Strengthening Water Supply System Adaptive Capacity to Climate Change_ Central Region of Taiwan

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Methodologies and Objective

- **Methodologies**

  Follow the same methodologies presented in the previous talk.

- **Objective**

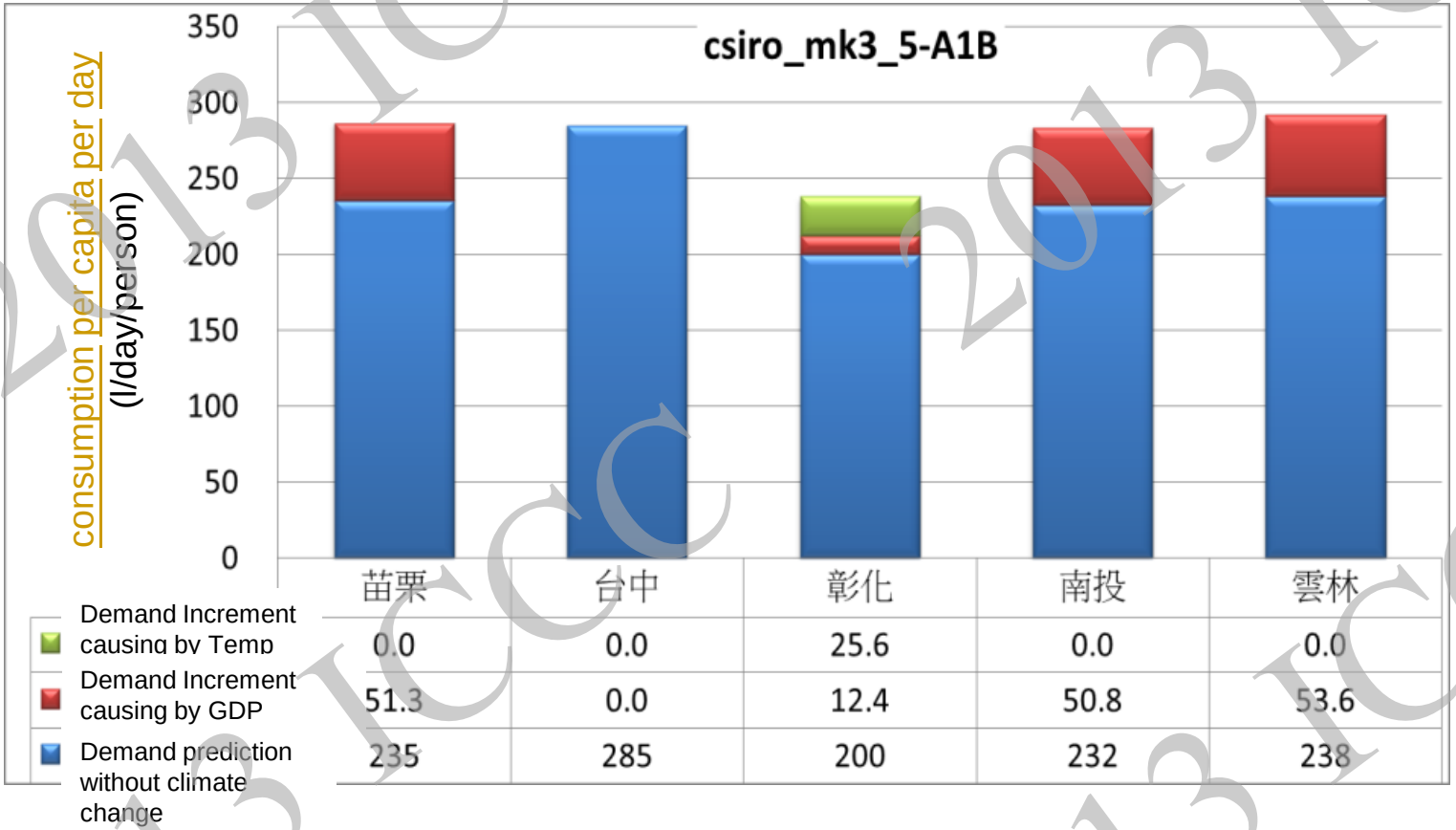
  Similar to the previous talk but we are focus on the central region of Taiwan.

Main Tasks and Research Area

- Water Demand Prediction
- Risk Maps of Water Supply Considering Climate Change
- Adaptive Strategies (Action plans) planning

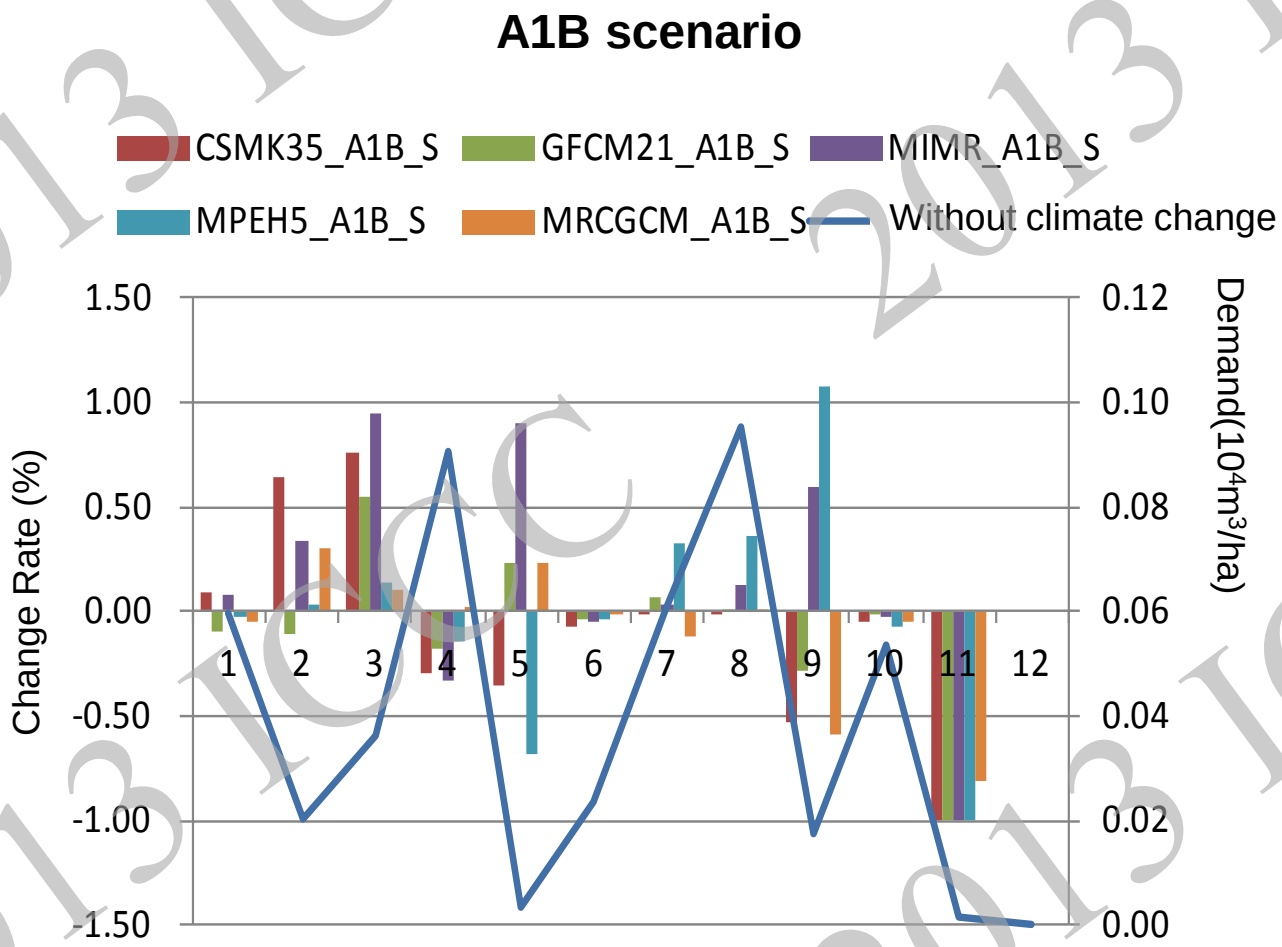
Total population of the study area is about 5.8 million. (1/4 of the total population in Taiwan)

Water Demand Prediction-Domestic Water Use



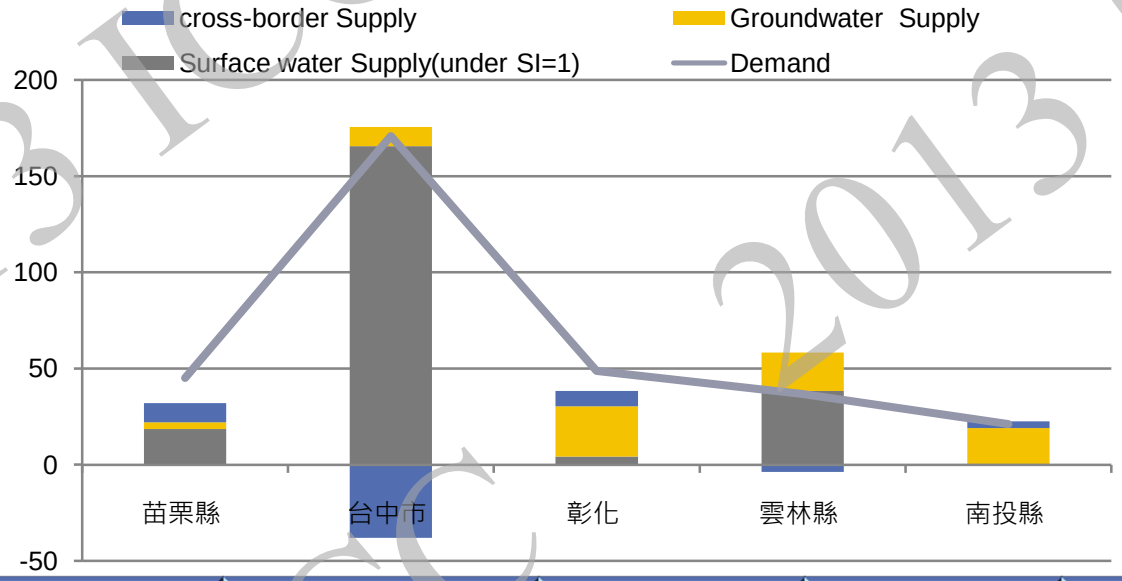
Water Demand Prediction- Agricultural Water Use

- Use **TaiWAP** to estimate irrigation water use
- The annual consumption change rate of central Taiwan is between **-1~3.35**%



Water Shortage Considering Climate Change

Summary of water shortage for existing system with A1B and most severe case of GCM model

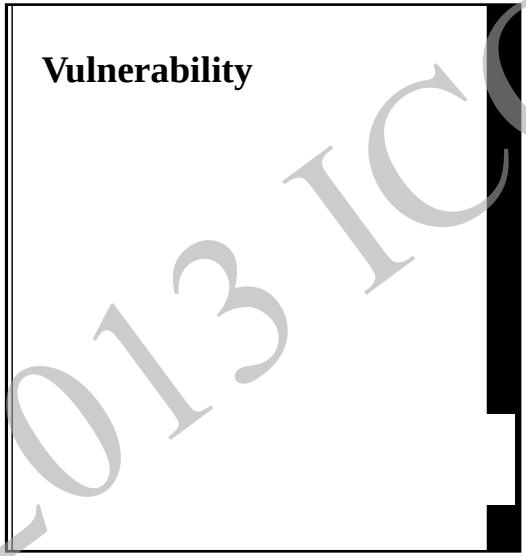


	苗栗縣	台中市	彰化	雲林縣	南投縣
Demand	45.03	170.76	48.77	36.71	21.10
Surface water Supply (under SI=1)	18.50	165.50	4.30	38.33	0.00
Groundwater Supply	3.50	10.00	26.00	20.00	19.00
cross-border Supply	10.00	-38.00	8.00	-3.80	3.50
Water shortage cause by climate change	6.29	13.00	7.29	8.01	3.54
Total Water shortage	13.03	33.26	10.47	-17.82	-1.40

Risk Maps Considering Climate Change _ Methodology

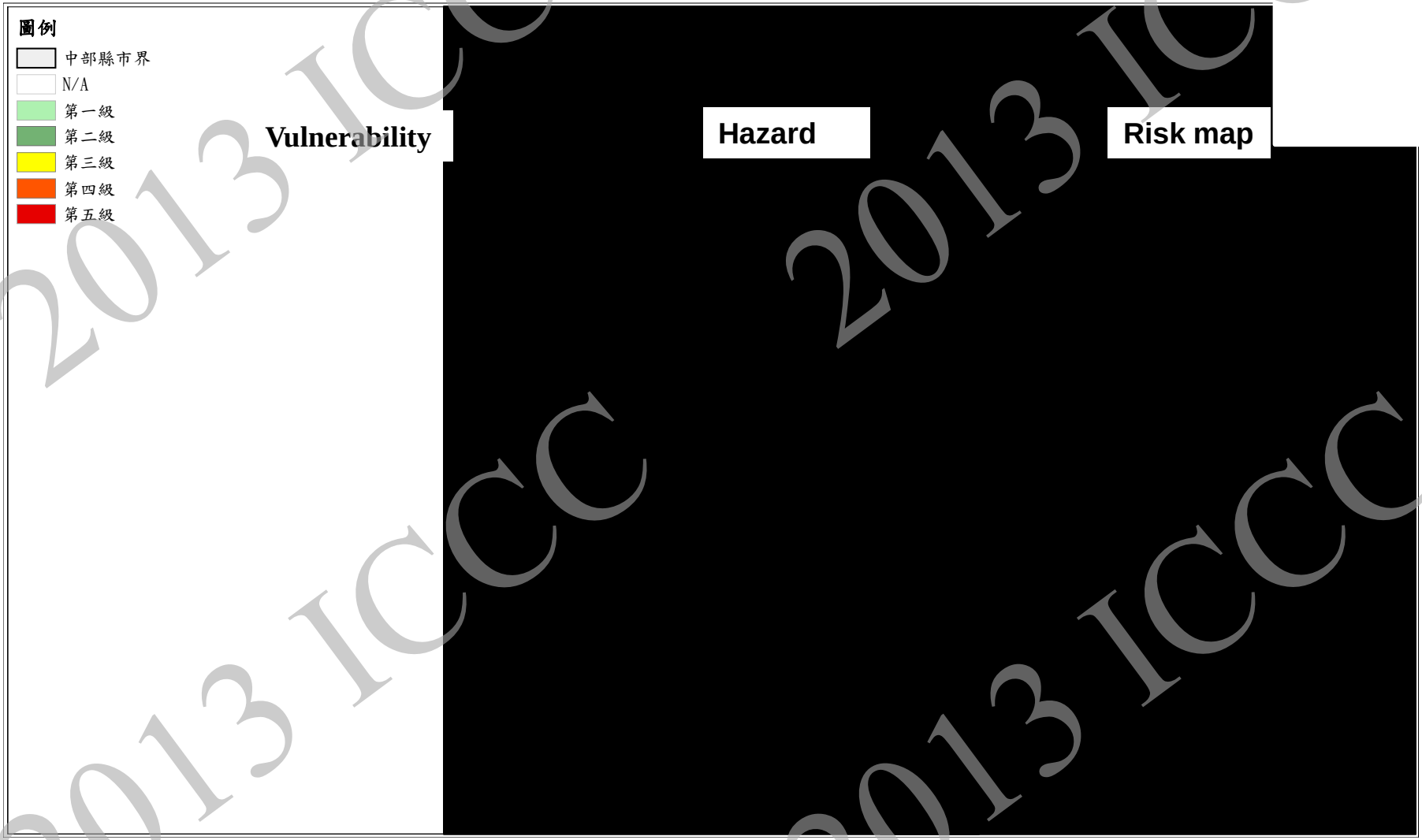
Risk map

	Vulnerability				
Hazard	**1**	**2**	**3**	**4**	**5**
1	1	1	1	1	2
2	1	1	2	2	3
3	1	2	2	3	4
4	1	2	3	4	5
5	2	3	4	5	5



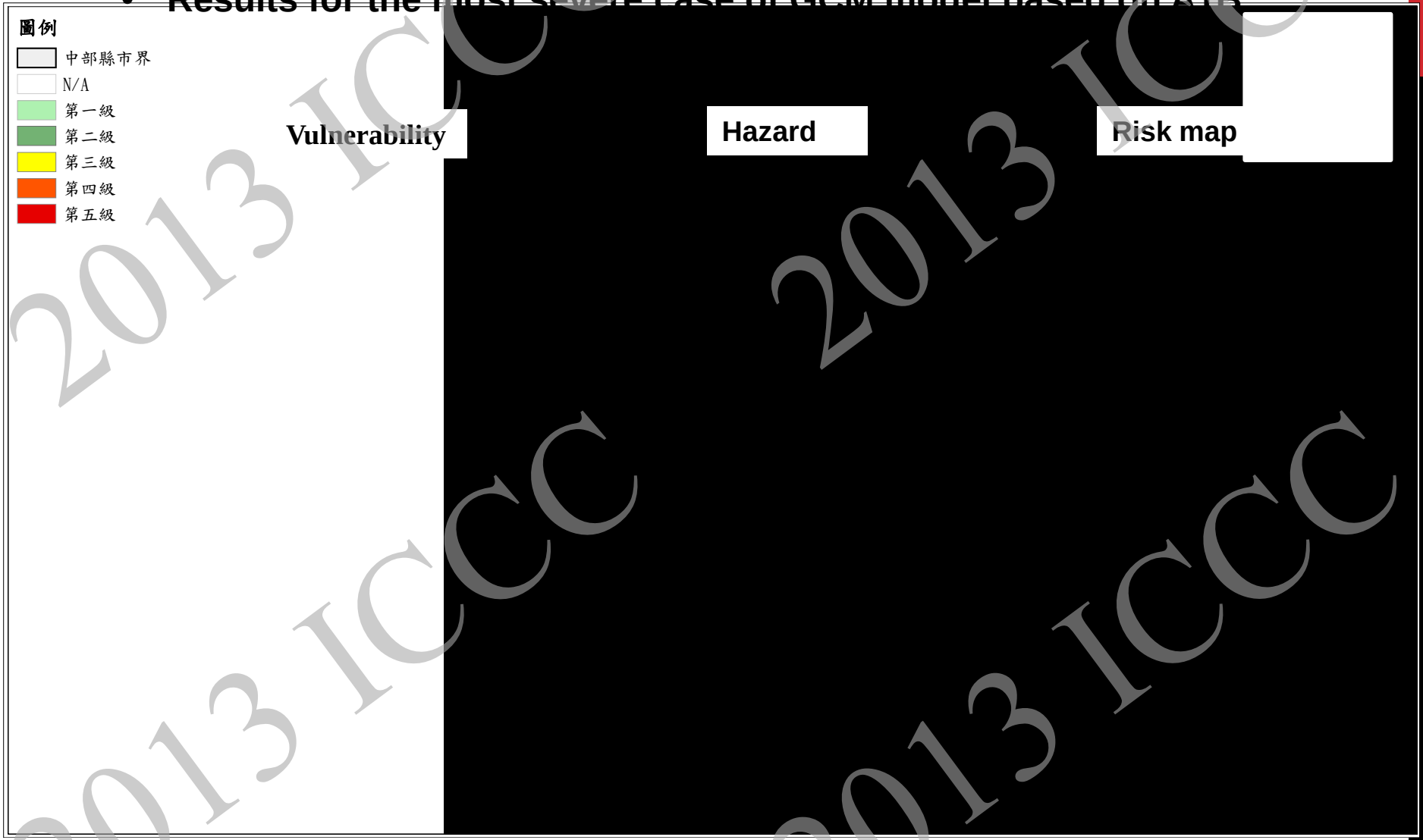
Risk Maps Considering Climate Change _Domestic Water Use

- **Results for the most severe case of GCM model based on A1B**



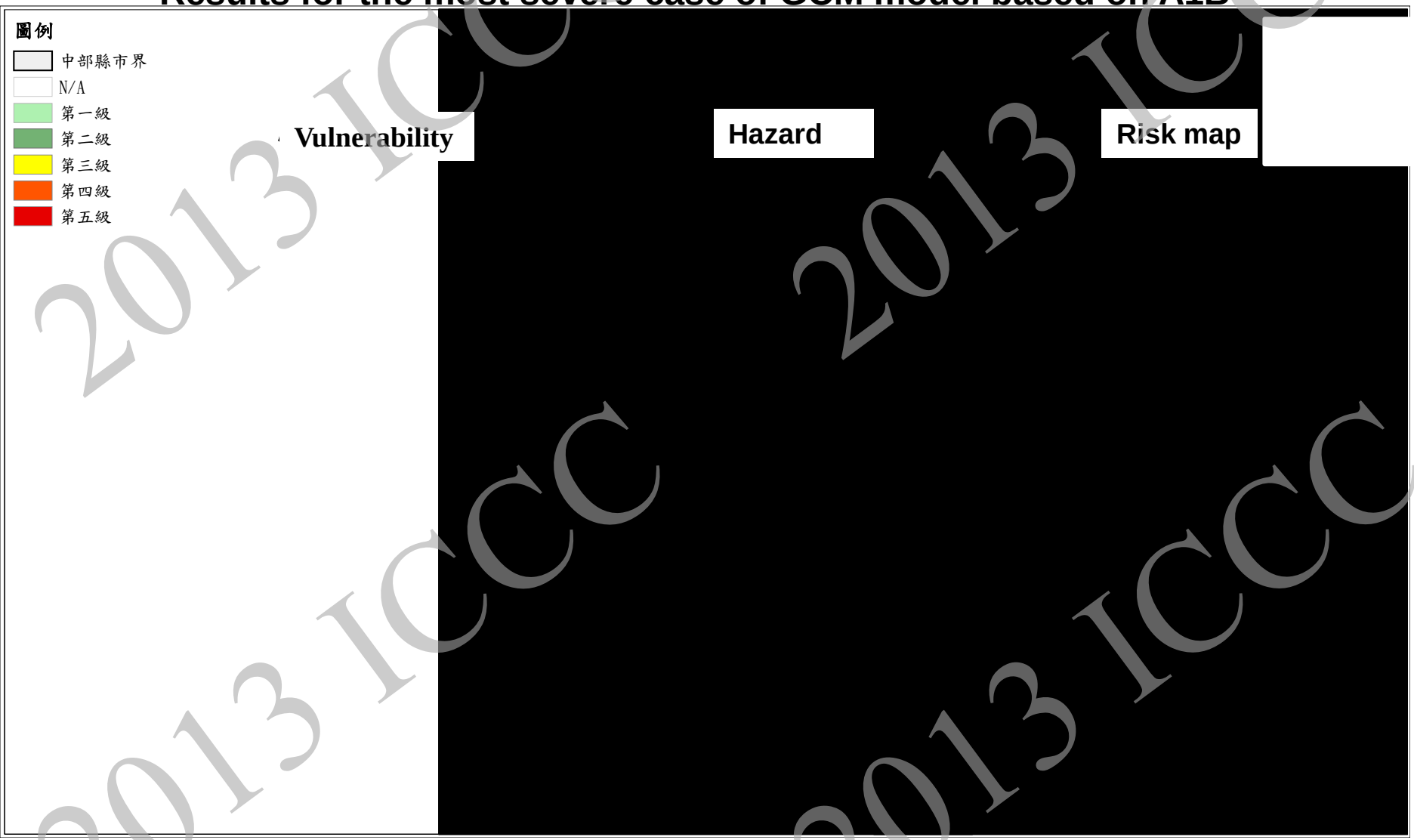
Risk Maps Considering Climate Change _Industrial Water Use

- **Results for the most severe case of GCM model based on A1B**



Risk Maps Considering Climate Change _Agricultural Water Use

- Results for the most severe case of GCM model based on A1B



Adaptive Strategies Planning (1/3)

- **Water shortage after applying only the strategies proposed by the Master Plan**

	Miaoli	Taichung	Changhua	Yunlin	Nantou
Demand	45.03	170.76	48.77	36.71	21.10
Surface water Supply (under SI=1)	18.50	165.50	4.30	38.33	0.00
Groundwater Supply	3.50	10.00	4.00	0.00	15.00
cross-border Supply	0.00	-28.00	8.00	-6.00	3.50
Water Supply after applying the Master Plan	29.38	0.00	21.48	0.00	3.98
Total Water shortage	**-6.35**	**23.26**	**10.99**	**4.38**	**-1.38**

Adaptive Strategies Planning (2/3)

Multi-criteria assessment –example of Taichung

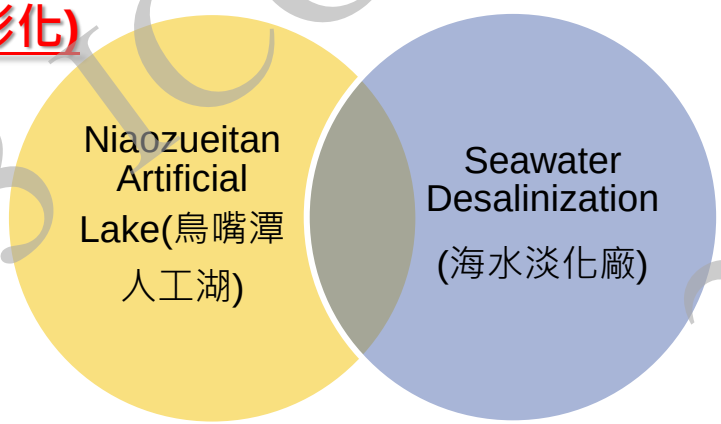
Indicator	Adaptive strategy	Score				
		1	2	3	4	Total
Effectiveness	1	X	0	0	1	1
	2	0	X	0	1	1
	3	1	1	X	1	3
	4	0	0	0	X	0
Sustainability	1	X	0	0	0	0
	2	1	X	0	0	1
	3	1	0	X	0	1
	4	1	0	0	X	1
Legitimacy	1	X	0	0	0	0
	2	1	X	0	0	1
	3	1	0	X	0	1
	4	1	1	1	X	3
Urgency	1	X	0	1	1	2
	2	0	X	1	1	2
	3	0	0	X	0	0
	4	0	0	1	X	1

1. Seawater Desalinization
2. Futian Domestic Wastewater Treatment Plant
3. Water Saving
4. Tap Water pipe replacement

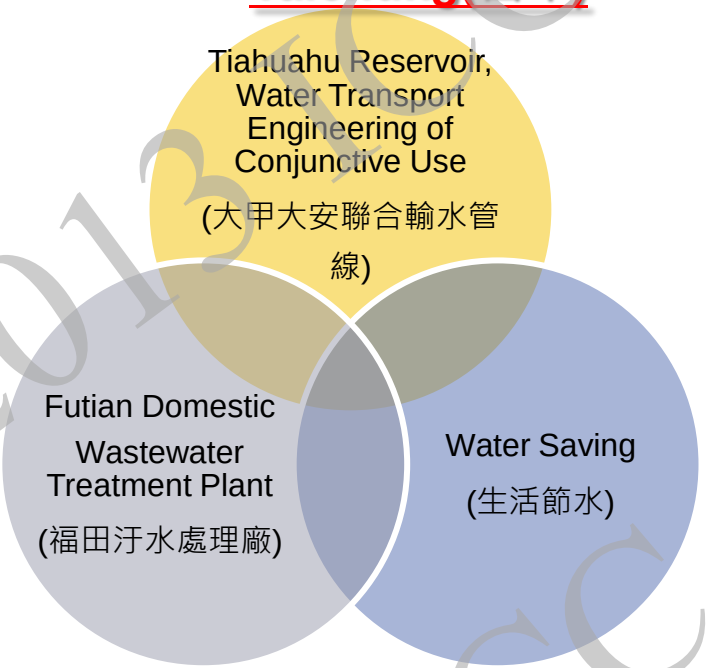
Adaptive Strategies Planning (3/3)

- **Adaptive strategies proposed by this study in addition to the Master Plan**

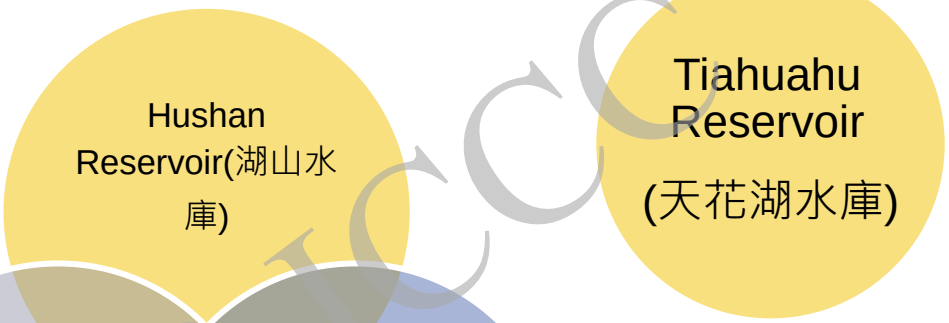
Changhua(彰化)



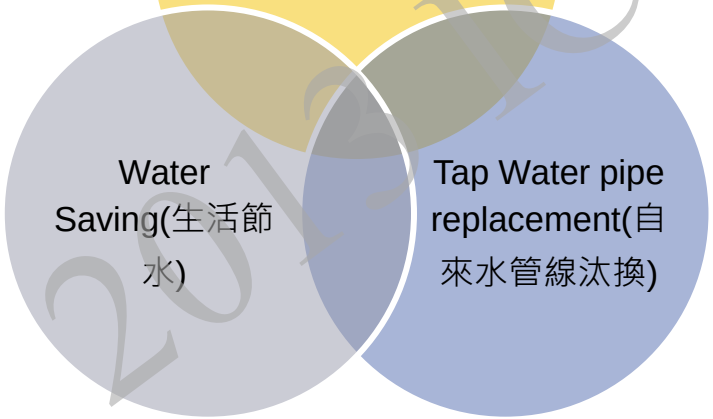
Taichung(台中)



Yunlin(雲林)



Miaoli(苗栗)



Nantou(南投)

Conclusions

- This study has predicted the future water demands (Domestic and Agricultural) increase caused by the variation (increase) of temperature and GDP.
- The study have proposed several adaptive strategies (action plans) in addition to that proposed by the Master Plan. The strategies include Seawater Desalinization, Water Saving(Yunlin), Tap Water pipe replacement, Futian Domestic Wastewater Treatment Plant, Water Saving(Taichung).

Thank you for Your Attention

Impact assessment of water shortage

Total Water Shortage

- $Demand_{scenario}$-Surface water $Supply_{scenario}$ -Groundwater $Supply_{scenario}$

⇔ Economic + Climate Change

Water Shortage cause by climate change

- ($Demand_{scenario}$-Surface water $Supply_{scenario}$ -Groundwater $Supply_{scenario}$)- ($Demand_{baseline}$-Surface water $Supply_{baseline}$ -Groundwater $Supply_{baseline}$)

⇔ Climate Change

Rainfall trend Analysis

Intensity

The time of change point are at about 1980s

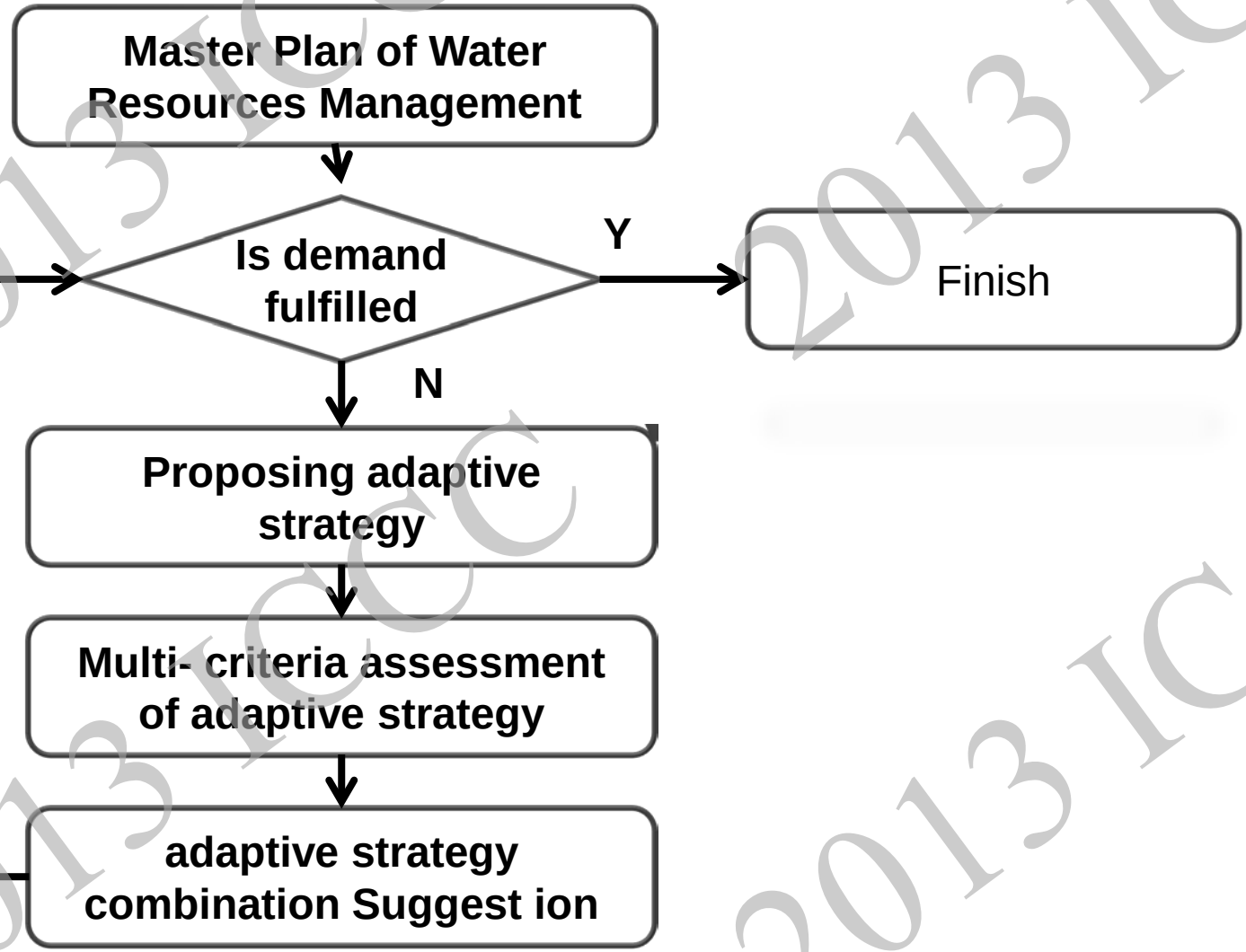
Sequential drought days

Basin	Station	MWP test		KW test
		Change point	Significant or not	Significant or not
Zhonggang River(中港溪)	南庄(1)	1993	N	-
	大河	1986	N	-
Houlong River(後龍溪)	新店	1972	N	-
	橫龍山	1978	Y	Y
	紙湖	1956	N	-
Daan River (大安溪)	卓蘭(2)	1977	N	-
	坪林國小	2001	N	-
	新開國小	2003	N	-
	松安	2003	N	-
	象鼻(1)	1980	Y	Y
	雙崎(2)	1973	N	-
	鯉魚潭	2001	N	-
Dajia River(大甲溪)	桃山	2003	N	-
	合歡啞口	1987	N	-
	松茂	1988	Y	Y
Wu River(烏溪)	凌霄	1990	N	-
	北山(2)	2003	N	-
	惠蓀(2)	2003	N	-
	清流(1)	1960	N	-
Zhuoshui River(濁水溪)	卡奈托灣(2)	1993	否	-
	東埔	1984	否	-
	草嶺(2)	1986	否	-
	西巒	1984	是	是
	關門	1977	否	-

Basin	Station	MWP test		KW test
		Change point	Significant or not	Significant or not
Zhonggang River(中港溪)	南庄(1)	1928	N	-
	大河	1985	N	-
Houlong River(後龍溪)	新店	1972	N	-
	橫龍山	1979	N	-
	紙湖	1965	N	-
Daan River (大安溪)	卓蘭(2)	1913	N	-
	坪林國小	2003	N	-
	新開國小	1996	N	-
	松安	1998	N	-
	象鼻(1)	1985	Y	Y
	雙崎(2)	1985	Y	Y
	鯉魚潭	2003	N	-
Dajia River(大甲溪)	桃山	1975	N	-
	合歡啞口	1988	N	-
	松茂	1988	Y	Y
Wu River(烏溪	凌霄	1985	N	-
	北山(2)	1986	Y	Y
	惠蓀(2)	2004	N	-
	清流(1)	2004	N	-
Zhuoshui River(濁水溪)	卡奈托灣(2)	1985	Y	Y
	東埔	1927	N	-
	草嶺(2)	1988	Y	Y
	西巒	1985	Y	Y
	關門	1992	N	-

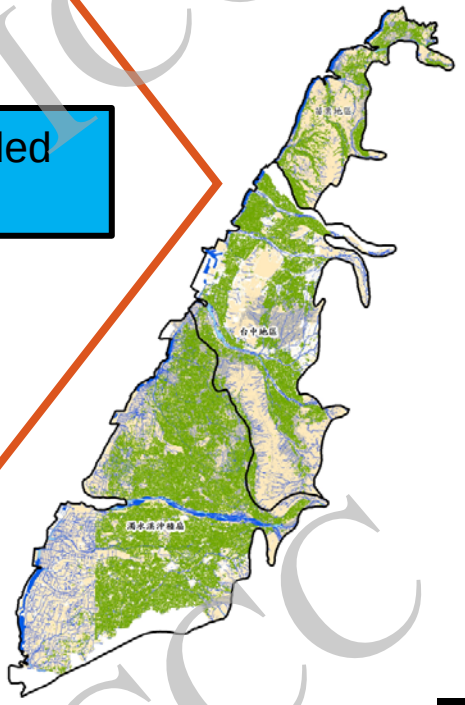
Adaptive Strategy Proposing

Procedure



Impact assessment of climate change-potential groundwater supply

land use



Dry farm

River

Impervious area

Paddy field

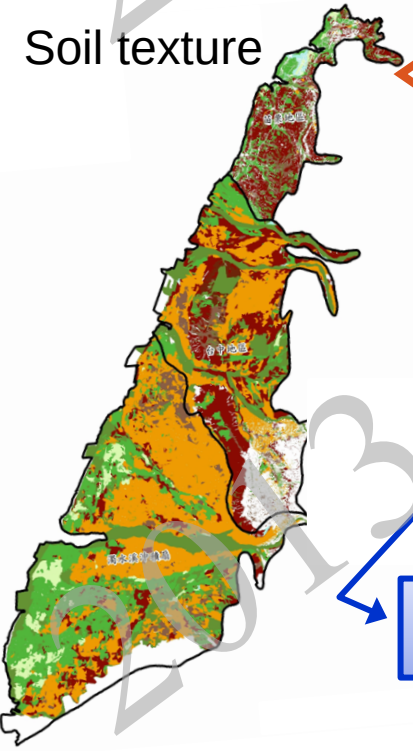
Impounded body

Non-infiltration capacity

non-irrigation period

irrigation period

Soil texture



infiltration from rainfall

infiltration from Saturated soil

Rainfall infiltration formula

Saturated soil permeability formula

infiltration capacity

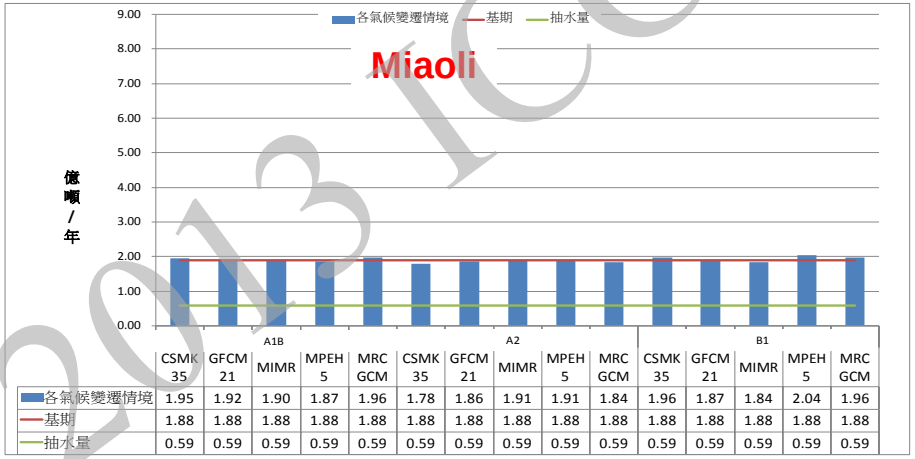
$Q = A \cdot P \cdot \alpha_{soil}$

$Q = A \cdot t \cdot \Phi_{soil}$

A:area[L^2] ; t:time[T] ; P: average monthly rainfall [L] ;
Φ_{soil}: saturated soil permeability [L/T] ;
α_{soil}:the soil rainfall infiltration coefficient [Dimensionless]。

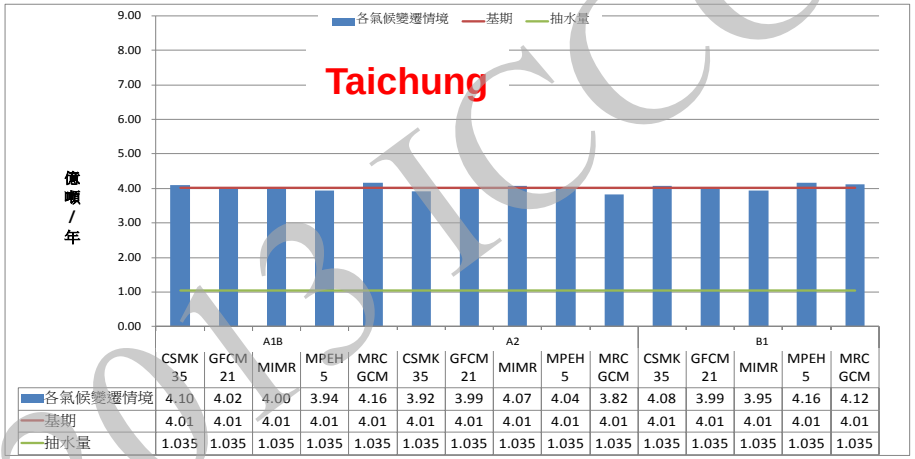
Impact assessment of climate change

Impact assessment of potential groundwater supply



	A1B					A2					B1				
	CSMK 35	GFCM 21	MIMR	MPEH 5	MRC GCM	CSMK 35	GFCM 21	MIMR	MPEH 5	MRC GCM	CSMK 35	GFCM 21	MIMR	MPEH 5	MRC GCM
各氣候變遷情境	1.95	1.92	1.90	1.87	1.96	1.78	1.86	1.91	1.91	1.84	1.96	1.87	1.84	2.04	1.96
基期	1.88	1.88	1.88	1.88	1.88	1.88	1.88	1.88	1.88	1.88	1.88	1.88	1.88	1.88	1.88
抽水量	0.59	0.59	0.59	0.59	0.59	0.59	0.59	0.59	0.59	0.59	0.59	0.59	0.59	0.59	0.59

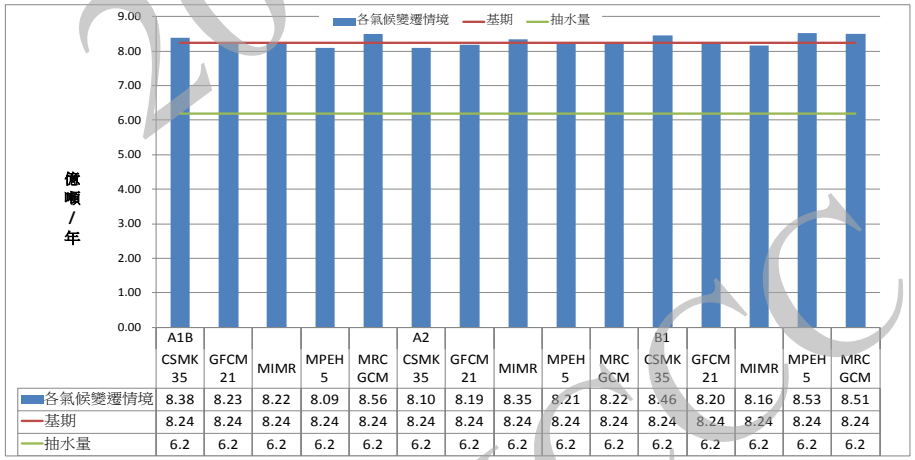
Change rate is between -5.47~8.07%



	A1B					A2					B1				
	CSMK 35	GFCM 21	MIMR	MPEH 5	MRC GCM	CSMK 35	GFCM 21	MIMR	MPEH 5	MRC GCM	CSMK 35	GFCM 21	MIMR	MPEH 5	MRC GCM
各氣候變遷情境	4.10	4.02	4.00	3.94	4.16	3.92	3.99	4.07	4.04	3.82	4.08	3.99	3.95	4.16	4.12
基期	4.01	4.01	4.01	4.01	4.01	4.01	4.01	4.01	4.01	4.01	4.01	4.01	4.01	4.01	4.01
抽水量	1.035	1.035	1.035	1.035	1.035	1.035	1.035	1.035	1.035	1.035	1.035	1.035	1.035	1.035	1.035

Change rate is between -4.80~3.68%

Zhuoshui River basin



	A1B					A2					B1				
	CSMK 35	GFCM 21	MIMR	MPEH 5	MRC GCM	CSMK 35	GFCM 21	MIMR	MPEH 5	MRC GCM	CSMK 35	GFCM 21	MIMR	MPEH 5	MRC GCM
各氣候變遷情境	8.38	8.23	8.22	8.09	8.56	8.10	8.19	8.35	8.21	8.22	8.46	8.20	8.16	8.53	8.51
基期	8.24	8.24	8.24	8.24	8.24	8.24	8.24	8.24	8.24	8.24	8.24	8.24	8.24	8.24	8.24
抽水量	6.2	6.2	6.2	6.2	6.2	6.2	6.2	6.2	6.2	6.2	6.2	6.2	6.2	6.2	6.2

Change rate is between -1.77~3.91%