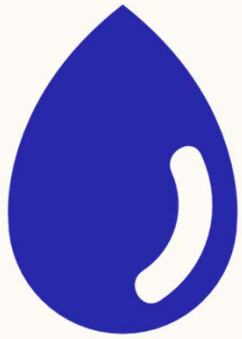
3.1 Monitoring & Warning

A county



3.1.1 Real-time rainfall-runoff monitoring system

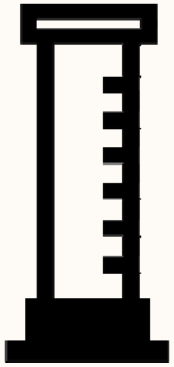
Rainfall->precipitation stations



Water level/discharge->gauging stations

3.1.1 Real-time rainfall-runoff monitoring system

Differing in economic conditions, three levels of monitoring system are proposed.



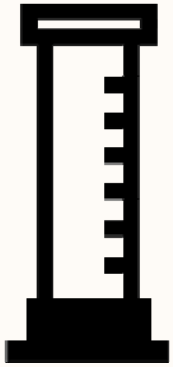
Simplified monitoring stations

Artificial monitoring stations

Automatic monitoring stations

3.1 Monitoring & Warning

Simplified monitoring stations: Community-based



1) Use simple equipment always with obvious warning marks
2) Transfer information by simple ways such as sound signal
3) Observe when it rains, and strengthen observation when it rains heavily
4) Suitable for remote areas with poor communication conditions

3.1 Monitoring & Warning

Simplified monitoring stations

A glassy rain gauge

3.1 Monitoring & Warning

Simplified monitoring stations

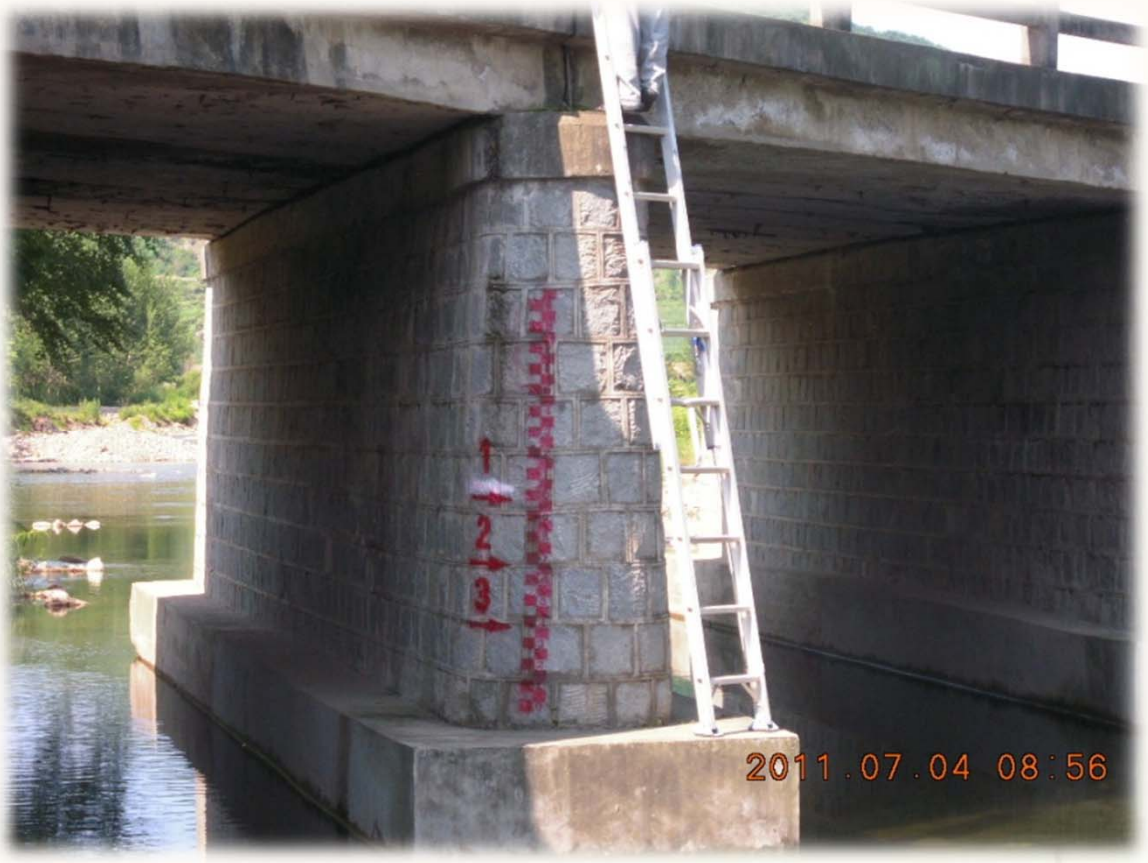
A simple water gauge at riverside

Simplified monitoring stations

A simple water stage gauge at bridge pier

3.1 Monitoring & Warning

Simplified monitoring stations



A simple gauging station at a bridge pier

3.1 Monitoring & Warning

Artificial monitoring stations: labor-consuming but cheap

1) Usually use siphon rain gauges, water gauges, and observation road
2) Report flood information by speech or phone call
3) Perform timing observation and report, with the frequency increasing when heavy rain occurs
4) Suitable for areas with public communication resources.

3.1 Monitoring & Warning

Artificial monitoring stations

A siphon rain gauge

3.1 Monitoring & Warning

Artificial monitoring stations

water gauges and observation road

3.1 Monitoring & Warning

Automatic monitoring stations: efficient but expensive

1) Measure rainfall by rainfall observation field/automatic rain gauges
2) Measure water level by automatic water stage gauges
3) Perform timing report but the frequency increases in an emergency situation
4) Transfer information by Communication Terminal
5) Suitable for areas with good communication and economic conditions

3.1 Monitoring & Warning

Automatic monitoring stations

precipitation stations

3.1 Monitoring & Warning

Automatic monitoring stations

precipitation stations

3.1 Monitoring & Warning

Automatic monitoring stations -- sensors in the flow

A float-type stage gauge

3.1 Monitoring & Warning

Automatic monitoring stations

A pressure type water gauge

A bubble type water level gauge

3.1 Monitoring & Warning

Automatic monitoring stations-- sensors not in the flow

A ultrasonic water level gauge

A radar water level gauge

3.1 Monitoring & Warning

Automatic monitoring stations

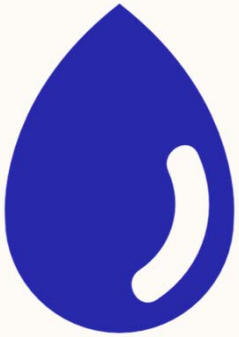
A radar water level gauge on-the-spot scene

3.1.2 Principles of equipment/facilities layout

Precipitation-monitoring station

- 20-100 km^2/station
- 20-30 km^2/station in serious disaster-prone area
- At least one in a village

3.1.2 Principles of equipment layout



Water level monitoring station

(A: Controlling area)

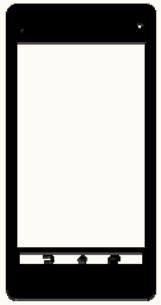
- A>100 km^2, general flash flood
- 50<A<100 km^2, serious flash flood

3.1.3 Communication network

Satellite

2,000,000

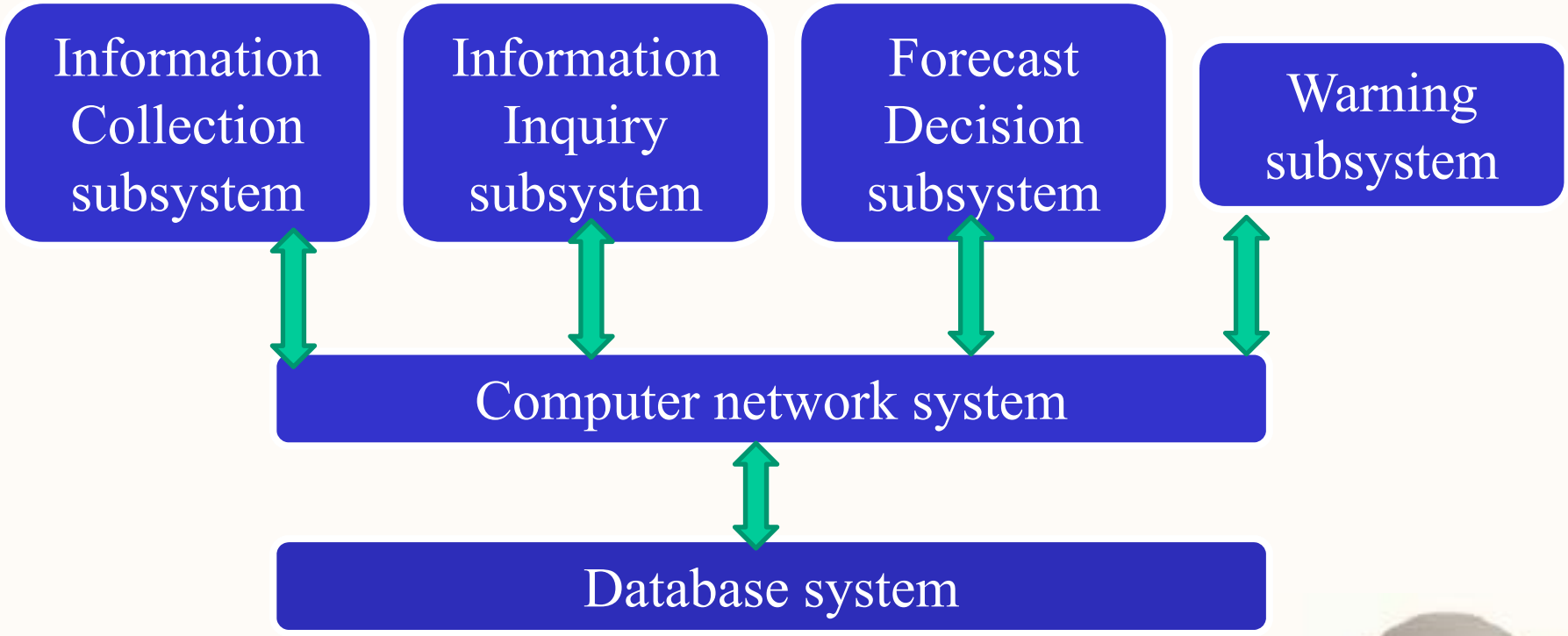
Ultra High Frequency/Very High Frequency



Global System for Mobile Communications
GPRS

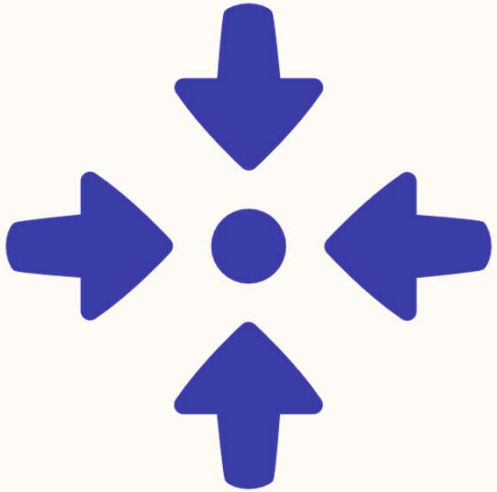
Public Switched Telephone Network

3.1.4 Data collection and forecasting system



Diagrammatic sketch of the flash flood monitoring and waning system

3.1.4 Data collection and forecasting system



Data collection

- **hardware**
  - Communication equipment for data reception
  - Computers for data processing
  - Power
  - Facilities for equipment installation
  - Lighting protection system
- **software**
  - Software for real-time data reception and processing

3.1.4 Data collection and forecasting system

Information query

- **Real-time data**
  - Rainfall information
  - Meteorological information
  - Engineering information
- **Basic data**
  - river, flash-flood ditch, gage, embankment, reservoir, disaster-zone, safe zone, threated zone, economics
- **Forecast results information**

3.1.4 Data collection and forecasting system

Forecast & decision making

- Rainfall analysis & forecast
- Warning information
- Maintenance & management

3.1.4 Data collection and forecasting system

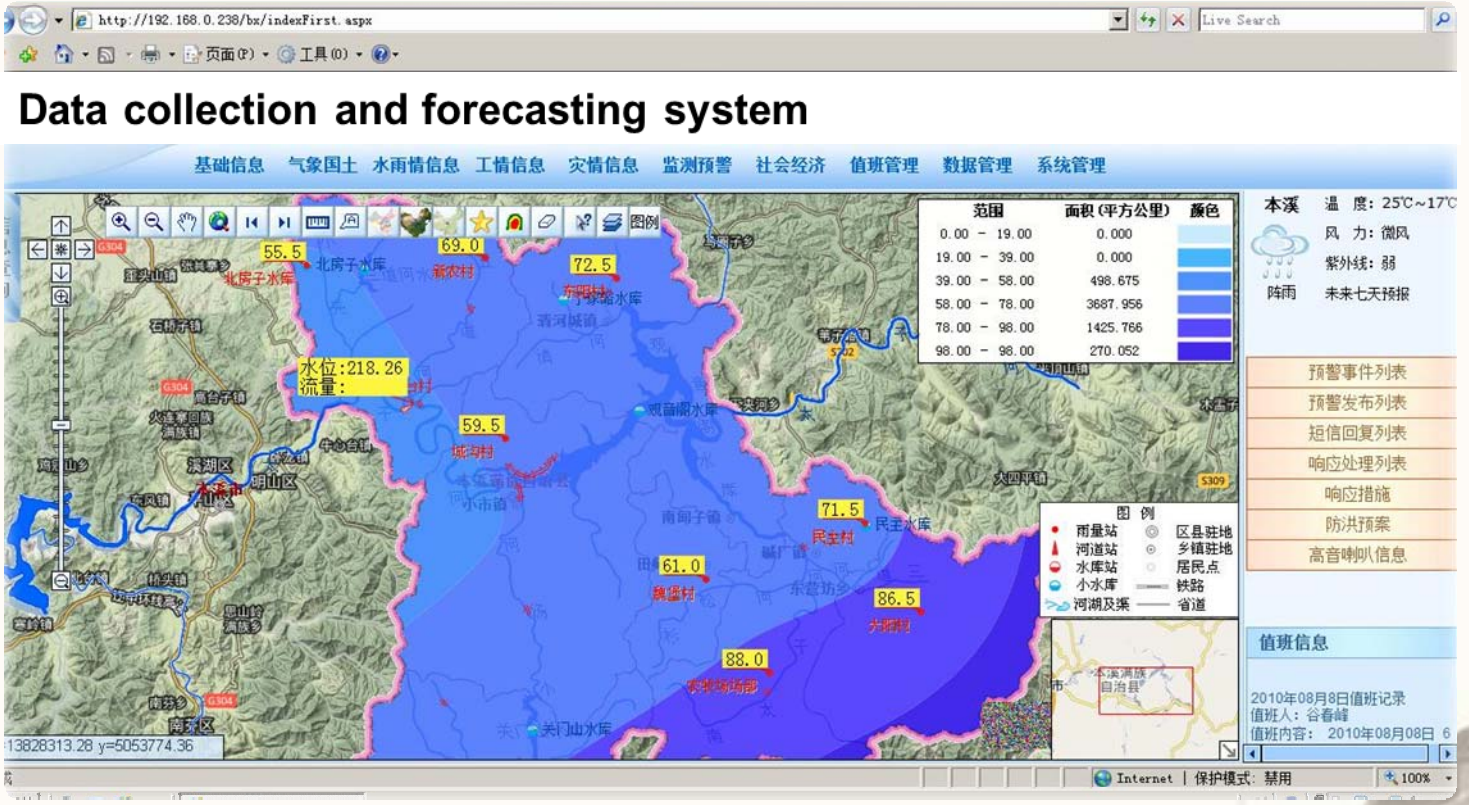
Warning

- To the public
  - telephone
  - Text message
  - radio
- To the organization commander
  - fax

3.1.4 Data collection and forecasting system

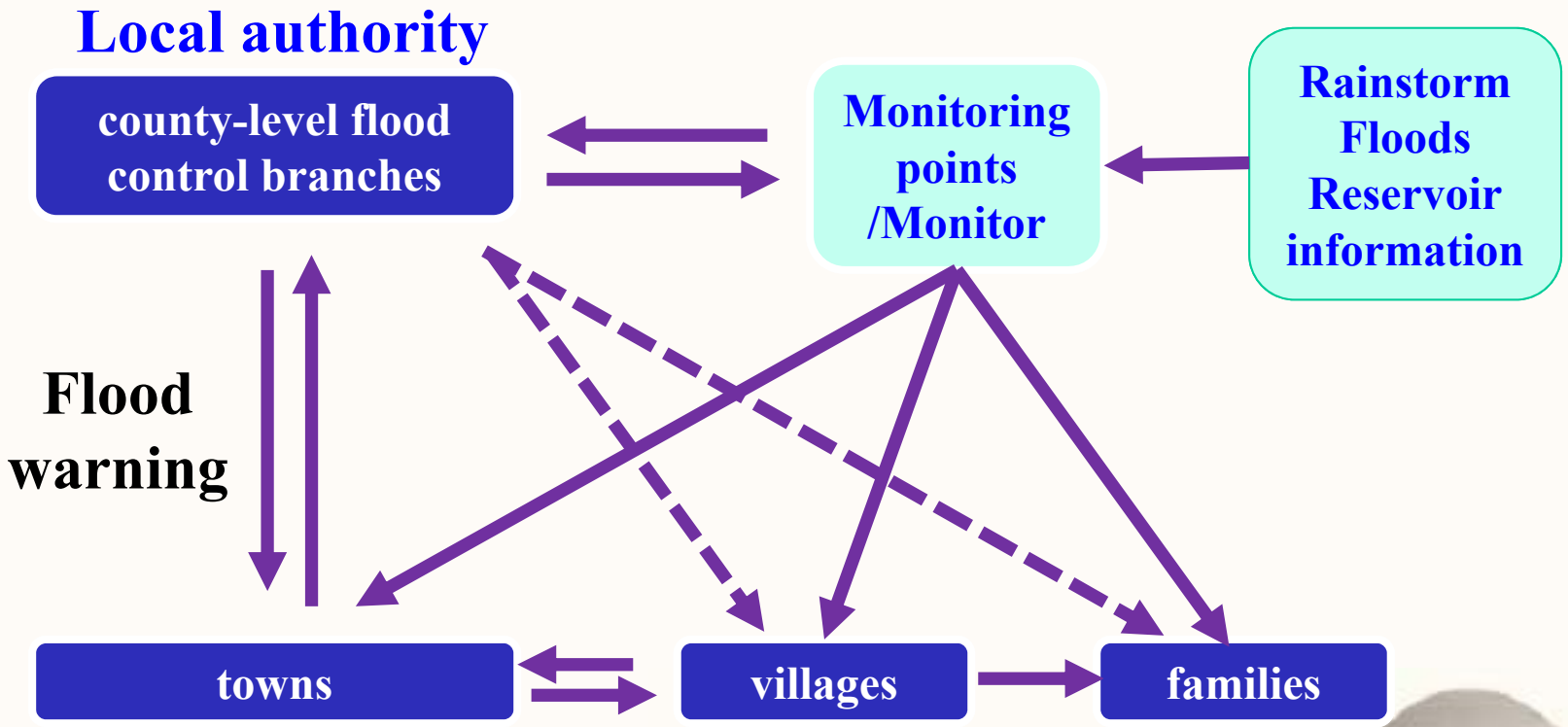
Samples of platform - center control system

3.1.4 Data collection and forecasting system



Samples of platform-software interface

3.1.5 Early-warning subsystem



Flood warning system

3.1.5 Early-warning subsystem

Warning information sent by mobile phone

3.1.5 Early-warning subsystem

——03 双山子镇东风村

Devices for warning –high pitch radio

3.1.5 Early-warning subsystem

——02 双山子镇东风村

Devices for warning –high pitch radio

3.1.5 Early-warning subsystem

Devices for warning –high pitch radio

3.1.5 Early-warning subsystem

Devices for warning –high pitch radio

3.1.5 Early-warning subsystem

Warning Gong (communication interruption)

3.1.5 Early-warning subsystem

Using pyrotechnics in case that communication interruption take places

3.2 Implementation plan

Disaster prevention plan is

the basis to command decision-making, scheduling and disaster relief,

the guidance for Grassroots organizations and the masses to protect properties and human lives

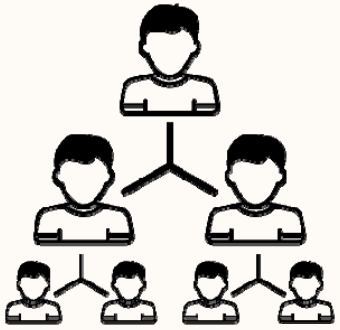
3.2 Implementation plan

Basic information

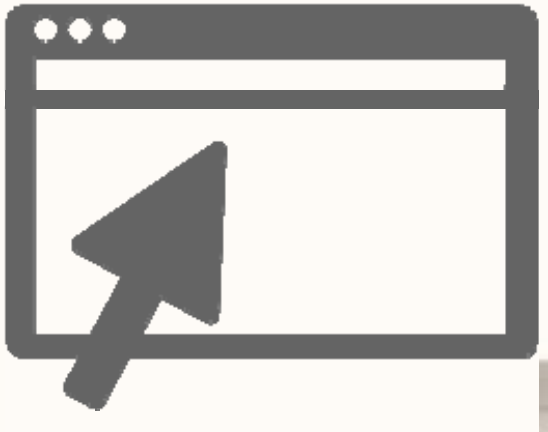
- Basic natural and economical condition in this area
- Type of flash flood disasters
- Historical losses of flash flood disasters
- Formation mechanisms and characteristics of flash flood

3.2 Implementation plan

Assign responsibilities to different groups/levels



Establish detailed monitoring and pre-warning plans

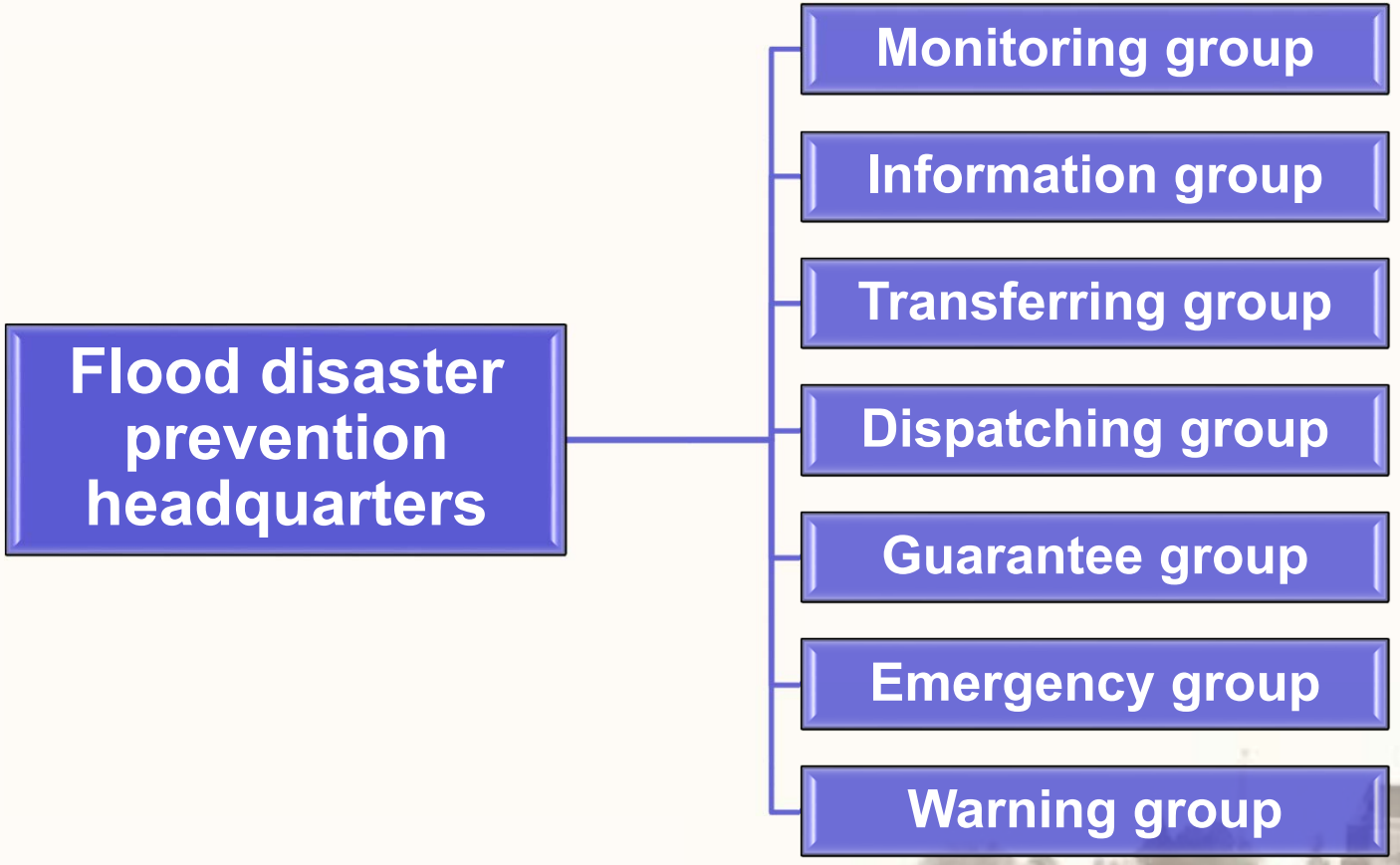


3.2 Implementation plan

Rescue and aftermath plan

- Requirements for transferring and setting people
- Detailed rescue plans during the disaster
- Detailed recovery plans after the disaster

3.3 Organization-- seven groups



3.3 Organization

Monitoring group:
rainfall and water stage

3.3 Organization

Information group: collecting, analyzing, and reporting data

3.3 Organization

Evacuation group: transfer every person in the given routes to shelters

3.3 Organization

Dispatching group:
contact different authorities/agencies

3.3 Organization

Logistics group

3.3 Organization

Emergency recue group

3.4 Publicity and training

四、山洪灾害该如何预防

（一）广泛宣传 增强意识

各级政府要在县、镇（乡）、村、工矿、机关、学校、企业的广大群众中积极开展山洪灾害防御知识普及教育，要做到家喻户晓，老幼皆知，增强防范意识，提高自防、自救、互救能力。

（二）制定预案 落实责任

要事先制定山洪灾害防御预案，落实各级各类责任人和应急处置措施。

（三）突发事件 及时转移

降大暴雨时，要时刻观察身处周围的溪河水位和山体有无异常。特别是晚上，更应十分警觉，随时做好安全转移的准备。

（四）及时预警 迅速传递

遇到可能引发洪水、泥石流、滑坡的大暴雨，要立即采取鸣锣、打电话、广播等预先设定的报警措施，迅速向可能受威胁的居民和单位传递警报信息。

（五）堰塘水库 加强防范

降大暴雨时，要加强对堰塘水库水位、建筑物、堤岸等情况的观测，如有异常，要迅速转移受威胁群众。

（六）住宅基地 合理选择

建房应选择在平整稳定的山坡和高地，要远离河滩及沟谷等低洼地带。

（七）修路架桥 科学选择

修路、架桥等，要避开山体易滑坡、崩塌区域，特别是不能侵占溪河滩地。

（八）行洪河道 严禁设障

严禁向溪流倾倒垃圾、工程渣土等废物废料，堵塞河道，严禁侵占河流滩地。

（九）自然生态 人人保护

严禁乱砍滥伐、乱采乱挖、毁林开荒等破坏自然生态行为。

—5—

山洪灾害防御常识

五、山洪灾害发生时该怎么办

（一）发面预警 广而告之

当降水量达到设定临界值时必须发出避险转移预警。通过电台，广播，电视，手机，对讲机等方式告知，进入准备转移阶段。图5.1

图5.1

（二）组织转移 安全有序

安全转移本着就近，迅速，安全，有序的原则进行。先人员、后财产。先老幼病残人员，后其他人员。要事先制定转移路线和地点，落实撤离组织人员和责任。图5.2

图5.2

（三）洪水围困 理性求救

遭洪水围困，有通讯条件的，可利用通讯工具，寻求救援；无通讯条件的，要想办法向外界发出紧急求助信号，同时要主动采取自救措施。图5.3

警报求救　呼叫求救　通讯求救　打鼓求救

图5.3

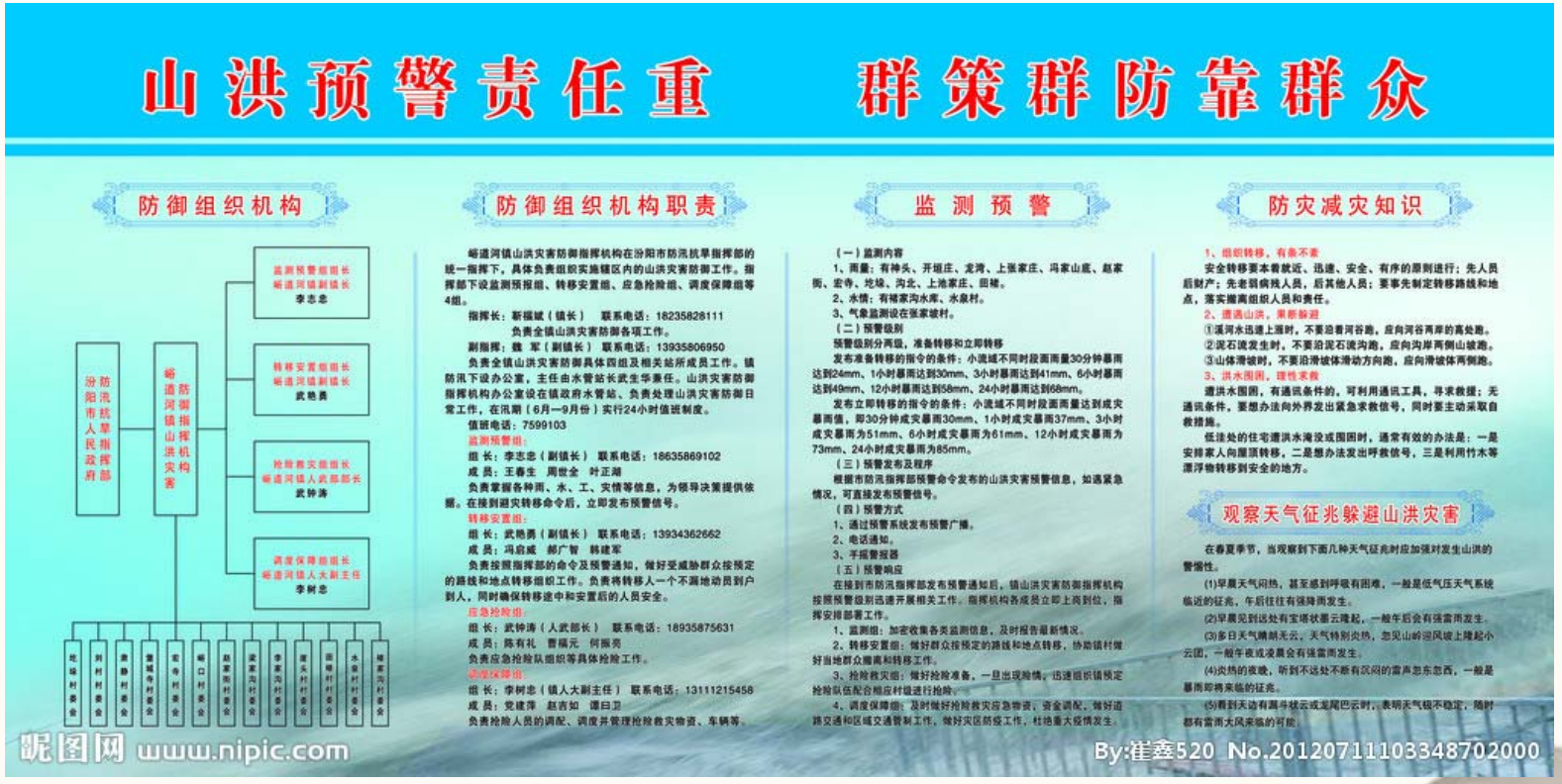
—6—

Handbook, videos, and tapes of disaster prevention

3.4 Publicity and training

Propaganda column of disaster prevention of flash flood

3.4 Publicity and training



Propaganda column of disaster prevention

3.4 Publicity and training

Warning signs of disaster prevention

3.4 Publicity and training

Warning signs of disaster prevention of flash flood

3.4 Publicity and training

Warning signs of disaster prevention

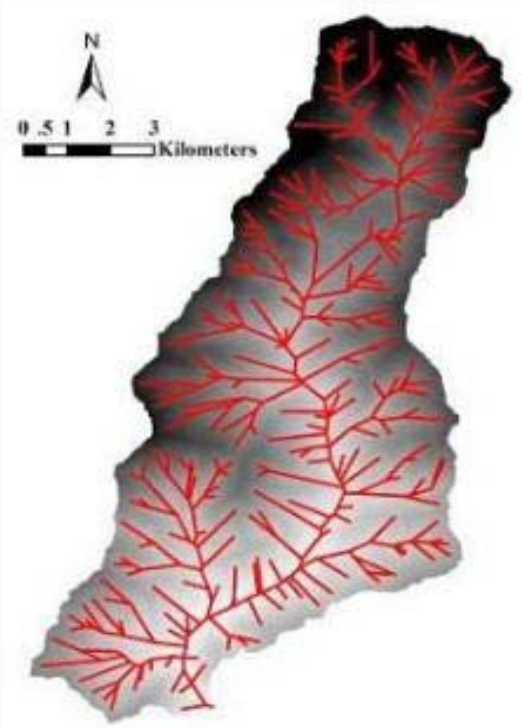
3.4 Publicity and training

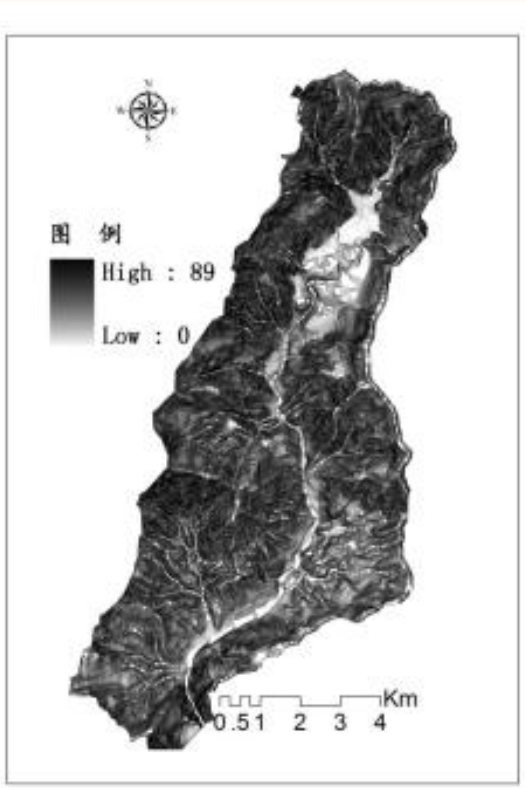
Public training in villages

3.4 Publicity and training

Evacuation exercises

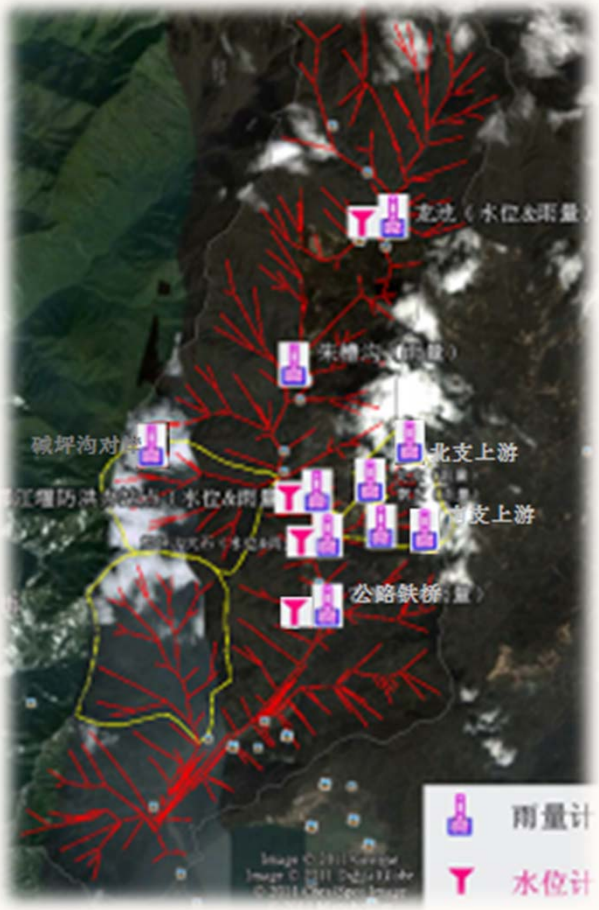
3.5 Longxi River basin





Area: 79 km^2; river slope of main channel >10%

3.5 Longxi River basin



Monitoring System

- Measurement of water level, rainfall，soil moisture
- 5 gauging points on main stream
- 5 investigation points in typical sub-basin

3.5 Longxi River basin

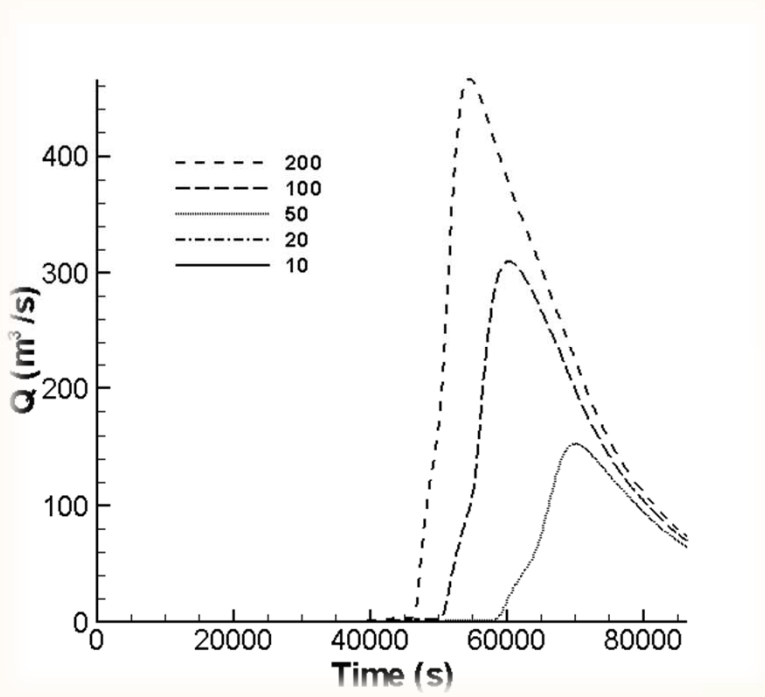
Water level gauge

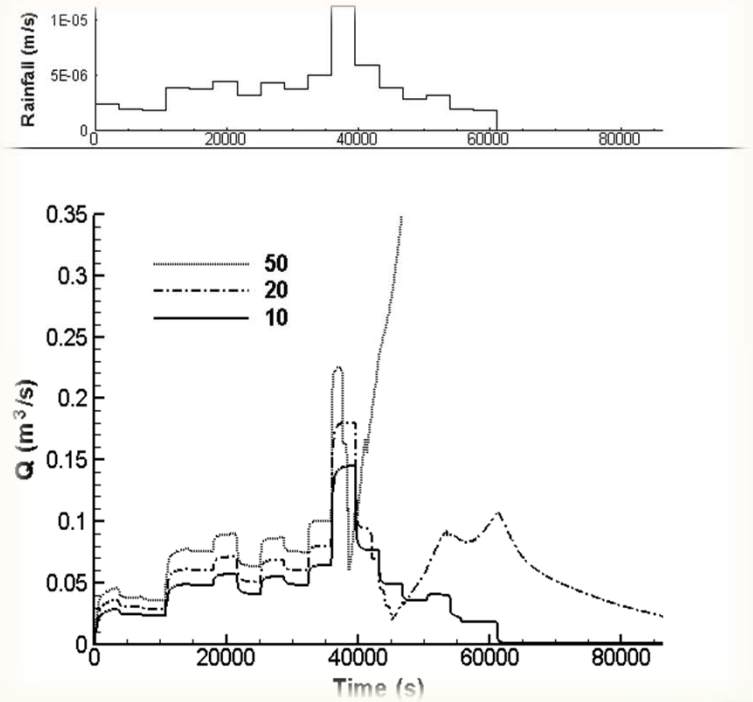
Pluviometer

3.5 Longxi River basin

Soil moisture measurement

3.5 Longxi River basin





Coupled hydrological and hydraulic models were developed for modeling the flash flood process

3.5 Longxi River basin

Location		Nanyuecun North
River no.		(0, 38)
Warning Discharge(m^3/s)		440
Flood peak(m^3/s)		749
Flood peak reverse time		18:05
First pre-warning (17:26 Releasing)	Calculation Discharge(m^3/s)	356
	Flood peak time	17:50
	Pre-warning condition	Ready to leave
	Time before flood peak	0:24
Second pre-waring (17:36 Releasing)	Calculation Discharge(m^3/s)	647
	Flood peak time	17:52
	Pre-warning condition	Leave at once
	Time before flood peak	0:16
Third pre-warning (17:51发布)	Calculation Discharge(m^3/s))	632
	Flood peak time	17:50
	Pre-warning condition	Leave at once
	Time before flood peak	-

Pre-warning System

- Discharge calculation based on rainfall data
- Forecast flood peak in 30 mins
- Give pre-warning based on flood peak forecast

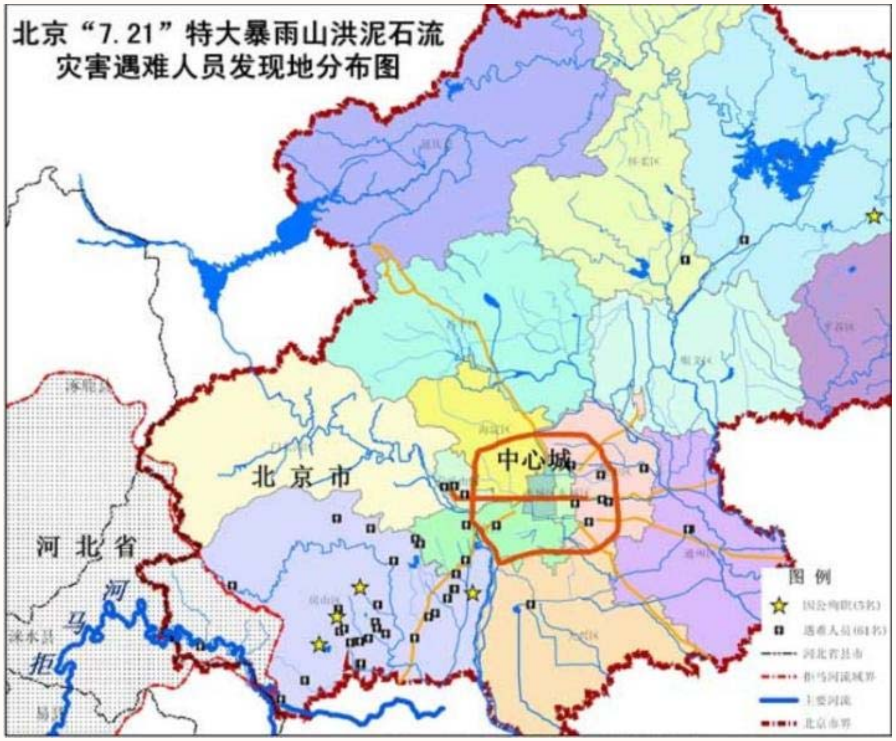
3.5 Case in southwestern China

3.5 Longxi River basin

Pre-warning information form app in mobile phone

3.6 Case in northern China

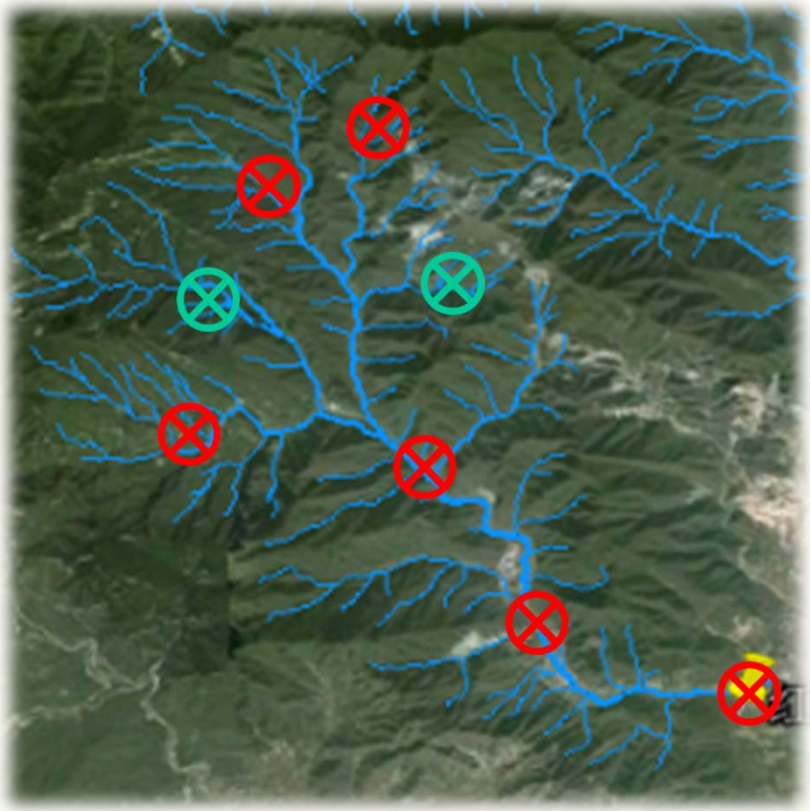
3.6 Hongluogu valley, Fangshan, Beijing



2012.7.21: Heavy rainstorm in Beijing, 79 death toll

Fangshan was damaged seriously

3.6 Hongluogu valley, Fangshan, Beijing



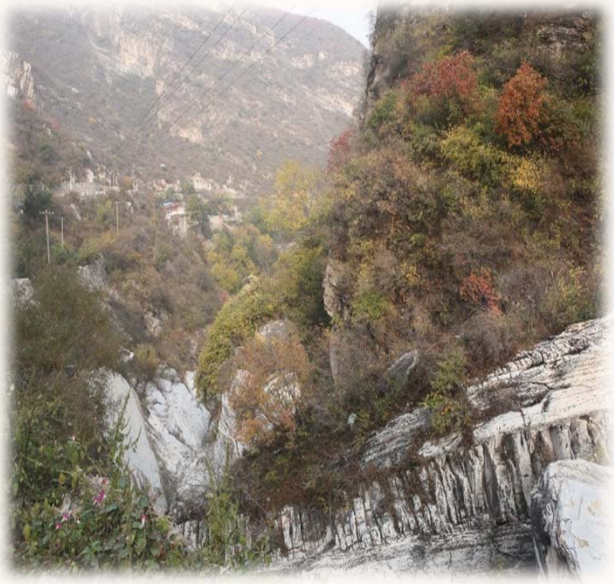
Residential area

Abandoned Residential area

Overview of Hongluogu Valley

- Area: 51 km^2
- Elevation difference:1200 m
- Slope: 2.4%
- hit in “2012.7.21” flash flood

3.6 Hongluogu valley, Fangshan, Beijing



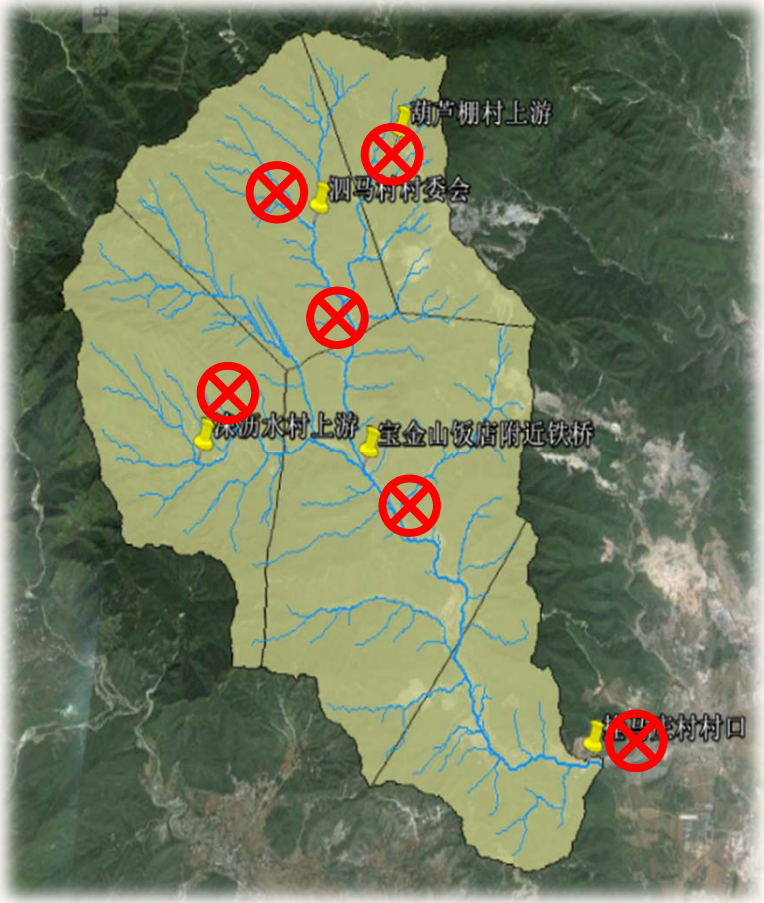
Complex natural & human factors

- Steep slope/Heavy rainstorm
- Plenty of loose deposit
- Boulders and drift wood
- Occupied/blocked flood channel

3.6 Hongluogu valley, Fangshan, Beijing

3.6 Hongluogu valley, Fangshan, Beijing

3.6 Hongluogu valley, Fangshan, Beijing



Monitoring system

- 6 automatic precipitation gauge stations
- 4 automatic water level gauges

3.6 Case in northern China

3.6 Hongluogu valley, Fangshan, Beijing

Precipitation stations at different elevations

3.6 Case in northern China

3.6 Hongluogu valley, Fangshan, Beijing

Water level gauge

Two sub-watersheds have a complete set of monitored rainfall, water level, and soil moisture data.

Useful for model validation and calibration.

Difficult to measure the discharge with strong sediment movement

3.6 Case in northern China

3.6 Hongluogu valley, Fangshan, Beijing

Monitoring system

Formulate the evacuation plan against flash flood

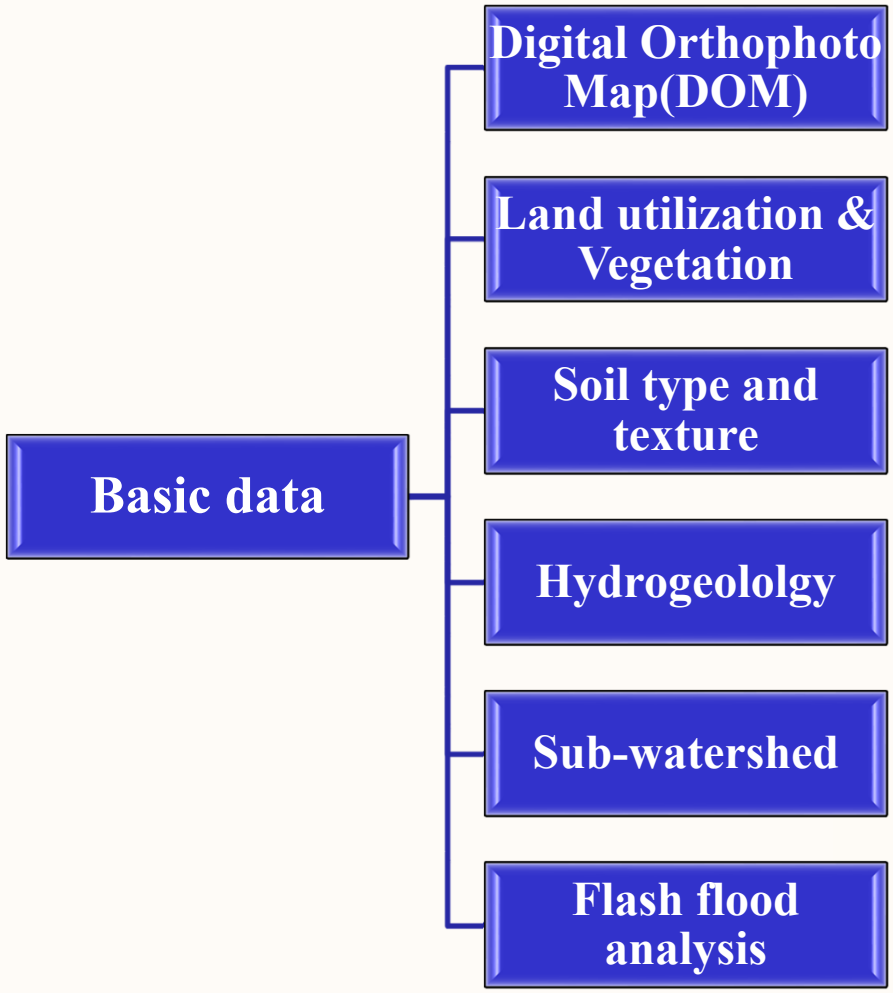
Study the impact of sediment transport on flash flood properties

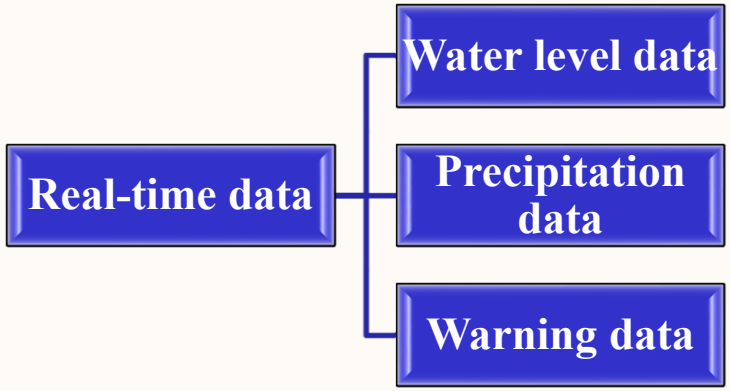
4. Toward future: Big data platform

4.1 Data platform

4.1 National Data Platform

China Institute of Water Resources and Hydropower Research is in charge of the platform development.

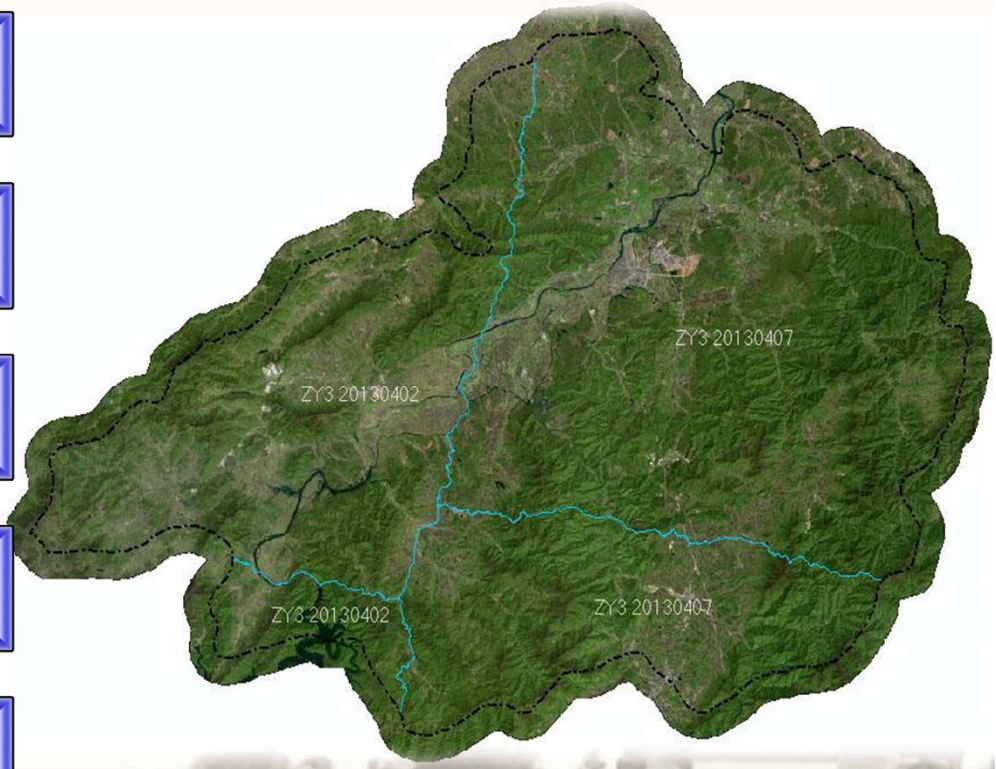




4.1 National Data Platform

- Basic data
  - Digital Orthophoto Map(DOM)
  - Land utilization & Vegetation
  - Soil type and texture
  - Hydrogeololgy
  - Sub-watershed
  - Flash flood analysis

Digital Orthophoto Map(DOM) Data



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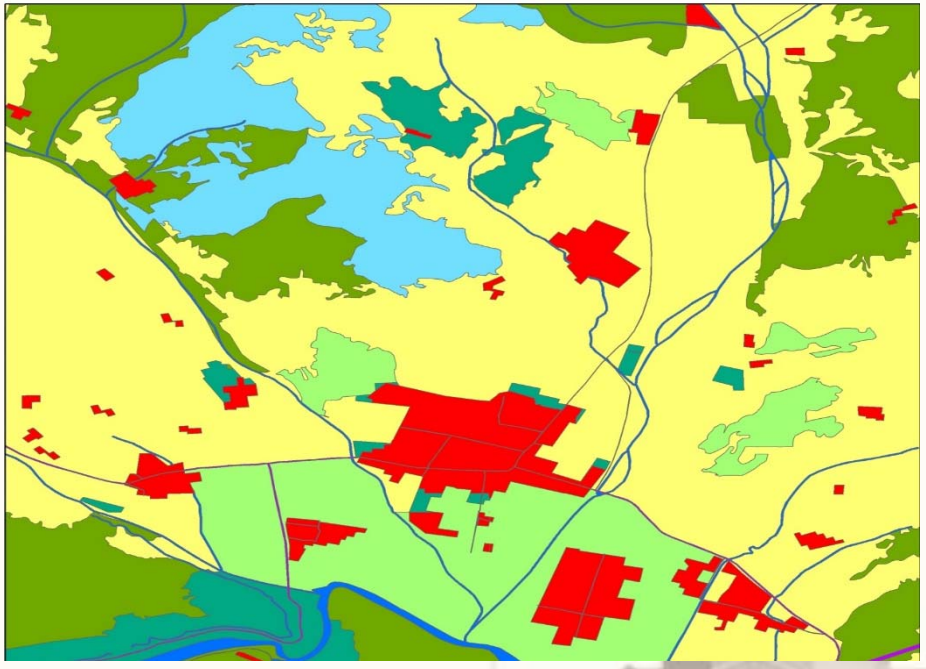
Land utilization & vegetation



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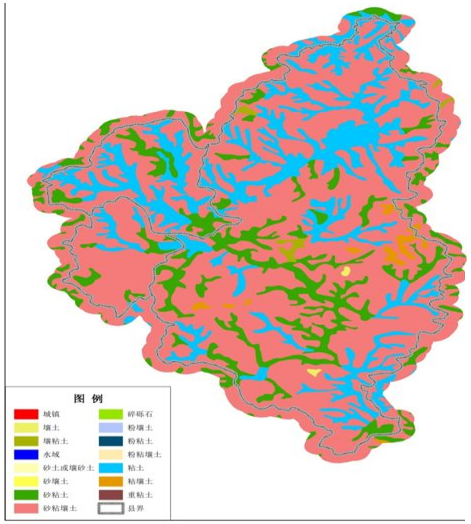
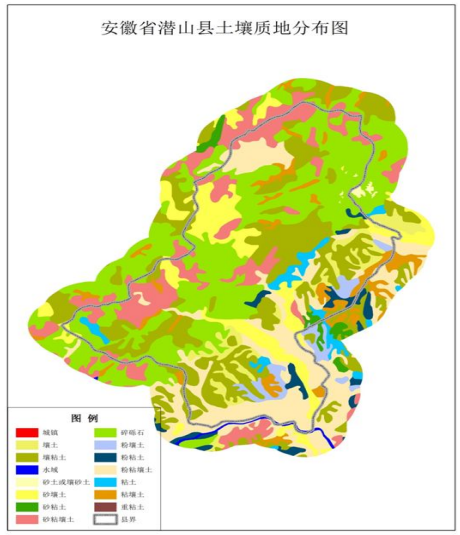
Agrotype and soil texture data





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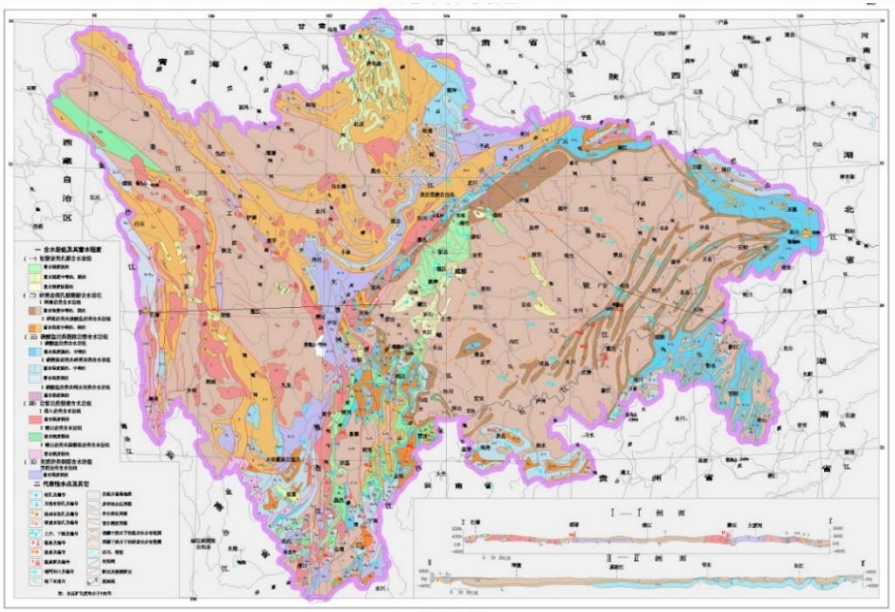
Hydrogeololgy map



4.1 Data platform

4.1 National Data Platform

- Basic data
  - Digital Orthophoto Map(DOM)
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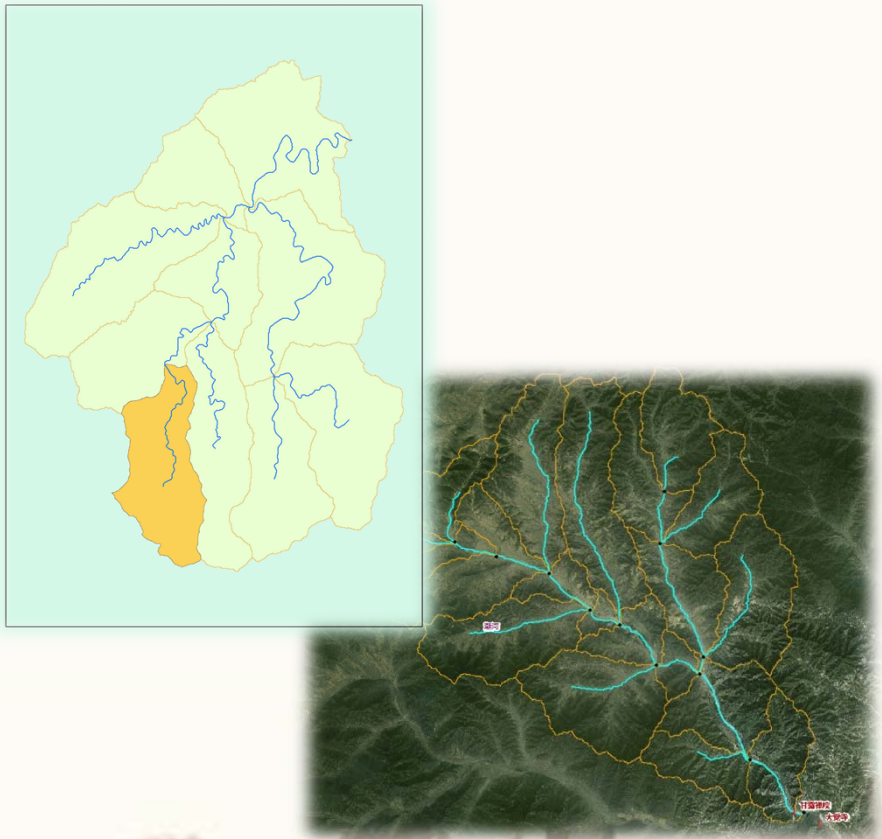
  - Hydrogeololgy
  - Sub-watersheds
  - Flash flood analysis

Sub-watershed data



4.1 Data platform

4.1 National Data Platform

- Basic data
  - Digital Orthophoto Map(DOM)
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  - Soil type and texture
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  - Sub-watersheds
  - Flash flood analysis

Real-time data collection and analysis of rainfall and water

4.2 National service for disaster forecast

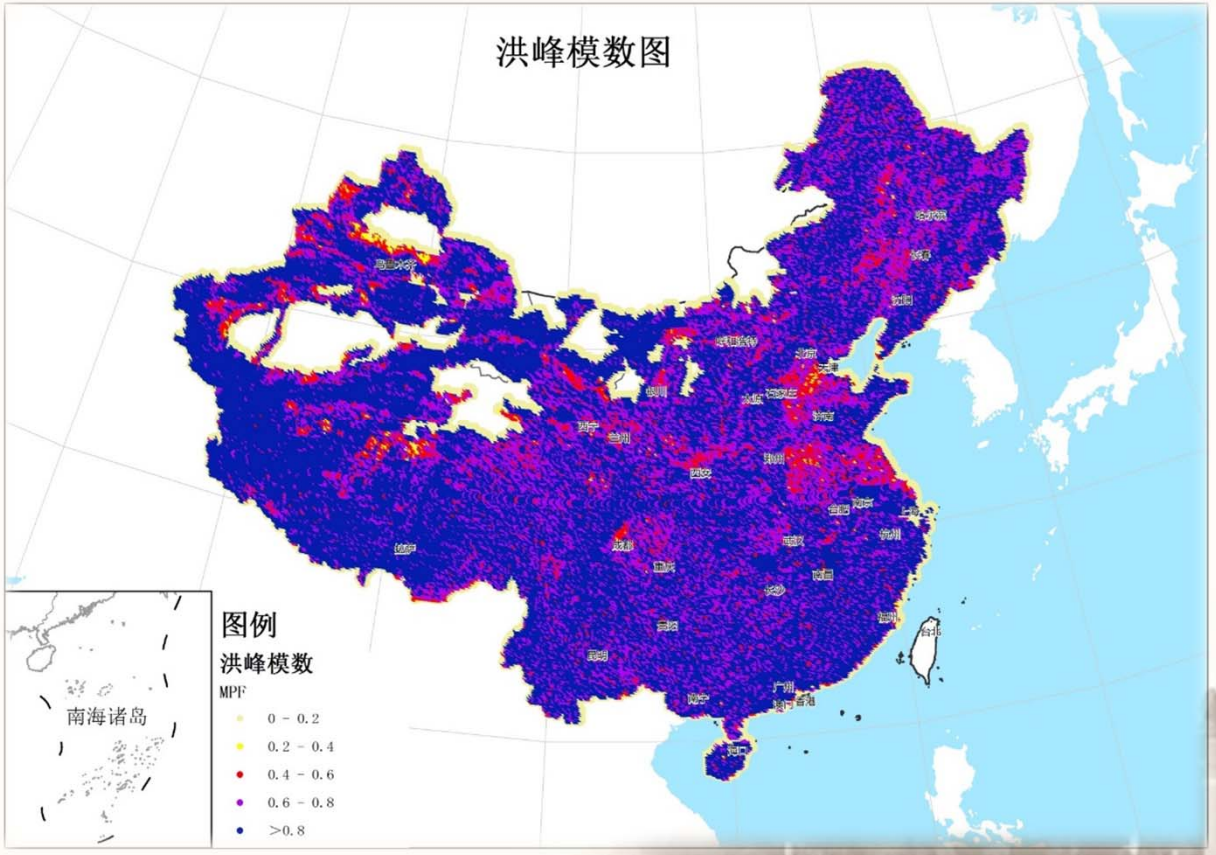
Regional flash flood disaster forecast and warning

Distribution of 20-year 6h rainstorm

4.2 National service for disaster forecast

Regional flash flood disaster forecast and warning

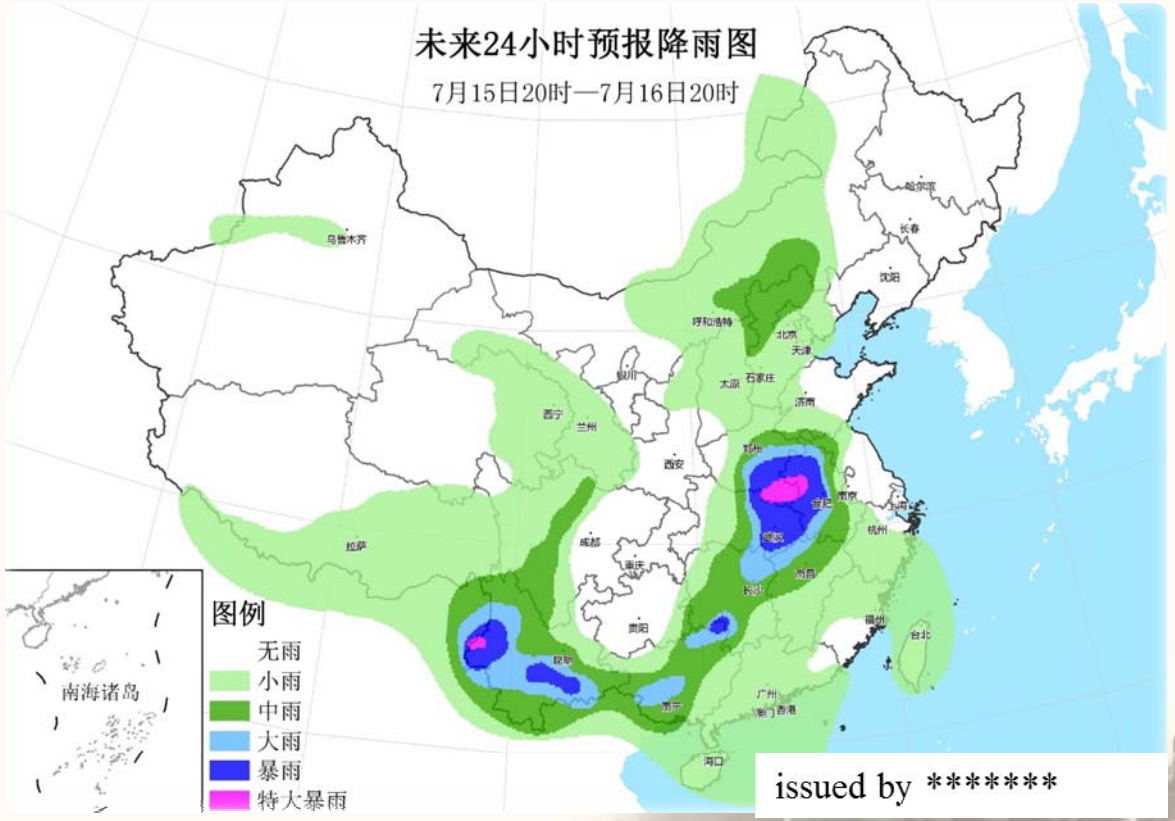
Distribution of peak discharge modulus



4.2 National service for disaster forecast

Regional flash flood disaster forecast and warning

24h forecast of precipitation



4.2 National service for disaster forecast

Regional flash flood disaster forecast and warning
24h forecast of risk level

Summary

清華大學 Tsinghua University

Summary

A brief overview of flash flood hazard mitigation in mainland China is presented.

Mainland China is a large area with diverse development extent. The county-level flood hazard mitigation plan has the same principles but differs in details among counties.

In general, China has started the effort of mitigating flash flood hazards in the last decade but is still on its first step. Further research and practices are required.

Thank you!