



Strengthening Water Supply System Adaptive Capacity

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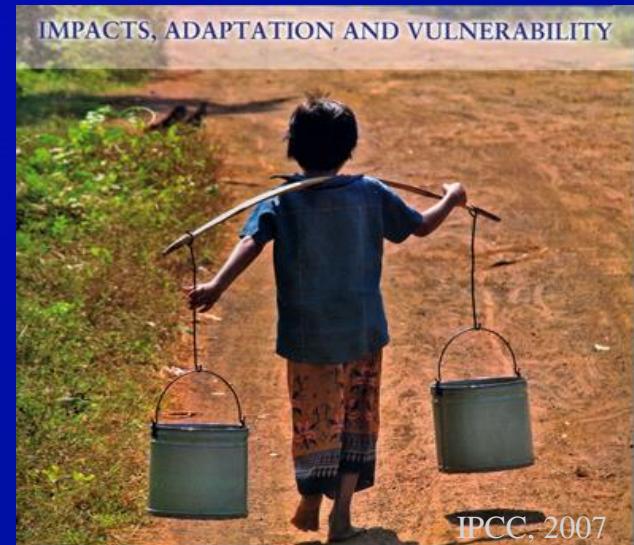
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- Recent Climate-Induced Disasters
- Future Possible Climate Change Impacts
 - Water Supply Carrying Capacity of the GaoPing Watershed
- Strengthening the Adaptive Capacity of Water Supply Systems
- Final Remarks





Recent Climate-Induced Disasters



More Frequent and Intensive Extreme Events!



Flooding in Taipei
Sept. 17, 2001
**Return Period of Rainfall more
than 150 years**



Drought in Taipei Area
Spring, 2002
Shihmen Reservoir



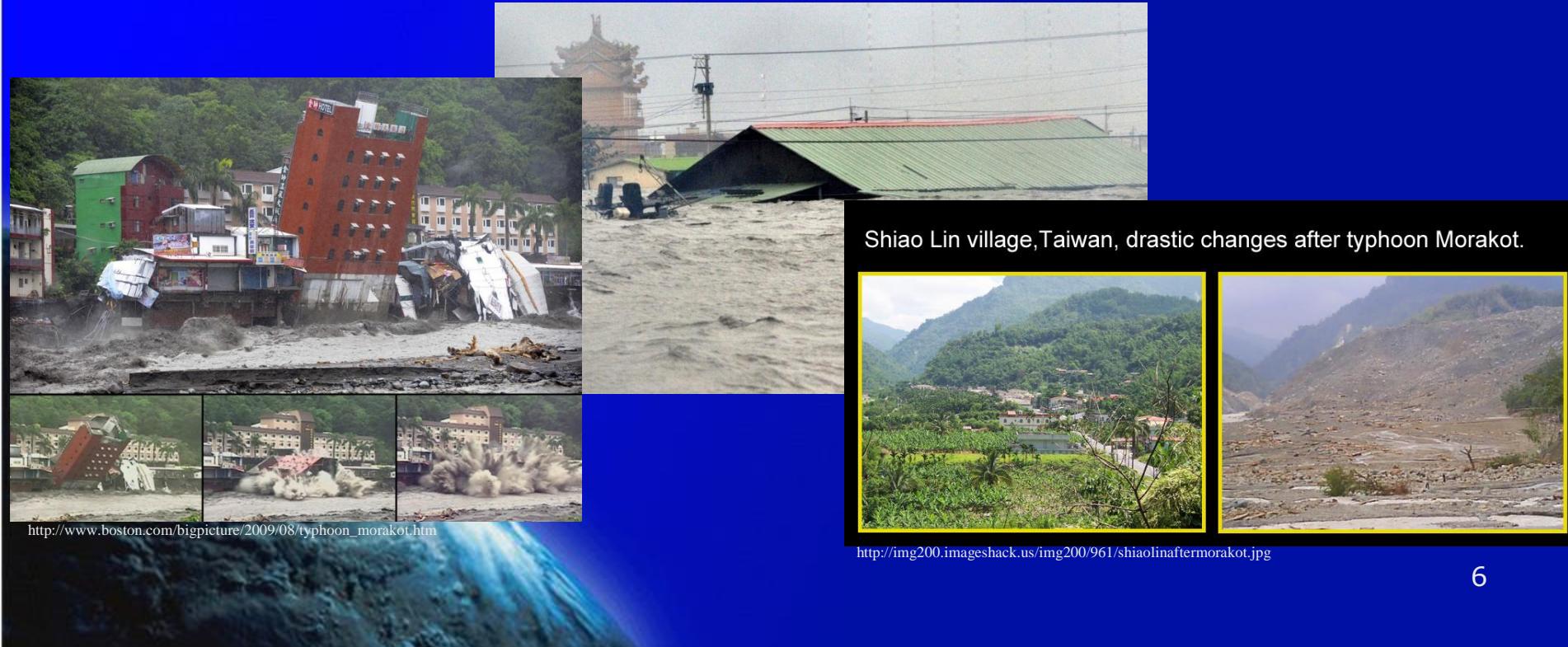
Typhoon Morakot

August 7-8, 2009



Typhoon Morakot

- The Typhoon Morako intruded Taiwan during 7th to 8th in 2009 and brought about **2,700 mm** total rainfall.
 - The **annual rainfall** in Taiwan is about **2,550mm**.



ChiaXian Weir 甲仙攔河堰

(2009/8/18, ten days after typhoon)



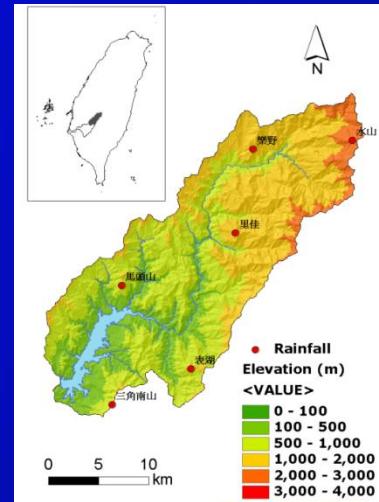
Zengwen Reservoir



Before 2009/8/8

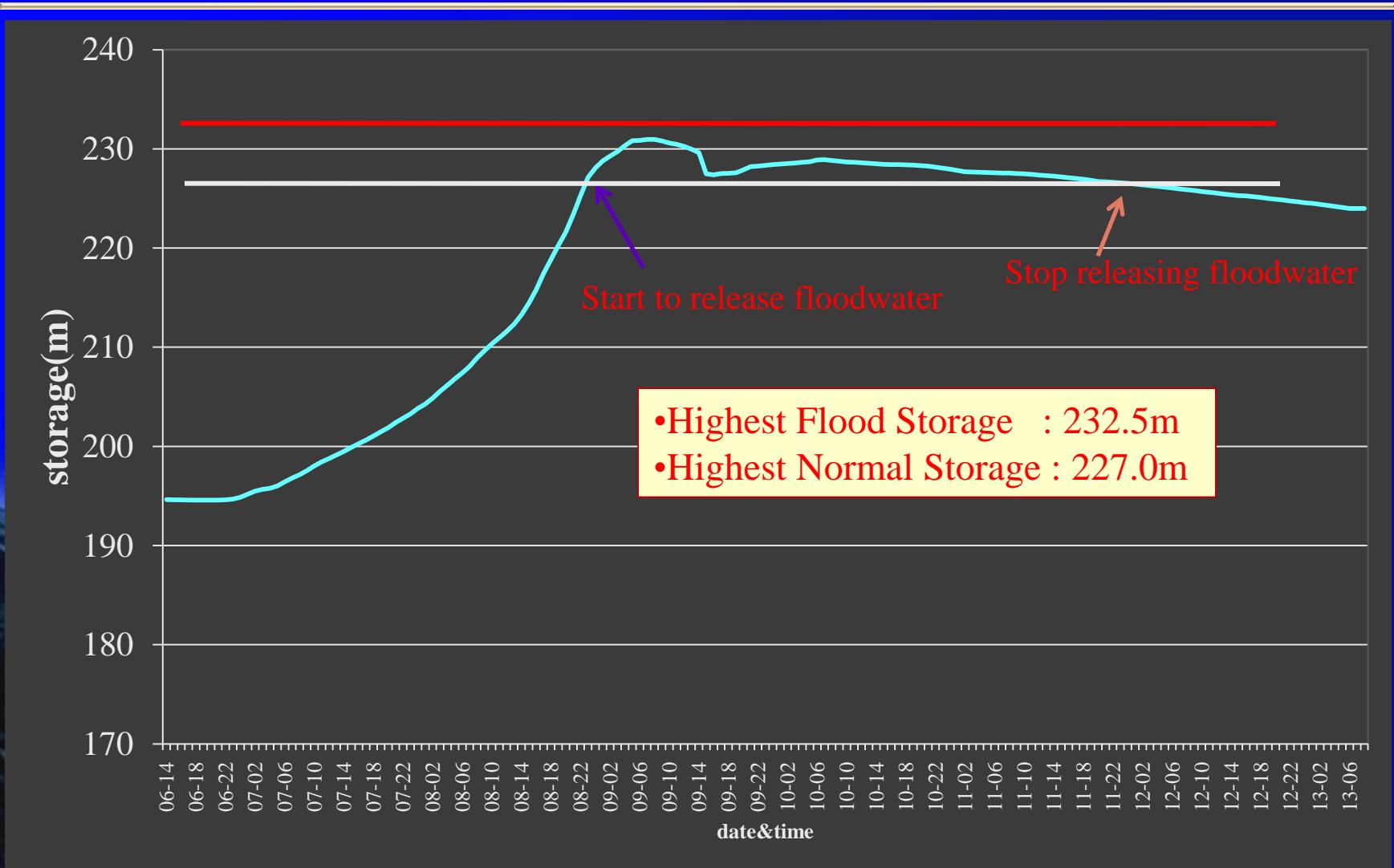


After 2009/8/8



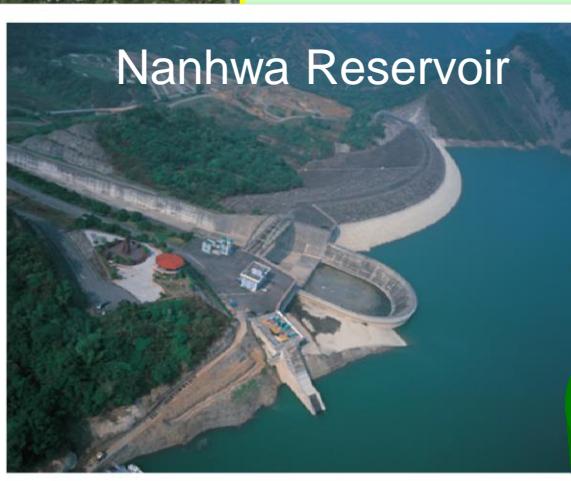
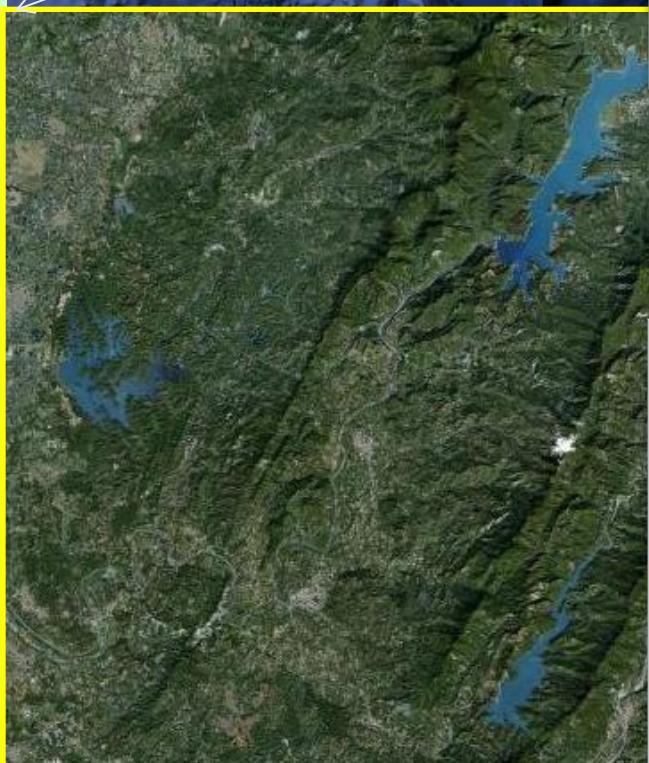
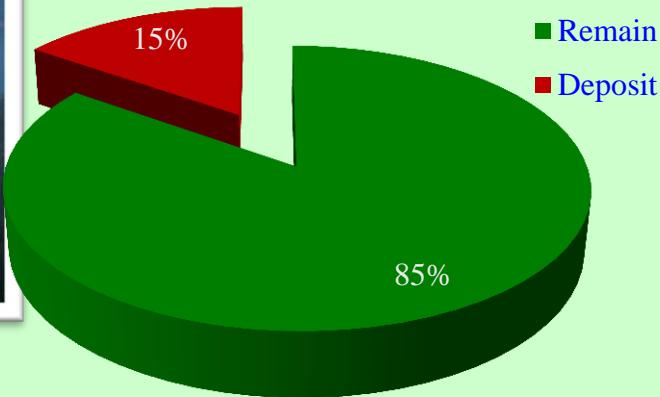
- Zengwen Reservoir
 - the most important reservoir in southern Taiwan
 - Watershed is 481 km^2
 - Annual rainfall is 2,897mm
 - Effective storage is 590 million tons.

Change of reservoir storage

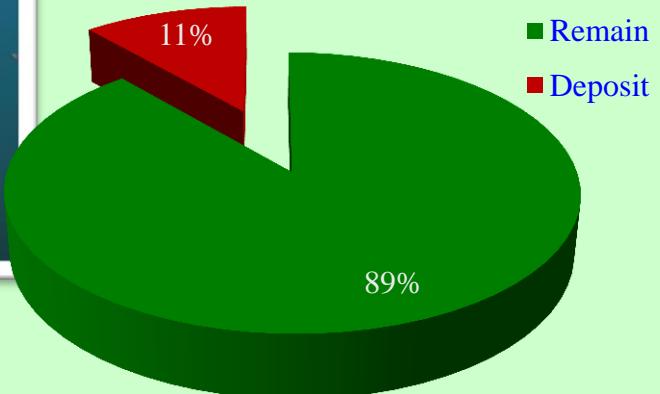




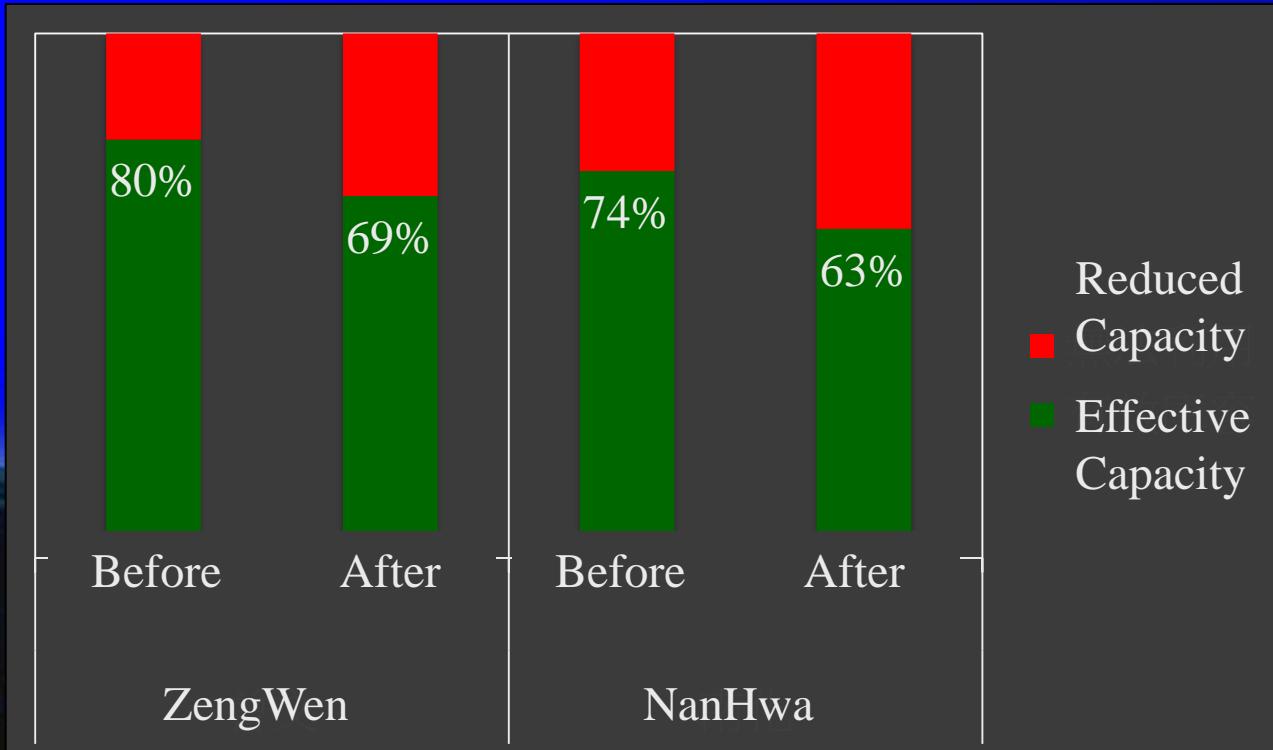
Capacity: 570 million m³
Deposit: 90 million m³



Capacity: 150 million m³
Deposit: 17 million m³



Typhoon Morakot Significantly Reduce Reservoir Effective Capacity



Learn From Typhoon Morakot

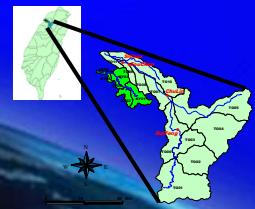
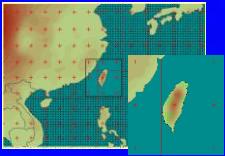
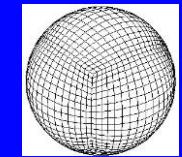
- Water shortage may not only be caused by insufficient streamflows, but also be induced by flood which results in high turbidity flows and facility malfunction.
- Extreme events may come frequently. Extreme flood follows serious drought, and then possible have another serious drought threat.
- Reservoir may be seriously reduced his capacity by a single event. A water supply system will become more and more vulnerable, if extreme events keep hitting the system before it can recover.
- Decreasing vulnerability and increasing resilience of a water supply system is urgent.



Future Possible Climate Change Impacts



Impact Assessment



GCM Projections



Downscaling



Future
Climate Scenarios



Weather Generation

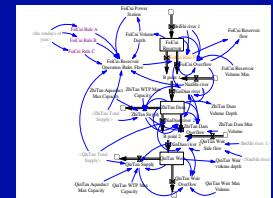
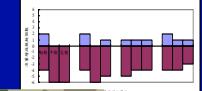
**Impact Information
for Decision Making**

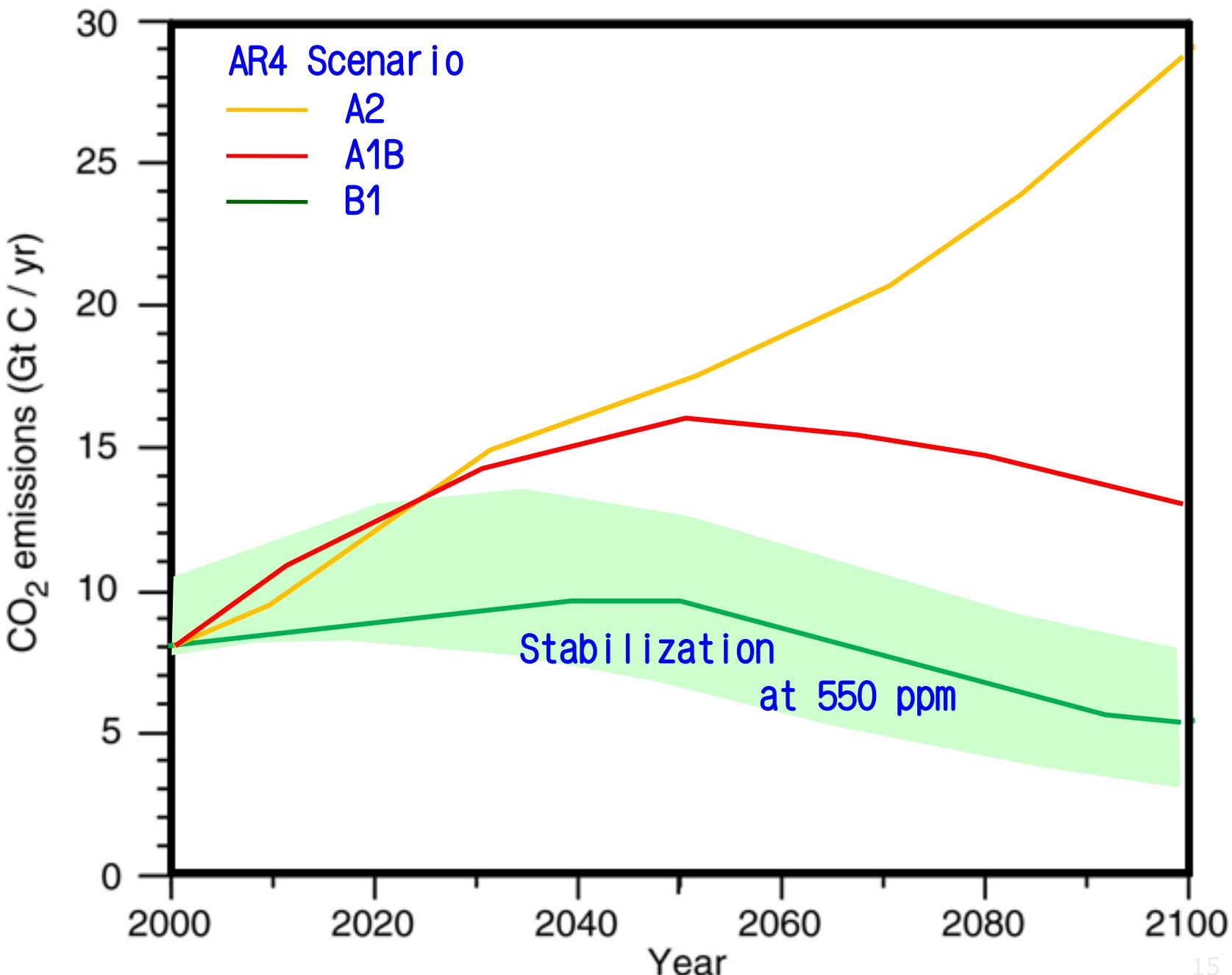


Water Supply System
Dynamics Model



Hydrological Model





Correlation between Observation and GCMs' Baseline

Monthly Mean Temperature

	CSMK3	GFDL2.0	GFDL2.1	HadCM3	INM	IPCM4	MIMR	ECHAM5	CGCM2.3.2	NCAR
台南	0.99	0.99	0.99	0.98	1.00	0.99	1.00	0.98	0.97	1.00
阿里山	0.99	1.00	0.99	0.98	1.00	0.98	0.99	0.98	0.97	1.00
高雄	0.99	0.99	0.99	0.98	1.00	0.99	0.99	0.98	0.97	1.00

Monthly Mean Rainfall

	CSMK3	GFDL2.0	GFDL2.1	HadCM3	INM	IPCM4	MIMR	ECHAM5	CGCM2.3.2	NCAR
曾文新村	0.59	0.92	0.92	0.53	0.96	0.45	-0.13	0.97	0.82	0.93
西阿里關	0.58	0.93	0.91	0.54	0.97	0.44	-0.12	0.97	0.82	0.92
旗山(4)	0.58	0.93	0.91	0.53	0.97	0.45	-0.11	0.97	0.81	0.91
甲仙(2)	0.58	0.94	0.91	0.55	0.97	0.43	-0.11	0.97	0.81	0.91
美濃(2)	0.58	0.94	0.91	0.56	0.96	0.42	-0.10	0.97	0.82	0.92
三地門	0.59	0.95	0.92	0.61	0.95	0.40	-0.07	0.98	0.79	0.91
六龜(4)	0.56	0.94	0.91	0.55	0.97	0.45	-0.11	0.98	0.82	0.91
梅山(2)	0.44	0.93	0.83	0.54	0.94	0.34	-0.18	0.93	0.86	0.91

Downscaling Method

- Simple Downscaling
 - Delta Method
 - Bias Correlation

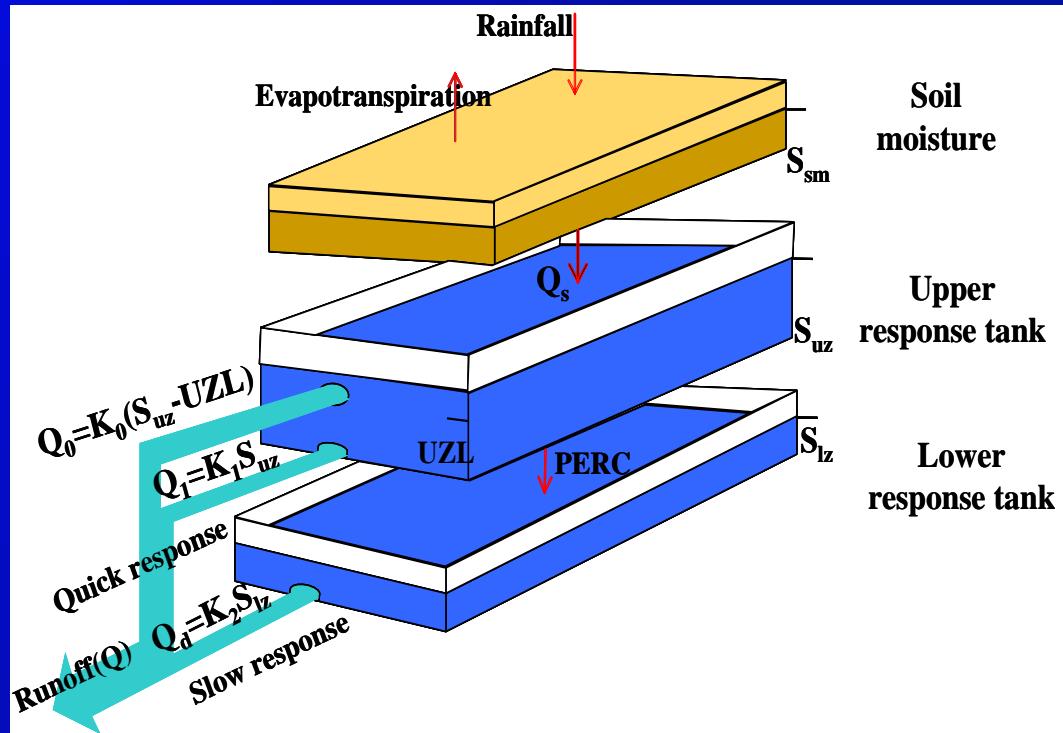
Simulation Models

- Weather Generation Model produce daily weather data based on different climate scenarios.
- Hydrological Models – HBV and GWLF simulate current and future streamflows.
- Water Supply System Dynamics Model – It is developed by Vensim System Dynamics Modelling tool.

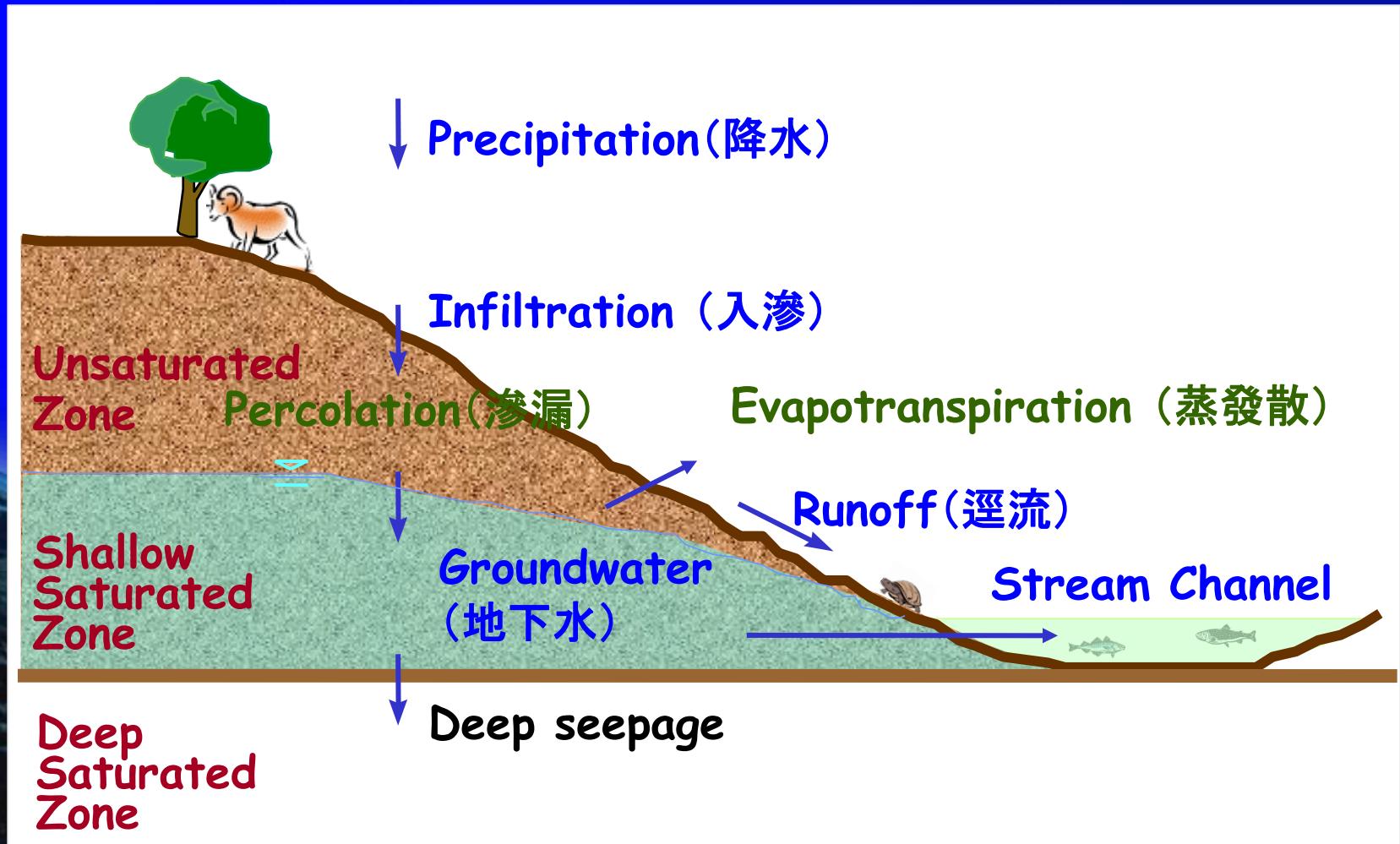
HBV Model

■ Parameters

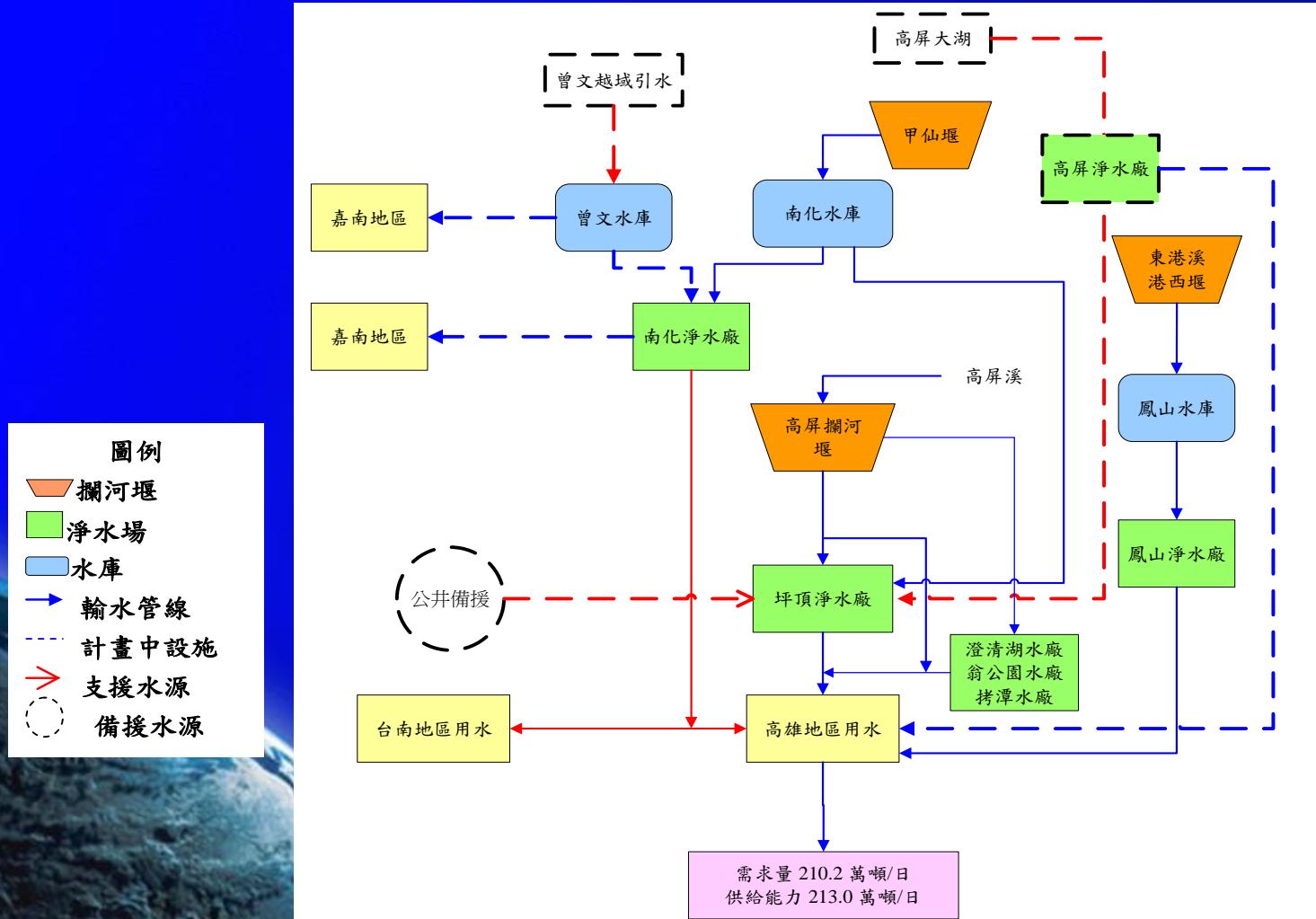
- FC (Field Capacity)
- $\beta \backslash LP$ (Parameter)
- UZL (Outflow height)
- *Recession Coefficient*
 - K_0 (UZL)
 - K_1 (upper tank)
 - K_2 (lower tank)
- Ce (coefficient of ET)
- $PERC$ (Percolation)



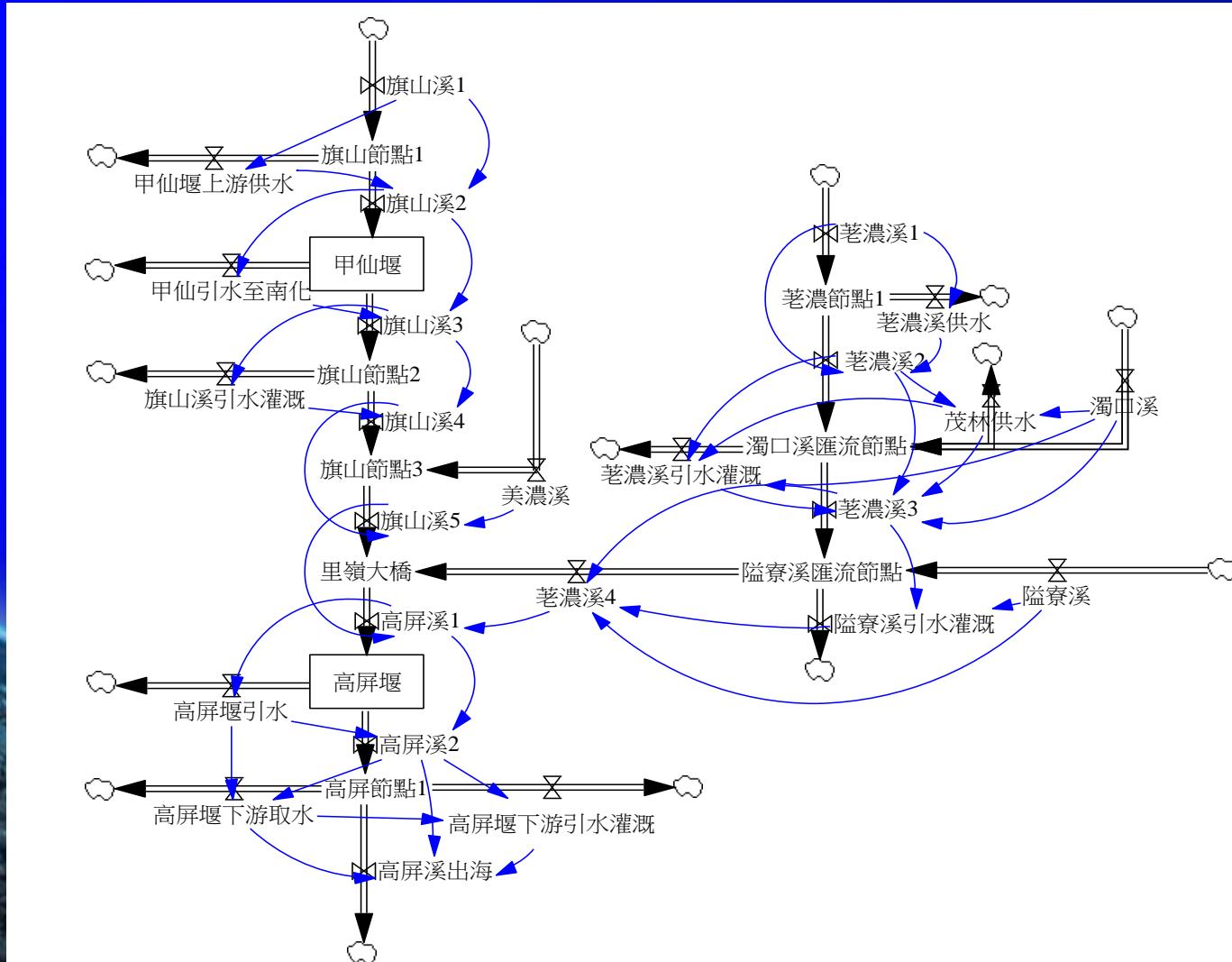
Streamflow component of the GWLF model



Water Supply System - Gaoping Area

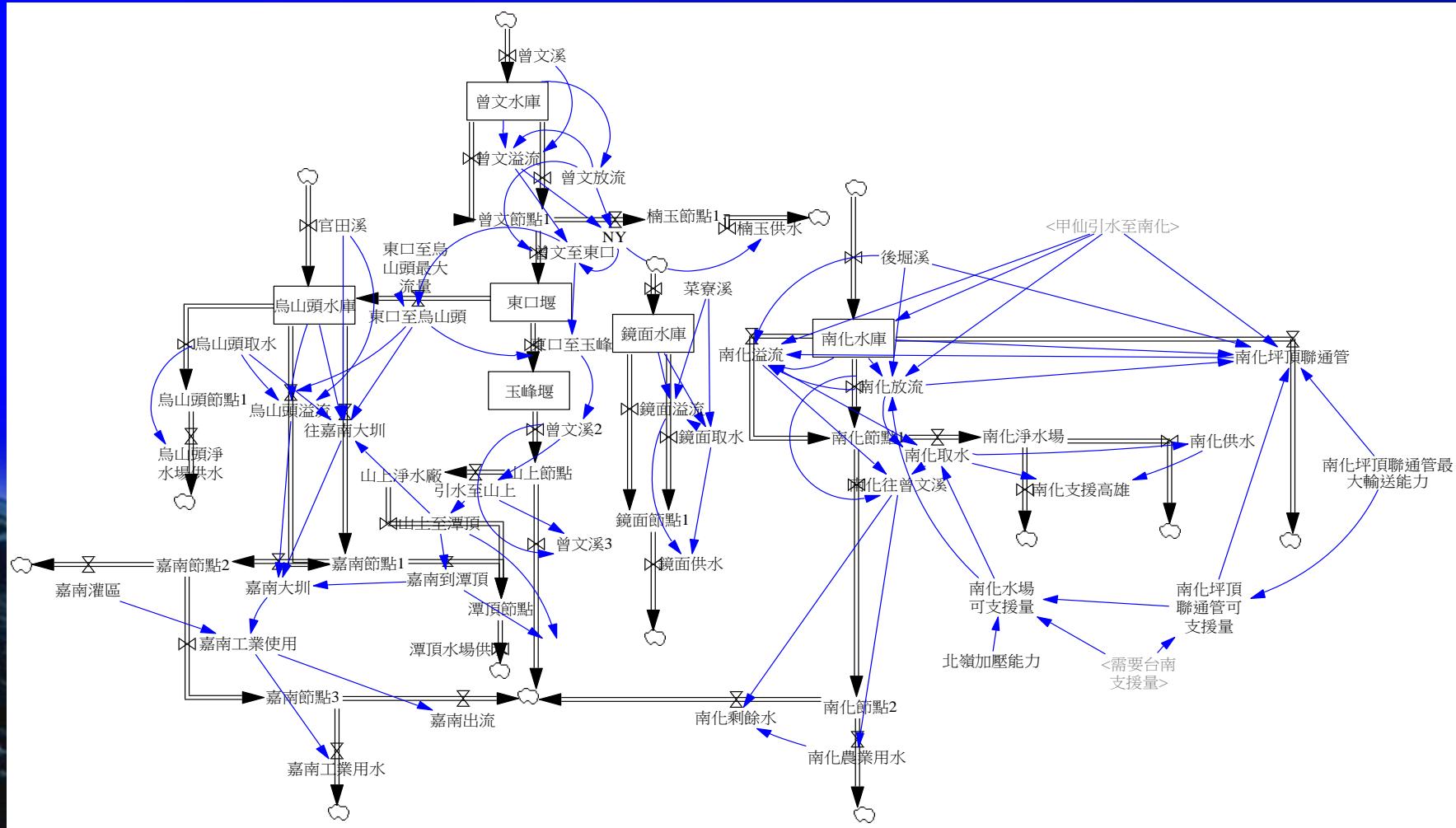


Water Supply System Dynamics Model - the Gaoping System



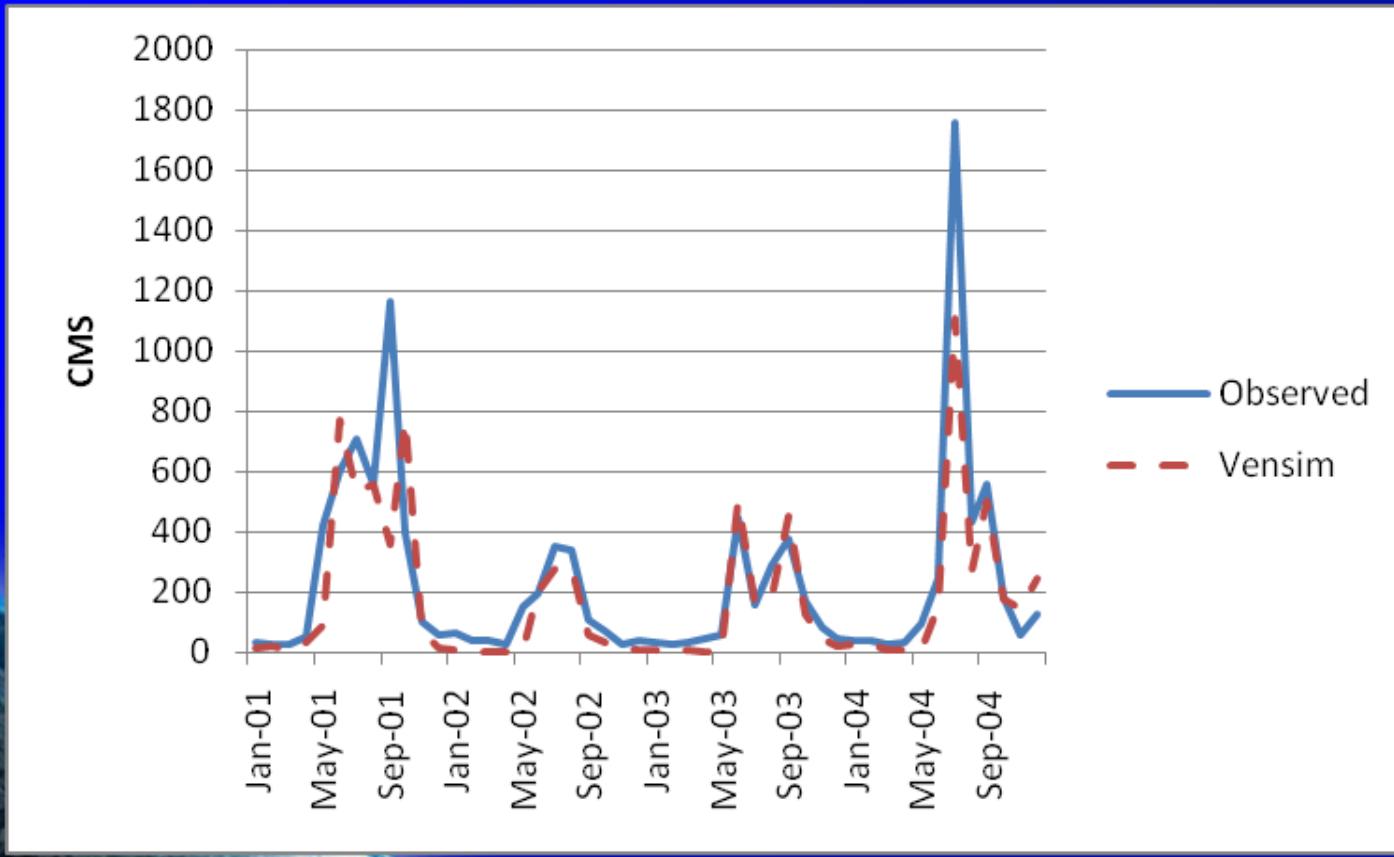
Water Supply System Dynamics Model

- the Zengwen Creek system



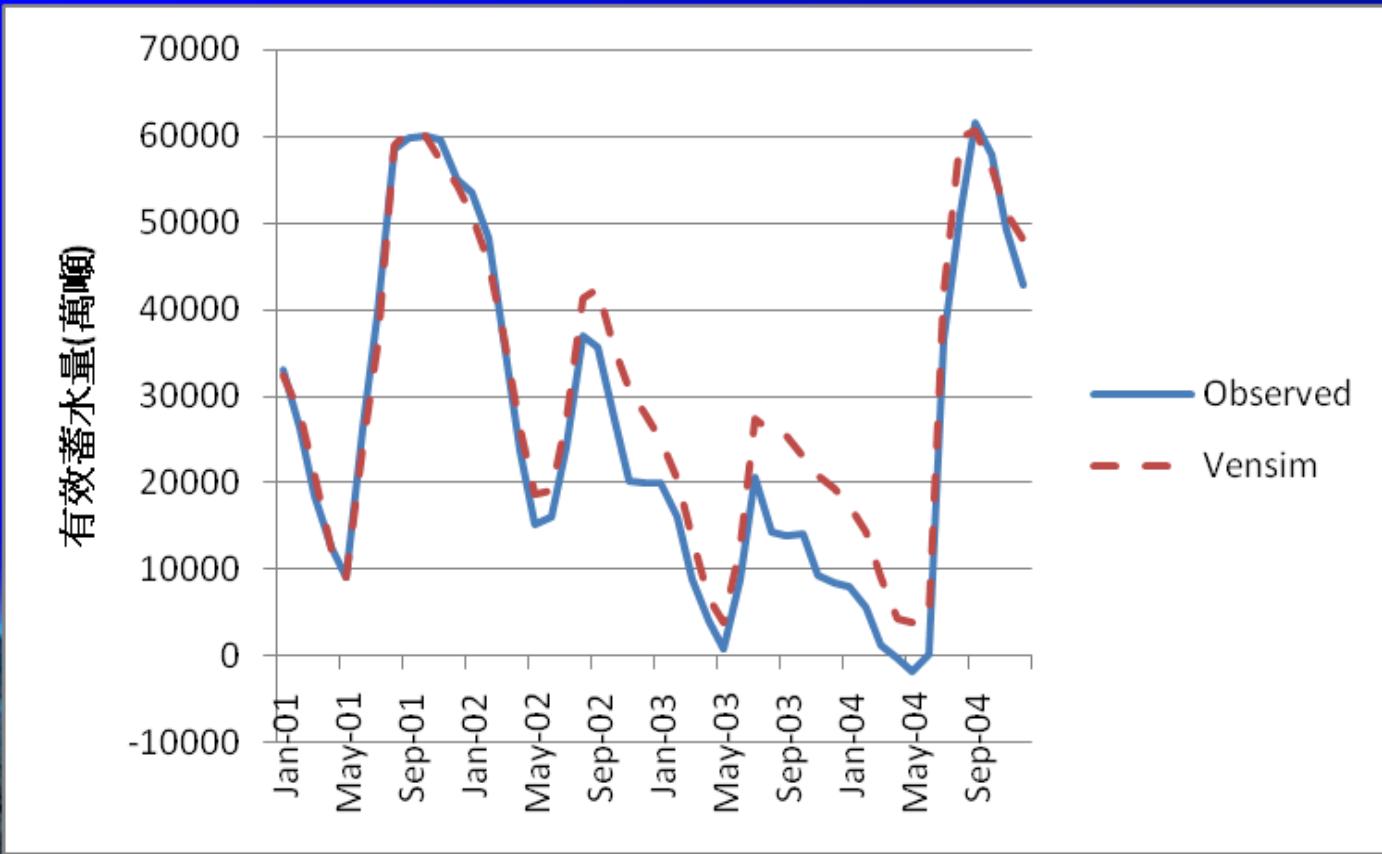
Verification of System Dynamics Models

- Flows @ Liling Bridge Gage Station



Verification of System Dynamics Models

- Storage @ Zengwen Reservoir



Index to evaluate the risk of water deficit

- Shortage Index

$$SI = \frac{100}{N} \overline{\text{a}}_{i=1}^N \left(\frac{D_i}{S_i} \right)^2$$

- Deficit Percent Day Index, DPD Index

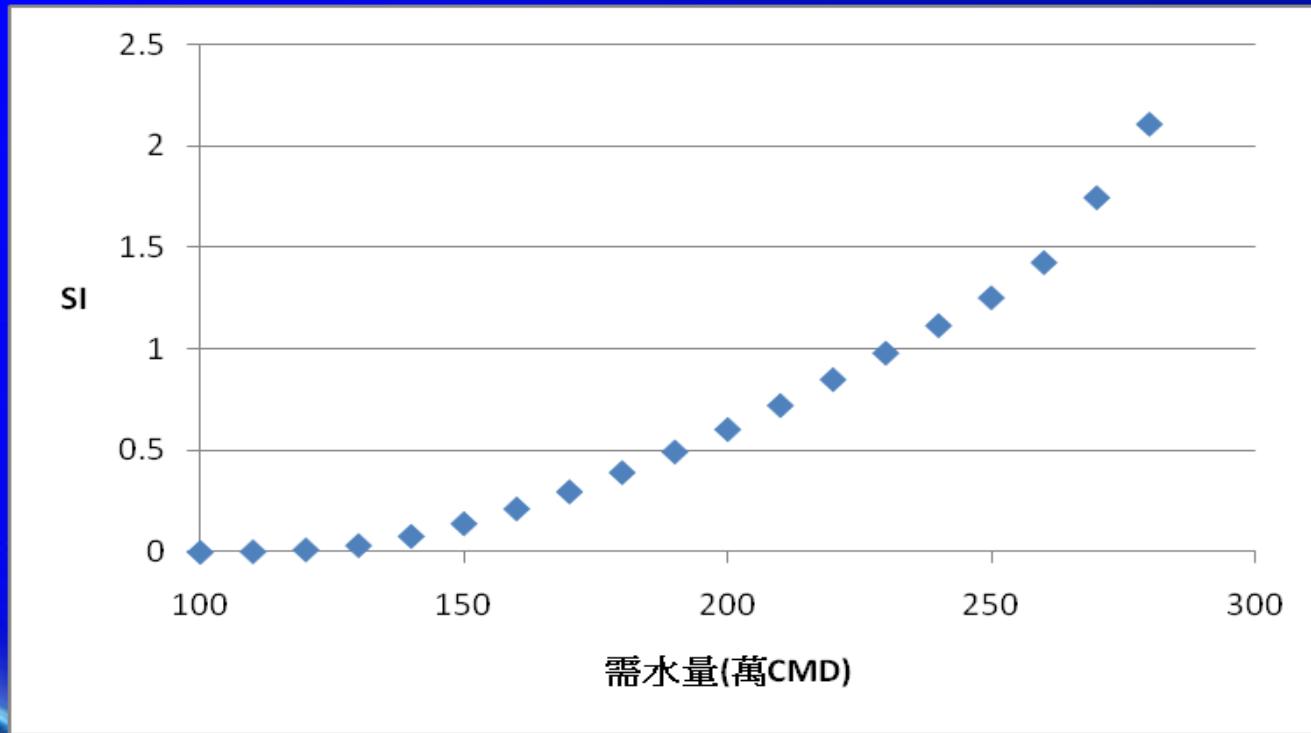
$$DPD = \overline{\text{a}}_{d=1}^{N_d} D\%$$

The Criteria of Water Deficit

- Current shortage index (SI) is about 0.39 which is used as a reference.
- This study uses the threshold of DPD=1500 % -day to evaluate the water supply ability.

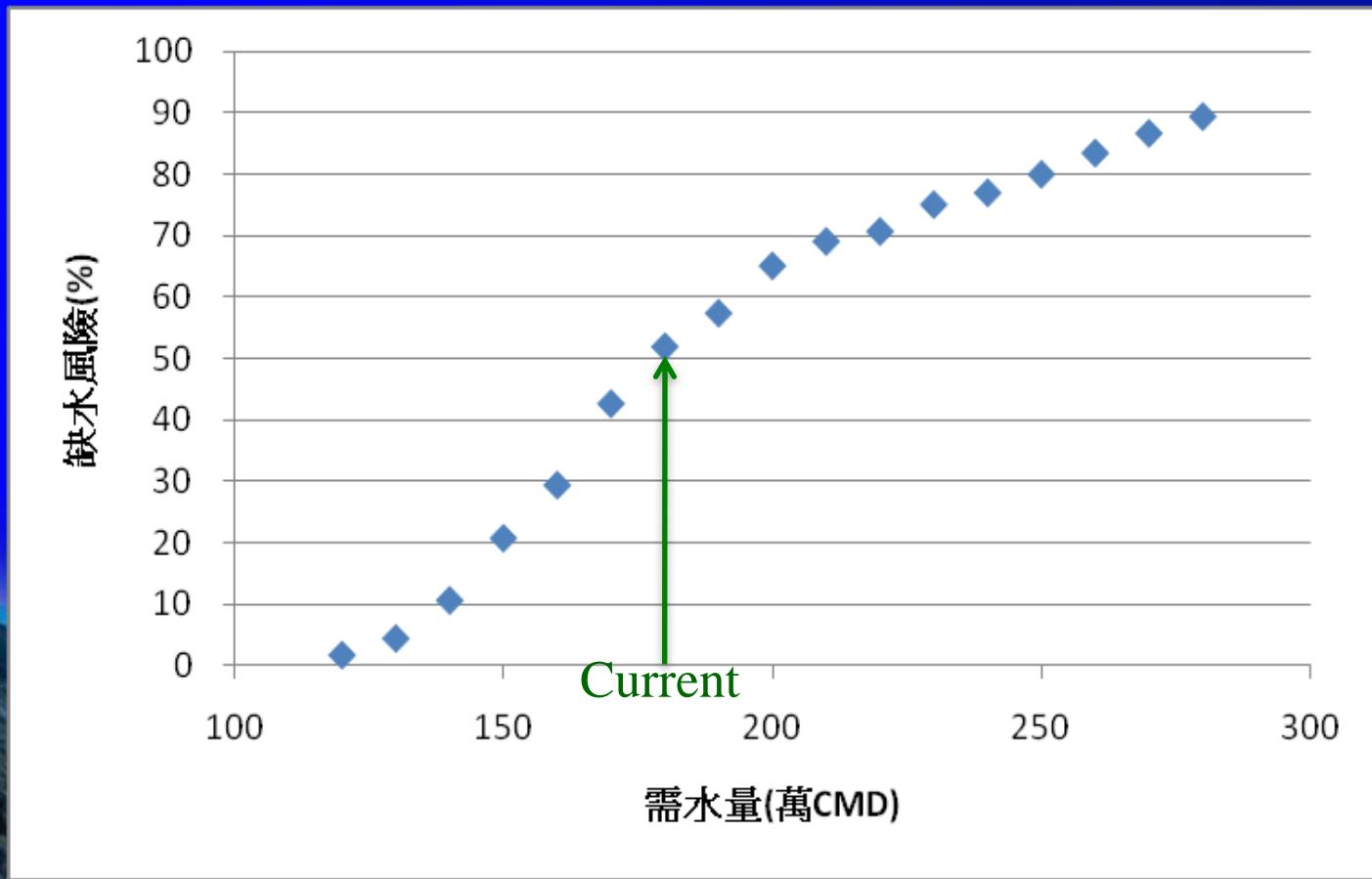


Current Water Supply Carrying Capacity

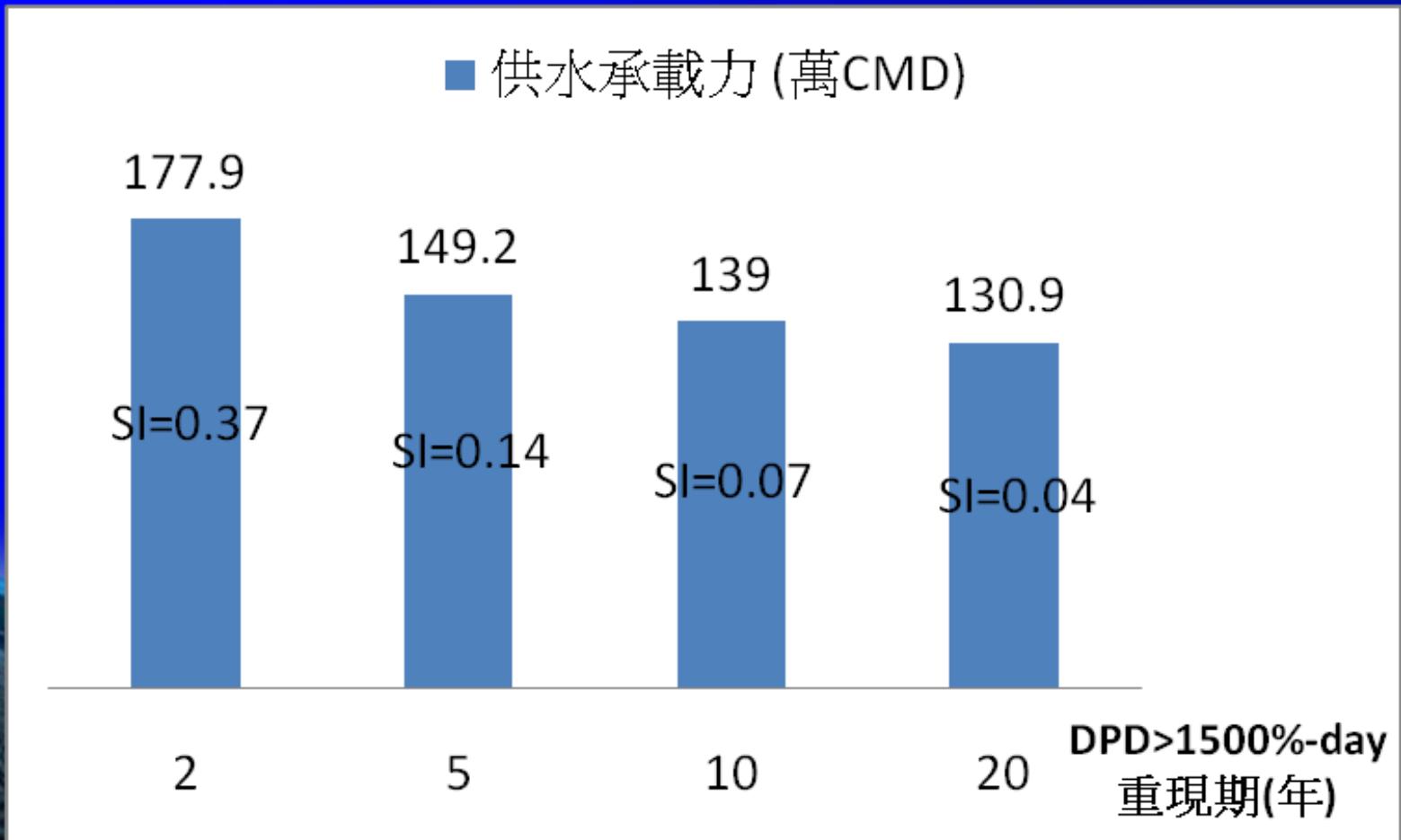


SI	0.1	0.5	1	Current 0.39
Water Supply (10 ⁴ CMD)	143.5	190.6	231.5	180

Risk of Water Deficit with the criterion of DPD>1500%-day



Current Carrying Capacity of Water Supply System

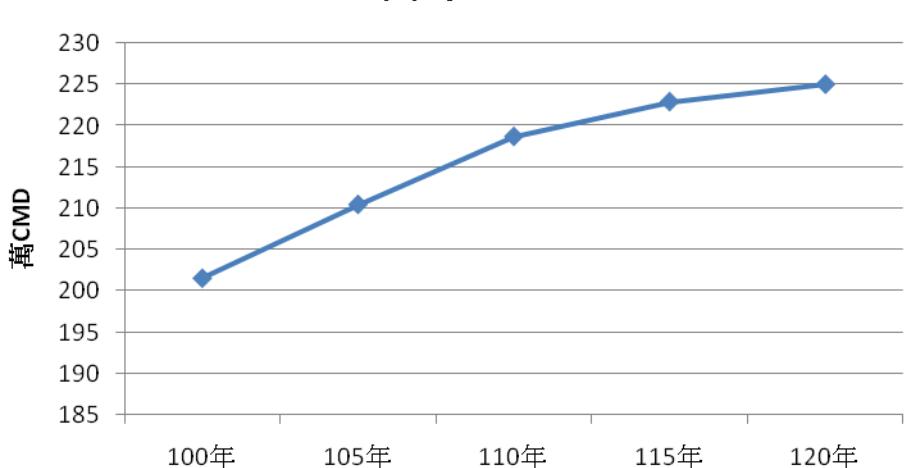


Project Future Water Demand due to growth of Industry and Population

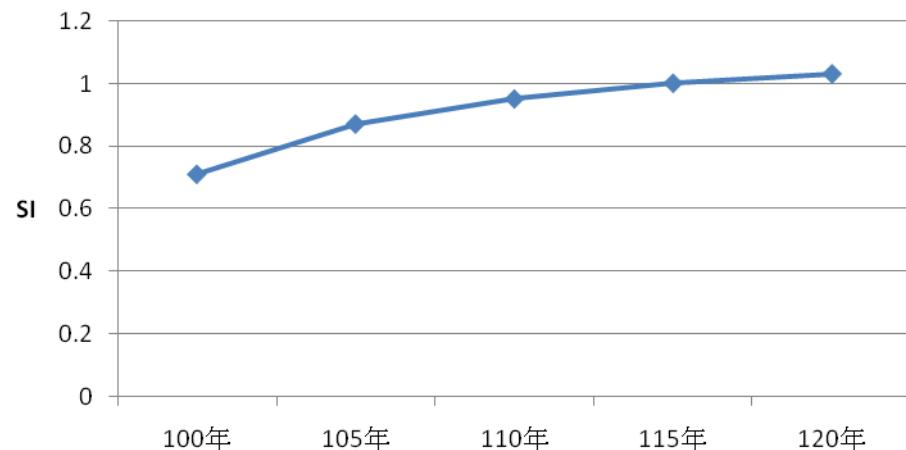
	2011	2016	2021	2026	2031
Demand	201.6	210.5	218.7	222.9	225
SI	0.71	0.87	0.95	1.00	1.03

Unit: 10^4CMD

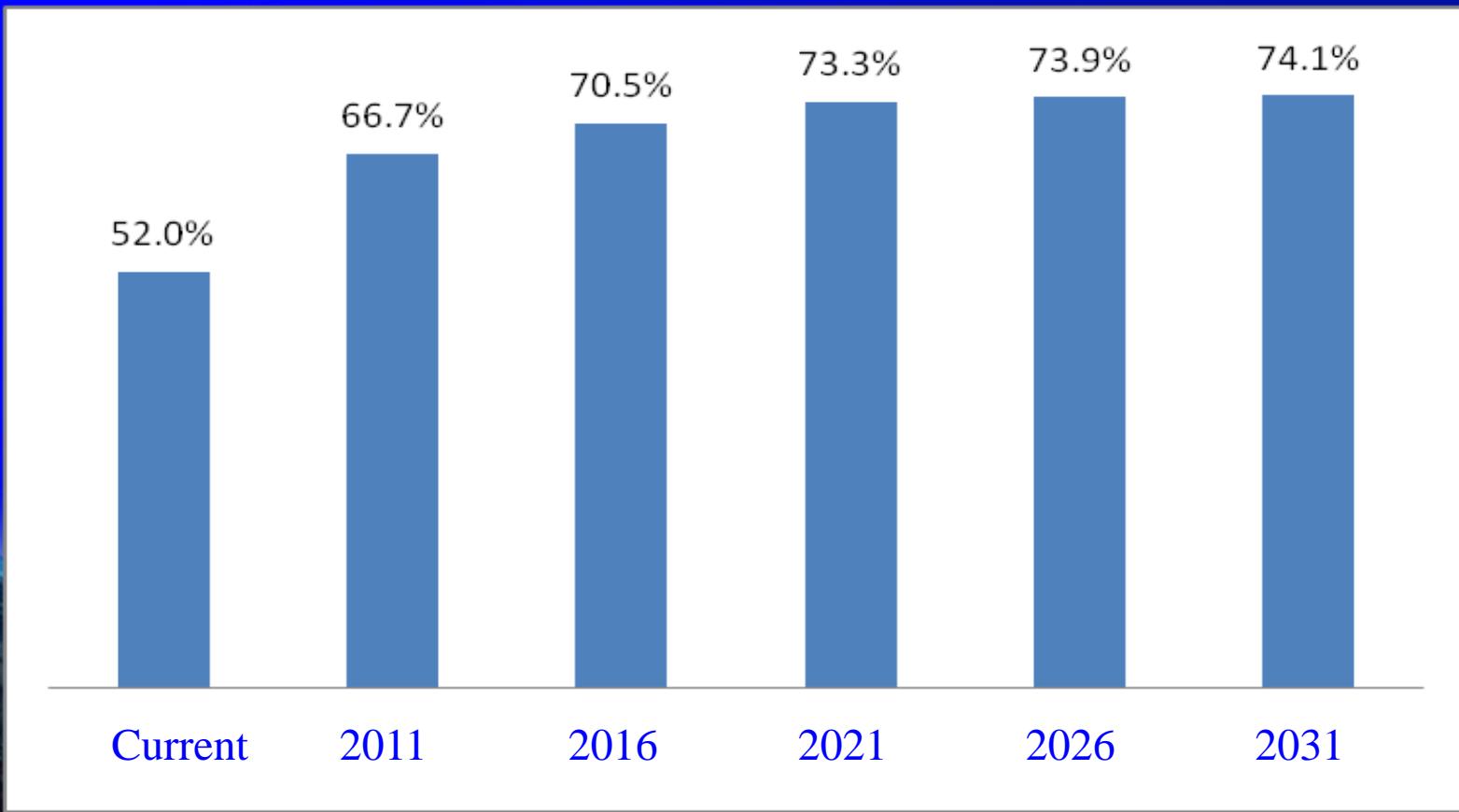
需水量



SI



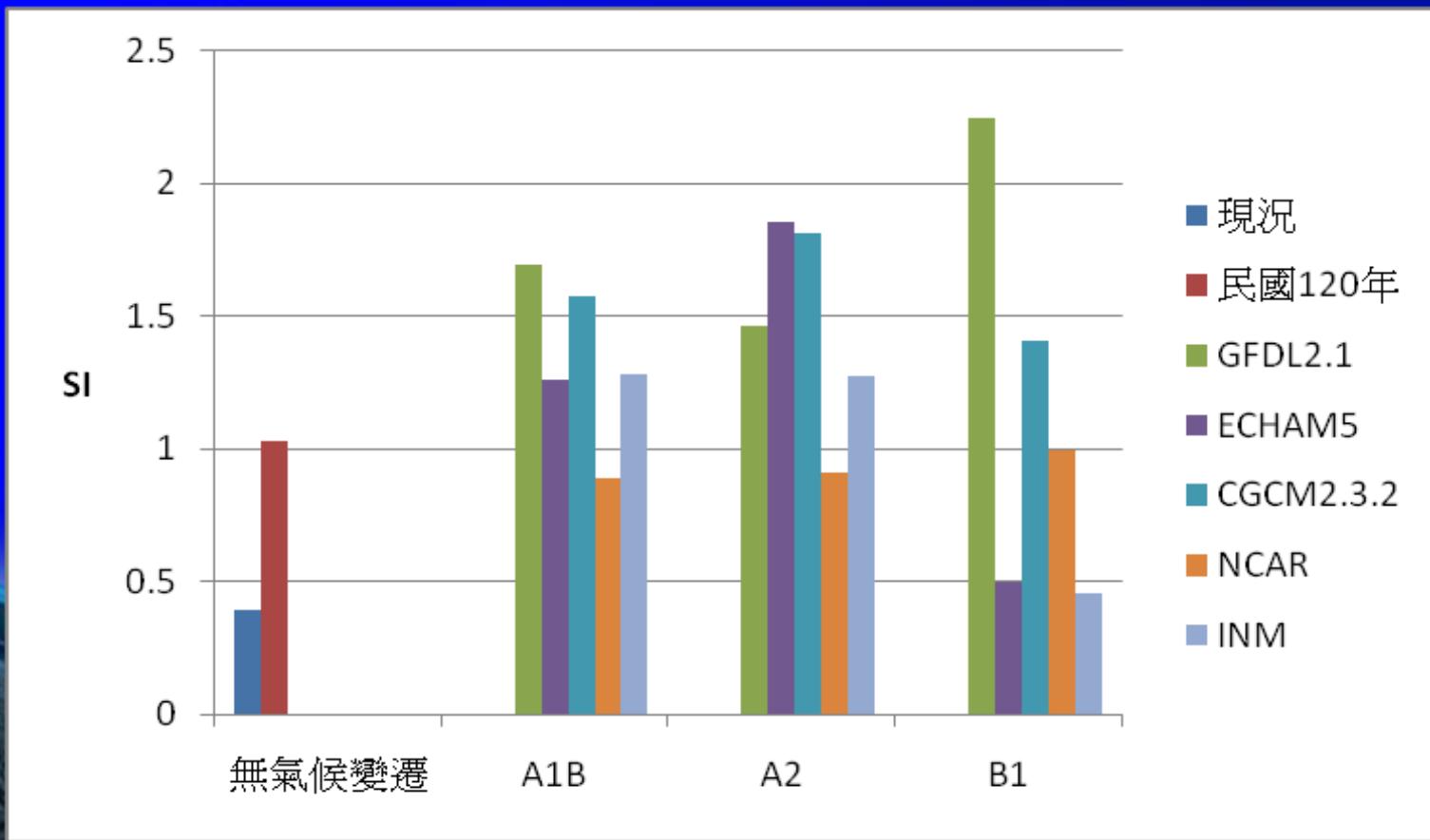
Risk of Water Deficit (DPD>1500%-day)



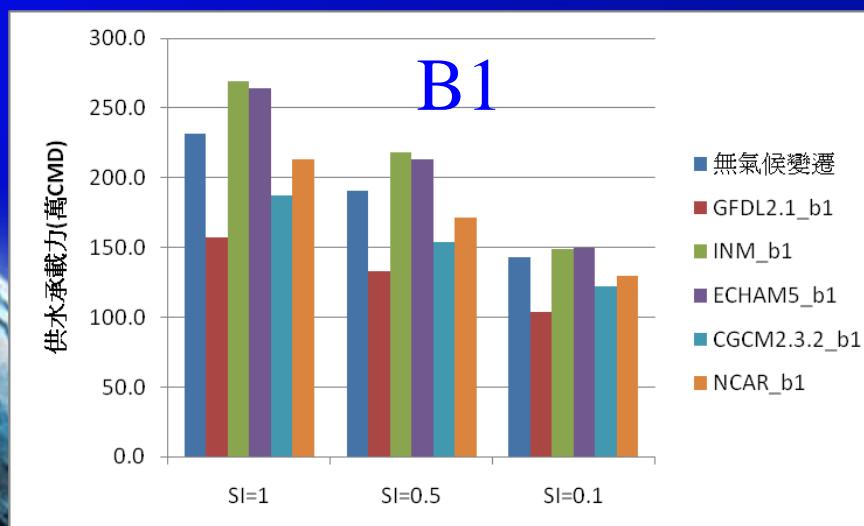
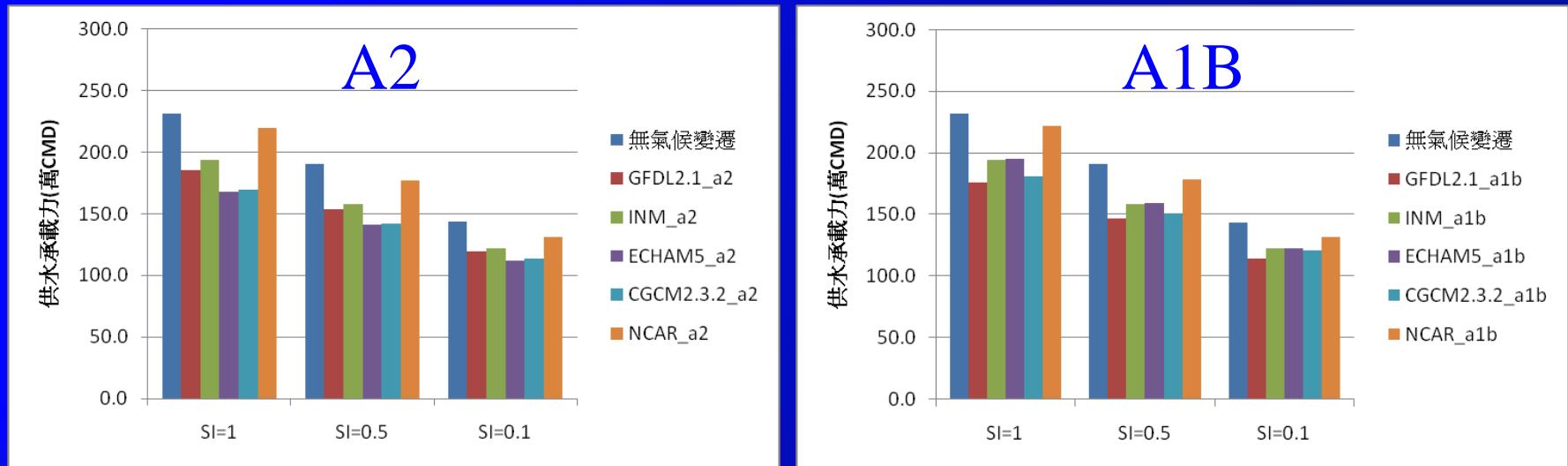
Climate Change Impacts on Gaopin Water Supply Carrying Capacity@2031

	SI=1	SI=0.5	SI=0.1
W/O Climate Change	231.5	190.6	143.5
GFDL2.1_a1b	175.9	146.7	114.5
INM_a1b	193.9	158.2	122.7
ECHAM5_a1b	195.3	159.3	122.4
CGCM2.3.2_a1b	180.5	150.9	121.2
NCAR_a1b	221.5	177.9	131.5
GFDL2.1_a2	185.5	153.9	119.9
INM_a2	193.6	157.6	122.3
ECHAM5_a2	168.4	140.8	112.2
CGCM2.3.2_a2	169.5	142.0	113.8
NCAR_a2	219.9	177.3	131.5
GFDL2.1_b1	157.3	132.9	103.7
INM_b1	268.8	218.4	149.1
ECHAM5_b1	264.1	213.0	149.6
CGCM2.3.2_b1	187.0	153.8	121.9
NCAR_b1	213.0	171.5	129.6

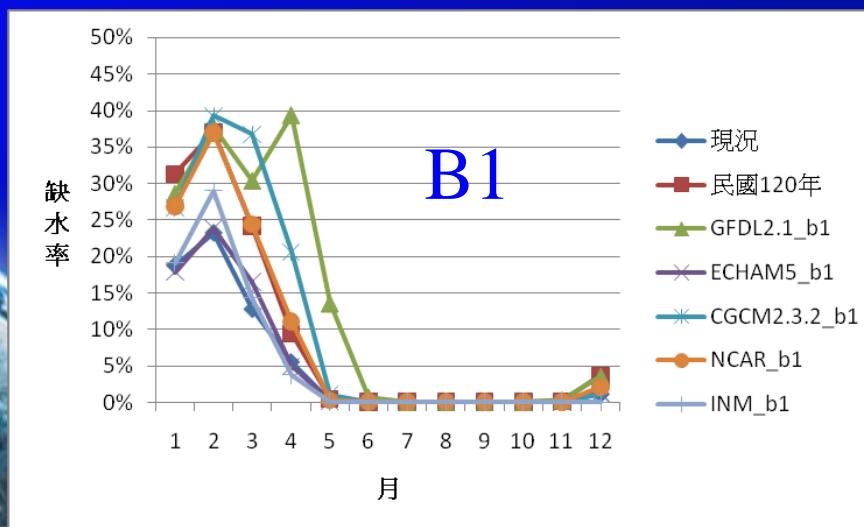
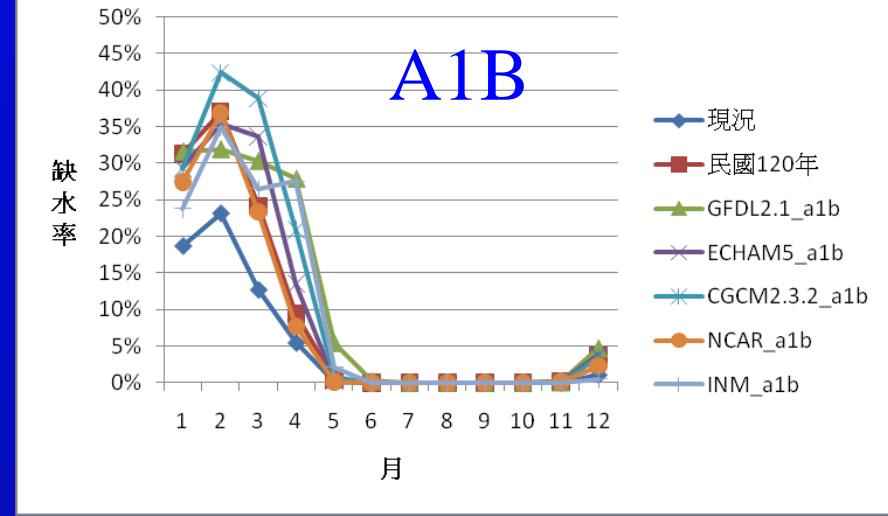
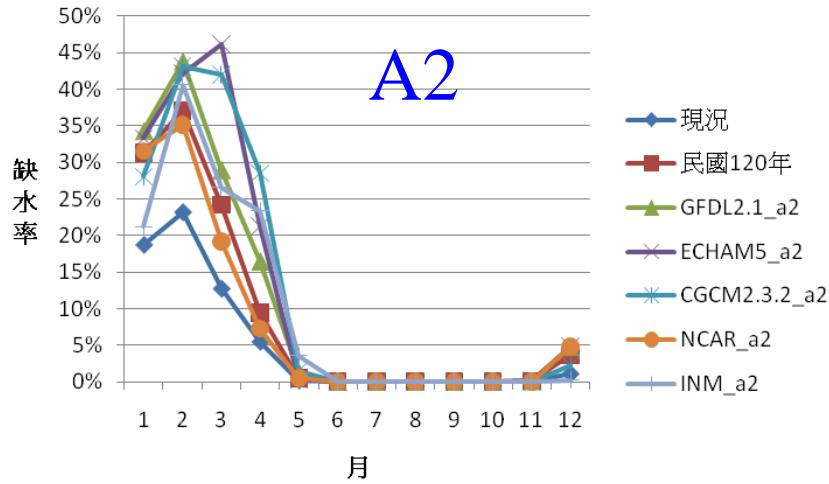
Climate Change Impacts on Gaoping Water Supply Carrying Capacity



Climate Change Impacts on Gaopin Water Supply Carrying Capacity @ 2031



Climate Change Impacts on Gaopin Water Supply Carrying Capacity @ 2031





Strengthening the Adaptive Capacity of Water Supply Systems



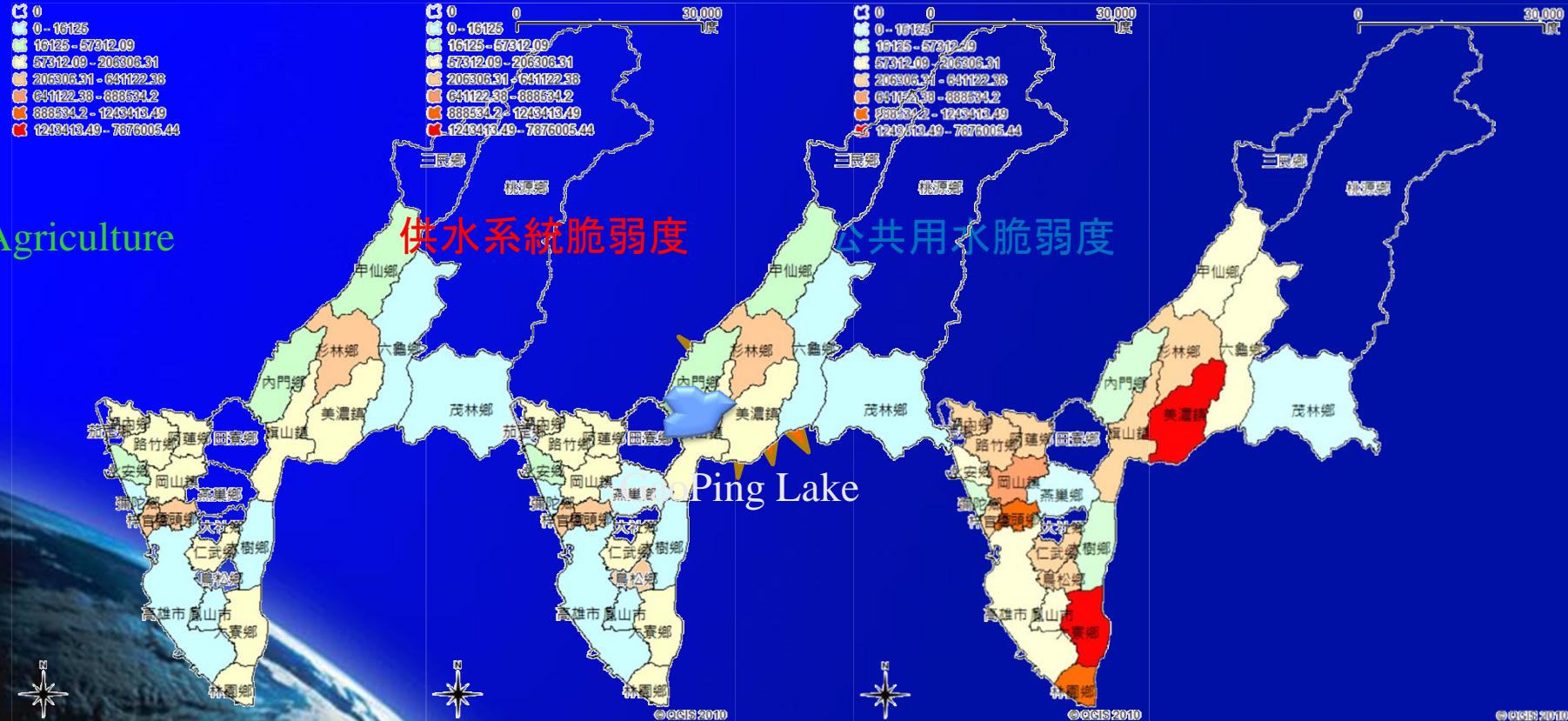
Whimtespertoisfindnsystem?

Goals

- Identifying hotspot (the most vulnerable areas)
- Developing distributed response systems

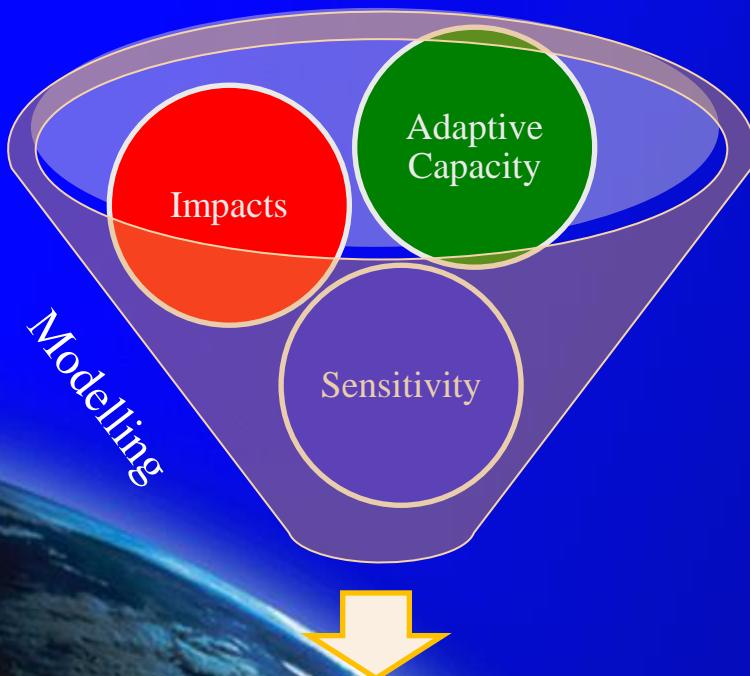


Establishing Vulnerable Maps



Vulnerability Assessment

$$V = F(\text{Impact}, \text{Adaptive Capacity}, \text{Sensitivity})$$



Vulnerability & Resilience

- Impacts
 - Changing Climate
- Adaptive capacity
 - Facilities
 - Governance & Management
- Sensitivity (Exposure)
 - Population
 - Agricultural and Industrial Productions

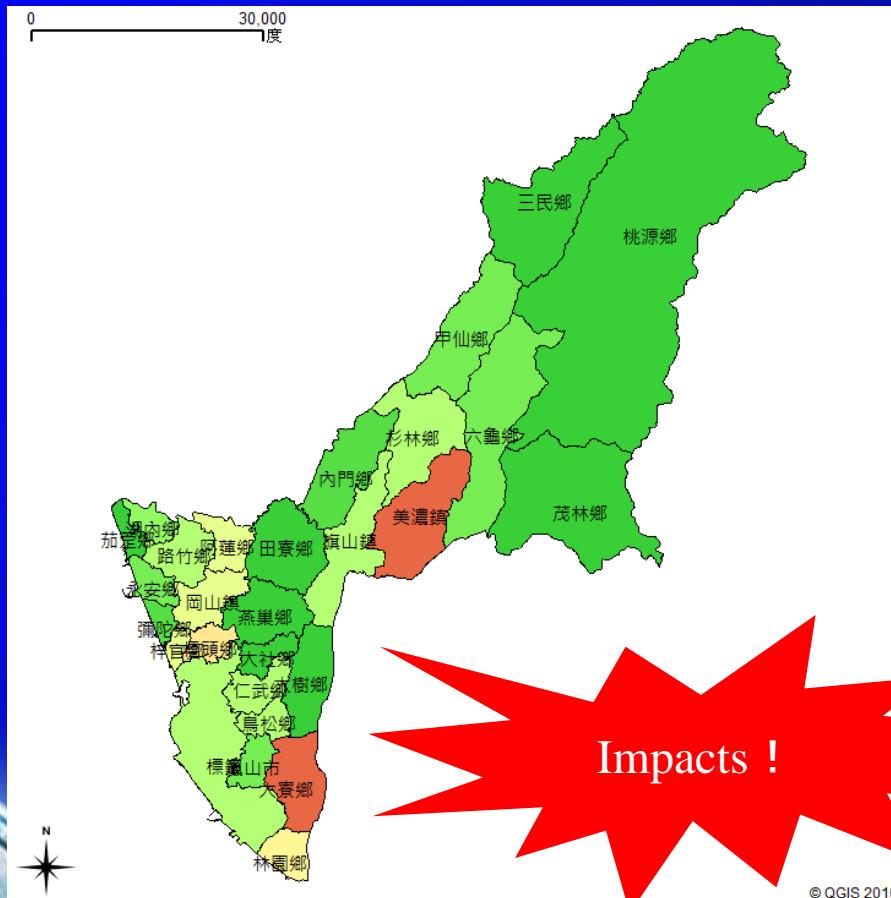
Vulnerability Map

Climate Scenarios

A1B

A2

B1



Adaptation Strategies

Strategy 1

Strategy 2

Strategy 3

Back

Taiwan Water Resources Assessment Program to Climate Change (TaiWAP)

<http://groups.google.com.tw/group/taiwap2>

The screenshot shows a Google Groups page for the group '氣候變遷對水資源衝擊評估模式 TaiWAP'. The page header includes links for Gmail, 日曆, 文件, 閱讀器, 所有網頁, 更多, and tedliu13@gmail.com | 我的群組. The main content area features the group's logo (a blue circle with a white water drop and three wavy lines) and the title 'Taiwan Water Resources Assessment Program to Climate Change'. Below the title, there is a message in Chinese: '有關TaiWAP的問題討論與解答以及版本更新均會在此發布。' and its English translation: 'Welcome! Here is the board for the announcement and discussion of TaiWAP.' It also states: '如果你對TaiWAP有興趣，請加入此群組。' and its English translation: 'If you are interested in TaiWAP, please join this group.' A note below says: '任何討論內容或版本更新通知都會自動傳送至您的 email。' and its English translation: 'All the discussion and announcement will be sent to your email.' At the bottom, there is a link to download the presentation: 'Download TaiWAP'.

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Google 網上論壇

氣候變遷對水資源衝擊評估模式 TaiWAP

上次之後的更新：3 則留言

首頁

Taiwan Water Resources Assessment Program to Climate Change

有關TaiWAP的問題討論與解答以及版本更新均會在此發布。

Welcome! Here is the board for the announcement and discussion of TaiWAP.

如果你對TaiWAP有興趣，請加入此群組。

If you are interested in TaiWAP, please join this group.

任何討論內容或版本更新通知都會自動傳送至您的 email。

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Download TaiWAP

TaiWAP與氣候變遷評估說明請點此下載(ppt)
TaiWAP and Climate Change Download(ppt in Chinese)

GWLF參數資料請點此下載(MS Word)
Parameters of GWLF in Taiwan Download(MS Word in Chinese)

氣象資料合成模式說明請點此下載
About weather generator in TaiWAP Download (MS Word in Chinese)

Components in TaiWAP

Future Scenario

This component allows users to define future scenarios for climate data. It includes a bar chart showing projected flow volumes for different years (2020s_P, 2050s_P, 2080s_P) across various river basins.

Trend Analysis

This component displays historical flow data trends for different river basins (e.g., Taitan River, Keelung River, Beishi River) over time.

HBV & GWLF Model

This component integrates the HBV and GWLF models to simulate hydrological processes. It shows flow volume data and a line graph illustrating model results.

Weather Generation Model

This component generates synthetic weather data for climate scenario analysis. It includes a bar chart showing generated flow volumes for different years (Baseline_I, 2020s_I, 2050s_I, 2080s_I) across various river basins.

Agri. Water Demand

This component represents agricultural water demand, which is a key factor in water resource management.

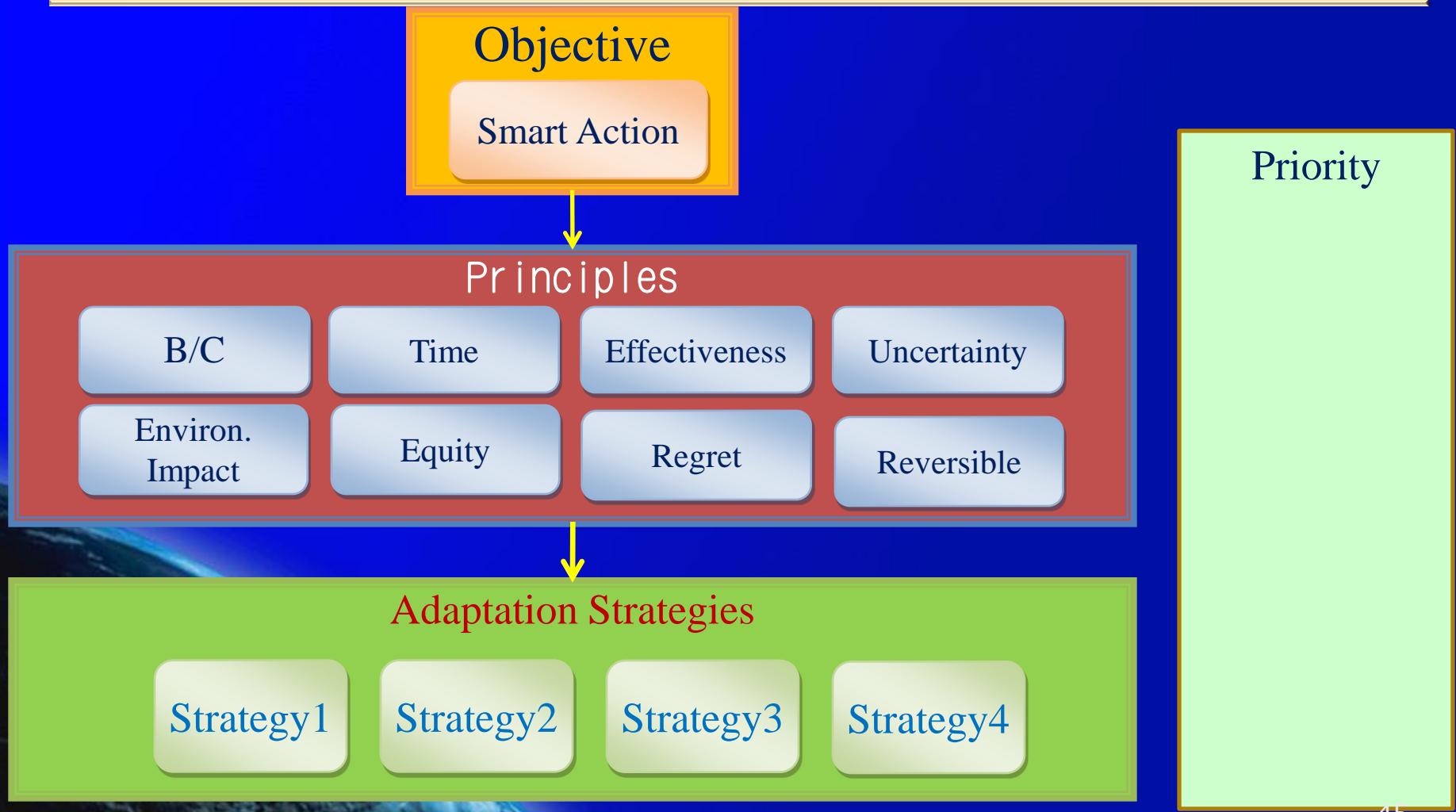
System Dynamics Model

This component uses System Dynamics modeling to analyze water resource systems. It includes a decision matrix (Vensim) and a bar chart showing SI values for different cities (Taipei, Banhsin, Xitun, Keelung) under different scenarios.

AHP tool

This component uses the Analytic Hierarchy Process (AHP) to evaluate and rank various water resource management schemes. It includes a decision matrix (AHP) and a list of evaluation criteria.

AHP Tool



Final Remarks

- Sustainable development is our goal. The abilities to evaluate climate change impacts and identify measures to strengthen adaptive capacity are very important to reach the goal.
- Engineer always designs their systems based on past statistics and assumes they are stationary. However, climate change makes different stories.
- How to reduce vulnerability and increase resilience for a system is very important.

Final Remarks

- How can we make wise decisions with uncertainty? Uncertainty is the major constraint on taking actions. Early warning and risk management systems are very important for adapting to future climate.
- Distributed response system may also be required to unload impacts. Possible measures for distributed response system may include rainwater harvesting, water recycling, groundwater, small lake, etc..

Thanks for Listening! Any Question is Welcomed!

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