Downscaling Future Climate Projections for Water Management

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Ministry of Science and Technology
Thailand

Outline

- Introduction to HAII
- Effect of climate change on reservoir inflows
- Agriculture water requirement under future climates
- Summary

Our Vision

Developing and applying **science and technology knowledge for agricultural and water resource management** in order to cope with critical climate change and,

Expanding the **accomplishment** through the design and development of strong and effective networking

Our Research Focuses

Operational real time monitoring & forecasting systems

- Telemetering system
- Weather forecasting system (WRF, WRF+ROM)
- Decision Support System (DSS)
- Flood Modeling System
- Optimization

System Integration

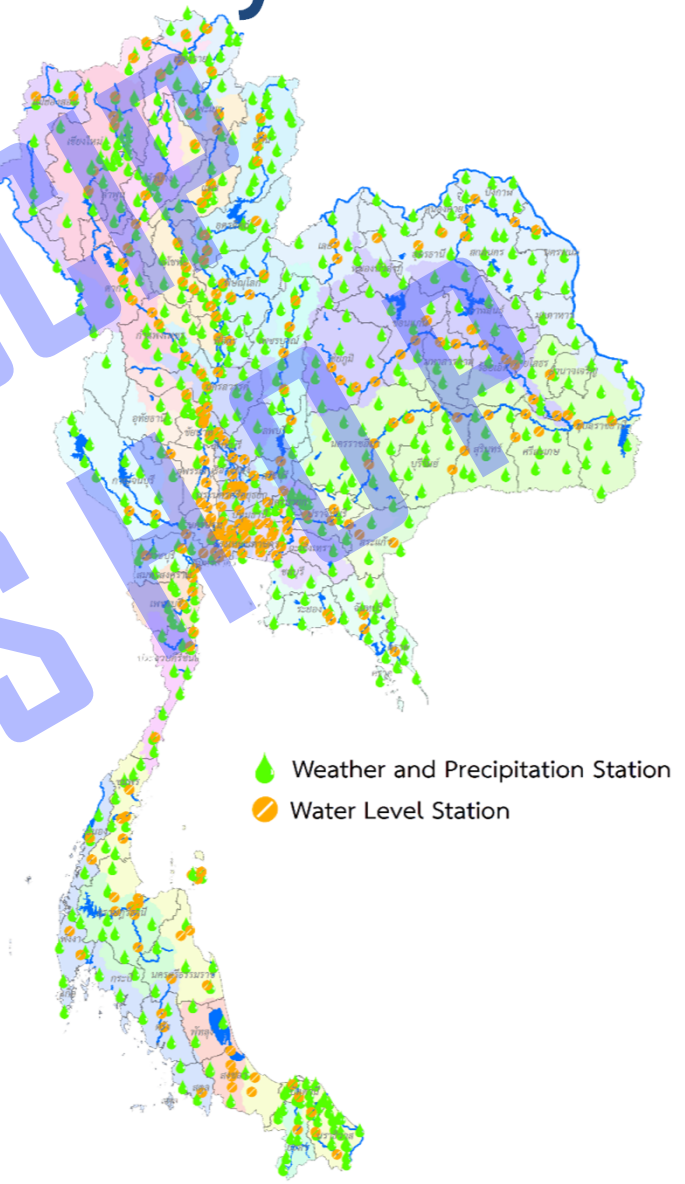
- Open architecture / Open source
- HPC, GPU, MIC
- Big Data, BI
- Cloud
- Internet of Things

Climate Change Adaptation and Planning

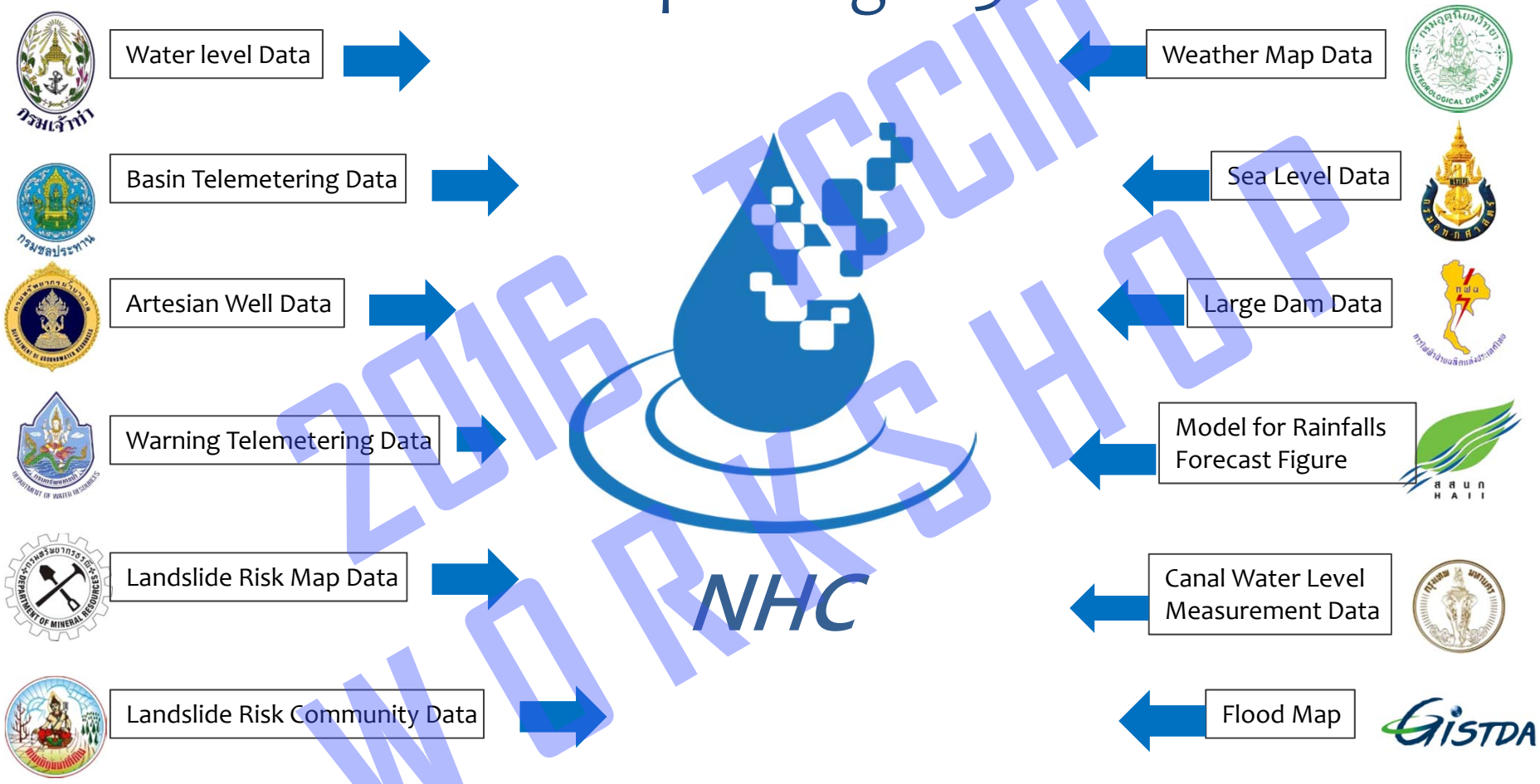
- Climate change scenarios and related effects
- Seasonal prediction
- Water resources assessment
- Land use planning & management
- Adaptations

Our Technology: **HAII Telemetry**

850 stations in operation



Integrating data from 13 agencies and expanding to 32+



Link and exchange data between 13 related water resource management government agencies and the National Hydroinformatics and Climate Data Center for research usage for monitoring and analyzing the situation.

High Performance Computing Facilities

Current Capacity

- Over 1000 CPU cores; 2088 GPU cores; 100 VMs; 300 TB storage
- Server farms, clustering-GRID environment

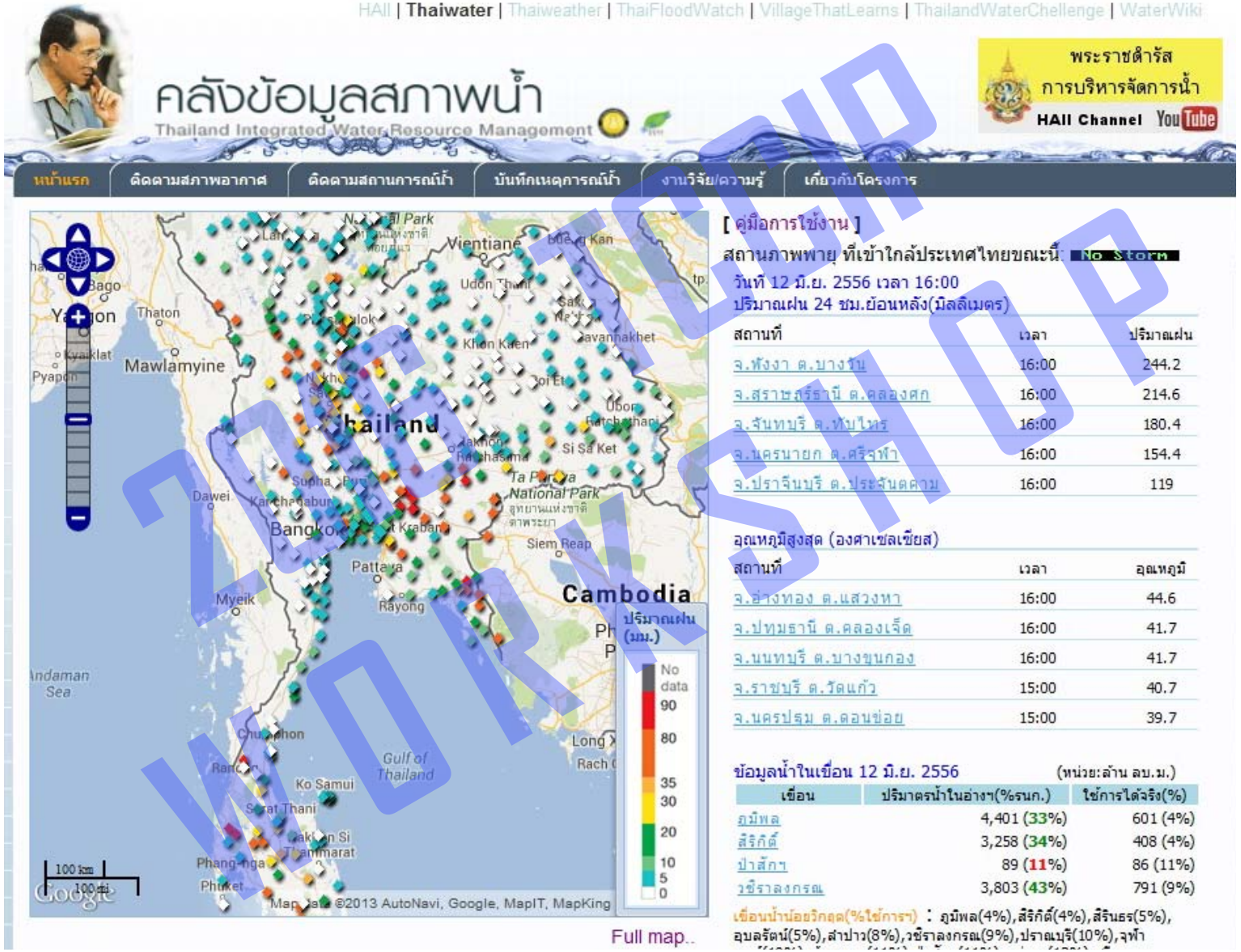
Data:

- Telemetering
- Satellite/radar images
- Internal/External Research
- Data exchange with partners

Services:

- Data warehouse
- Modeling
  - Weather Research Forecasting (WRF)
  - Coupling Model (WRF+ROM)
- Image Processing
- Public websites

www.thaiwater.net



S&T Adaptation for Strengthening Local Economy

To prevent economic loss from flood and drought, Thailand needs good water management system at every level, nationally or locally. The CWRM Network has been expanded throughout the country, and currently covers 60 main networks with more than 543 participated communities.




S & T Application

- Apply S&T such as GPS receivers, telemetering station, maps and satellite images for community survey
- Identify problems and solutions
- Water balance analysis
- Area-based analysis

Engineering/Innovation

- Simple infrastructure design suitable for the socio-geographical condition
- Systematically plan the work process, management and maintenance
- Local innovation

Sustainable Agriculture

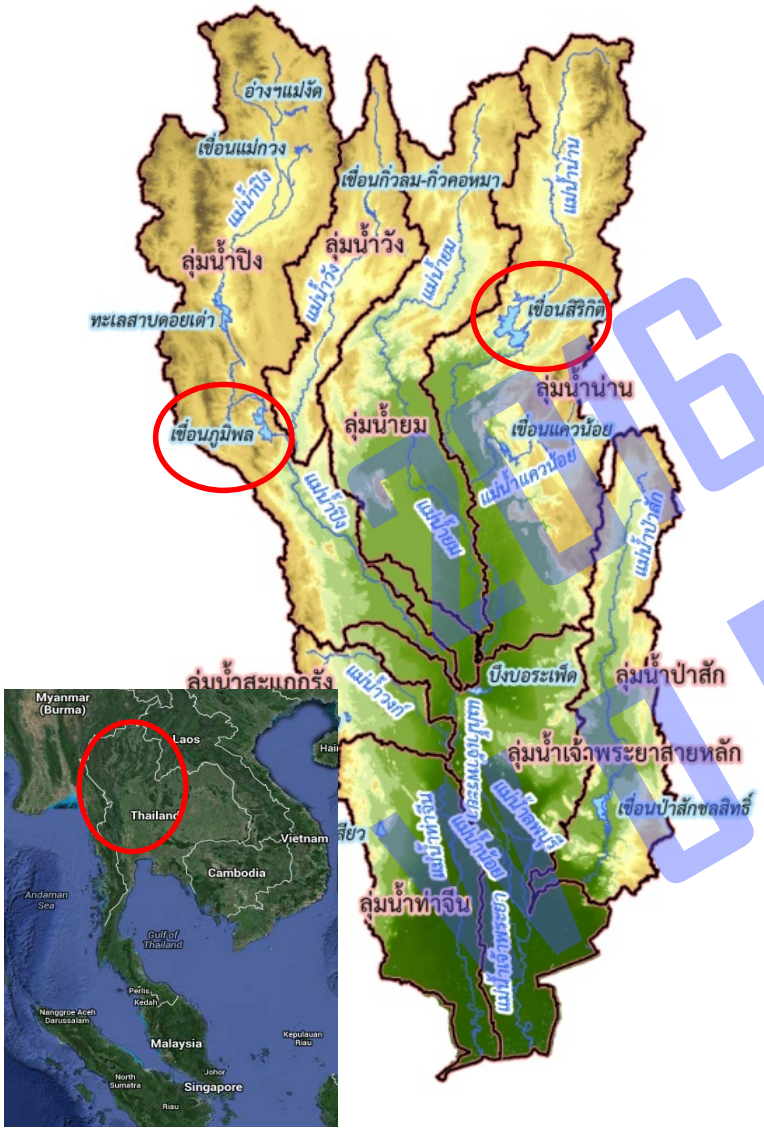
- Agroforestry
- Integrated agriculture
- Water quality management

Success

- Self-sufficiency
- Food security
- Expand the success to other communities

Effect of climate change on reservoir inflows

Background and study area



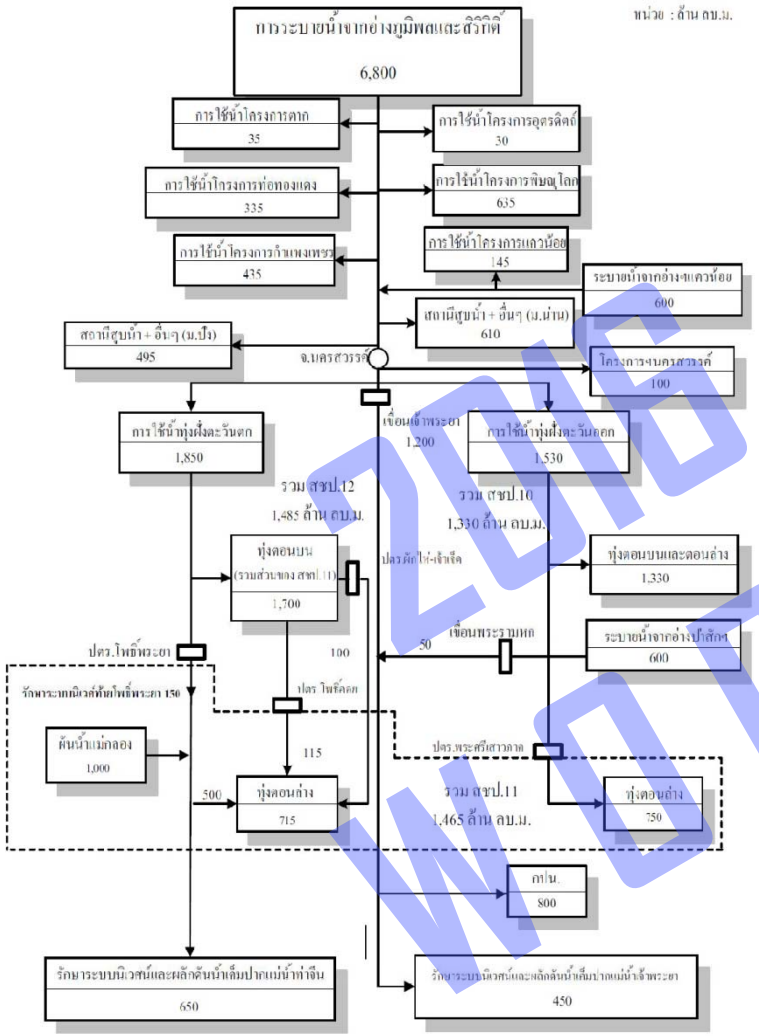
Background

- **Climate change & its impact on water resources**
- **Variation in rainfall and extreme events**
- **Impact on the water budgeting of Chao Phraya River Basin**
- **Reservoir inflow of Bhumibol and Sirikit reservoirs**

Chao Phraya River Basin

- Catchment area 160,000 km^2 (30% of Thailand)
- 4 major tributaries (Ping, Wang, Yom, Nan) to form Chao Phraya river
- Mean annual precipitation 1,374 mm (1950-1997)
- Bhumibol reservoir: Basin area 26,386 sq.km. capacity 13,462 MCM
- Sirikit reservoir: Basin area 13,130 sq.km. capacity 9,510 MCM

Chao Phraya River Basin



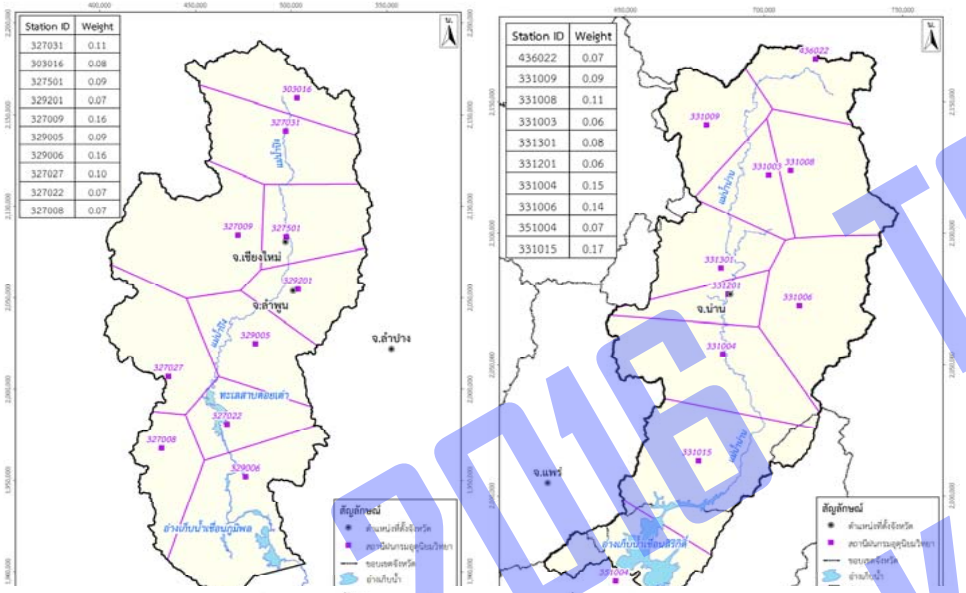
Water budgeting

- Bhumibol and Sirikit reservoirs are major sources for water supply in Choa Phraya River Basin (75% or 6,800 MCM)

Activity	Volume (MCM)
1. Above CPY barrage	2,820
2. Large irrigation projects below CPY Barrage	4,280
3. Ecological conservation	1,100
4. Water works	800
Total	6,800

Water distribution diagram for the Chao Phraya River basin for the dry season 2012/2013

Estimating reservoir inflow

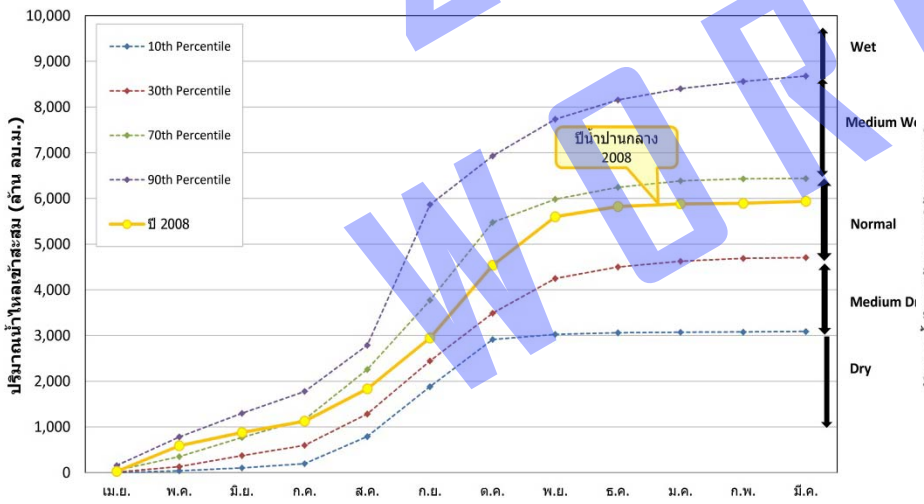


Station ID	Weight
327031	0.11
303016	0.08
327501	0.09
329201	0.07
327009	0.16
329005	0.09
329006	0.16
327027	0.10
327022	0.07
327008	0.07

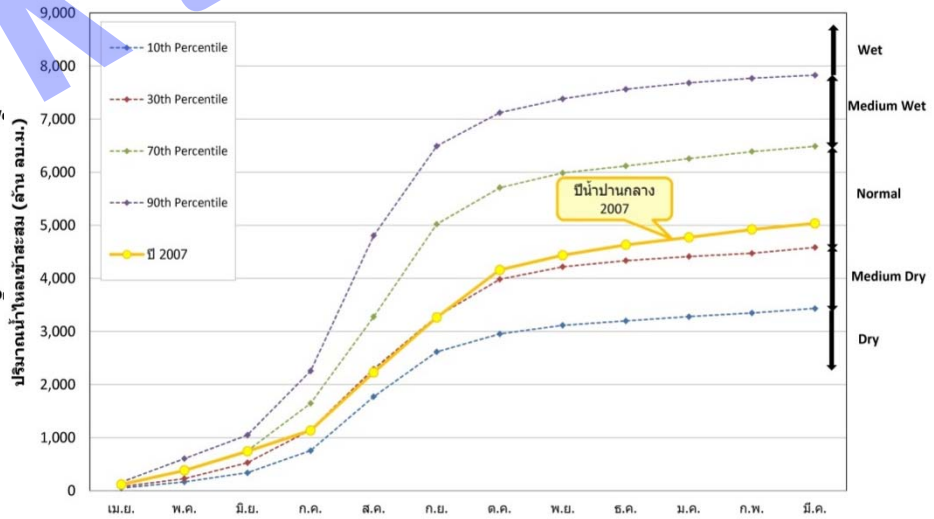
Station ID	Weight
436022	0.07
331009	0.09
331008	0.11
331003	0.06
331301	0.08
331201	0.06
331004	0.15
331006	0.14
351004	0.07
331015	0.17

- Estimate the impact of climate change on the monthly rainfall and evaporation, inflow to the Bhumibol and Sirikit reservoirs in the year 2050
- IPCC SRES CO_2 Emission Scenarios (13 GCMs)
  - A2: high CO_2 emission
  - A1B : moderate CO_2 emission
  - B1: low CO_2 emission
- Select based line year
  - Bhumibol reservoir used 2008
  - Sirikit reservoir used 2007

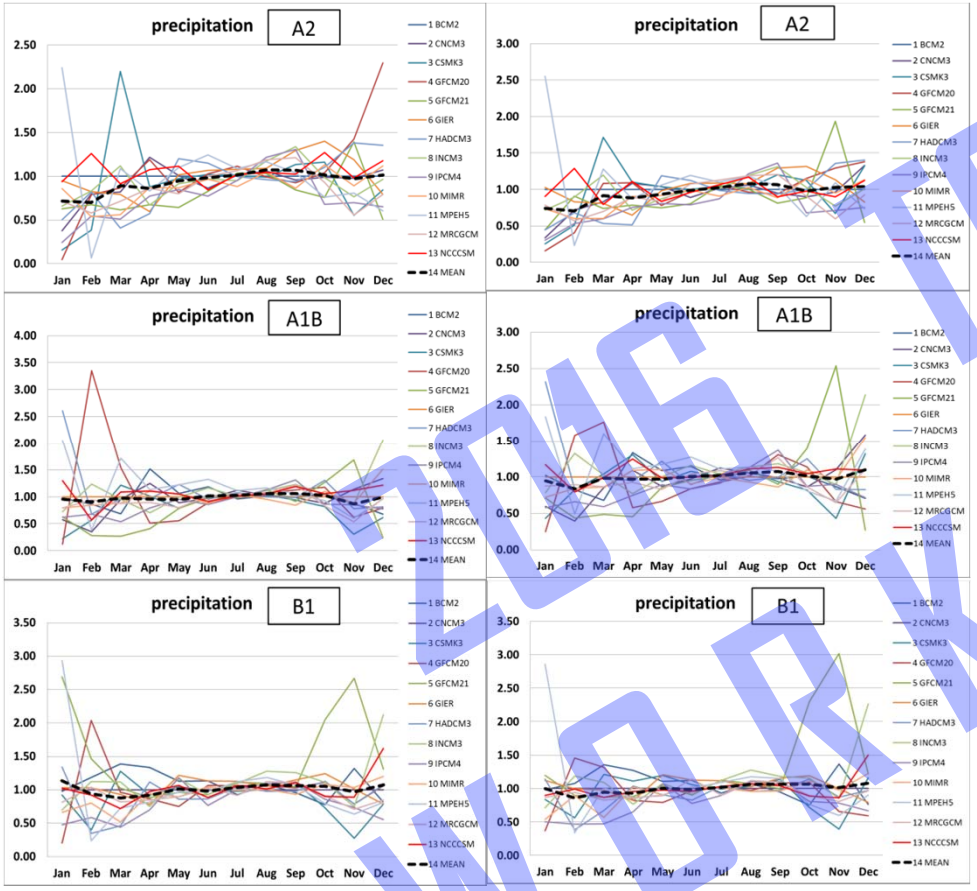
ปริมาณน้ำไหลเข้าสะสมของเขื่อนภูมิพล



ปริมาณน้ำไหลเข้าสะสมของเขื่อนสิริกิติ์



Effect on the monthly rainfall



Bhumibol reservoir

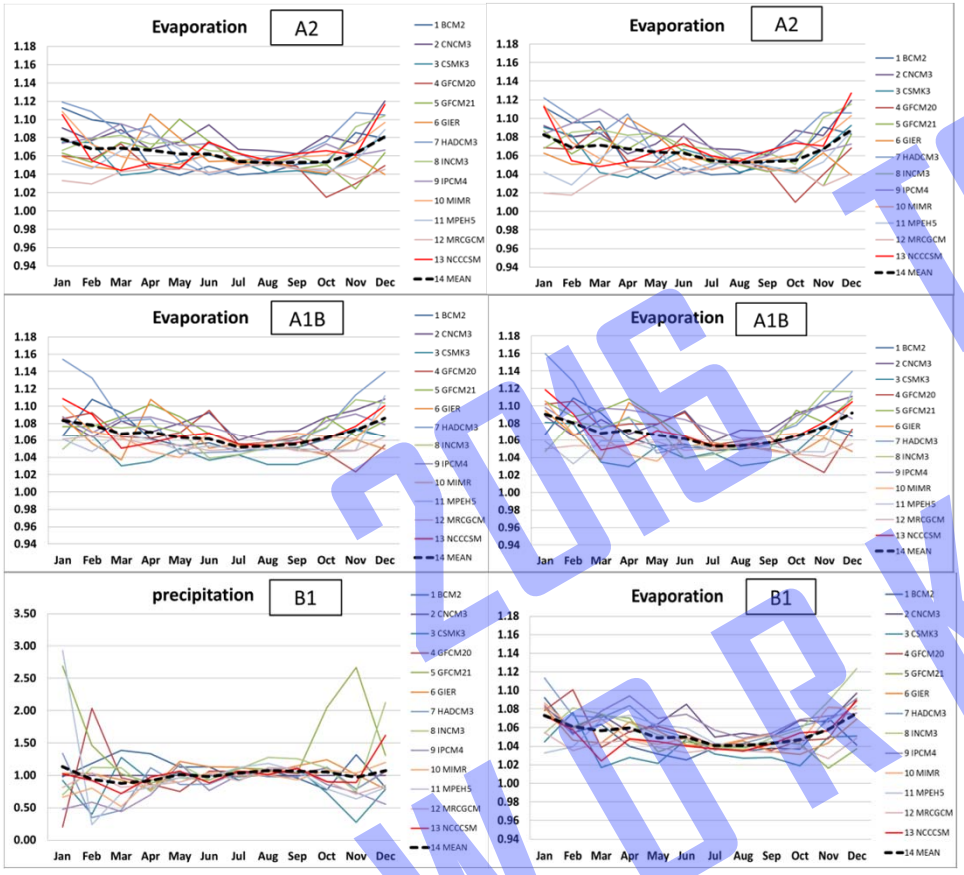
Sirikit reservoir

In the year 2050:

- Rainfall less than averaged 5% - 30% during January to March (Dry season)
- Rainfall higher than averaged 1% - 9% during July to September (rainy season)
- Deviation from based line

  A2 > A1B > B1

Effect on the monthly evaporation



Bhumibol reservoir Sirikit reservoir

In the year 2050:

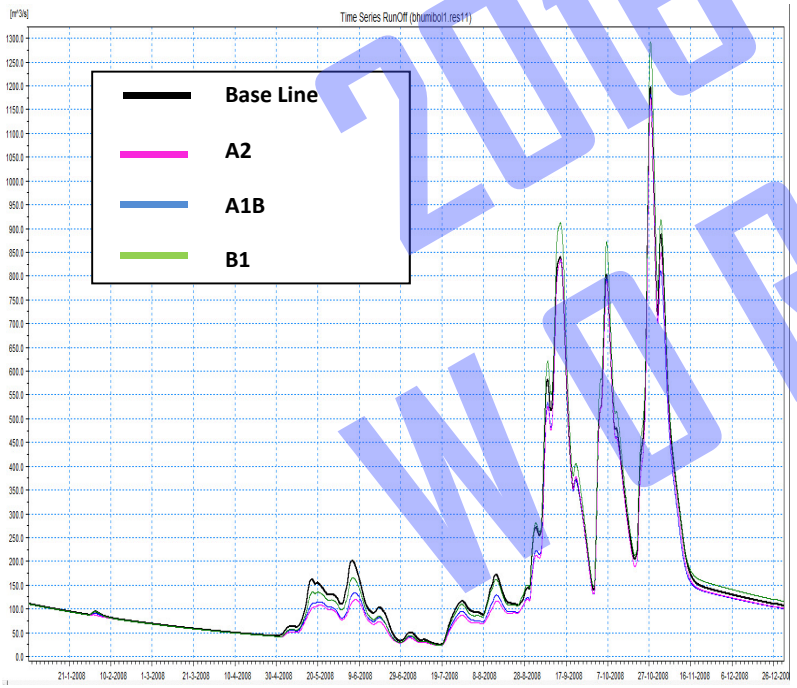
- Increase 4 to 8% from based line year
- Highest during December to January (Dry season)
- Lowest during July to August
- Deviation from based line

  A2 > A1B > B1

Effect on the reservoir inflow

Bhumibol reservoir

- A2 and A1B show reduction trend while B1 shows small increase of reservoir inflow
- highest inflow reduction 7.91% (A2) or 429 MCM/year

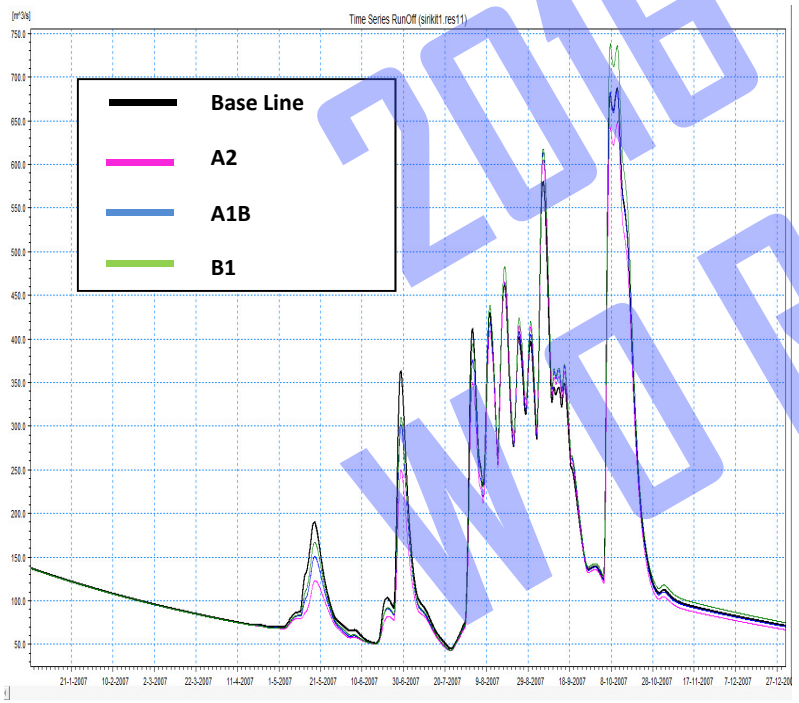


Scenario	Inflow (MCM)	Change from based line (%)
Base Line 2008	5,431.57	0.00
A1B 2050	5,034.74	-7.31
A2 2050	5,001.99	-7.91
B1 2050	5,582.60	2.78

Effect on the reservoir inflow

Sirikit reservoir

- A2 and A1B show small reduction trend while B1 shows small increase of reservoir inflow
- highest inflow reduction 4.87% (A2) or 238 MCM/year



Scenario	Inflow (MCM)	Change from based line (%)
Base Line 2007	4,891.25	0.00
A1B 2050	4,801.58	-1.83
A2 2050	4,653.02	-4.87
B1 2050	4,971.74	1.65

Agriculture water requirement under future climates

The description of GCM climate data used

Modeling group	Model designation	AGCM horizontal/vertical resolution	OGCM horizontal/veritical resolution
Beijing Climate Center, China Meteorological Administration	BCC-CSM1.1	T42 L26	1°lon x 1.33° lat
Canadian Center for Climate Modelling and Analysis	CanESM2	T63 L35	256 km x 192 km
Centre National de Researches Meteorologiques	CNRM-CM5	TL127 L31	1° lon x 1° lat
Commonwealth Scientific and Industrial Research Organization in collaboration with Queensland Climate Change Centre of Excellence	CSIRO-Mk3.6.0	T63 L18	1.875° lon x 0.9375° lat
NOAA Geophysical Fluid Dynamics Laboratory	GFDL-CM3	C48 L48	360 km x 200 km
Atmosphere and Ocean Research Institute, National Institute for Environmental Studies, and Japan Agency for Marine-Earth Science and Technology	MIROC5	T85 L40	256 km x 224 km
Norwegian Climate Centre	NorESM1-M	144 x 96 L26	384 km x 320 km

The evaluation of performance of bias corrected GCM climate data

GCM	Rainfall		Temperature	
	R^2	RMSE	R^2	RMSE
BCC	0.87	16.47	0.96	0.25
CanESM2	0.88	26.43	0.95	0.25
CNRM	0.88	19.45	0.95	0.25
CSIRO	0.84	30.88	0.96	0.23
GFDL	0.89	23.15	0.95	0.27
MIROC5	0.89	22.74	0.95	0.23
NorESM1	0.86	19.73	0.96	0.23

Rainfall and temperature observations from 76 TMD Stations (year 1979 – 2014)

The comparison of mean and standard deviation of observed and bias corrected GCM

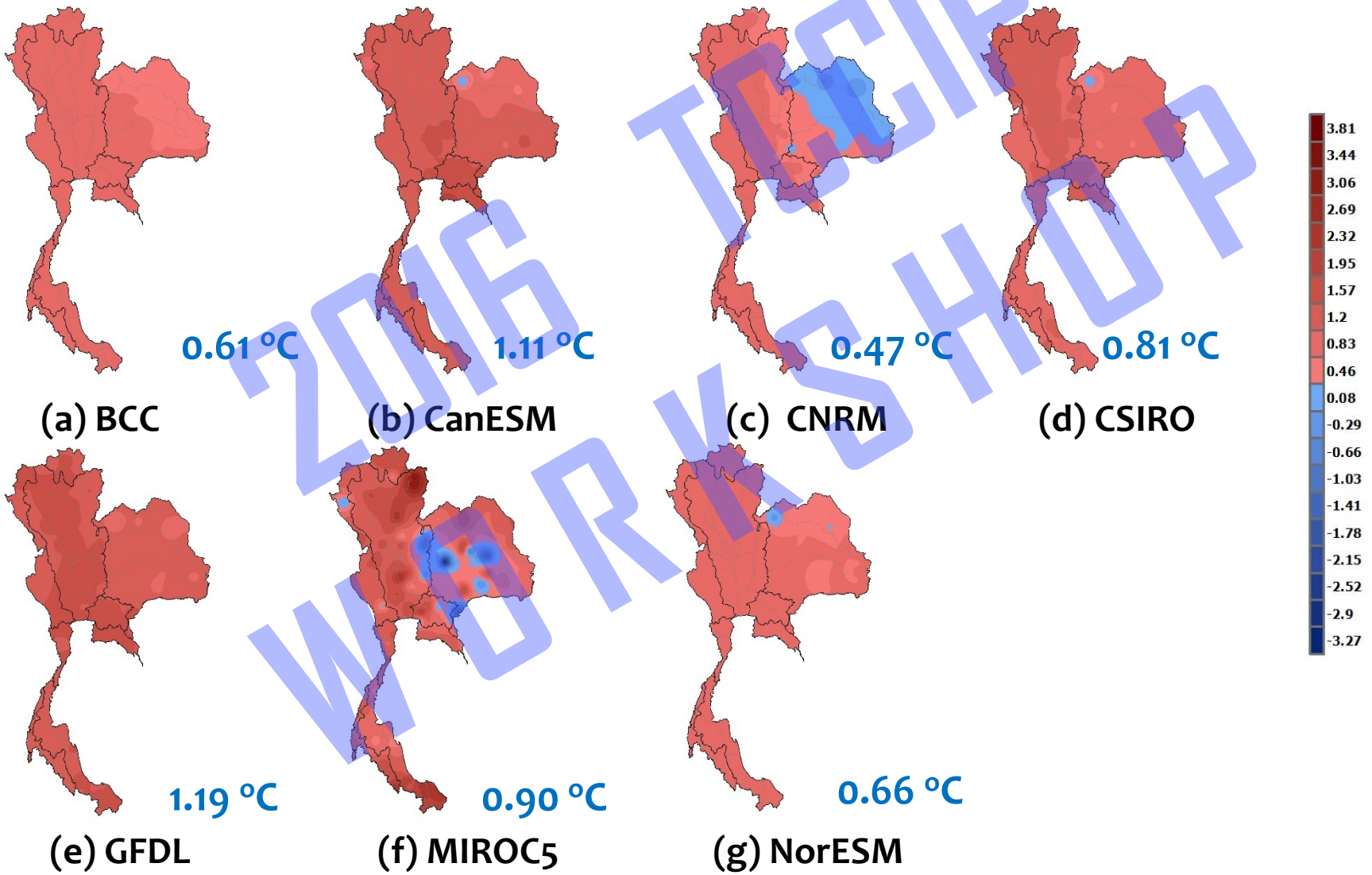
Observed/ GCM	Rainfall, mm/year				Temperature, °C			
	OBS Mean	Diff, %	OBS SD	Diff, %	OBS Mean	Diff, °C	OBS SD °C	Diff, %
Observed	1,342	-	145.44	-	27.73	-	0.63	-
BCC	1,390	3.58	196.01	35.89	27.74	0.01	0.77	23.16
CanESM2	1,376	2.53	239.07	65	27.78	0.05	0.72	14.59
CNRM	1,384	3.10	211.32	46.7	27.79	0.06	0.73	17.74
CSIRO	1,386	3.28	255.98	76.32	27.77	0.04	0.71	13.71
GFDL	1,377	2.60	226.56	56.17	27.76	0.03	0.79	26.25
MIROC5	1,386	3.24	219.00	50.86	27.77	0.04	0.73	17.08
NorESM1	1,389	3.44	204.84	41.99	27.75	0.03	0.70	11.58

Rainfall and temperature observations from 76 TMD Stations (year 1979 – 2014)

Summary of Temperature Change in year 2015 - 2039 under RCP4.5 and RCP8.5

RCP	Statistic	Change (%)							
		BCC	CanESM2	CNRM	CSIRO	GFDL	MIROC5	NorESM1	Average
RCP 4.5	Mean[1/]	0.61	1.11	0.47	0.81	1.19	0.90	0.66	0.82
	SD	27.95	30.19	26.39	31.97	32.69	39.16	23.55	30.27
RCP 8.5	Mean[1/]	0.72	1.23	0.62	0.88	1.18	0.90	0.65	0.88
	SD	24.25	31.17	20.39	36.80	30.44	31.20	26.57	28.69

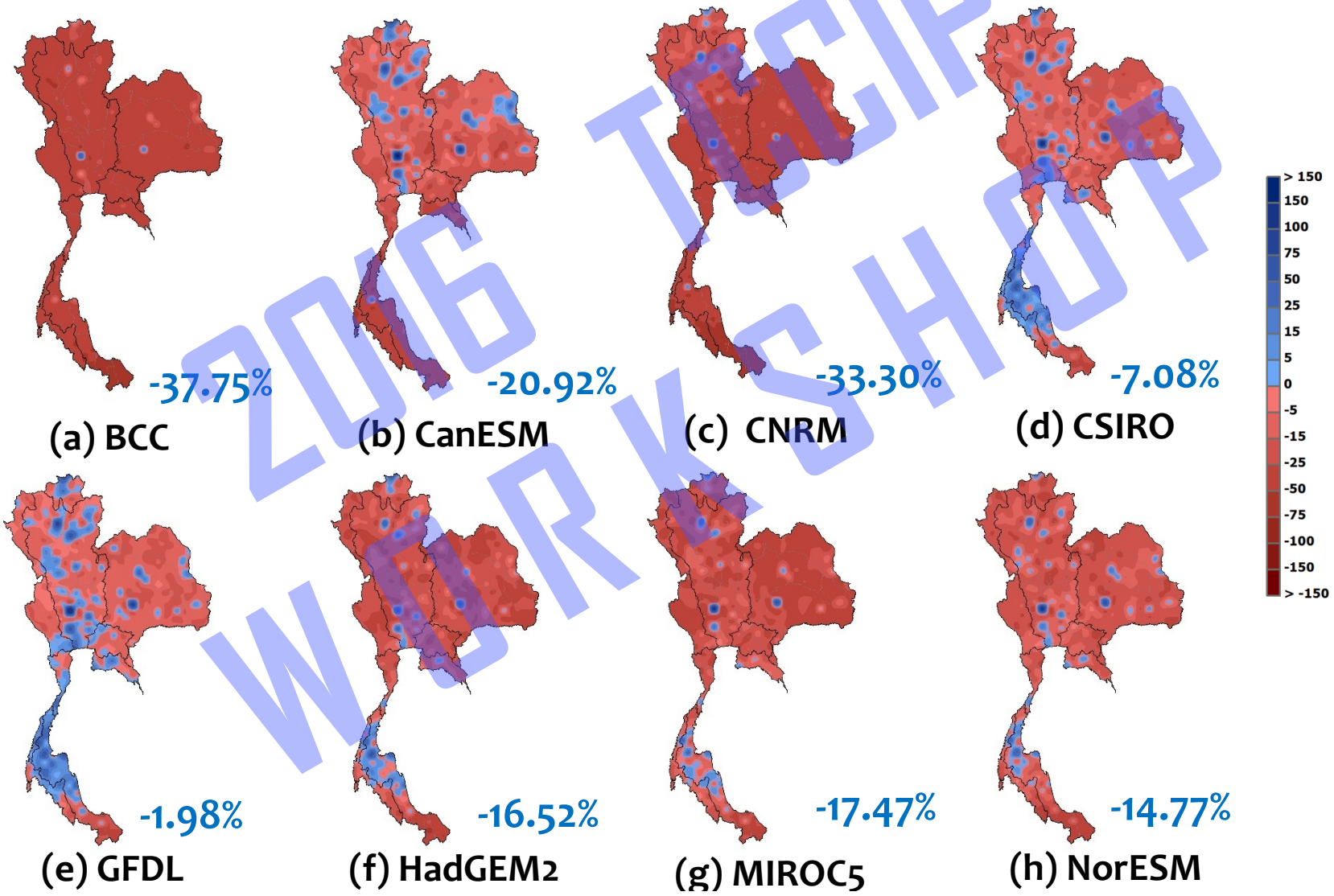
Change of Average Temperature in year 2015 - 2039 under RCP4.5



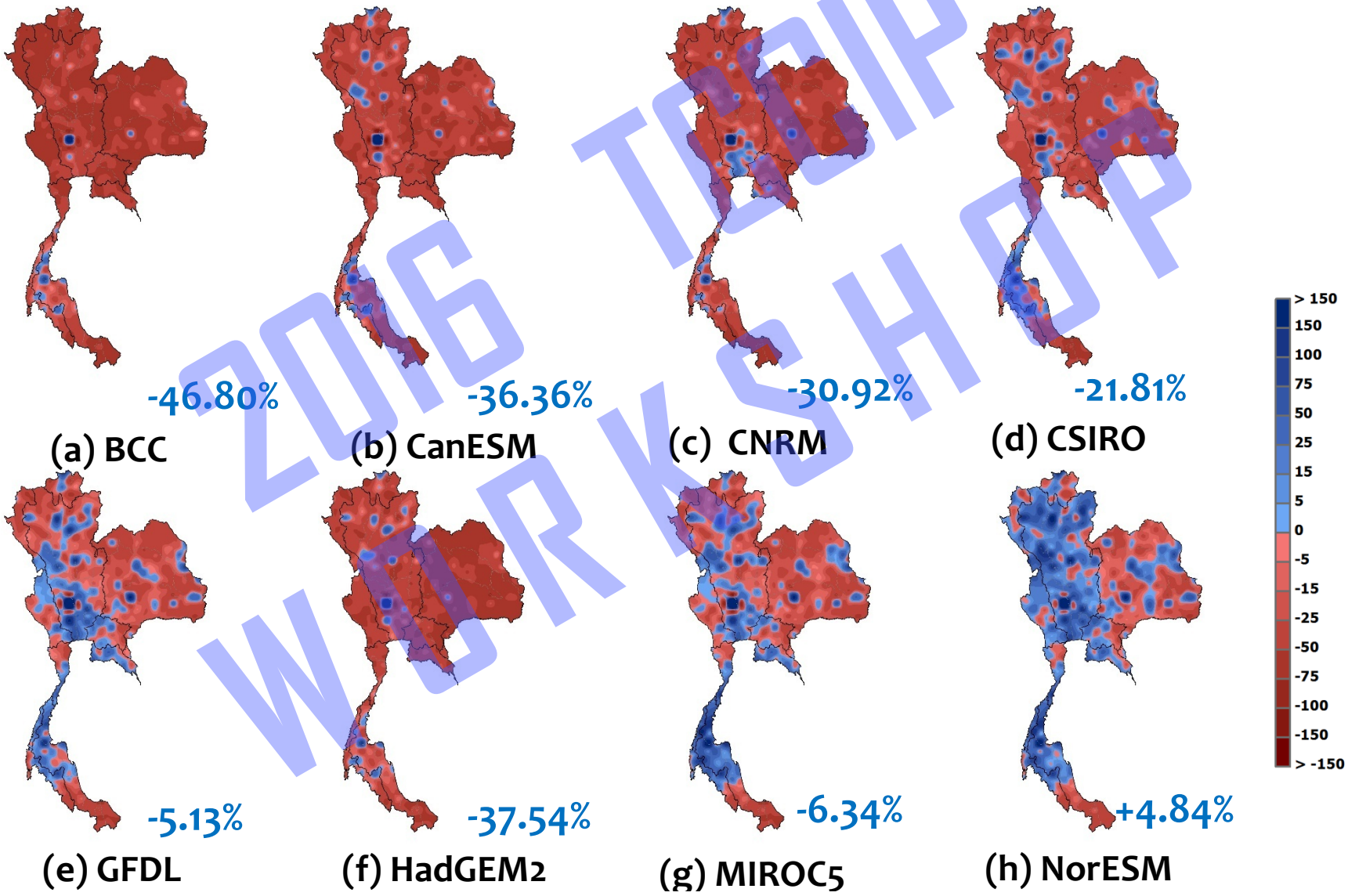
Summary of Change of Rainfall in year 2015 -2039 under RCP4.5 and RCP8.5

RCP	Statistic	Season/Annual	Change (%)							
			BCC	CanESM2	CNRM	CSIRO	GFDL	HadGEM2	MIROC5	NorESM1	Average
RCP 4.5	Mean	Wet	-37.75	-20.92	-33.3	-7.08	-1.98	-16.52	-17.47	-14.77	-18.72
		Dry	-46.8	-36.36	-30.92	-21.81	-5.13	-37.54	-6.34	4.84	-22.51
		Annual	-38.87	-22.93	-32.74	-9.53	-2.73	-19.79	-15.64	-11.66	-19.24
	SD	Wet	9.5	69.7	35.3	20.8	30.2	6.8	23	23.8	27.4
		Dry	-	-	48.7	47.3	24.9	-	89.4	68.6	28.1

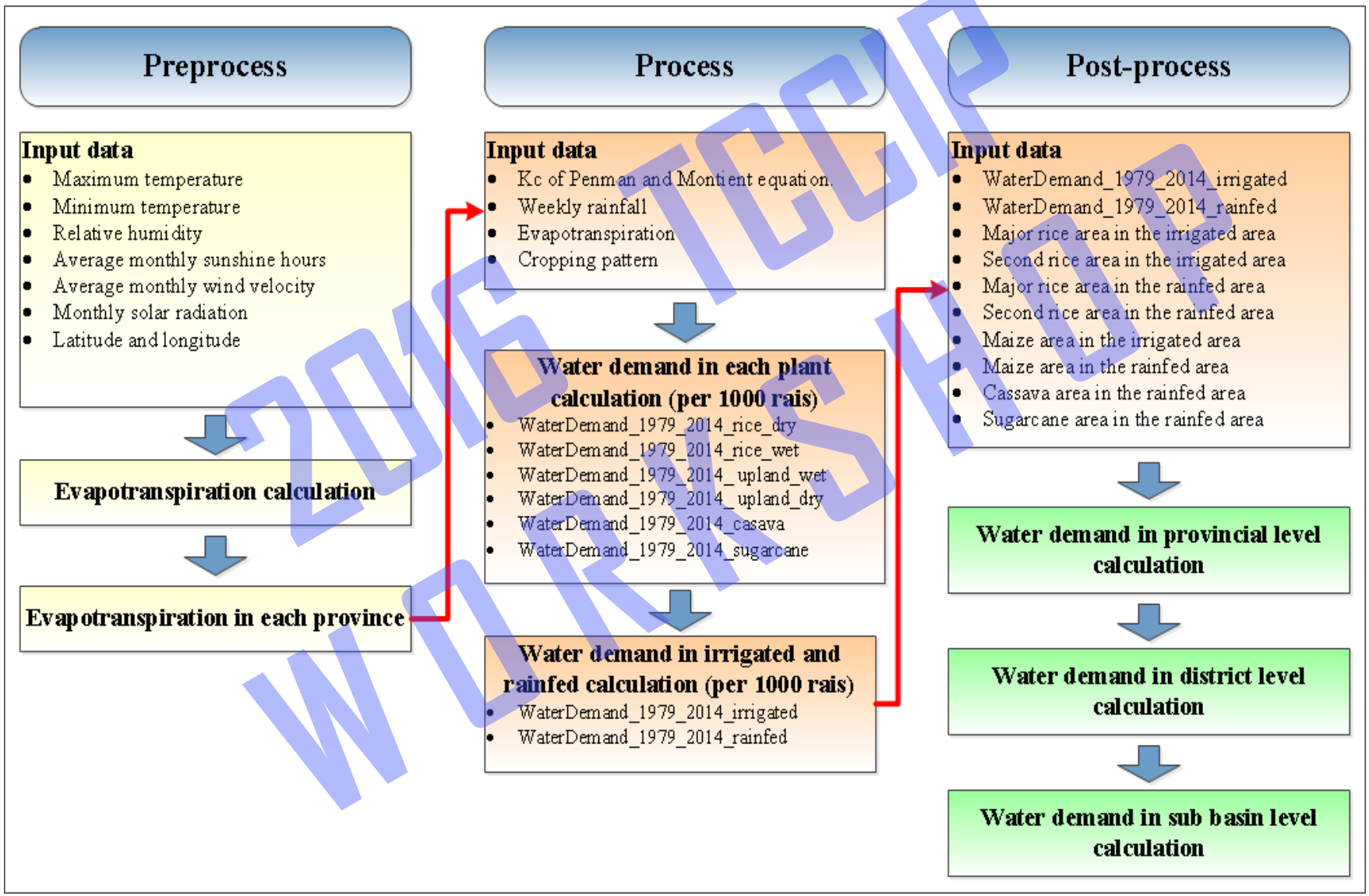
Change of Rainfall in Wet Season in year 2015 -2039 under RCP4.5



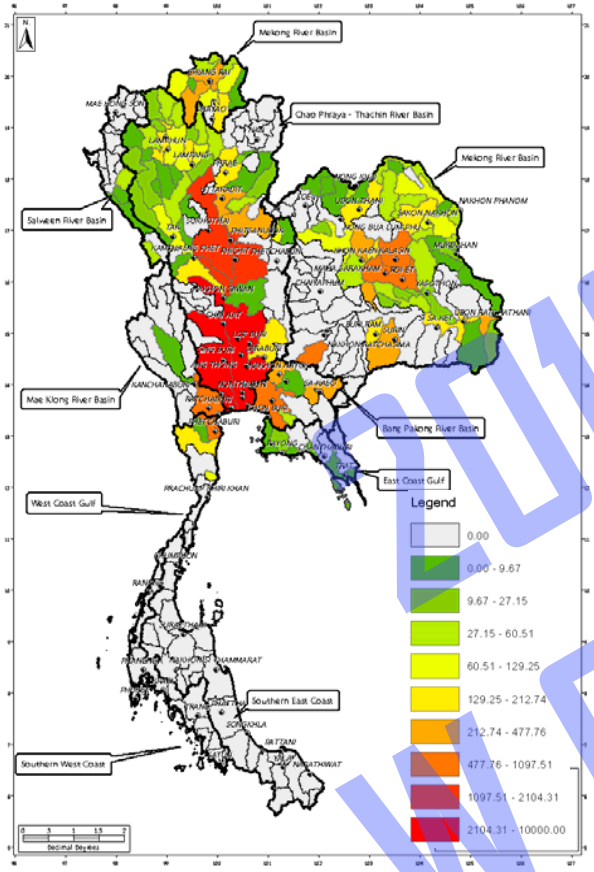
Change of Rainfall in Dry Season in year 2015 - 2039 under RCP4.5



Water requirement estimation procedures

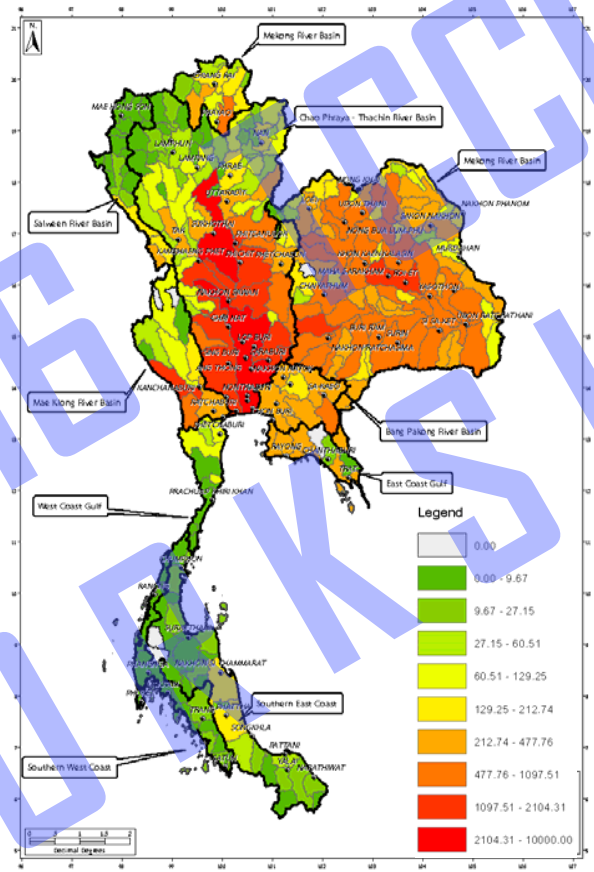


Water Requirement Estimation by Observed Climate Data



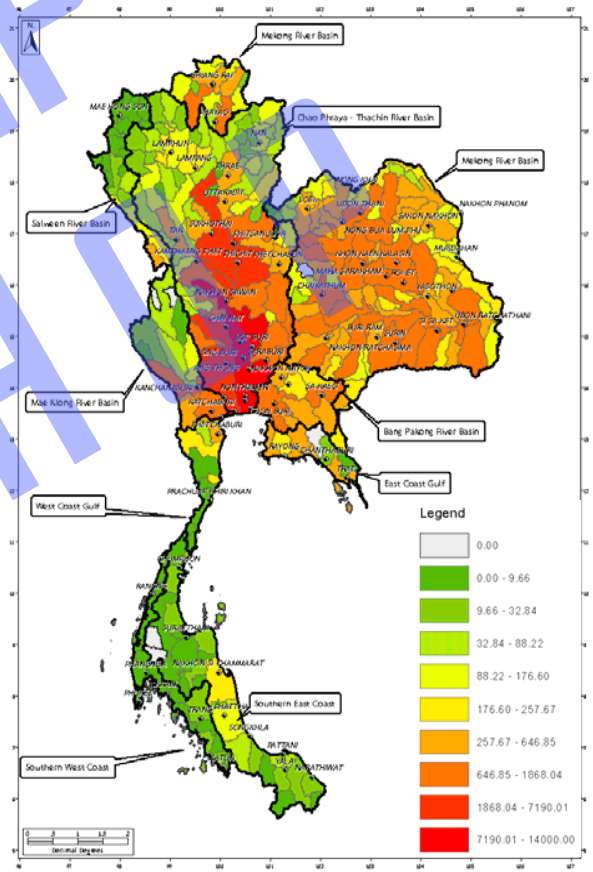
Irrigated Area

31,110 MCM



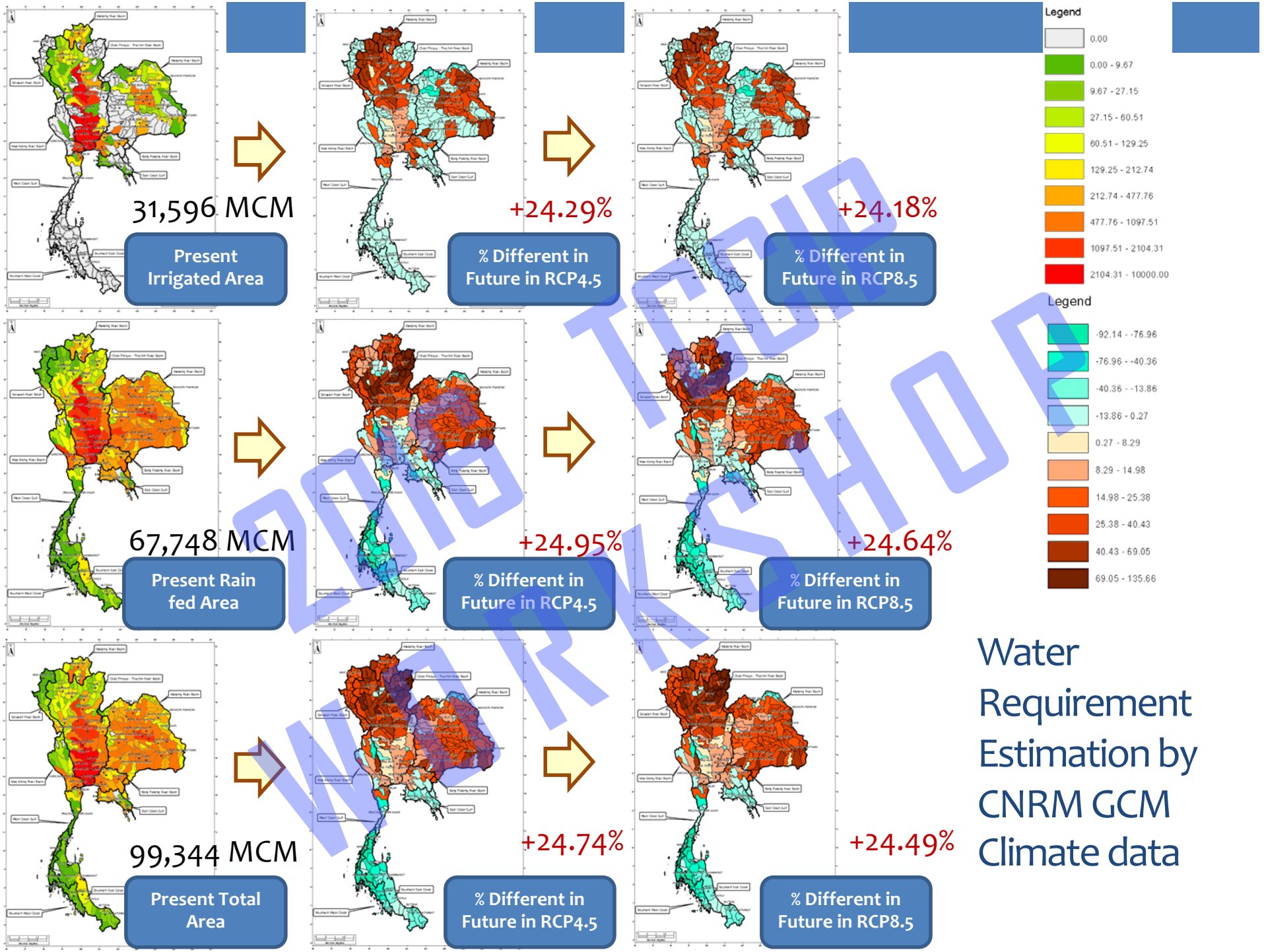
Rain fed Area

65,966 MCM



Total Area

97,076 MCM


31,596 MCM
Present Irrigated Area
+24.29%
% Different in Future in RCP4.5
+24.18%
% Different in Future in RCP8.5
67,748 MCM
Present Rain fed Area
+24.95%
% Different in Future in RCP4.5
+24.64%
% Different in Future in RCP8.5
99,344 MCM
Present Total Area
+24.74%
% Different in Future in RCP4.5
+24.49%
% Different in Future in RCP8.5
Legend
0.00
0.00 - 9.67
9.67 - 27.15
27.15 - 60.51
60.51 - 129.25
129.25 - 212.74
212.74 - 477.76
477.76 - 1097.51
1097.51 - 2104.31
2104.31 - 10000.00
Legend
-92.14 - -76.96
-76.96 - -40.36
-40.36 - -13.86
-13.86 - 0.27
0.27 - 8.29
8.29 - 14.98
14.98 - 25.38
25.38 - 40.43
40.43 - 69.05
69.05 - 135.66
Water Requirement Estimation by CNRM GCM Climate data

Summary

- Accurate hydrologic data is a vital part to improve disaster preparation and long-term planning for water management.
- Climate projection provides essential information to understand future hydrology conditions.
- A water management plan in response to the future climate condition will help policy maker in determining arable land areas and types of crops that are best for the condition

Thank you.

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