

The Impact of Climate Change on Irrigation Systems and Adaptation Measures (Phase I and Phase II)

(Case Study: Plaichumphol/Phitsanulok Irrigation Project
and Wang Bua Irrigation Project, Thailand)

By

Water Resources System Research Unit (WRSRU)
Faculty of Engineering, Chulalongkorn University
and

Plaichumphol Irrigation Office, Regional Irrigation Office 3,
and Kamphangphet Irrigation Office, Regional Irrigation Office 4,
Royal Irrigation Department (RID)

June 27, 2011



Joint/Collaborative Research

Water Resources System Research Unit (WRSRU),
Chulalongkorn University

Assoc. Prof. Sucharit Koontanakulvong

Assoc. Prof. Chaiyuth Sukhsri

Royal Irrigation Department (RID)

Mr. Kanching Kawsard

(Director of Plaichumphol Irrigation Office,
Regional Irrigation Office 3 (RIO 3)

Mr. Praphon Khamthai

(Director of Kamphangphet Irrigation Office,
Regional Irrigation Office 4 (RIO 4),

Japanese Institute of Irrigation and Drainage (JIID)



Presentation Contents

- Statement on Research Objectives
- Brief introduction to RID RIO3 and RIO4; and Plaichumphol and Wang Bua Irrigation Project
- Meteo-Hydrological Characteristics of the Nan and Ping Basins
- GCM data modification/downscaling
- Interviewed data/Questionnaires Analysis
- Impacts toward Irrigation System
- Adantation Mechanism/Schemes

Research Objectives

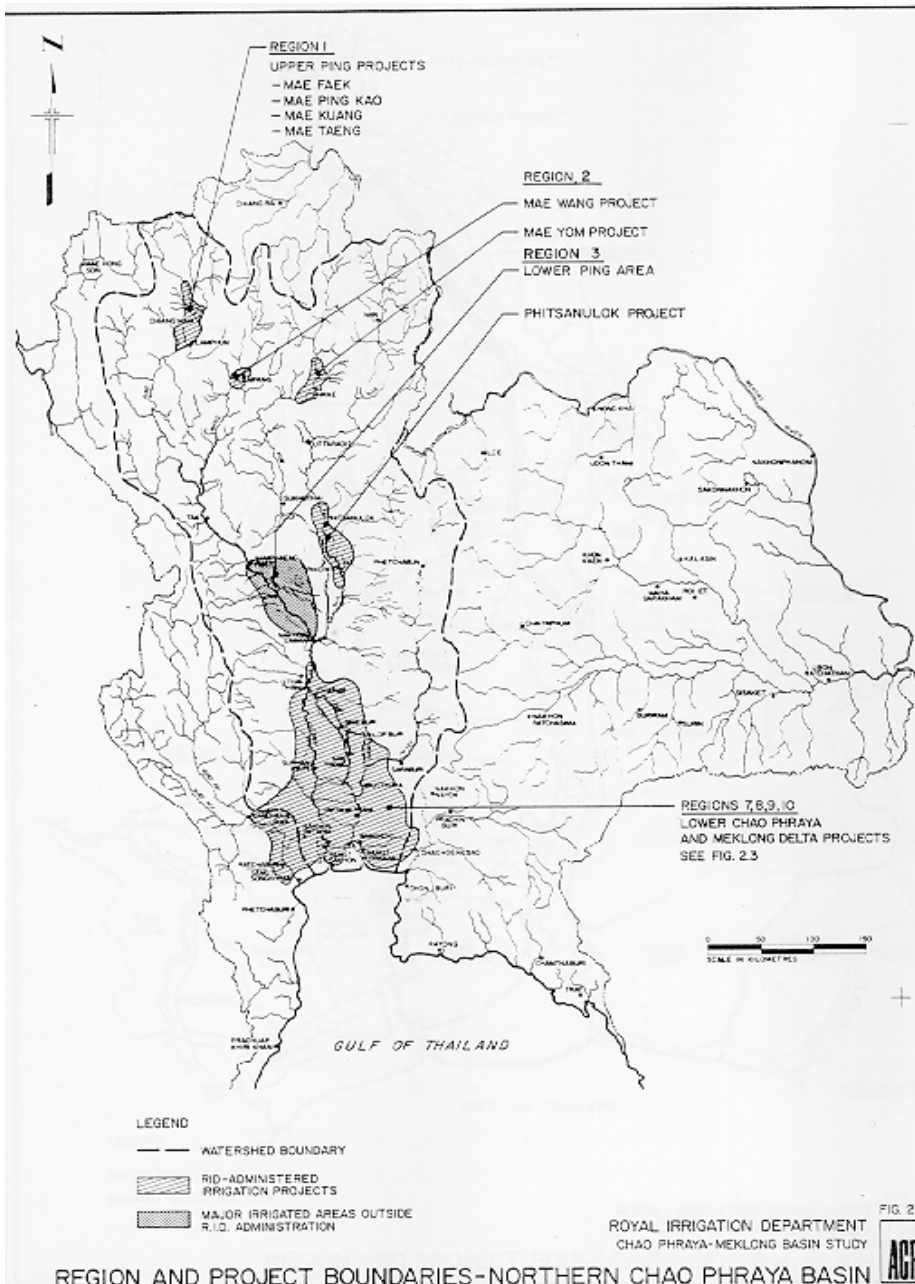
- To analyze the impacts of the climate change on agriculture and irrigation systems;
- To contribute/enhance joint researches among technical institutions and government line agencies;
- To accumulate the knowledge in the fields of agriculture, rural and water resources development as well as regional/global environmental conservation; and
- To disseminate the research finding/outputs to stakeholders

Research Activities

- Water/agricultural data collection and analyses
- Field surveys/interviews/questionnaires
- Impact assessment
- Adaptation simulation

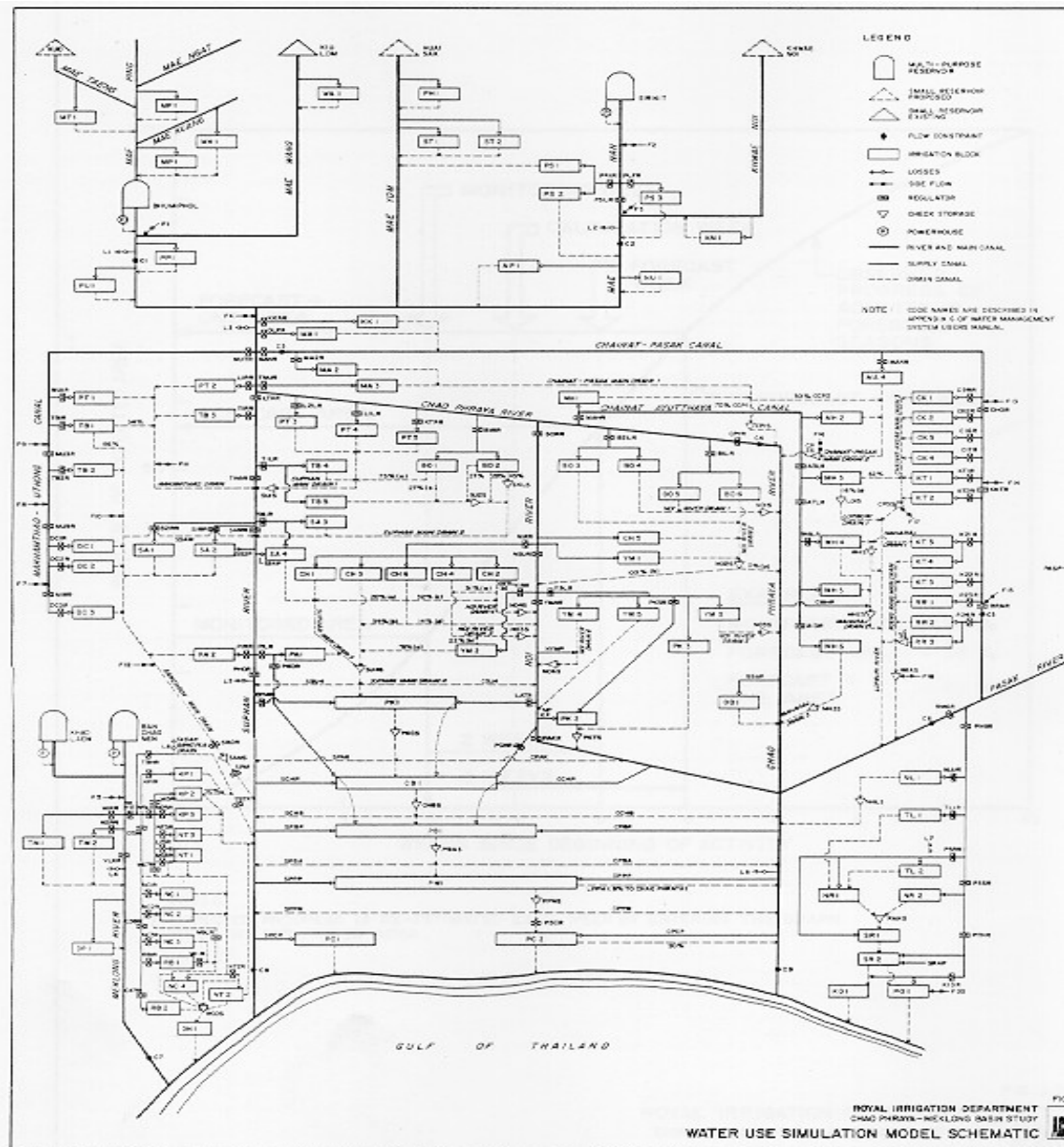


Part 1: Introduction to the Irrigation System and its Hydrological Conditions

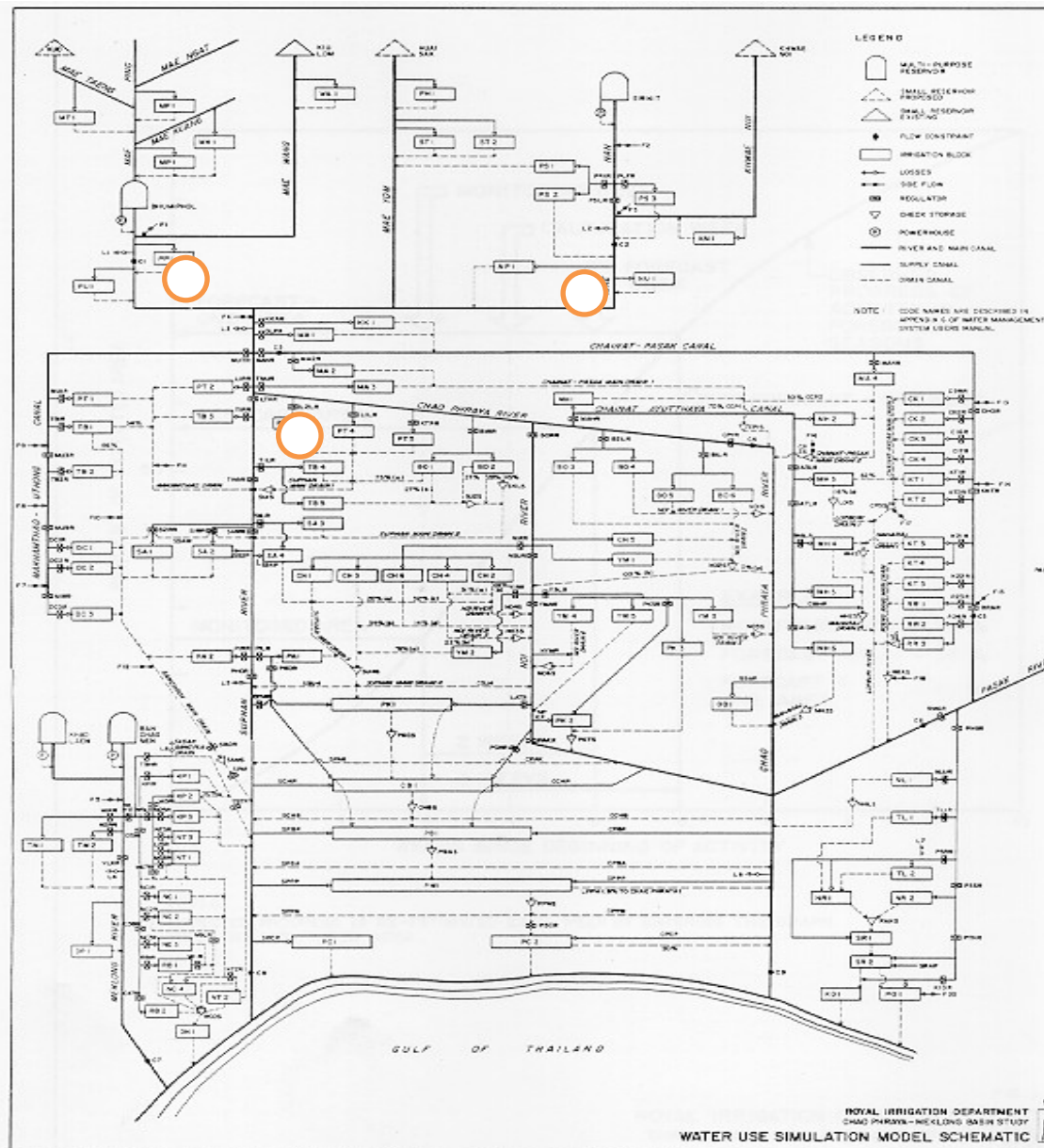


REGION AND PROJECT BOUNDARIES-NORTHERN CHAO PHRAYA BASIN

Schematic of Chao Phraya River Basin



Schematic of Chao Phraya River Basin

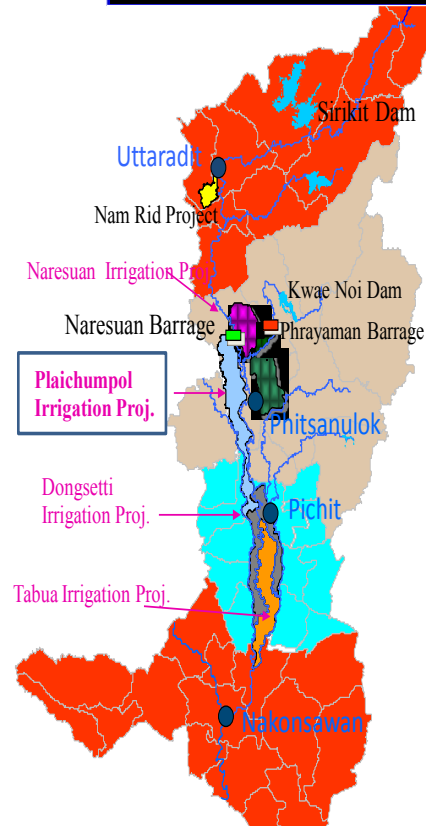


The Study Area 1



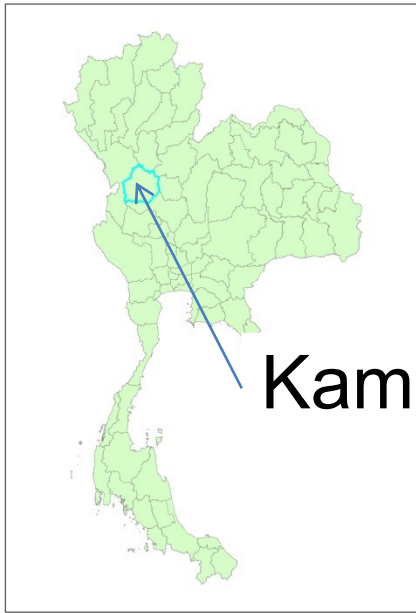
Phitsanulok Province

4 Provinces of the Lower North

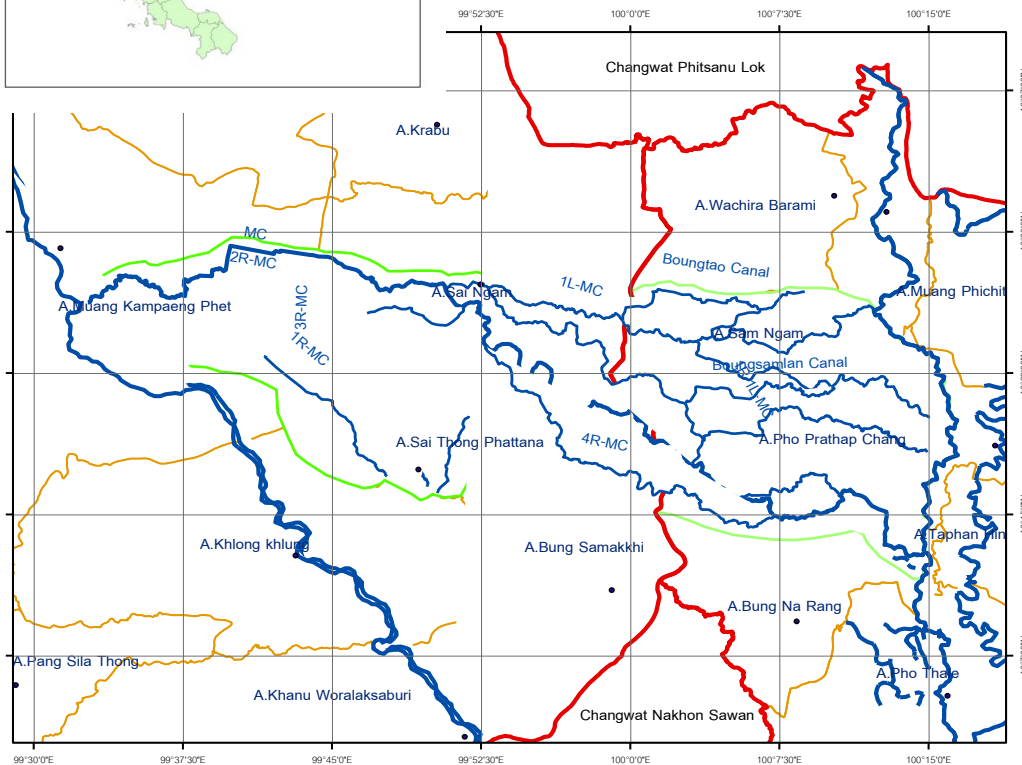


Plaichumphol Project/
Phitsanulok Irrigation
Project:
Conventional
irrigation system
(intensive/extensive),
supplement with
shallow groundwater
wells

The Study Area 2



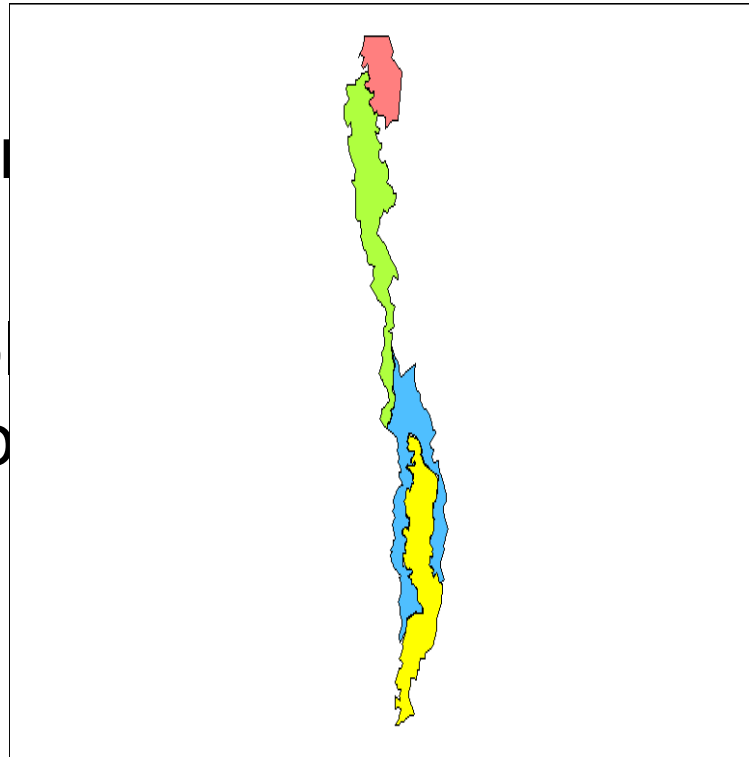
Kamphangphet Province



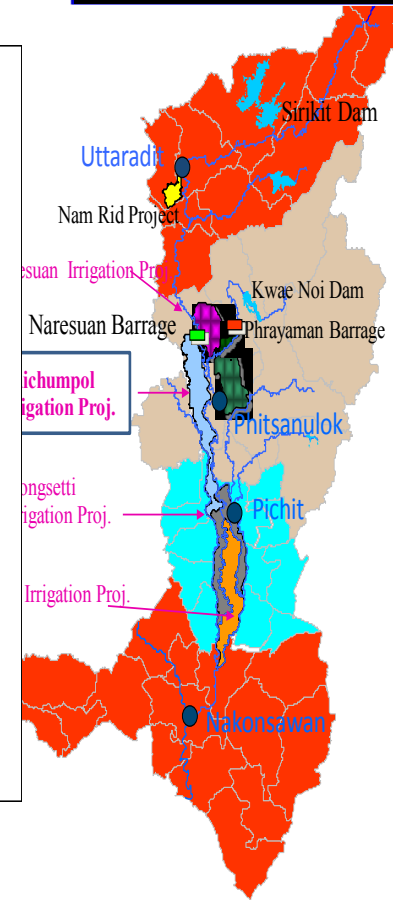
Wang Bua Irrigation Project:
Flooded irrigation (Colmatage) system, supplement with shallow groundwater wells

Area 1

- RID RIO 3
- Phitsanulok Irrigation Project
- Plaichumphong Irrigation Sub

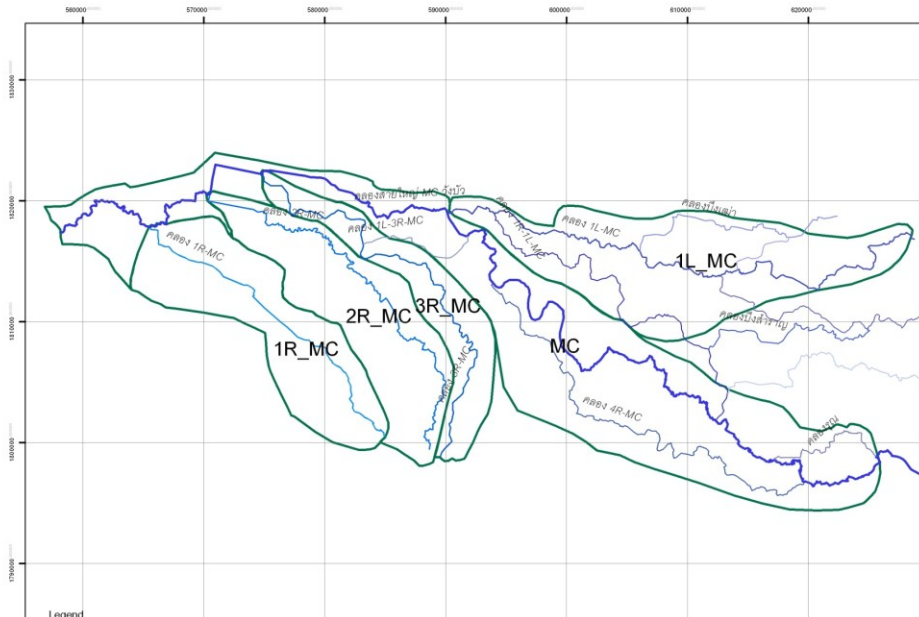


4 Provinces of the Lower North



Area 2

- RID RIO 4
- Kamphangphet Provincial Irrigation Office
- Wang Bua Irrigation Project





Bhumibol
Dam

TAK

SUKHOTHAI

Sirikit
Dam

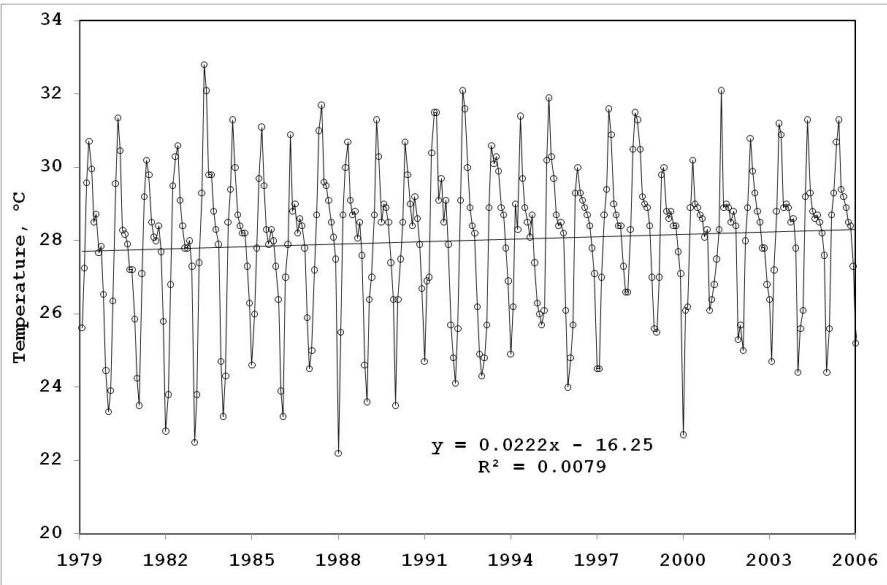
PHITSANULOK

KAMPHANGPHET

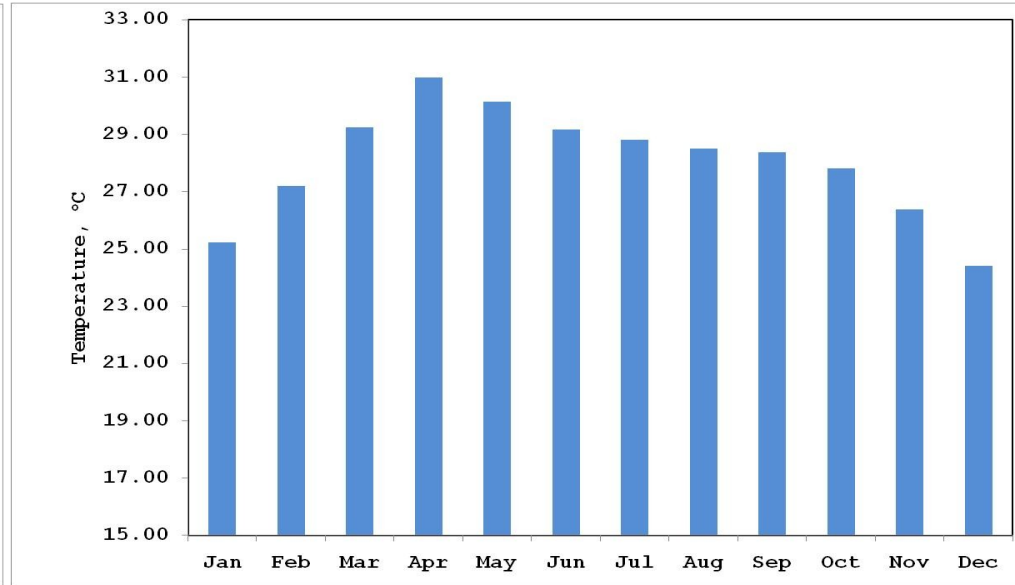
Hydrological Data Analysis

Hydrology and Climatic Conditions of Ping Basin

- Temperature



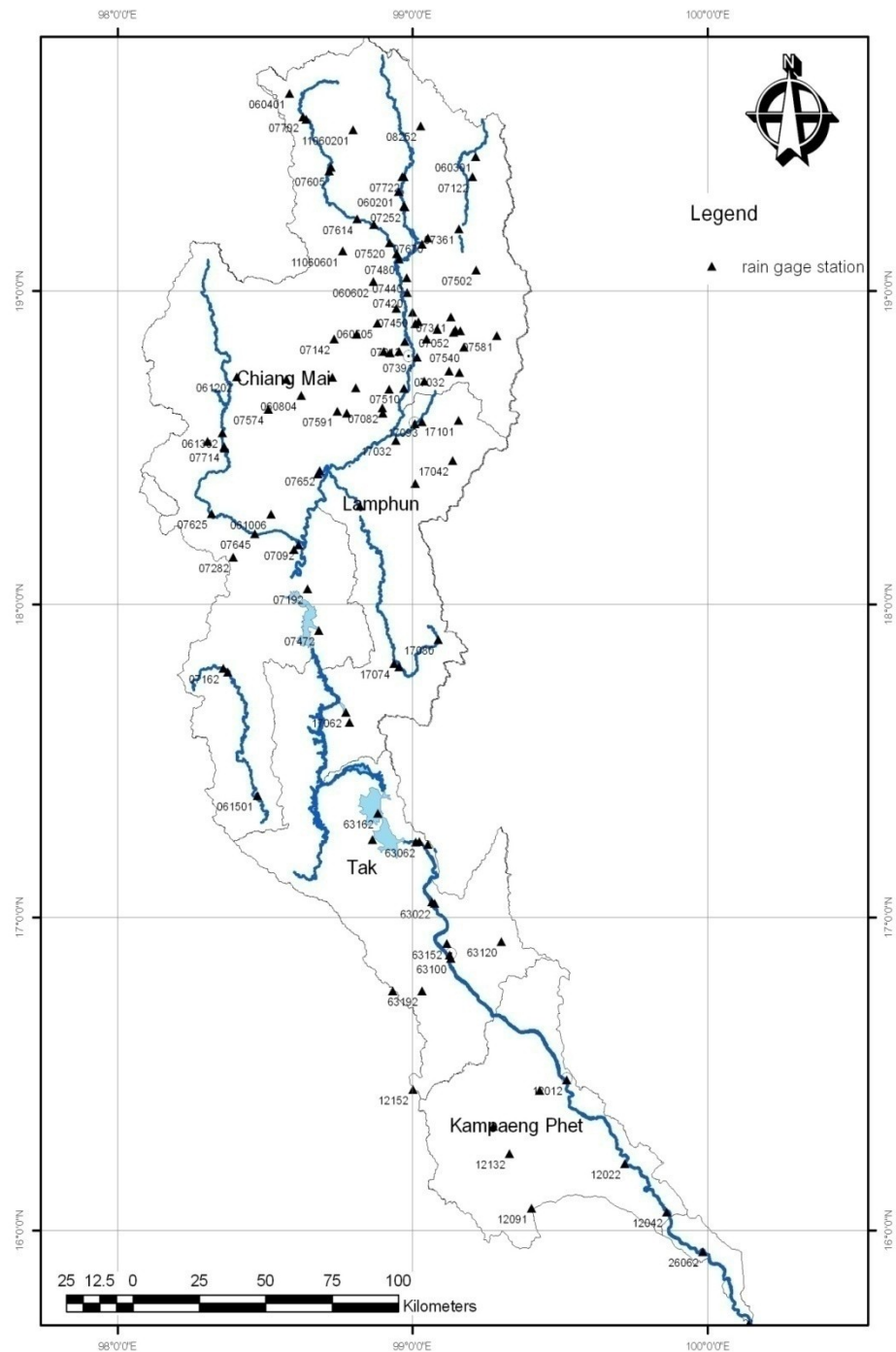
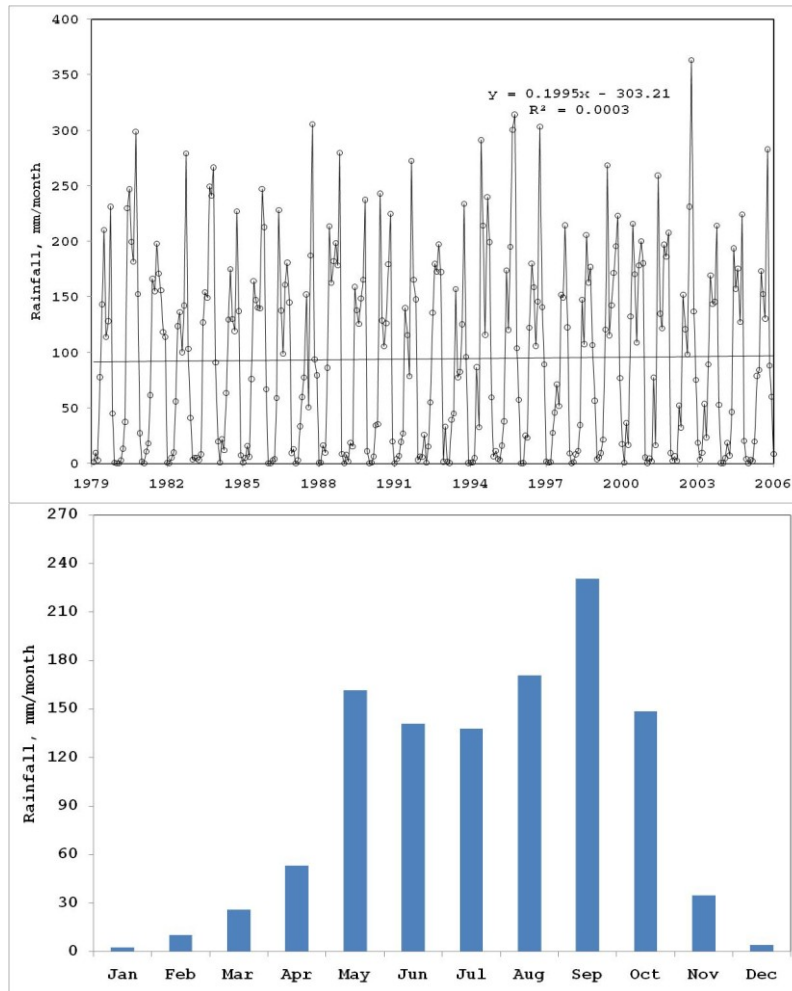
Trend



Monthly Average

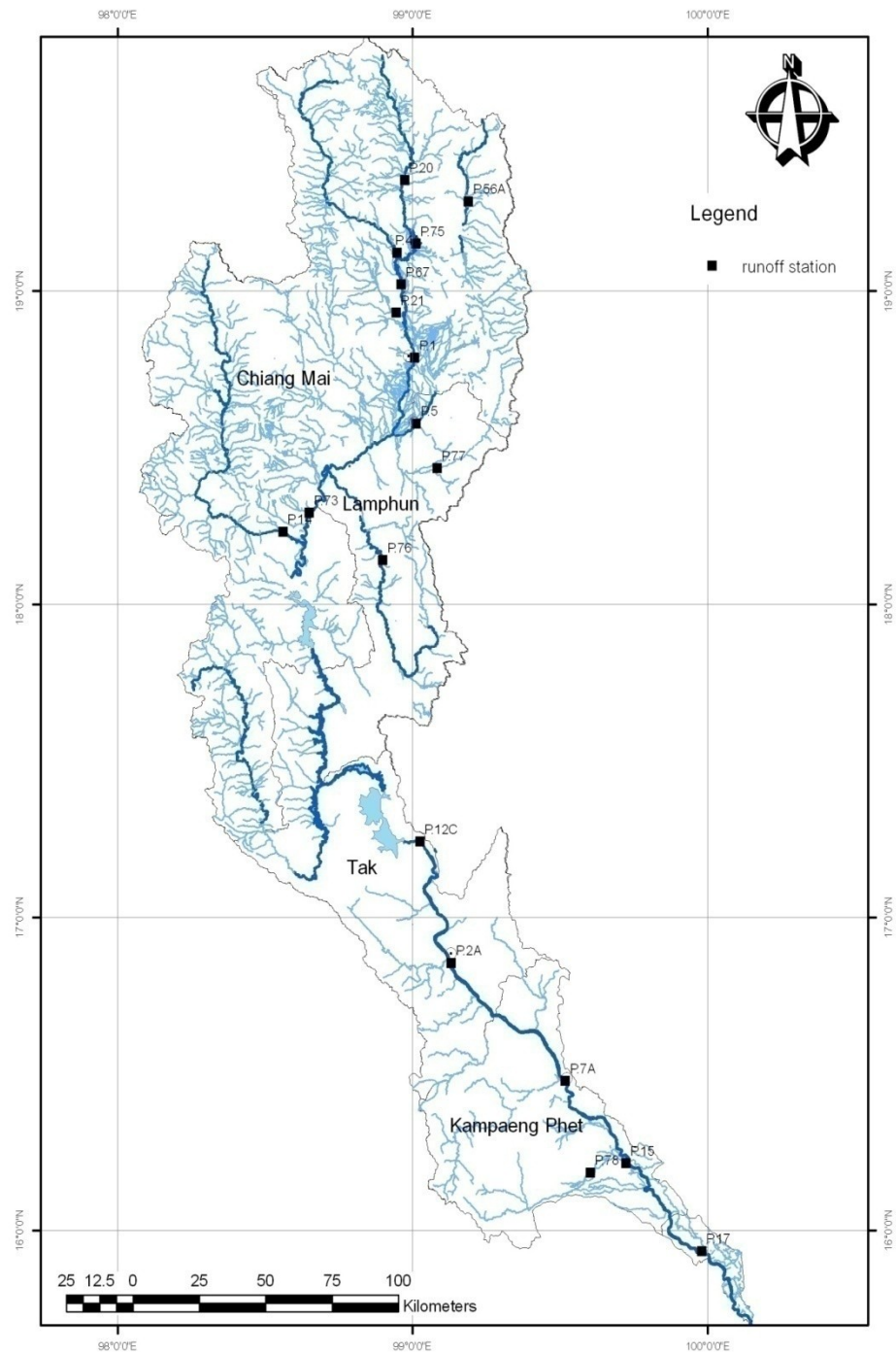
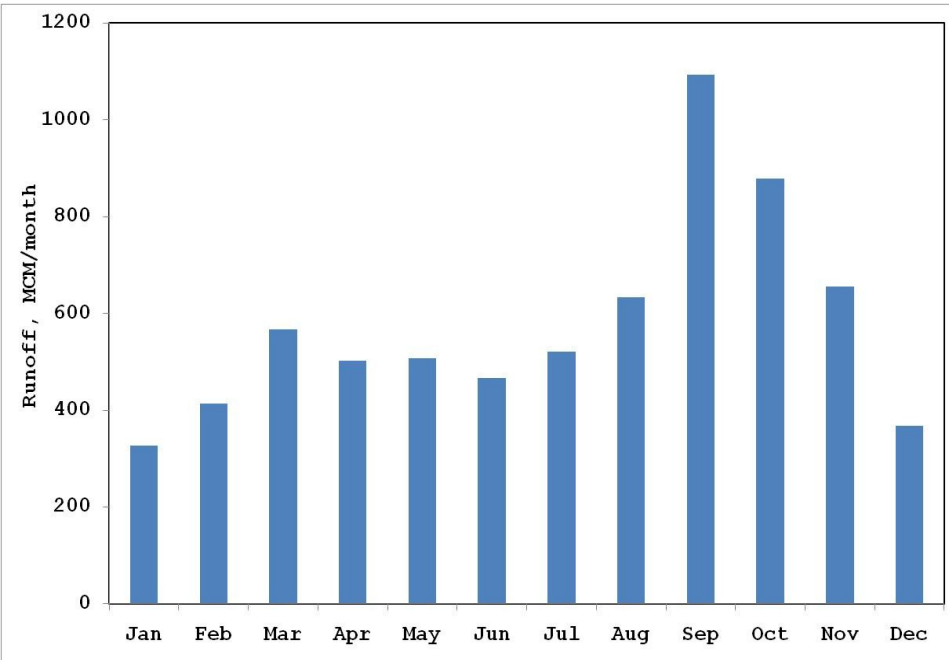
Hydrological Data Analysis

Monthly Average Rainfall



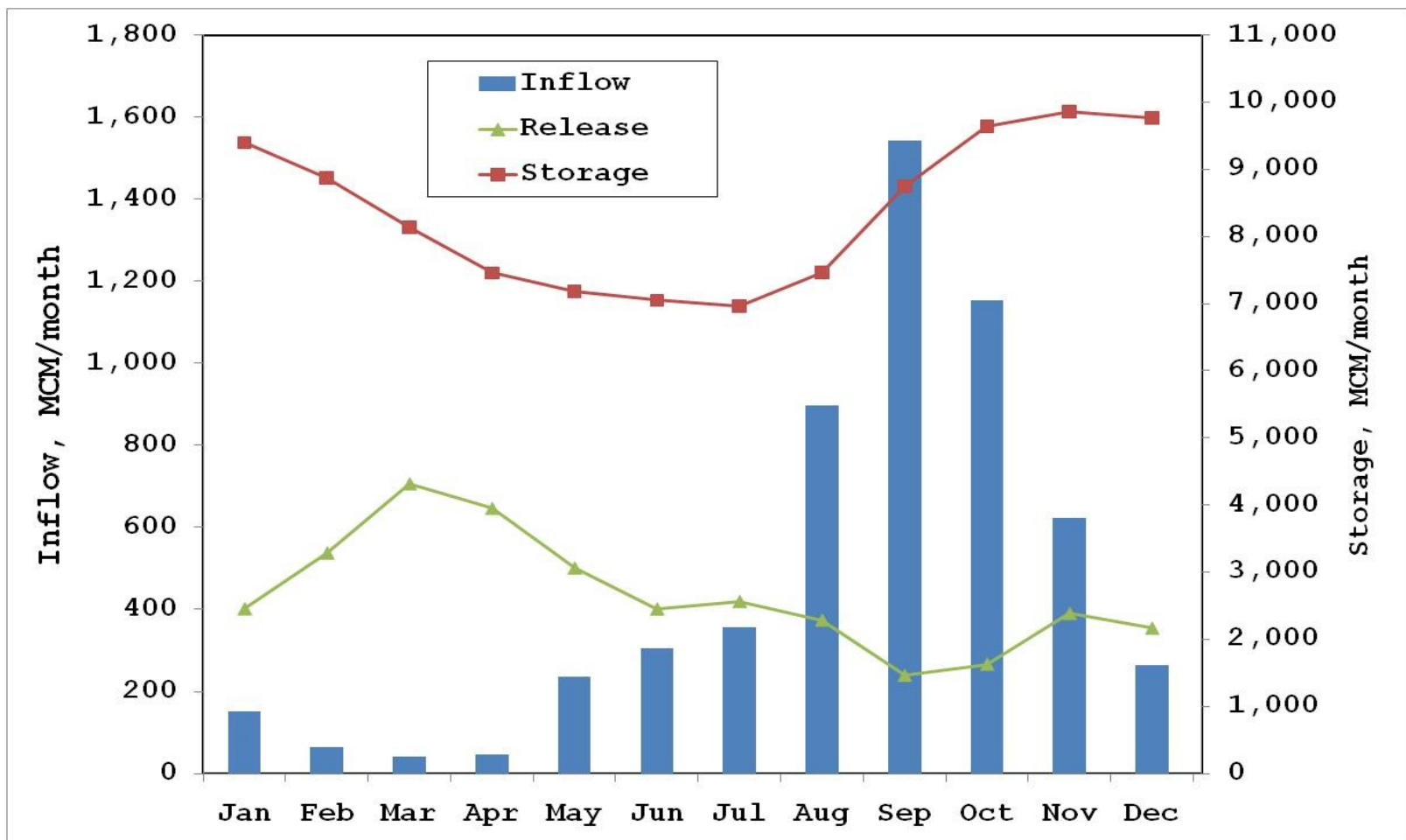
Hydrological Data Analysis

Monthly Average Runoff at Kamphaengphet



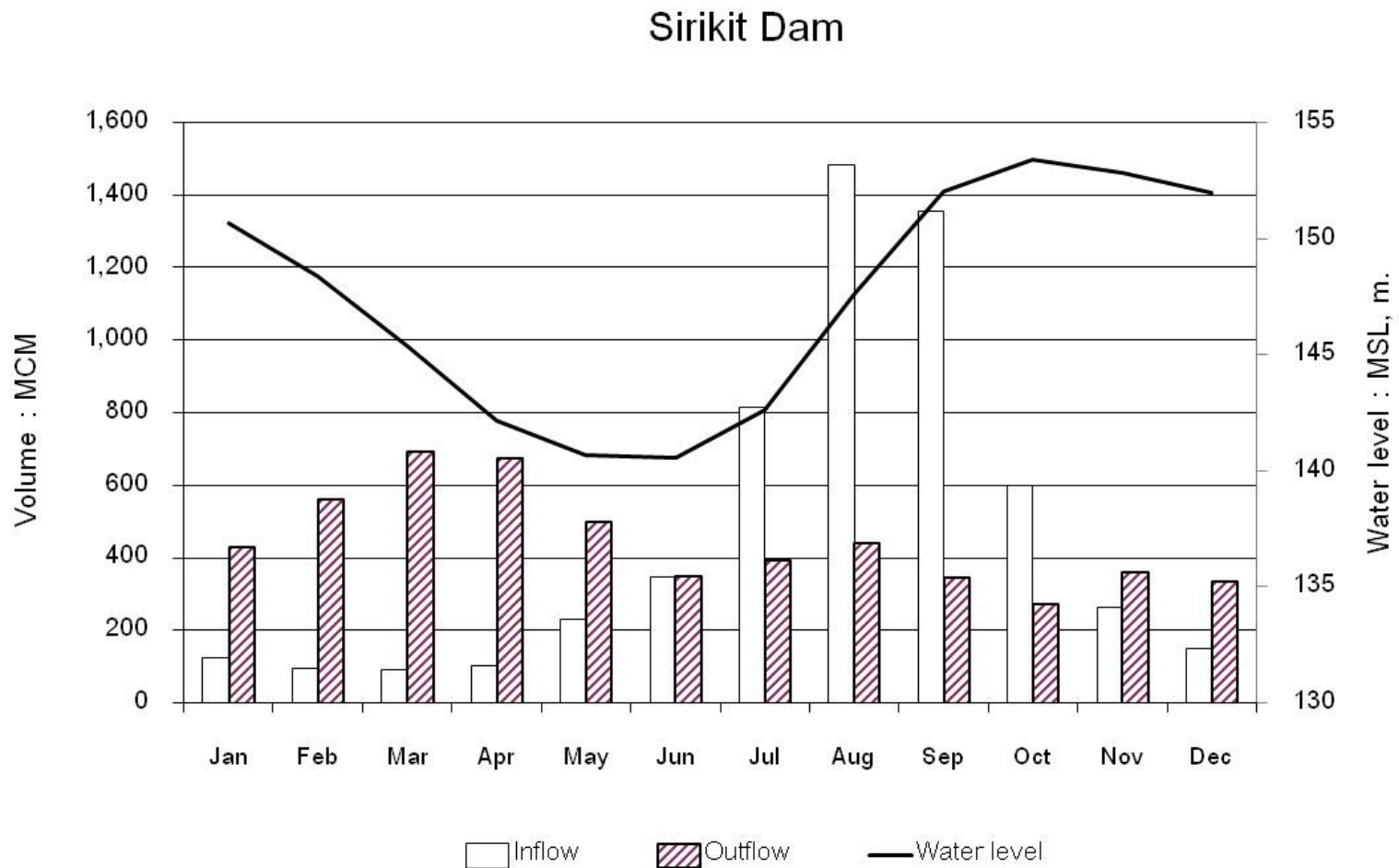
Water Allocation Pattern

Average monthly inflow/outflow to/from Bhumibol Dam



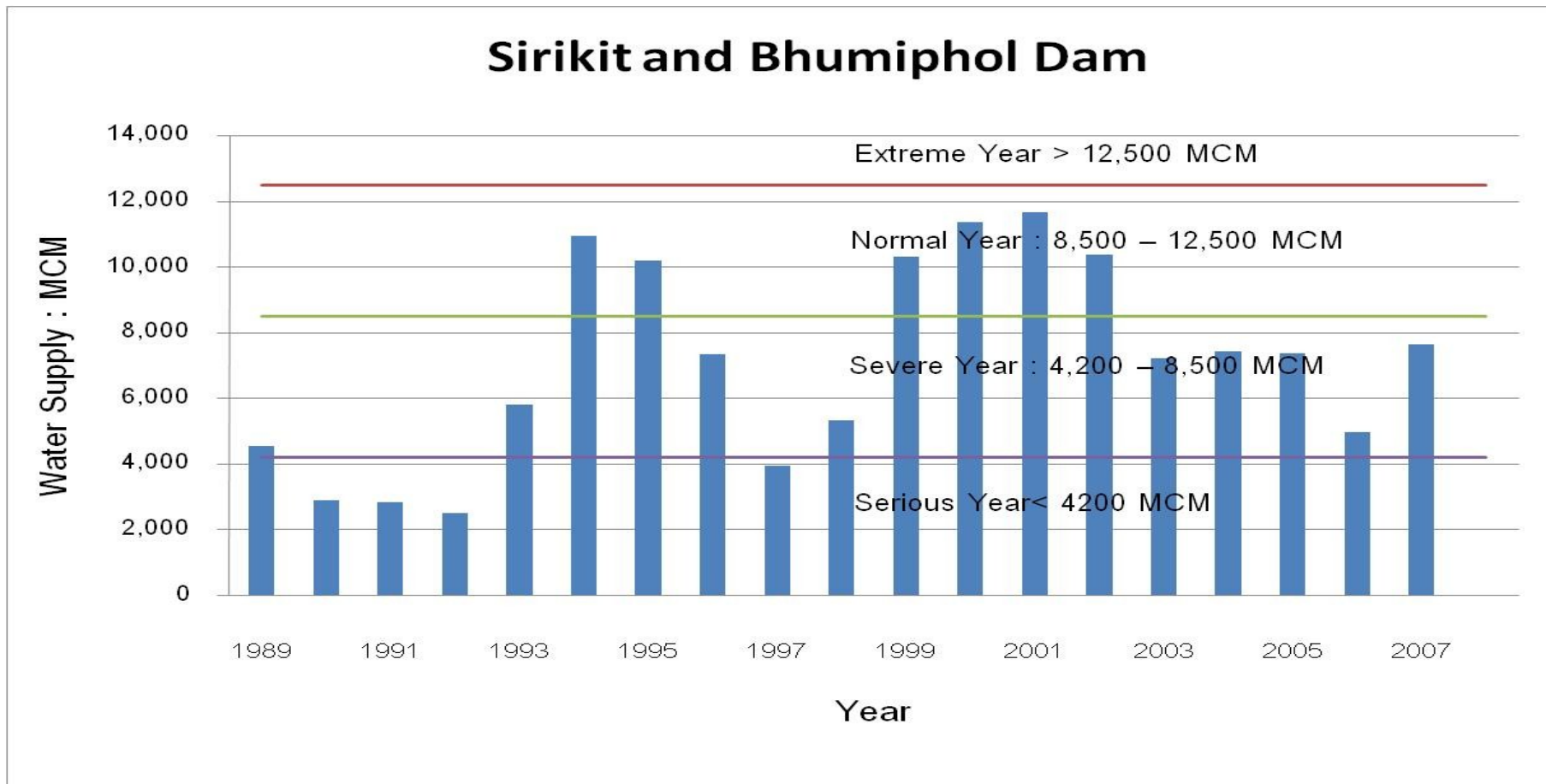
Water Allocation Pattern

Average monthly inflow/outflow to/from Sirikit Dam (1974-2008)



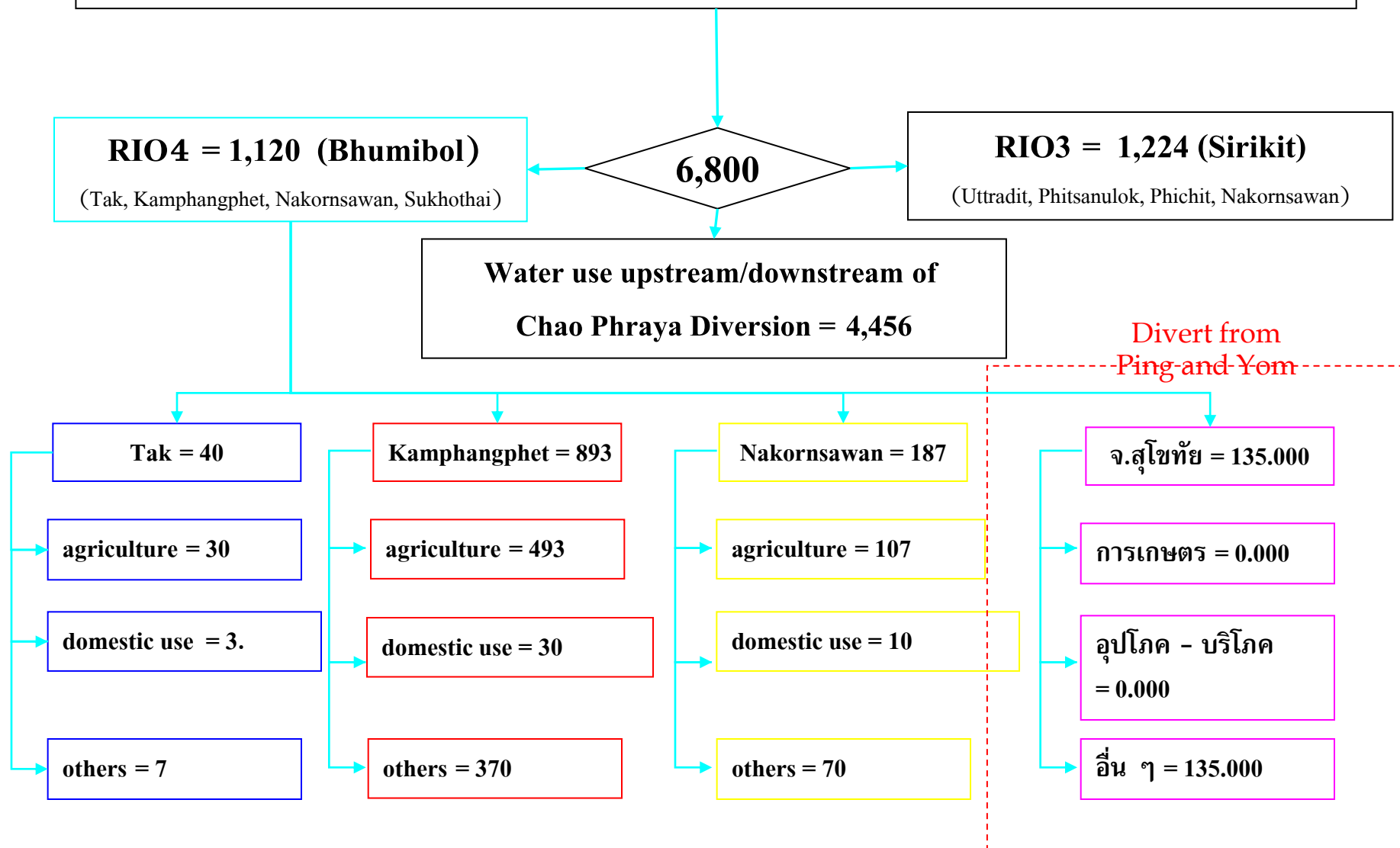
Water Allocation Pattern

Water Allocation Criteria Based on Bhumibol & Sirikit Storages (1974-2005)





Water Allocation Plan from Bhumibol and Sirikit Dam

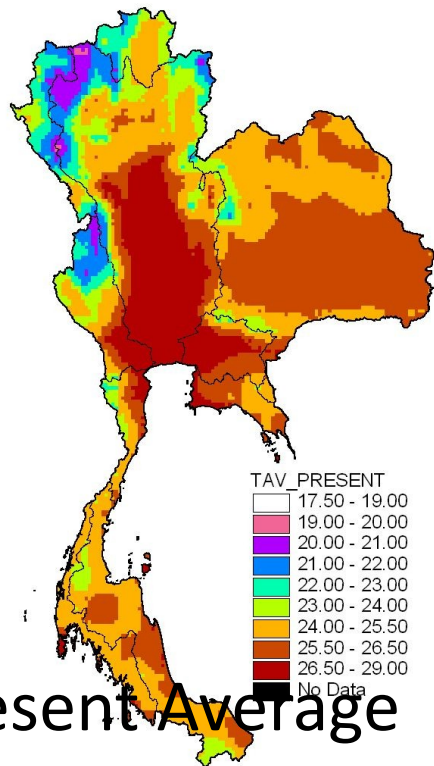


remarks : RIO = regional irrigation office for 2011 dry season

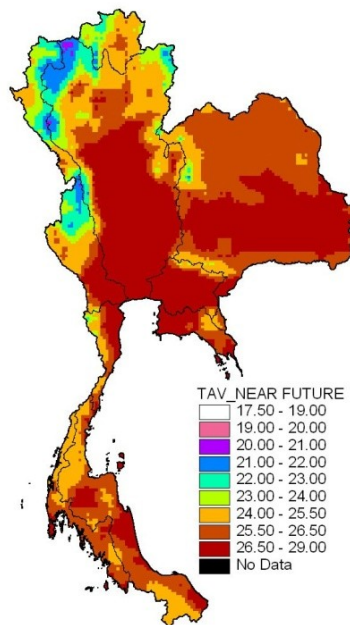
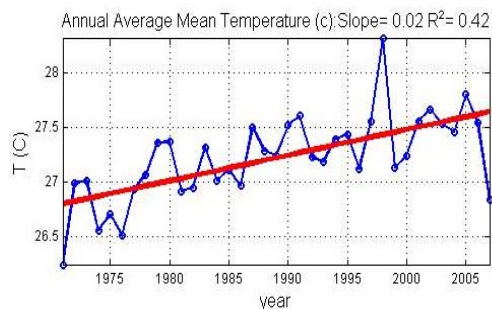
Unit : MCM

Part 2: Downscaling GCM Data to the Study Area

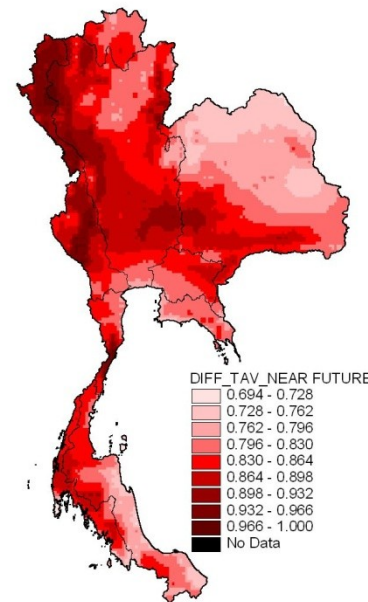
MRI GCM (Japan)



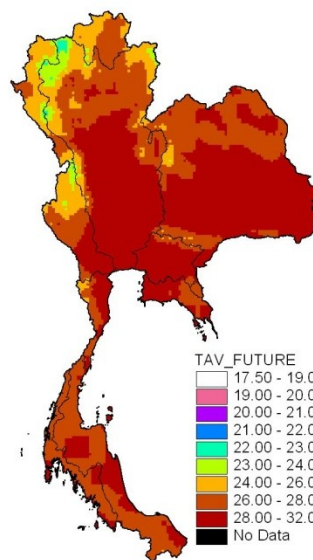
**Present Average
Temperature**



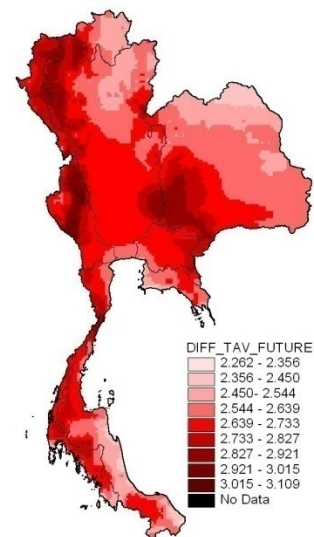
Near Future (2015-2039)



Difference

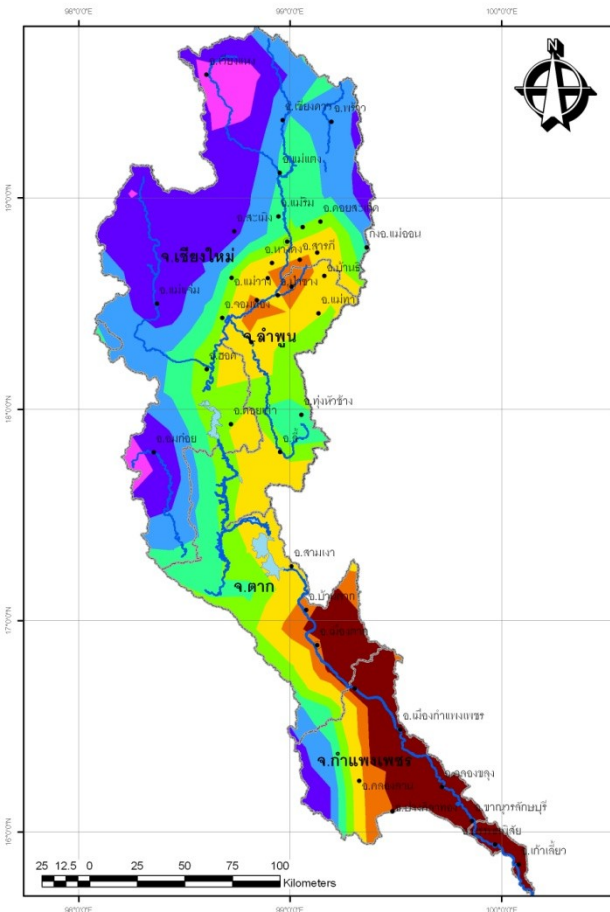


Far Future (2075-2099)

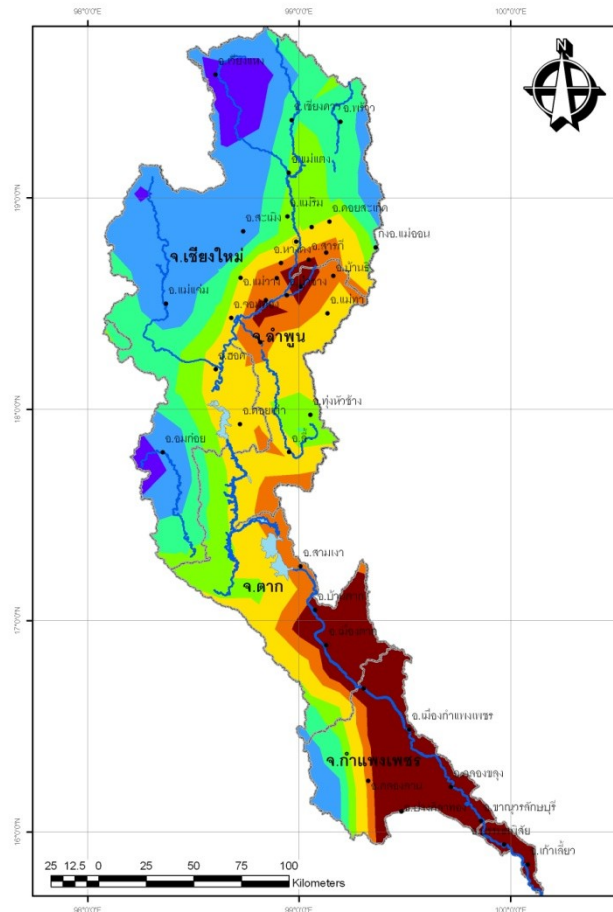


Difference

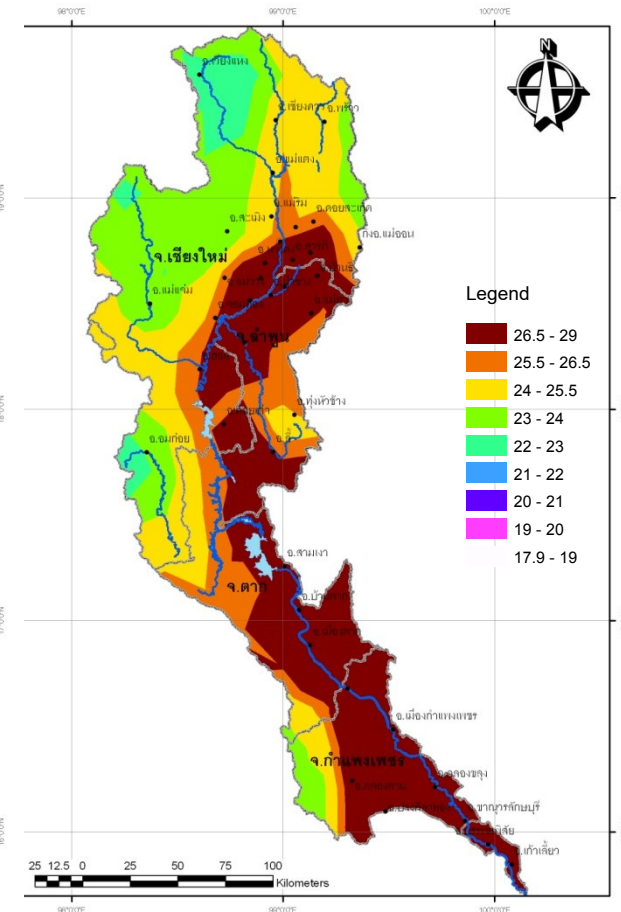
Average Temperature



Present
(1979-2003)

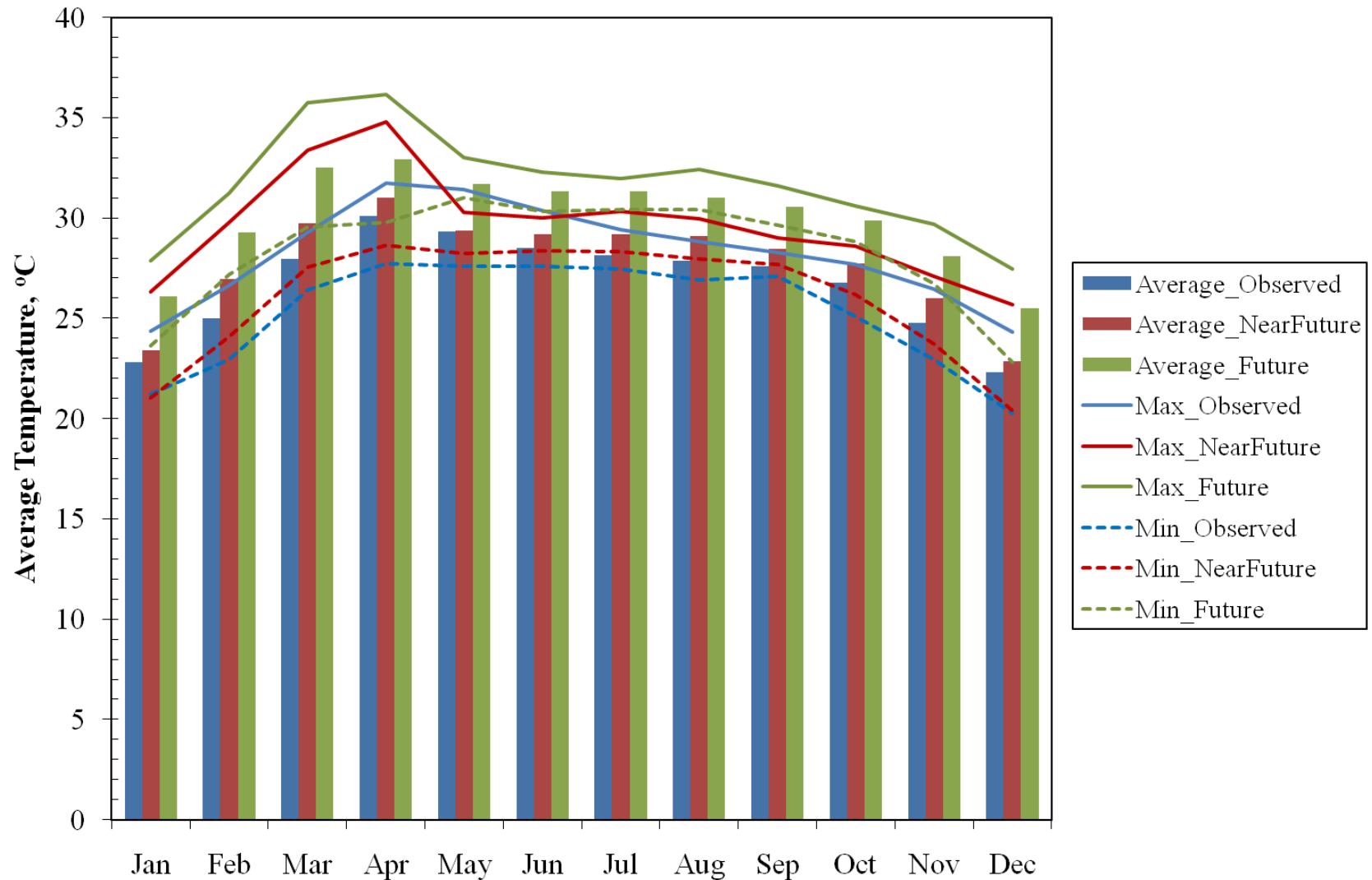


Near Future
(2015-2039)

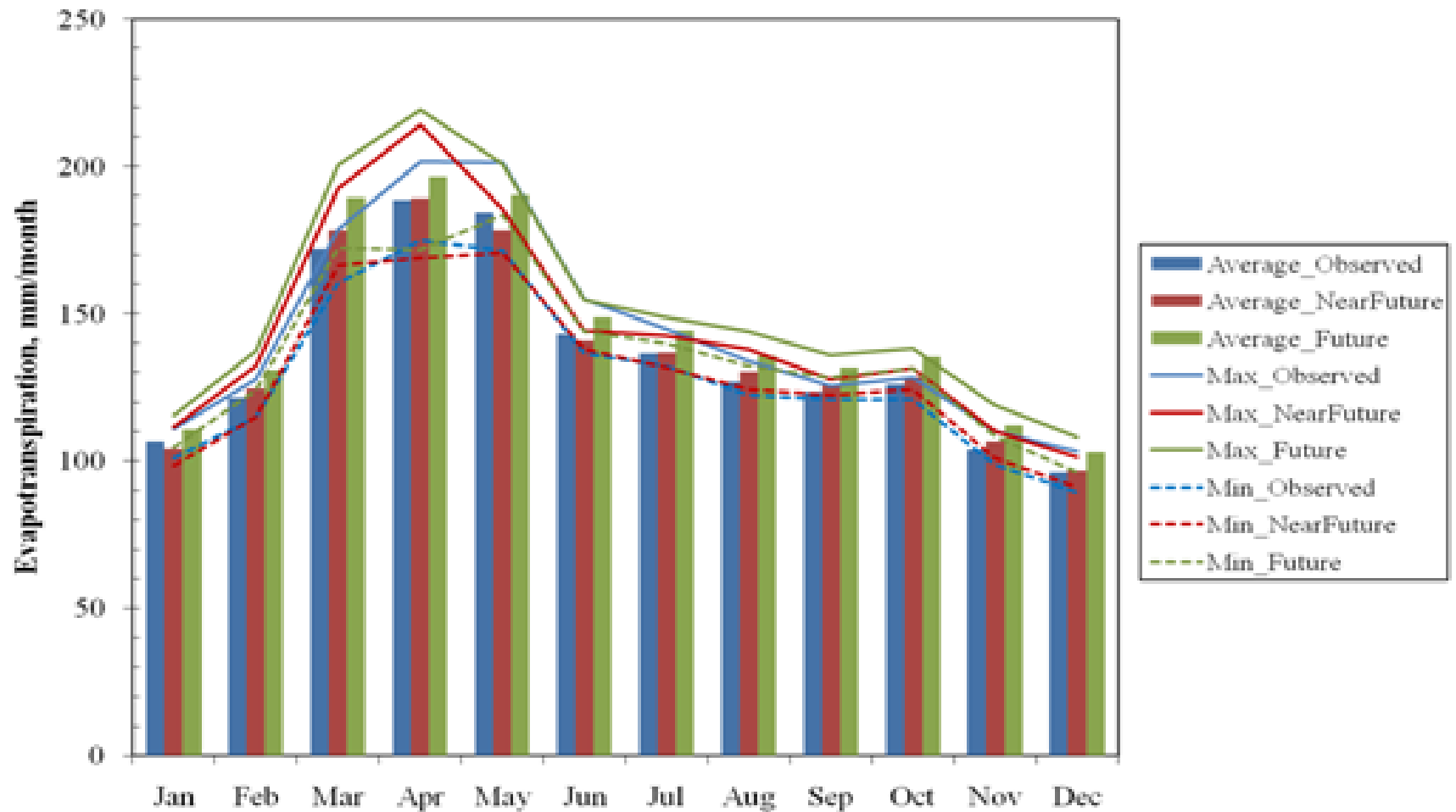


Far Future
(2075-2099)

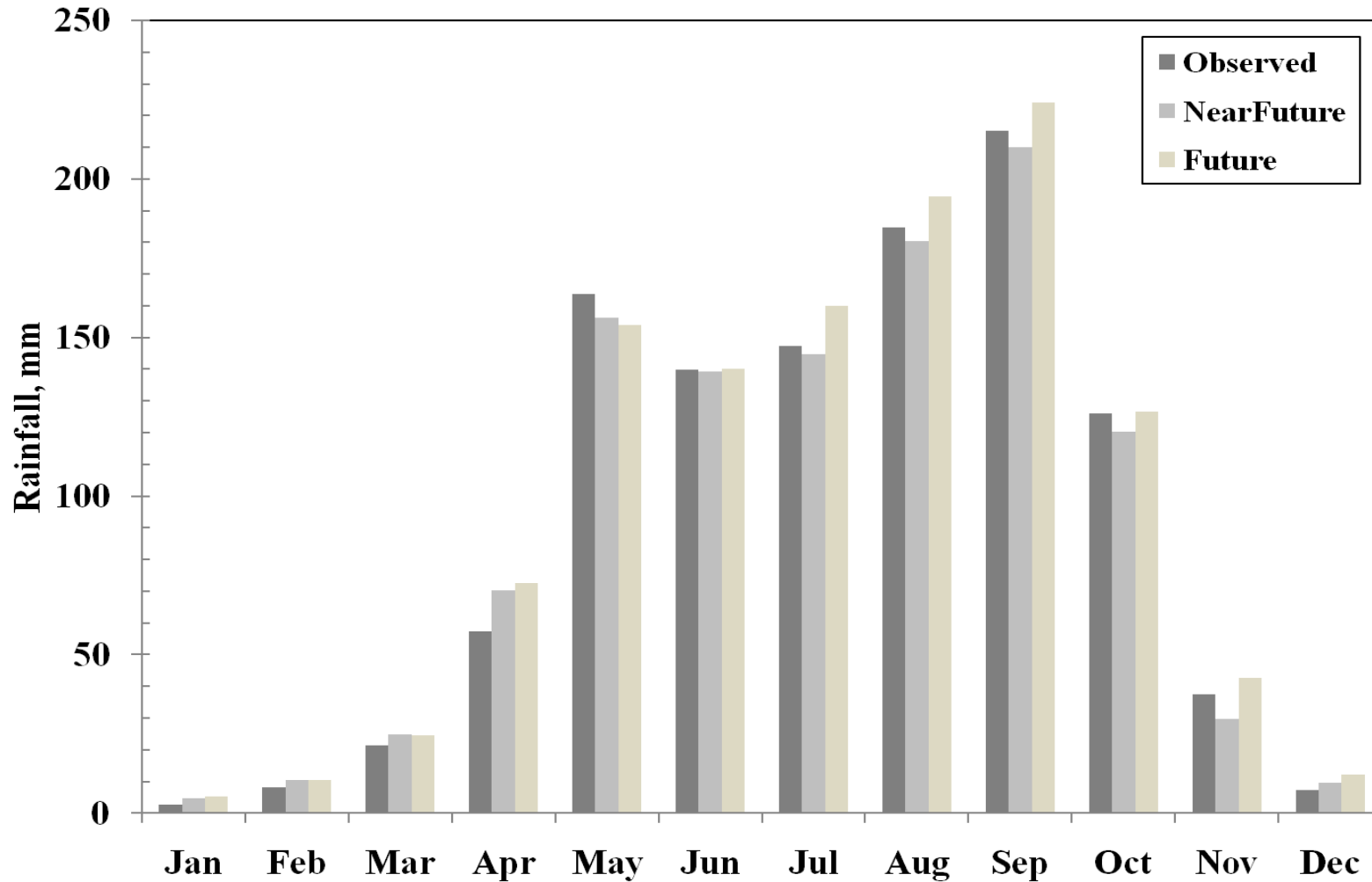
Comparison of Monthly Observed and Downscaled Near Future and Far Future Temperature



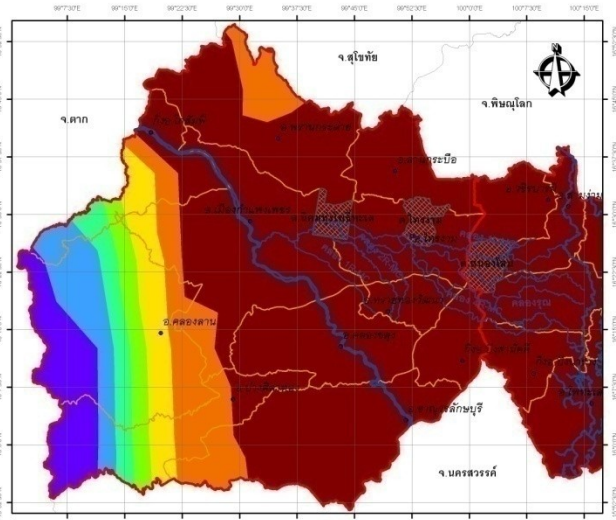
Comparison of Monthly Observed and Downscaled Near Future and Far Future Evapotranspiration



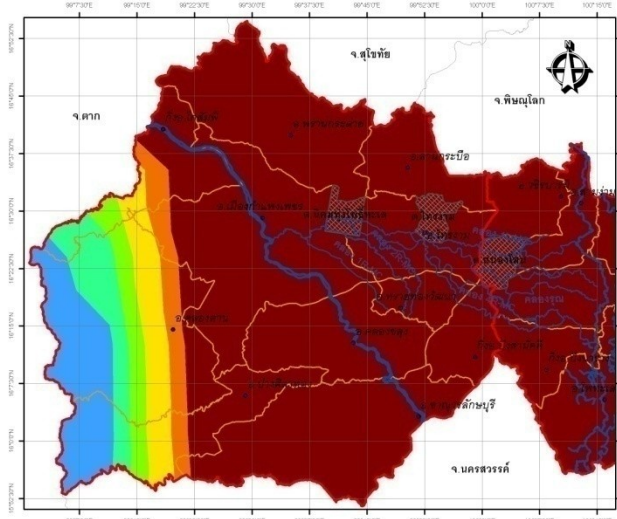
Comparison of Monthly Observed and Downscaled Near Future and Far Future Rainfall Data



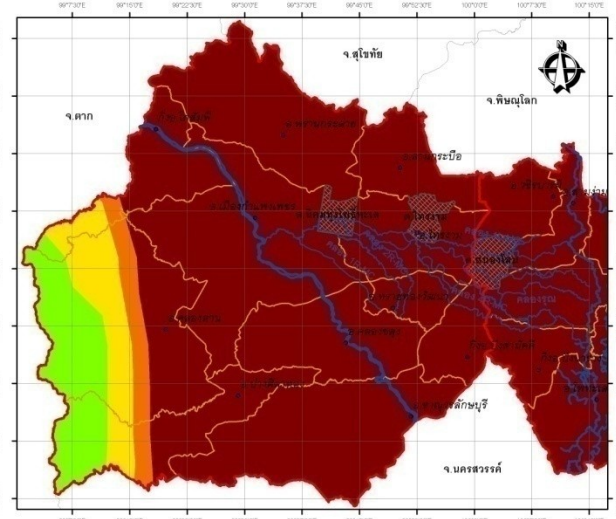
Average Temperature in Kamphangphet Province



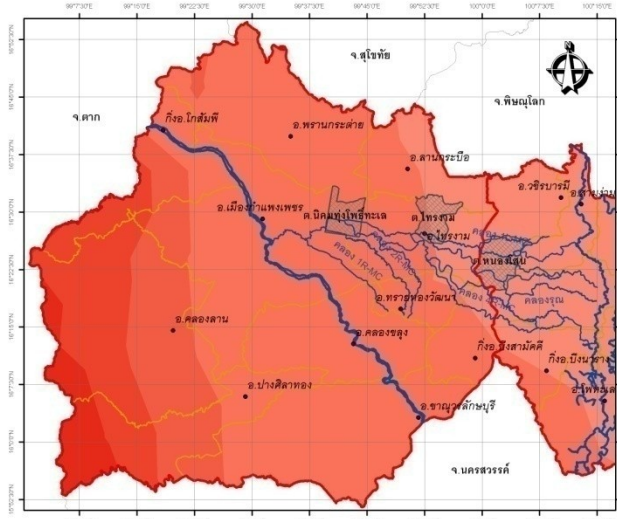
Present period
(1979-2003)



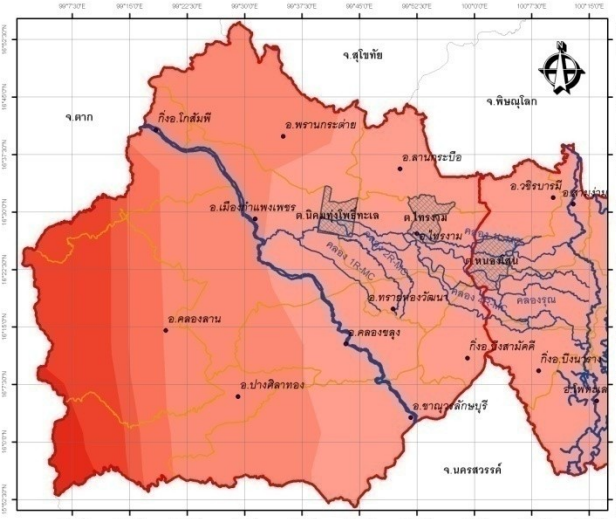
Near Future
(2015-2039)



Far Future
(2075-2099)

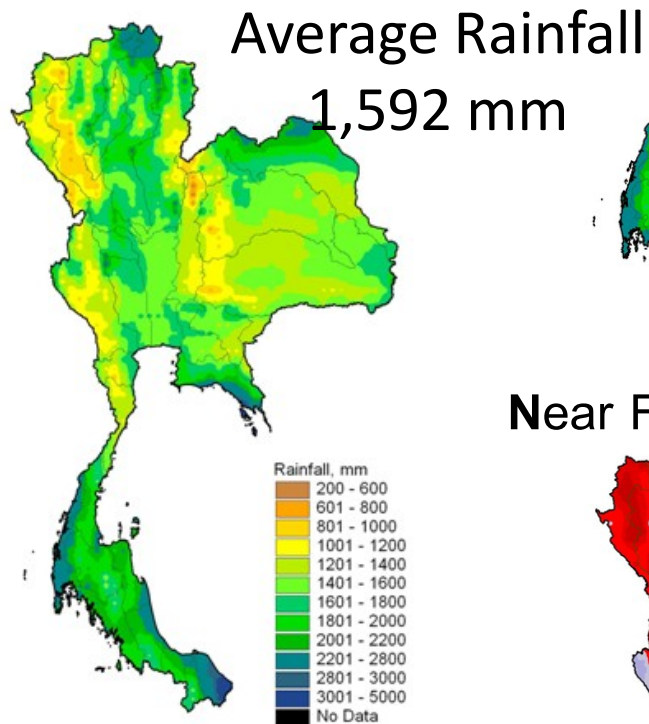


% Different Near Future
and Present

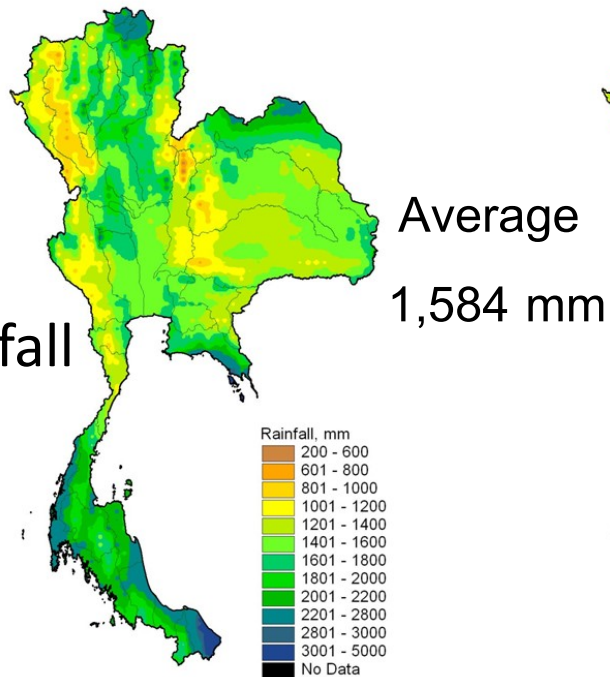


% Different Far Future
and Present

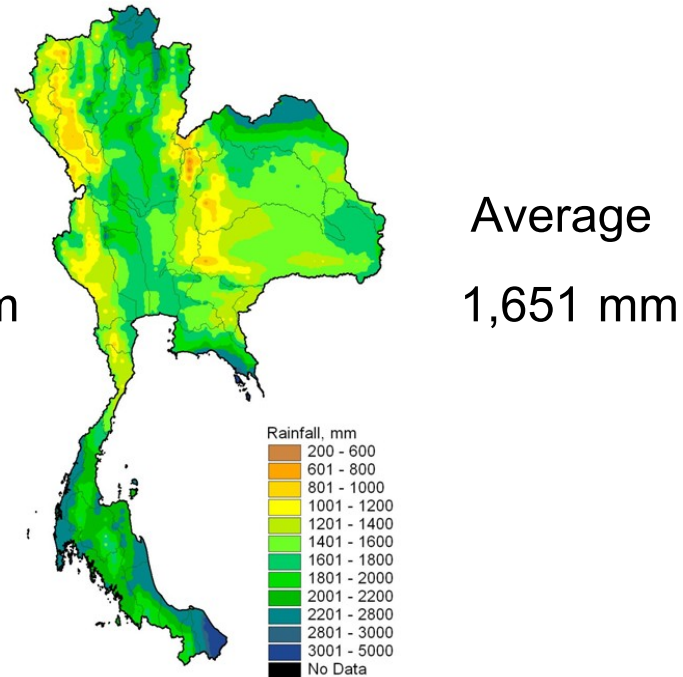
MRI GCM (Japan)



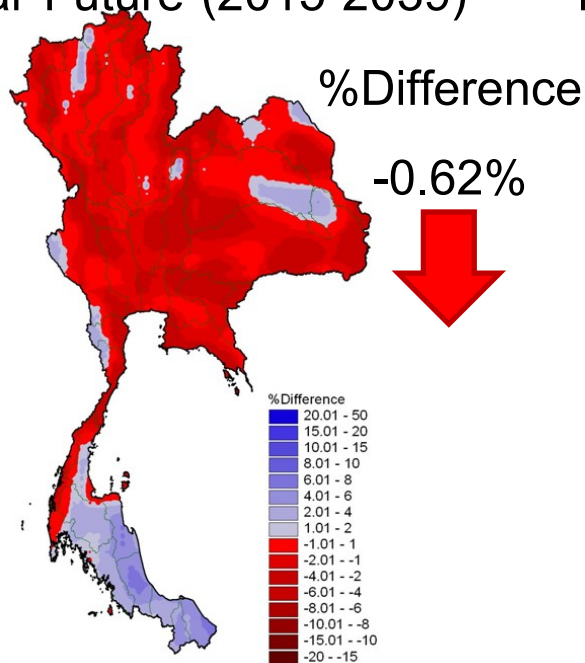
Present (1979-2006)



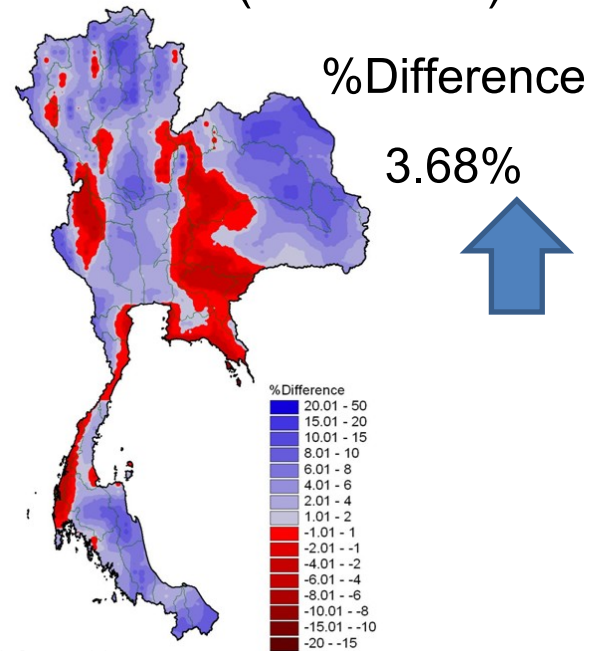
Near Future (2015-2039)



Far Future (2075-2099)

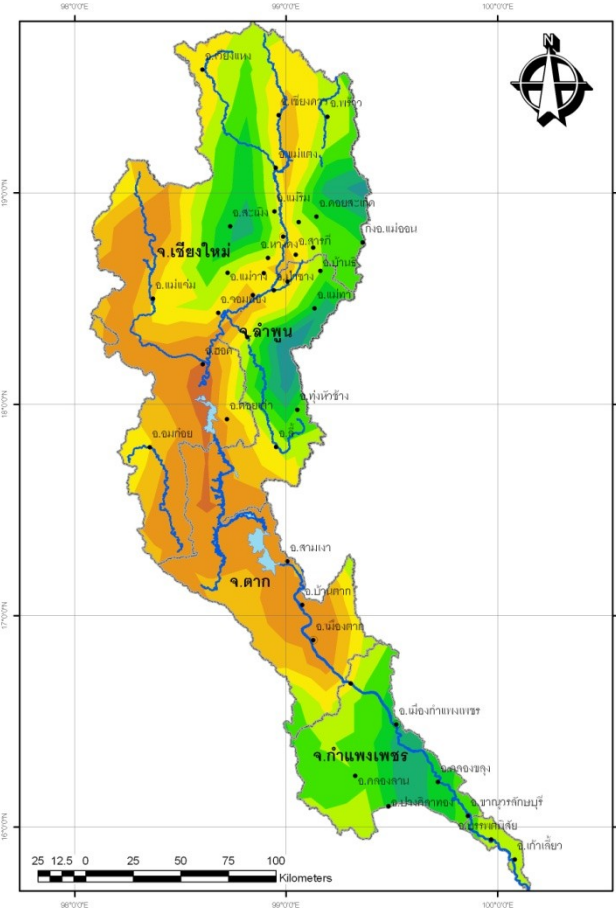


%Difference Near Future

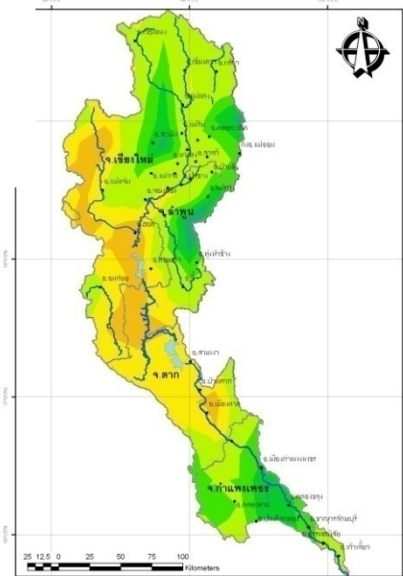


%Difference Far Future

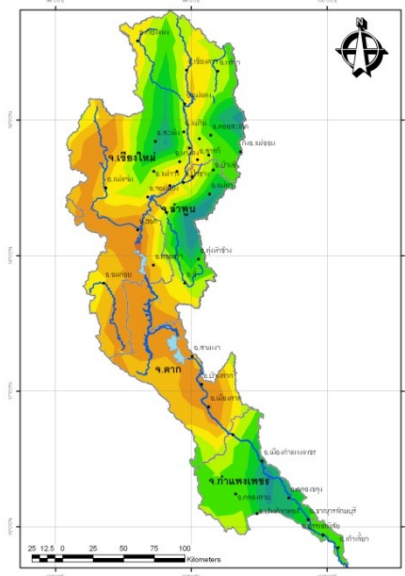
Average Annual Rainfall in Ping Basin



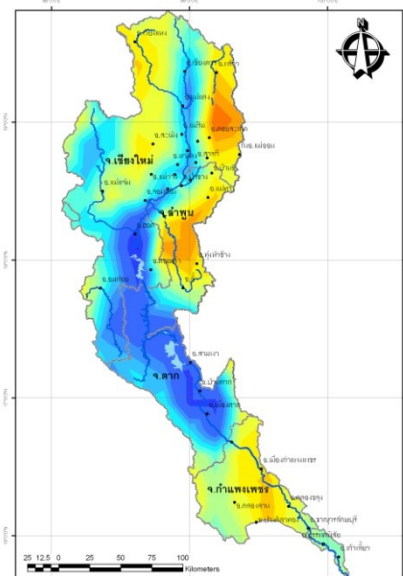
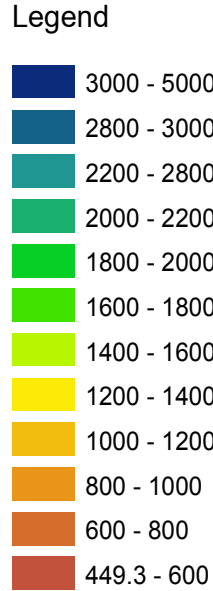
Present period
(1979 -2006)



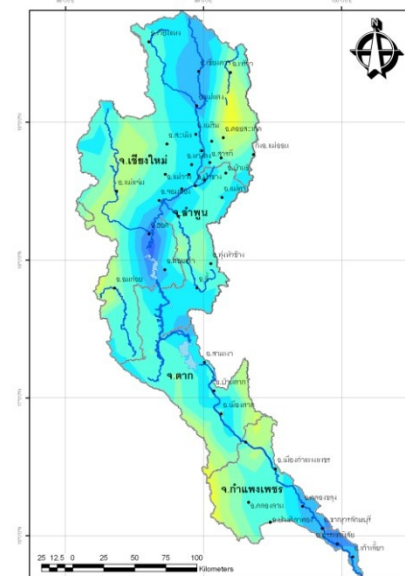
Near Future
(2015-2039)



Far Future
(2075-2099)



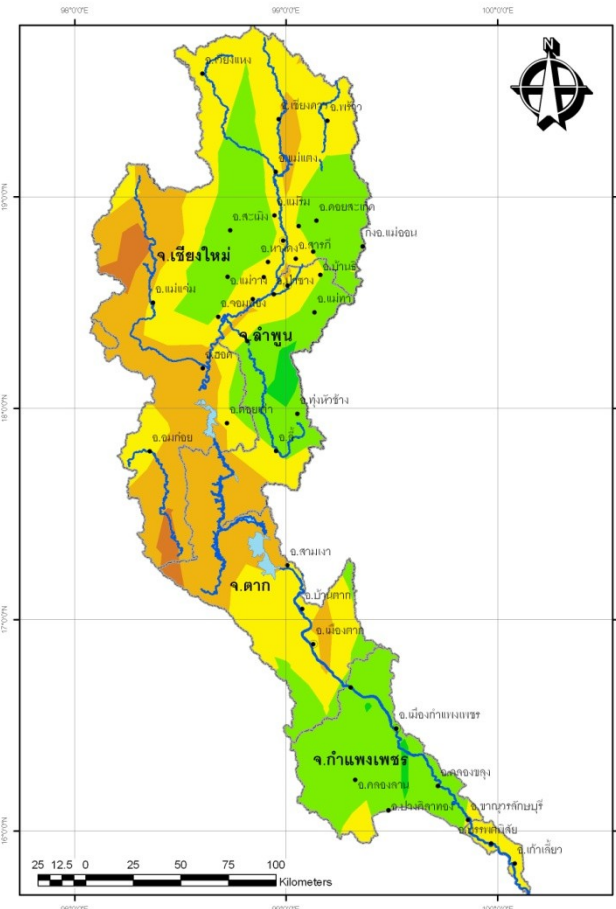
%Different Near Future and Present



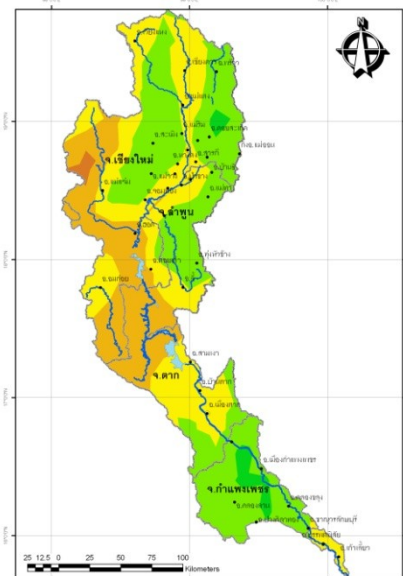
%Different Far Future and Present



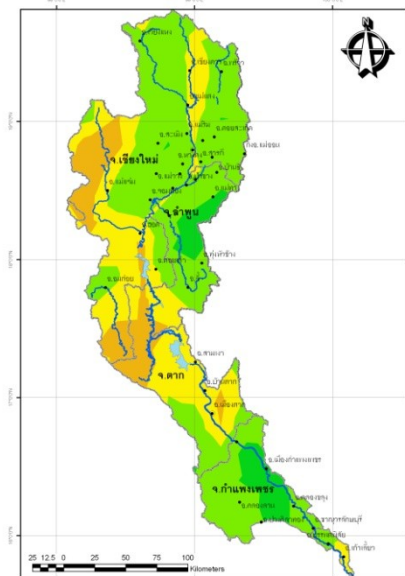
Maximum 5-days Rainfall



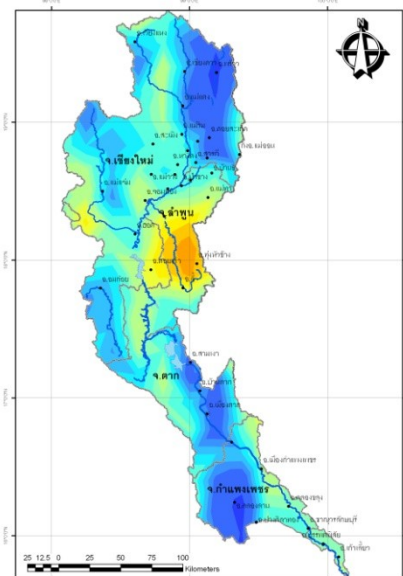
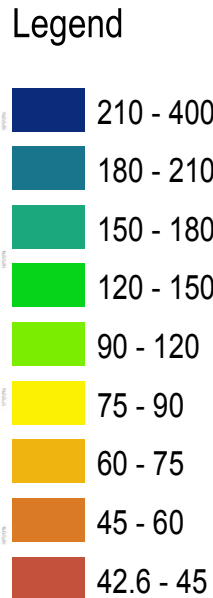
Present period
(1979-2003)



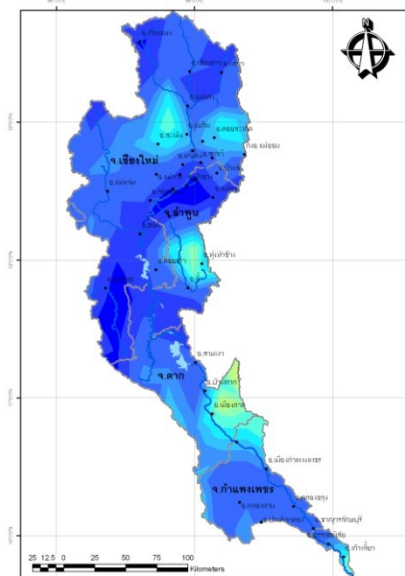
Near Future
(2015-2039)



Far Future
(2075-2099)



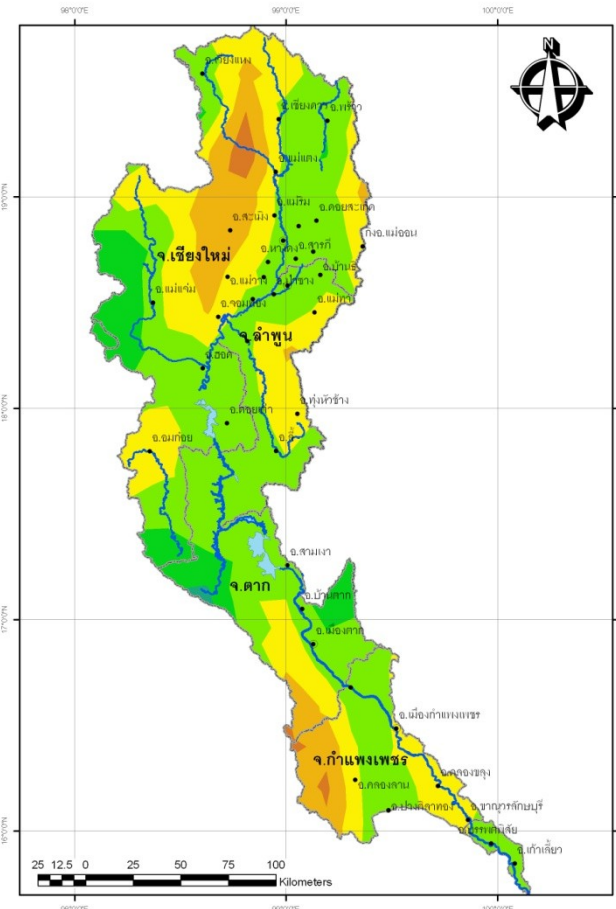
%Different Near Future and Present



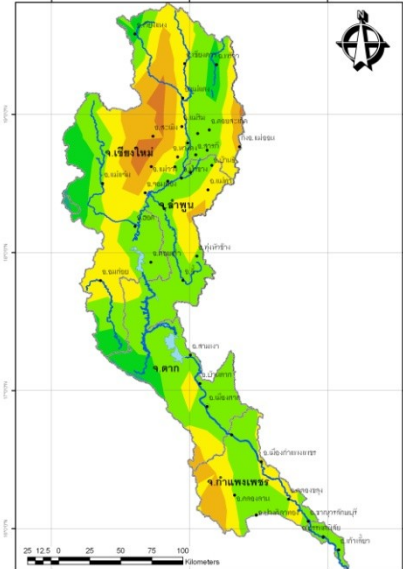
%Different Far Future and Present



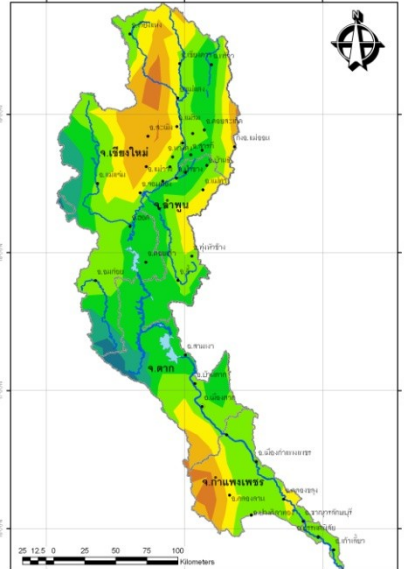
Consecutive Dry Days



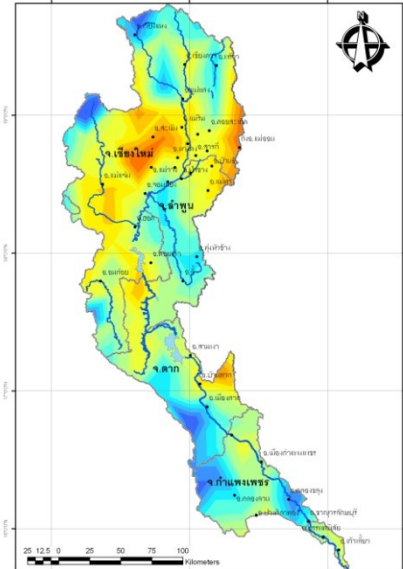
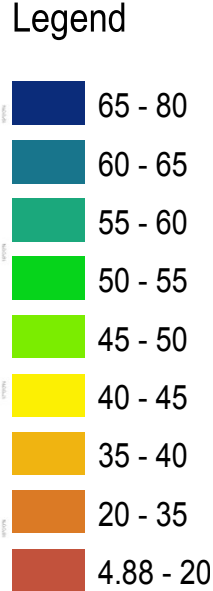
Present period
(1979-2003)



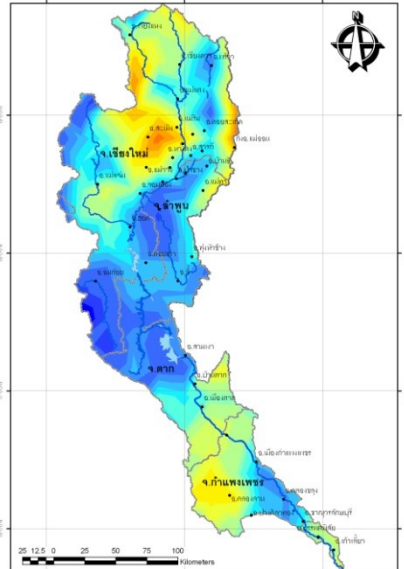
Near Future
(2015-2039)



Far Future
(2075-2099)



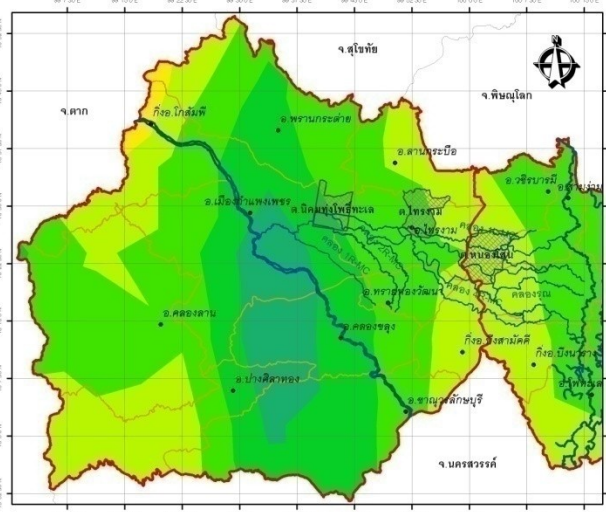
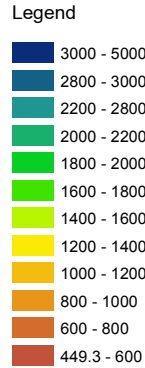
%Different Near Future and Present



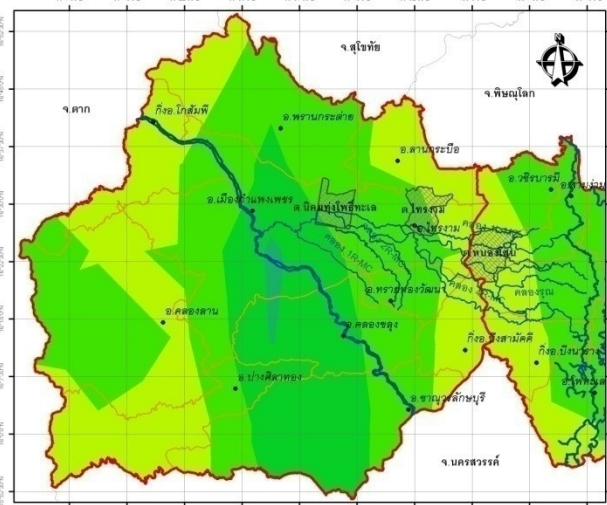
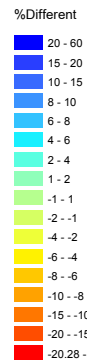
%Different Far Future and Present



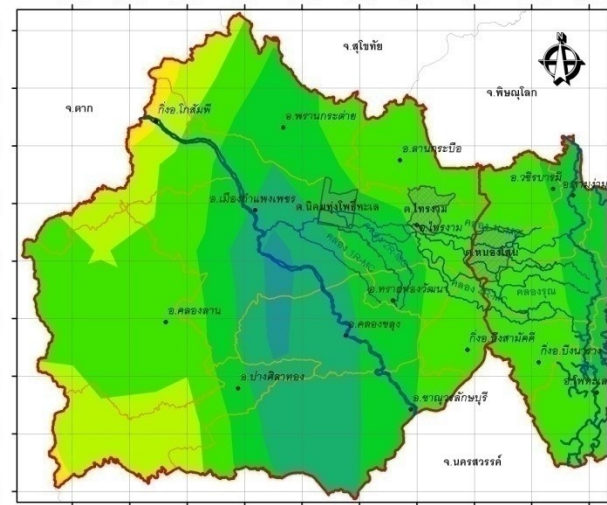
Average Annual Rainfall in Kamphangphet Province



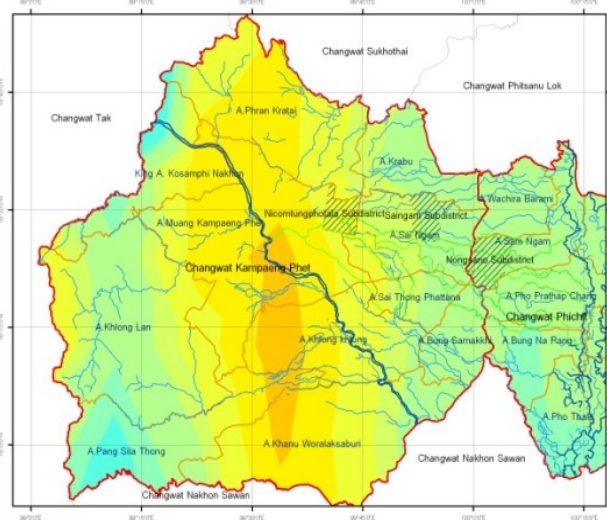
Present period
(1979 -2006)



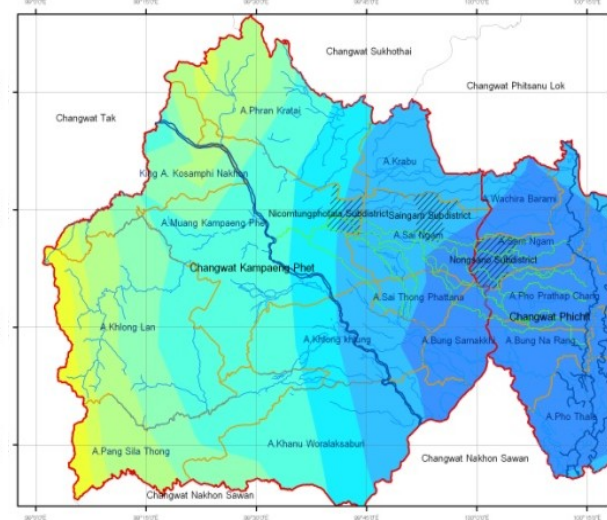
Near Future
(2015-2039)



Far Future
(2075-2099)

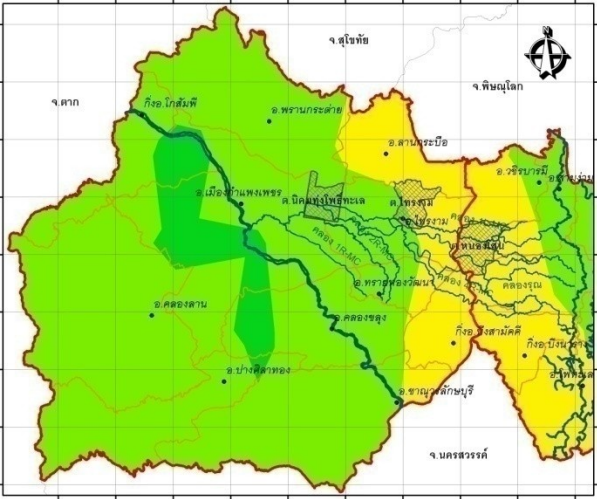
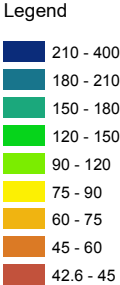


%Different Near Future
and Present

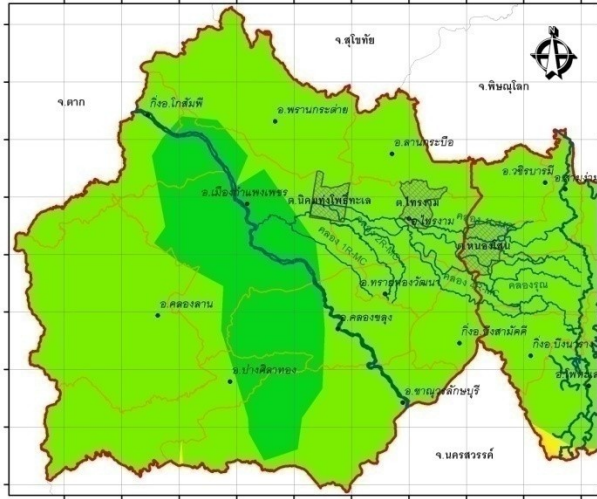


%Different Far Future
and Present

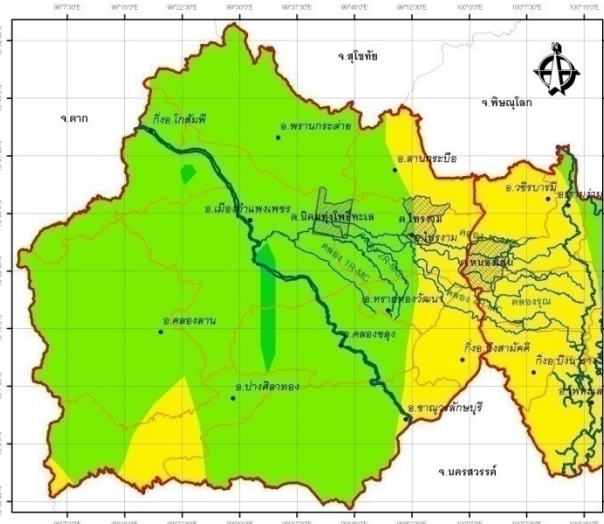
Maximum 5-days Rainfall



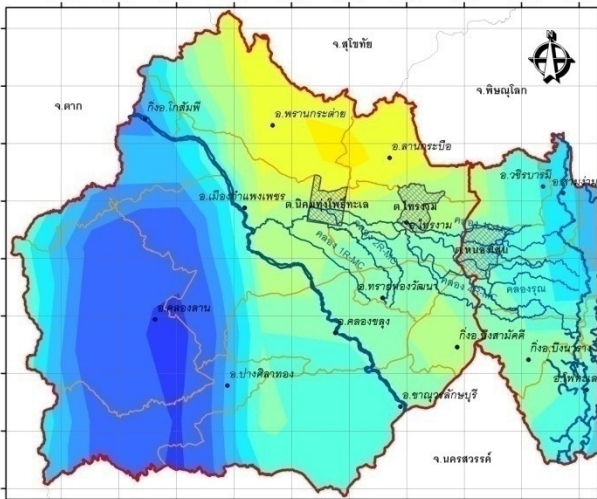
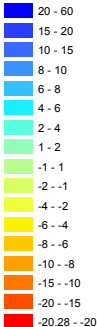
Near Future
(2015-2039)



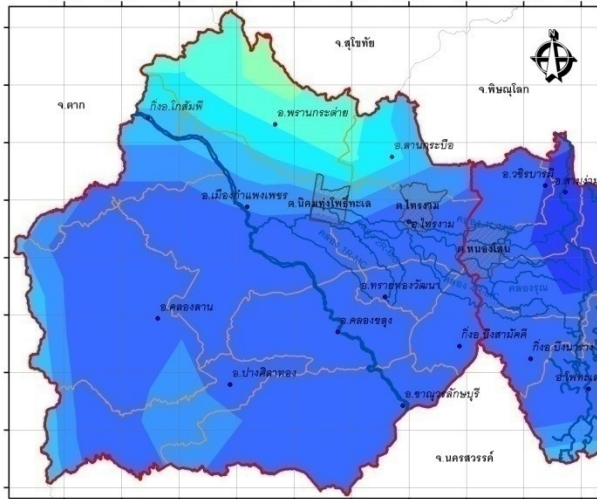
Far Future
(2075-2099)



Present period
(1979 -2003)

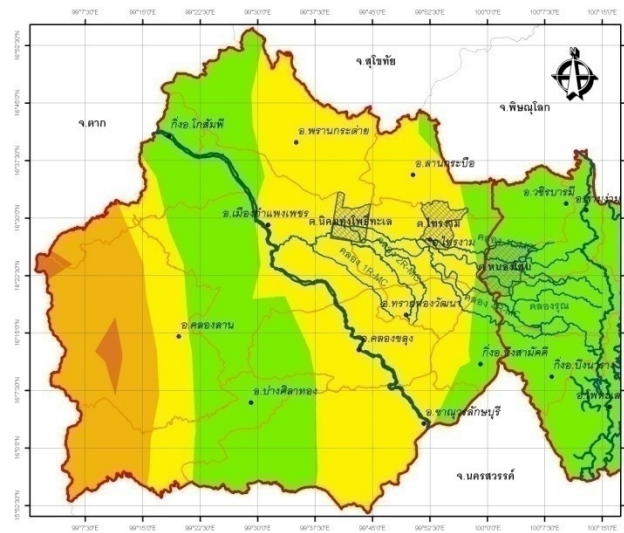


%Difference Near Future
and Present

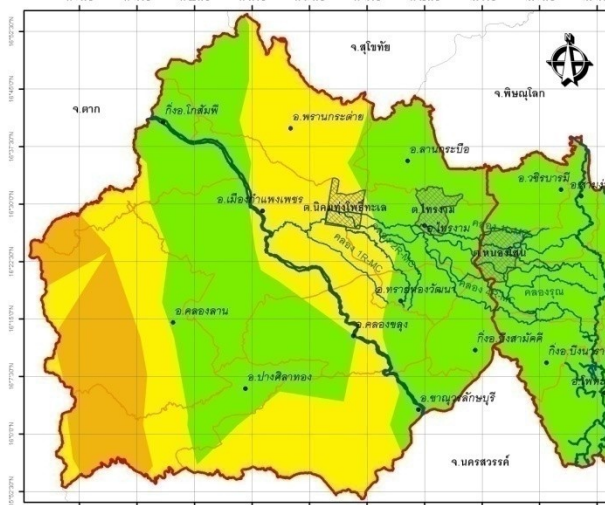


%Difference Far Future
and Present

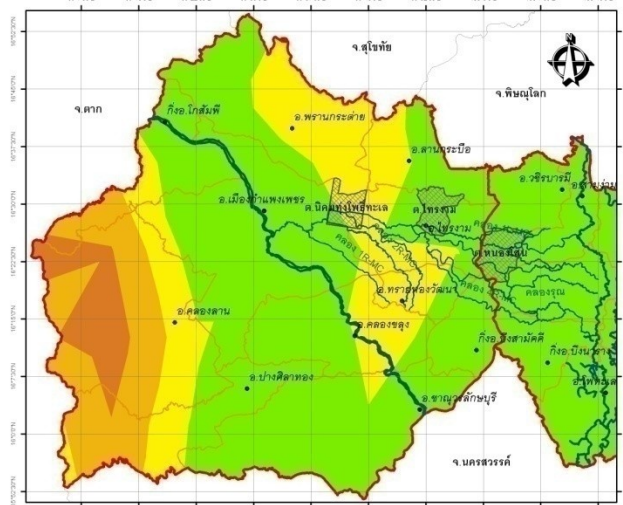
Consecutive Dry-days in Kamphangphet Province



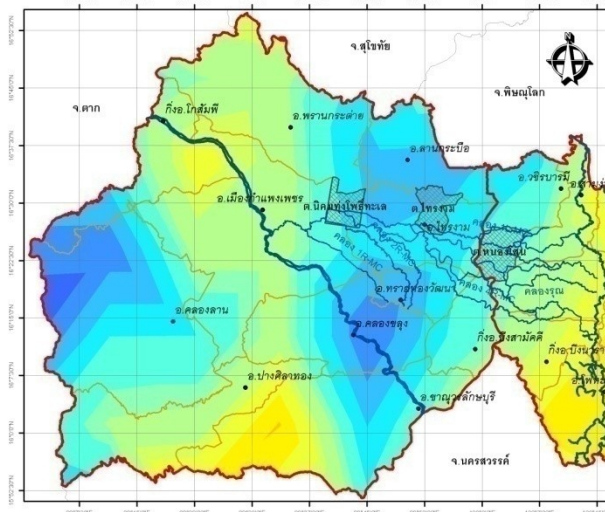
Present period
(1979 -2003)



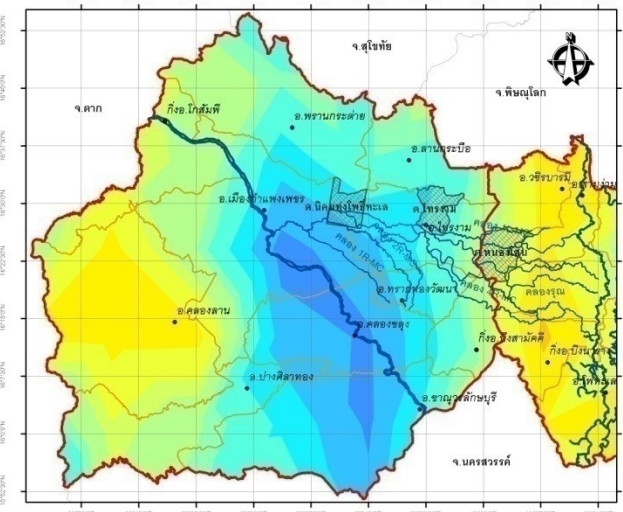
Near Future
(2015-2039)



Far Future
(2075-2099)



**%Different Near Future
and Present**



**%Different Far Future
and Present**

Conclusions: Changes from GCM

- In Near Future (N), the Upper Part of Ping Basin would face more droughts, but on the contrary in Far Future (F), it would face with increasing rainfalls more than the other parts i.e. more floods.
- In Near Future, the Upper Part of Nan Basin would face severe droughts more than the other parts.

Conclusions (con.)

- Rainfalls of N in May to November tend to decrease within range -0.29% to -20.77% especially November is less decreasing rain. Furthermore, rainfalls in December to April tend to increase within 15.49% to 75.01% especially January is the most increasing month.
- Rainfalls of F in every months tend to increase 0.32% to 98.95% . Especially January is the most increasing of N. However, the rainfall of May tend to decrease 5.95% .

Part 3: Interview Data Analysis

Interview Data Analysis

- To carry out field surveys/ questionnaires
- To compile information on location of irrigation/ water distribution infrastructures and groundwater wells
- To prepare irrigation field maps



[illegible]

Zone No. 1

Zone No. 2

Zone No. 3

Results from field survey on opinions on climate change, water management (problems, correction/adaptation measures on drought/flood situations), and recommendations on official/local government's assistances, from 153 sets of questionnaire responded by farmers, RID zonemen and irrigation project officers.

Types of queries		Goal number of queries (set)	number of queries (set)
Farmers	Zone No. 1 Nikom Village Office, Maung District, Phittsanulok Province	50	52
	Zone No. 2 Sai Ngam Village, Sai Ngam District, Phittsanulok Province	30	35
	Zone No. 3 Nong Sanon Village, Sam Ngam District, Phichit Province	50	49
	Total	130	136
Zonemen		6	6
RID		10	11
Total		146	153



Briefing, distributing
questionnaires and compilation
of responses from Area
Zonemen

At RID Wang Bua, O&M Project
Office, November 23, 2010





Briefing, distributing
questionnaires & compilation of
responses from RID Officers,
at RID Regional 4 Office,
December 19, 2010.



Field surveying and compilation of data on agriculture, irrigation practices and infrastructures, and location groundwater wells



Pictures of weir, canal, lateral and pump

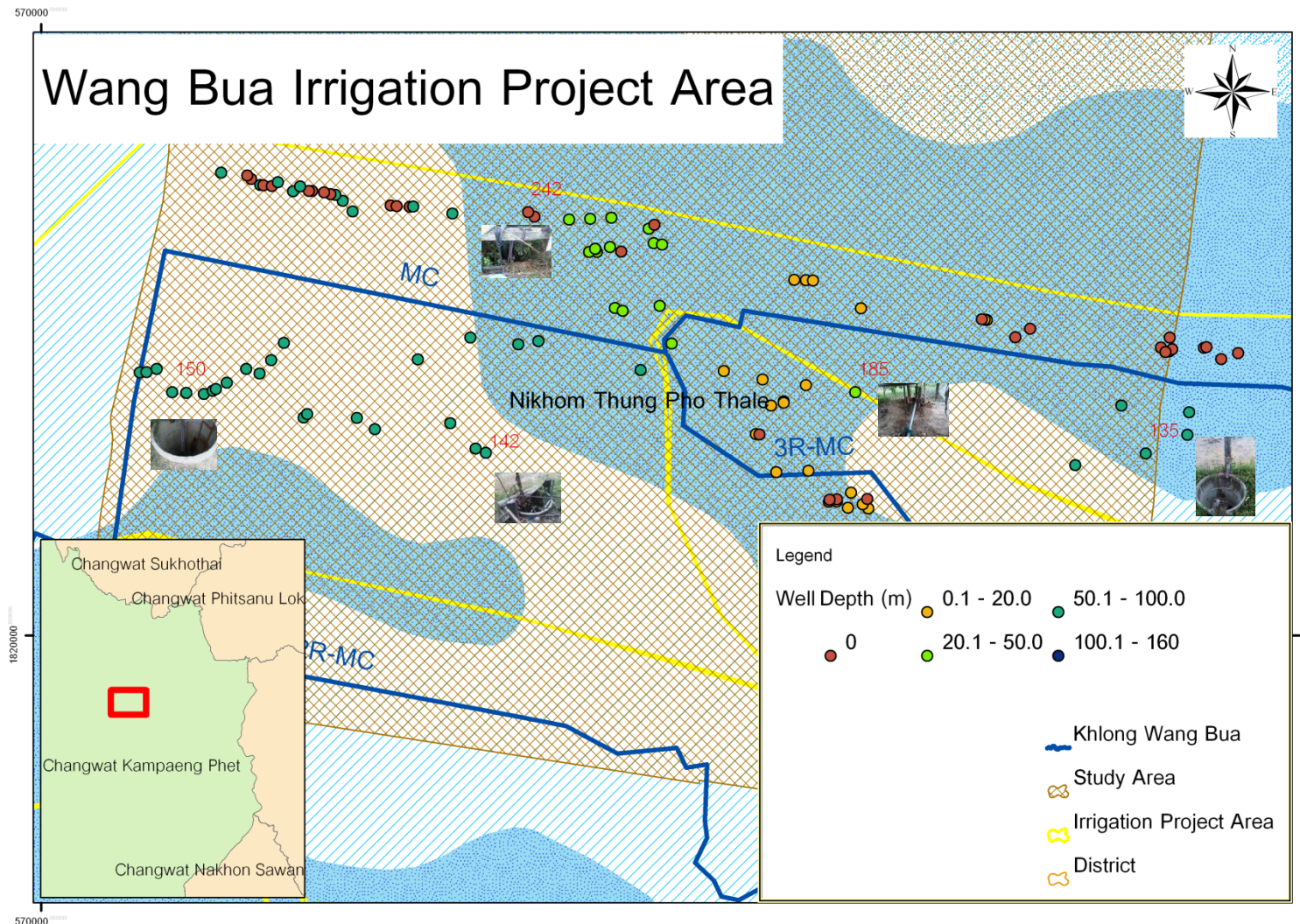


Surveying/Positioning of Groundwater Wells within Irrigation Areas



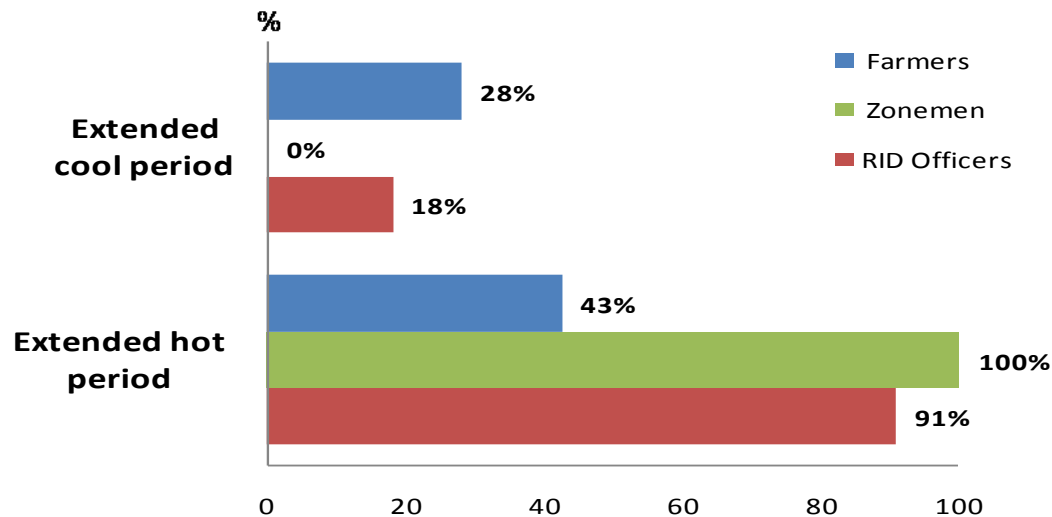
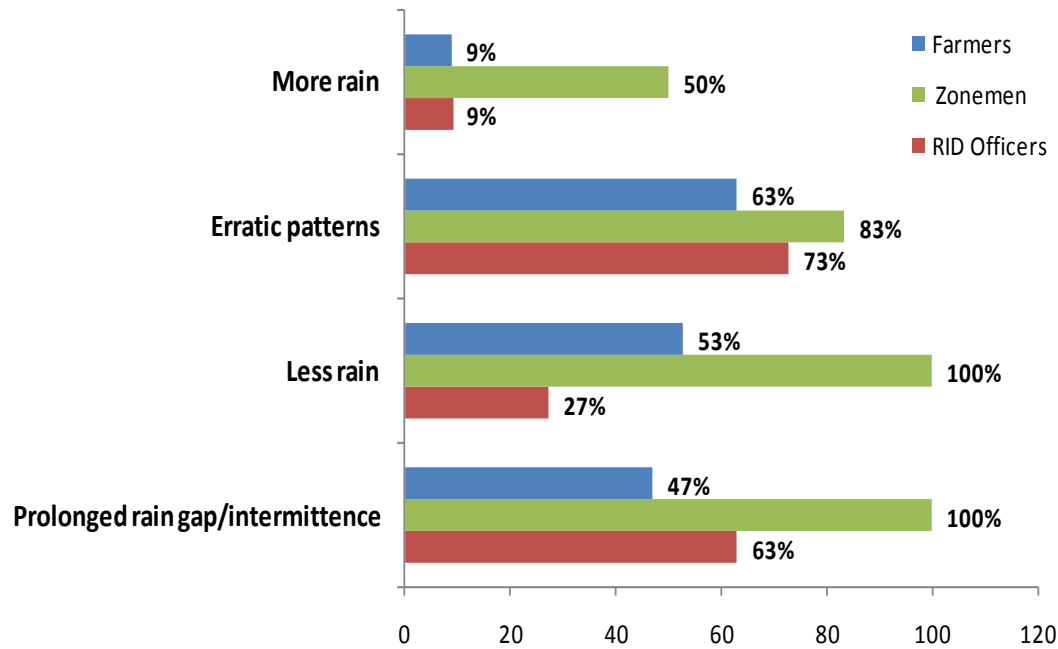
Zone No. 1

Wang Bua Irrigation Project Area



NO.	NAME	MOO	TUMBON	AMPHERE	PROVINCE	AREA	SIZE	DEPTH	PUMP	PUMP/HOUR	USE	UNUSE	UTM E	UTM N	DEPTH (M)
135	นางสาวบุญ เพชรรัตน์	3	นิคมทุ่งโพธิ์ทะเล	เมือง	กำแพงเพชร	16	3	18	11	42	✓		578594	1821416	72
142	นายจูน สุทธิรักษา	4	นิคมทุ่งโพธิ์ทะเล	เมือง	กำแพงเพชร	25	3	16		0	✓		573460	1821420	64
150	นายพิมพ์พา จันเจือ	4	นิคมทุ่งโพธิ์ทะเล	เมือง	กำแพงเพชร	60	3	18	110	48	✓		571019	1821893	72
185	นายประพนธ์ สามารถ	9	นิคมทุ่งโพธิ์ทะเล	เมือง	กำแพงเพชร	26	3	8	110	400	✓		576334	1821893	32
242	นายประดิษฐ์ คำคลอง	15	นิคมทุ่งโพธิ์ทะเล	เมือง	กำแพงเพชร	23	3	0		0	✓		573789	1823296	0

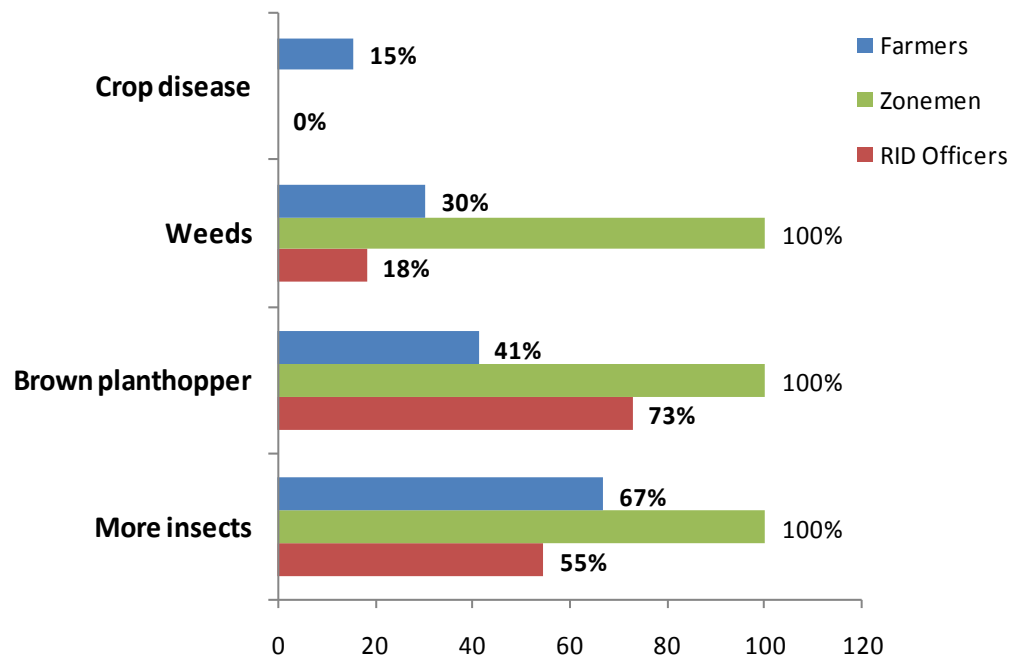
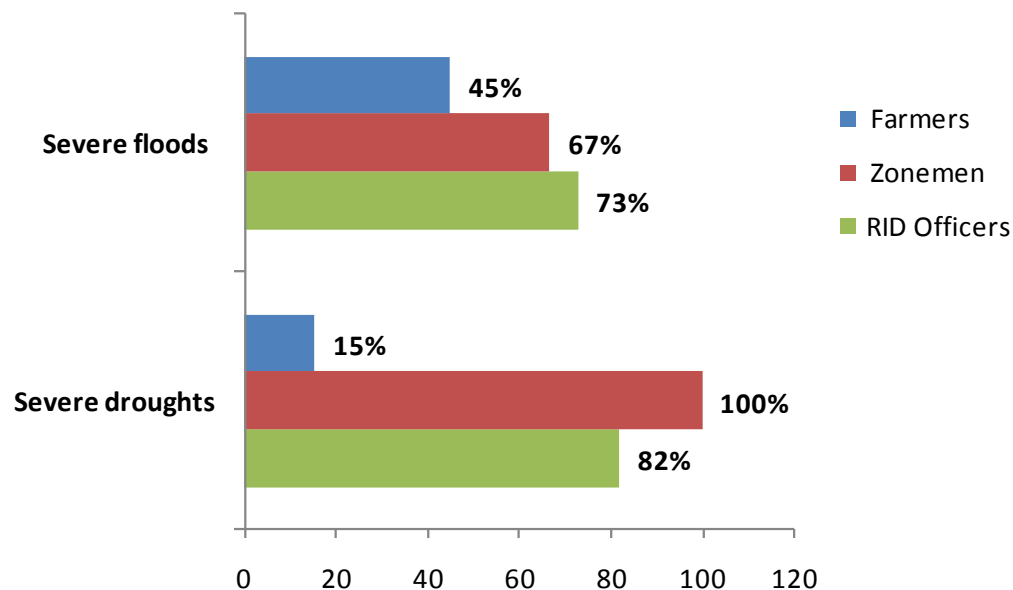
Attitude toward Climate Change (for the past 10 years, 1999-2009)



% of expressed opinion

In the planting area that you are in charge, at present, is there any change in climatic conditions from the past?

- Rainfall amount
- Climatic conditions



% of expressed opinion

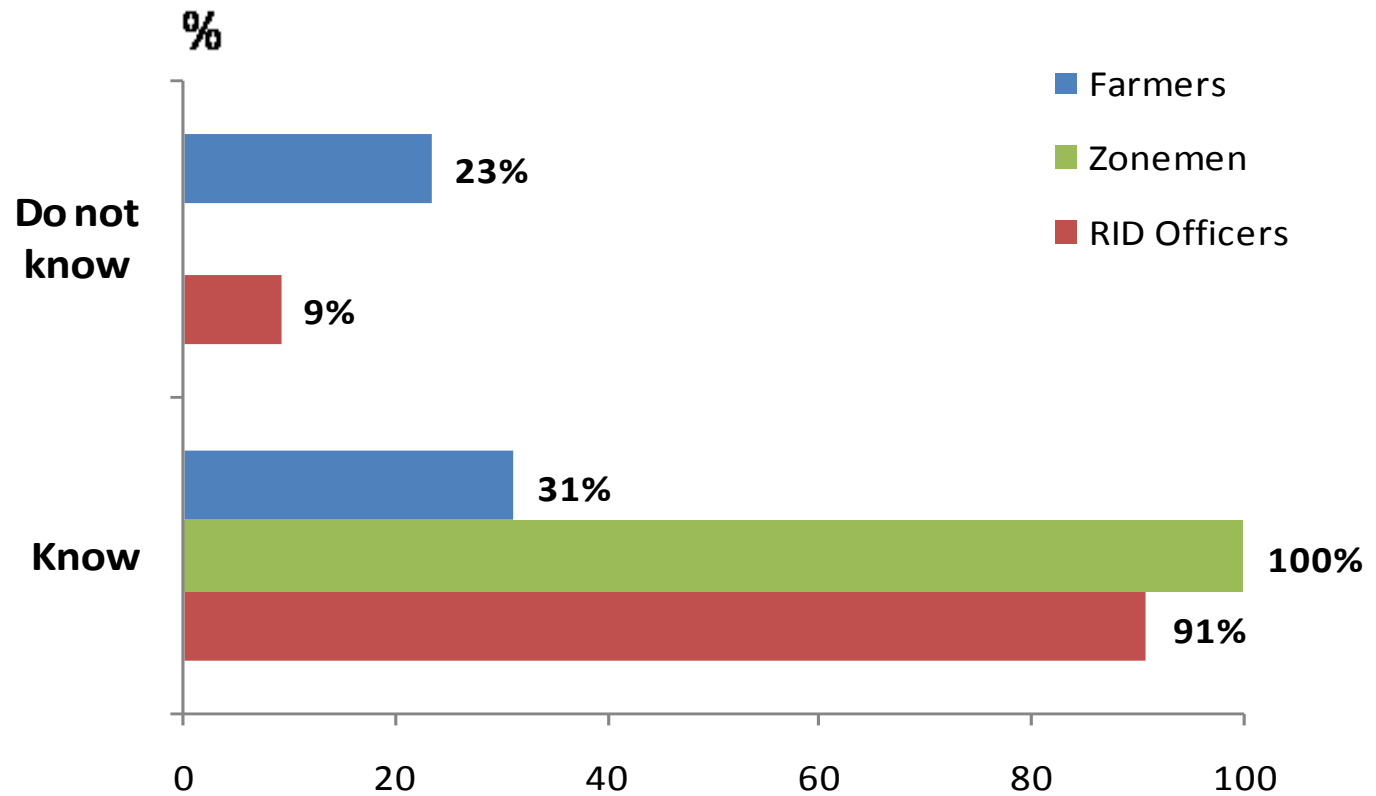
In the planting area that you are in charge, at present, is there any change in climatic conditions from the past?

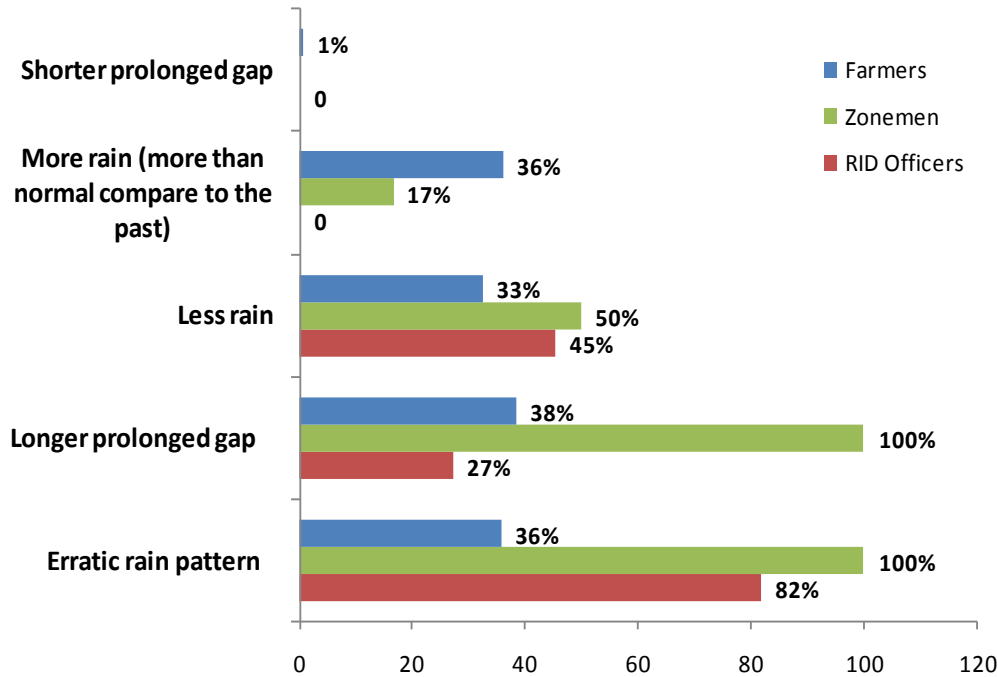
■ Natural disaster

■ Plant diseases

% of expressed opinion

Do you know the cause(s) of climate change?

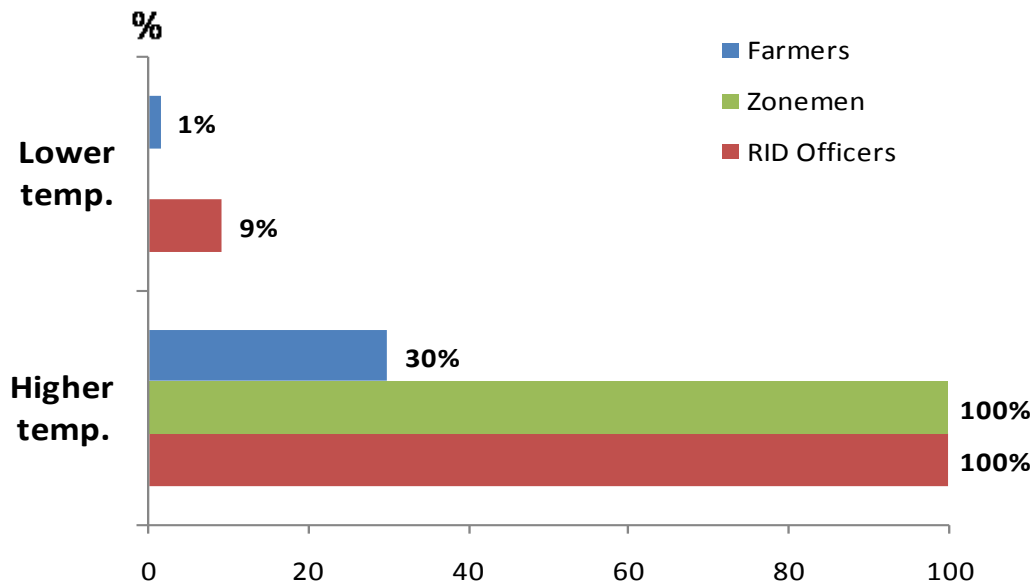




% of expressed opinion

What is the trend in future climatic conditions?

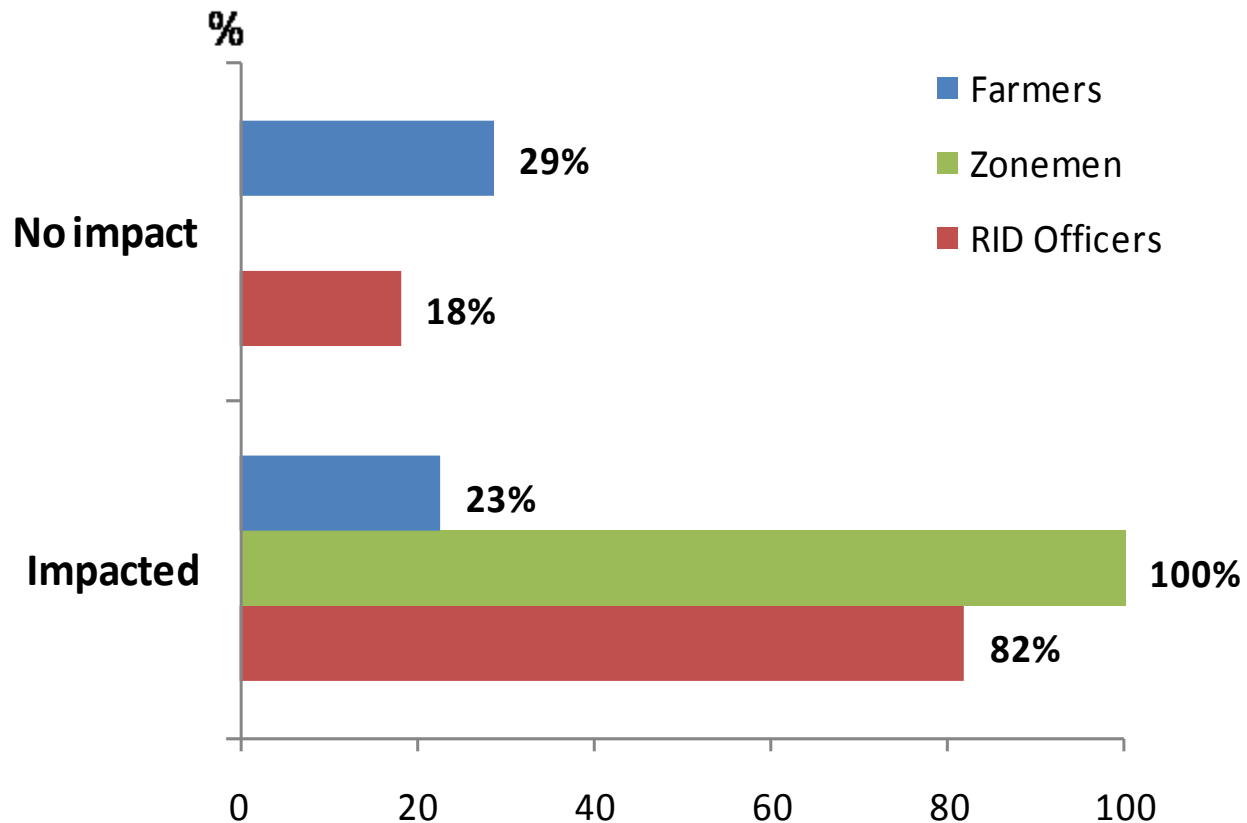
■ Rainfall amount



■ Weather

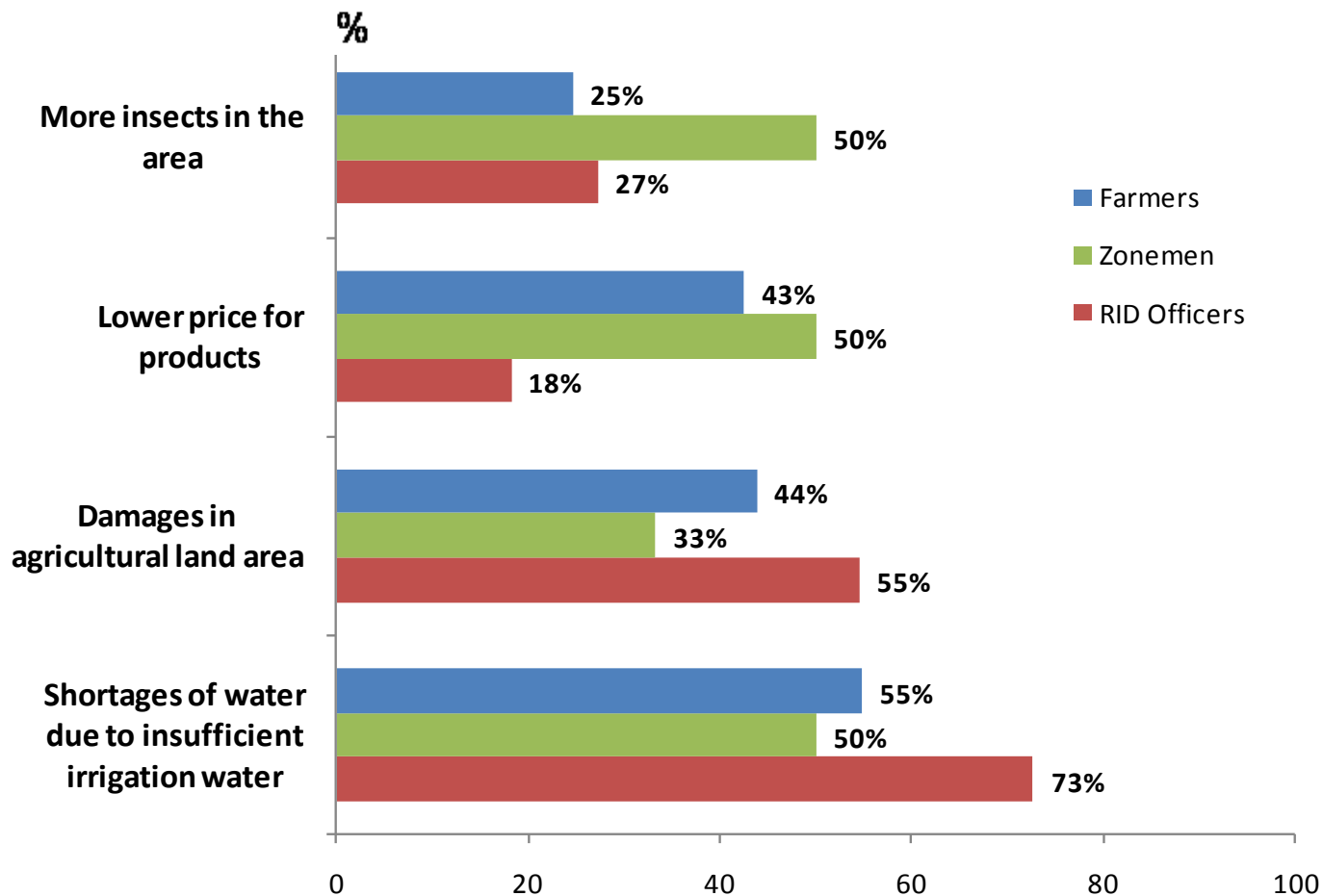
Problems/Corrective Measures/Adaptations with respect to droughts and floods

In areas under your responsibility is there any impact from natural disaster?



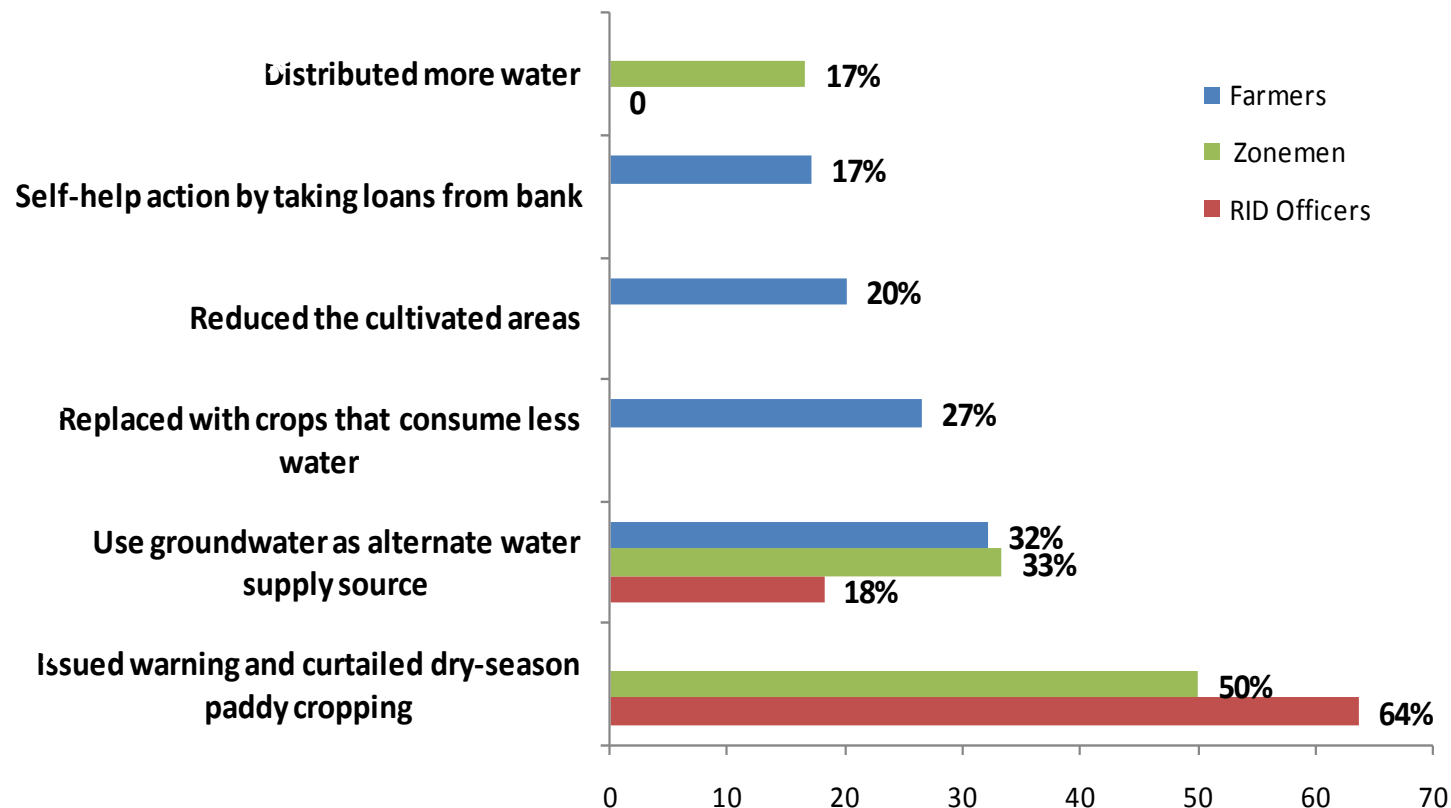
% of expressed opinion

Impacts from the past 2009 drought event



% of expressed opinion

During the 2009 drought event, how did you resolve the problem situations?

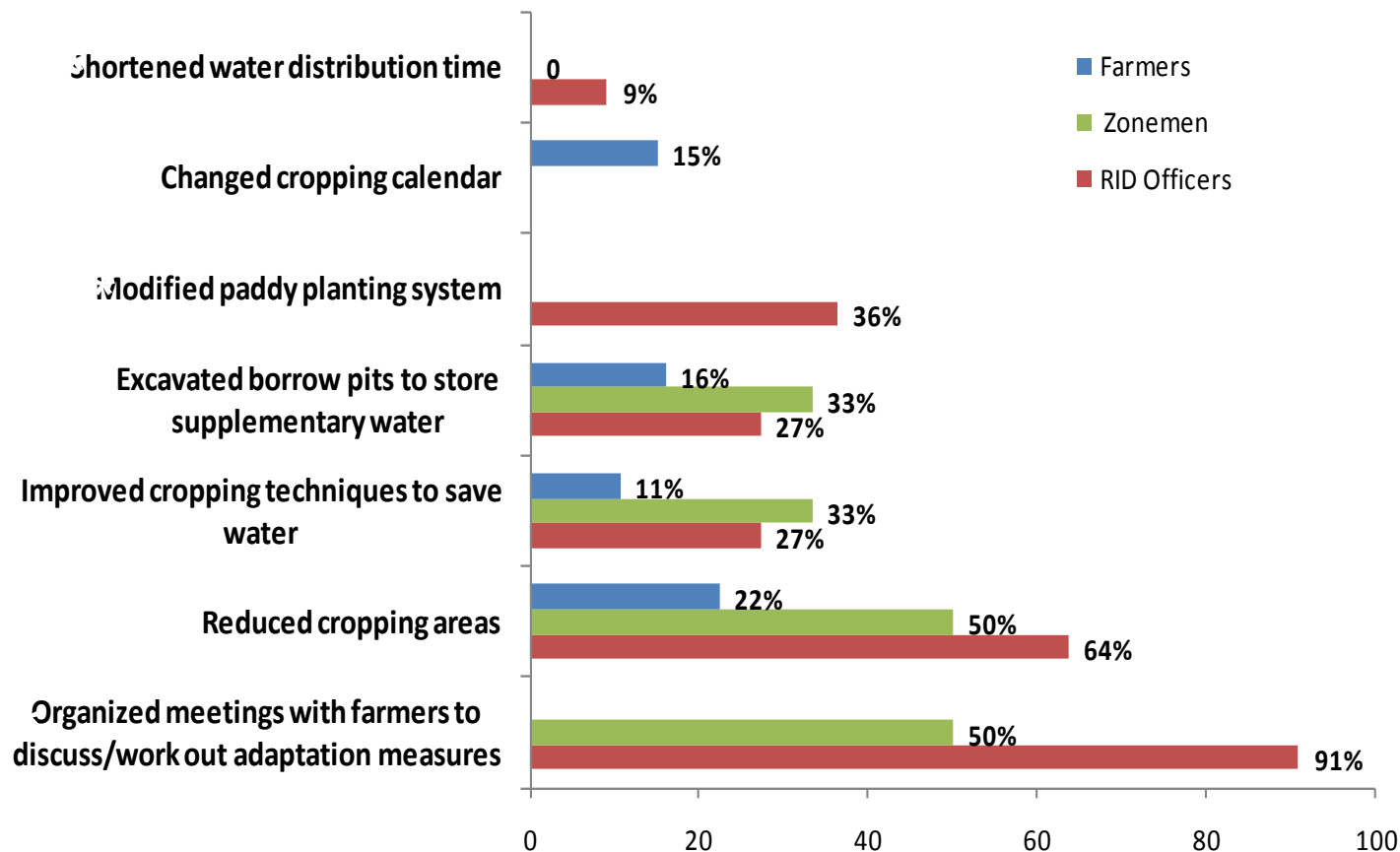


*Specific questions of the Farmers

**Specific questions of the Zoneman and RID officers

% of expressed opinion

Prior to the 2009 drought event, how did you prepare yourself before it happen?

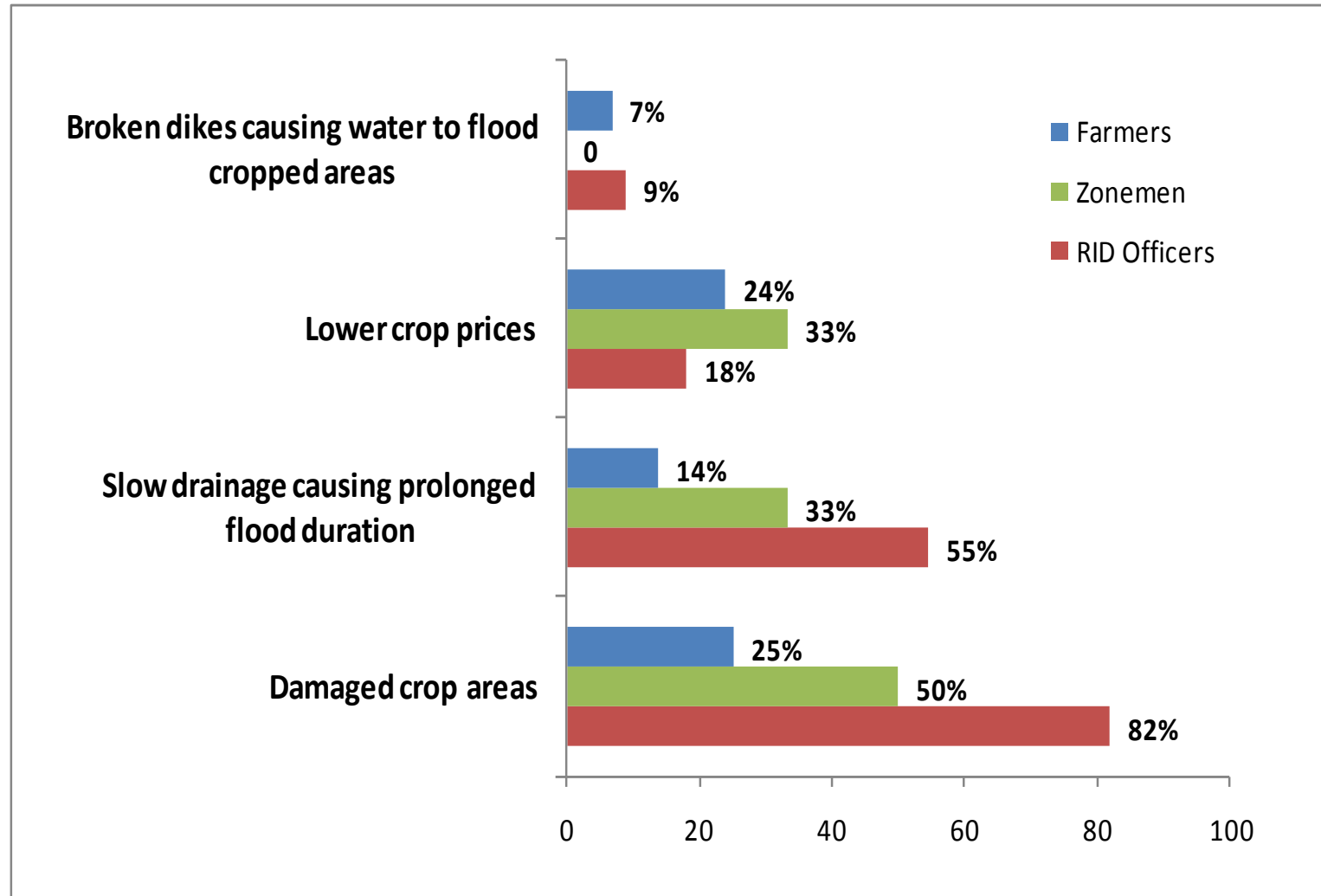


*Specific questions of the Farmers

**Specific questions of the Zoneman and RID officers

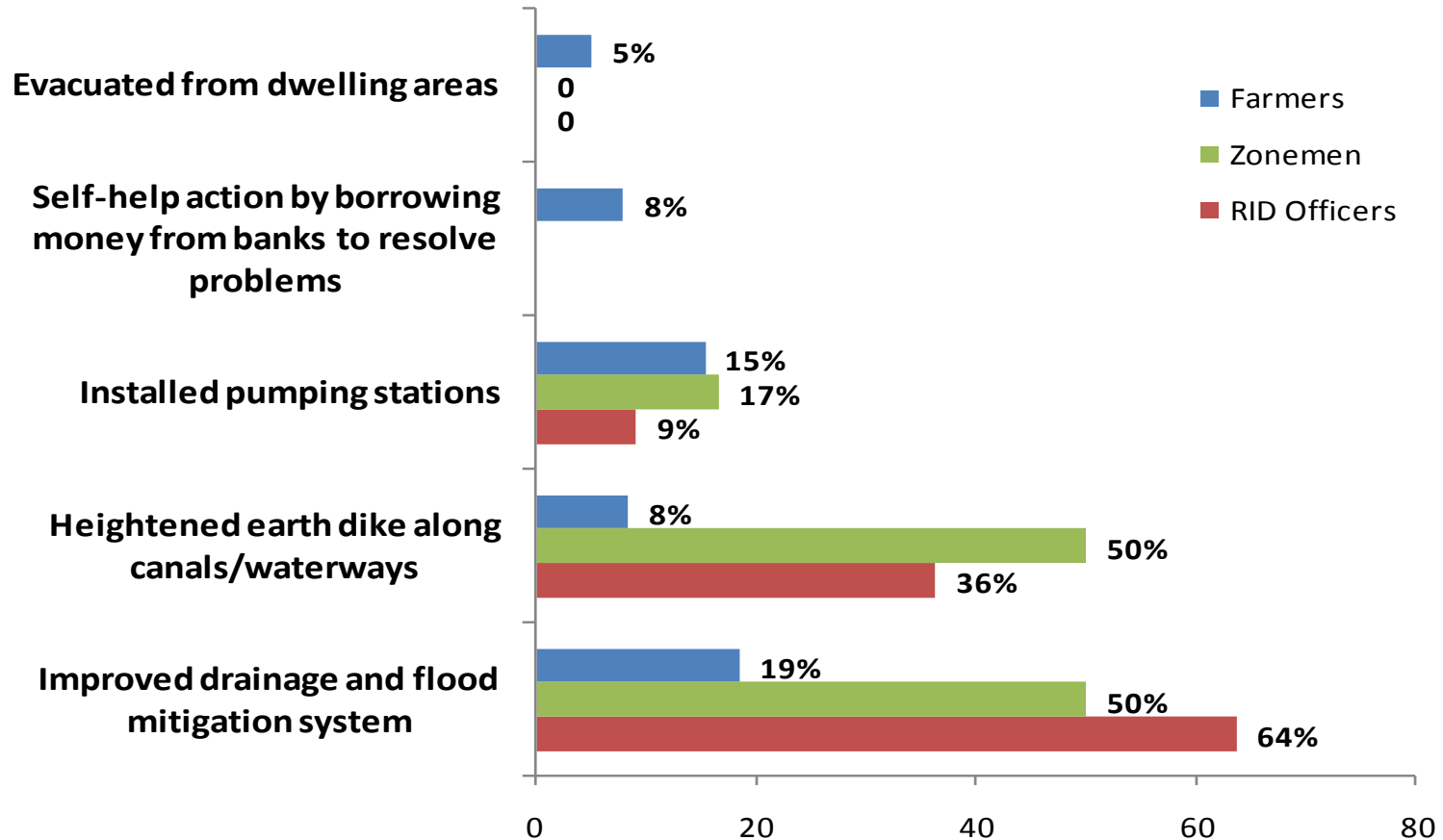
% of expressed opinion

Impacts from the 2010 flood event



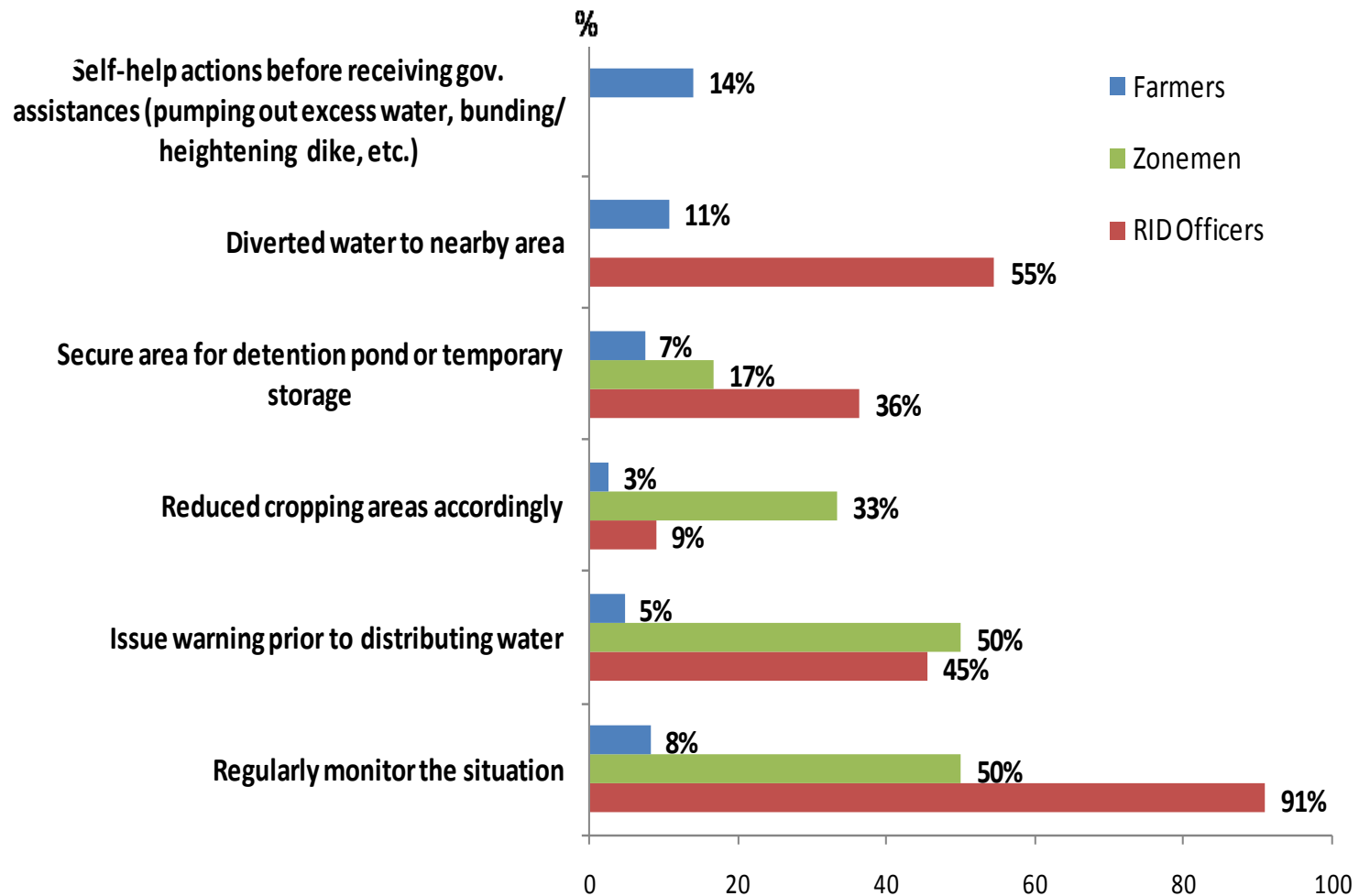
% of expressed opinion

During the 2010 flood event, how did you resolve the problems/situation?



% of expressed opinion

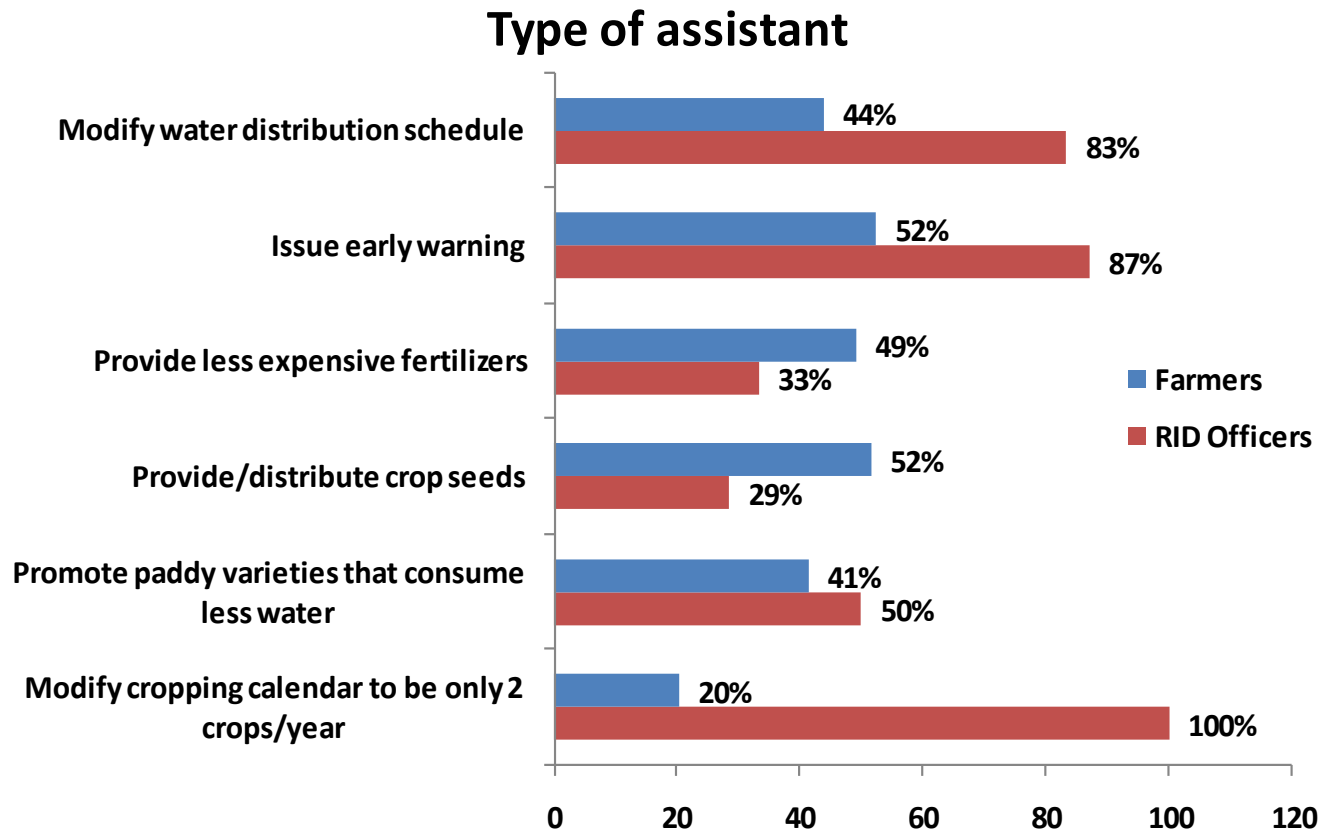
Prior to the 2010 flood event, how did you prepared yourself before it occur?



* Specific questions of the farmers

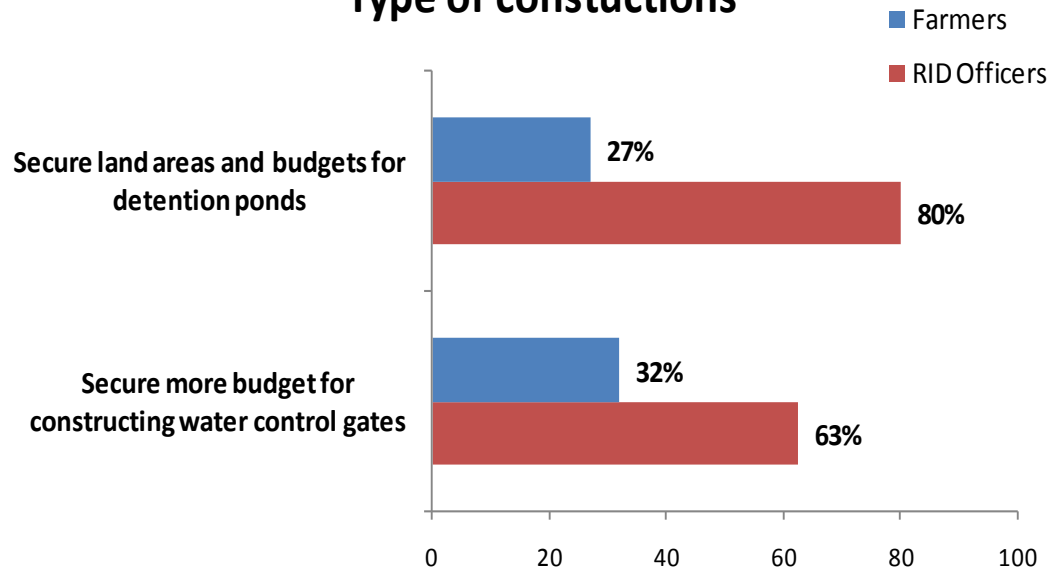
Recommendations to the government/responsible parties

From the natural disaster events and their impacts in the areas under your responsibility, **what should be the assistance from the Government ?**



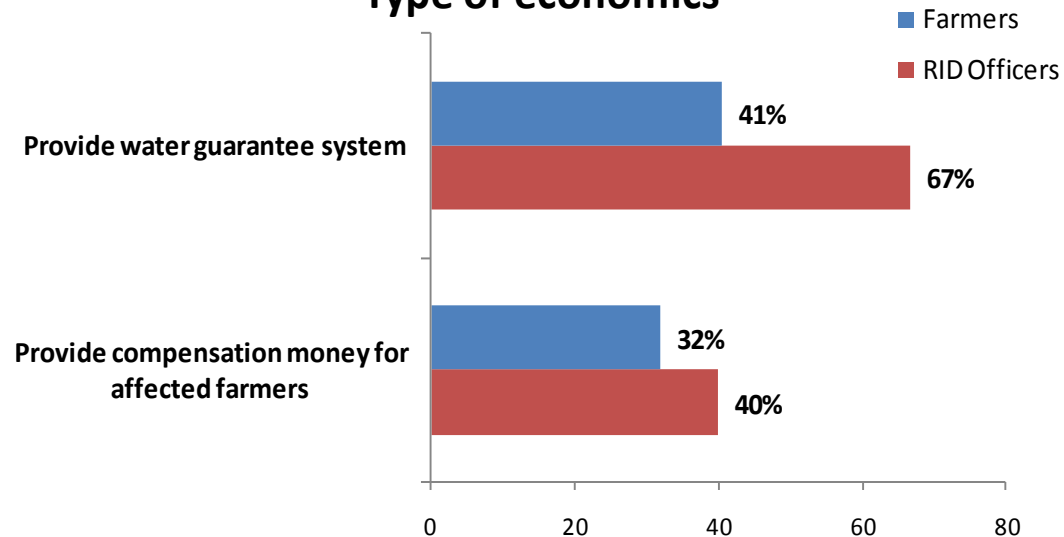
*** Specific questions of the farmers and RID officers

Type of constuctions

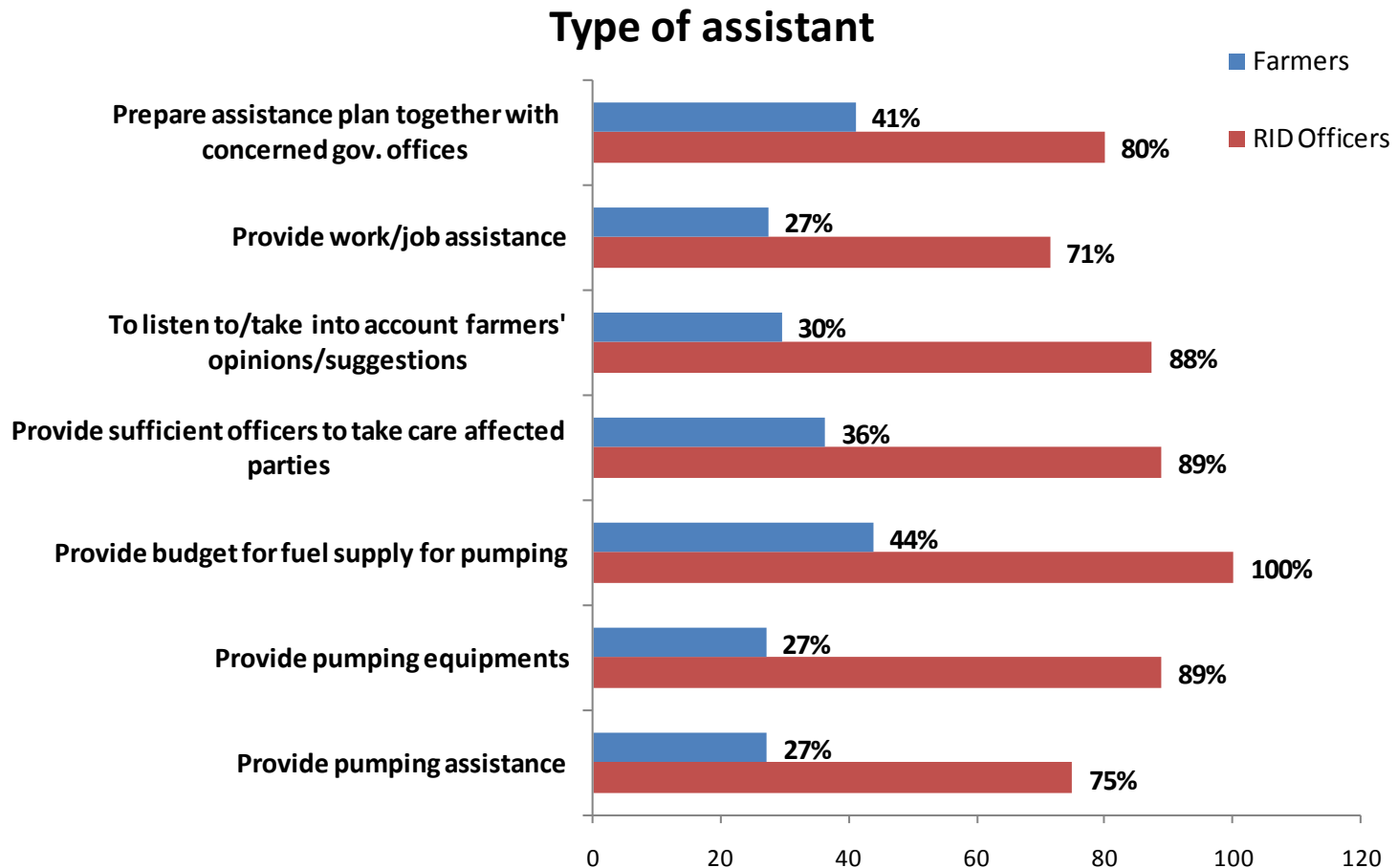


From the natural disaster events and theirs impacts in the areas under your responsibility, what should be the assistance from the Government ?

Type of economics

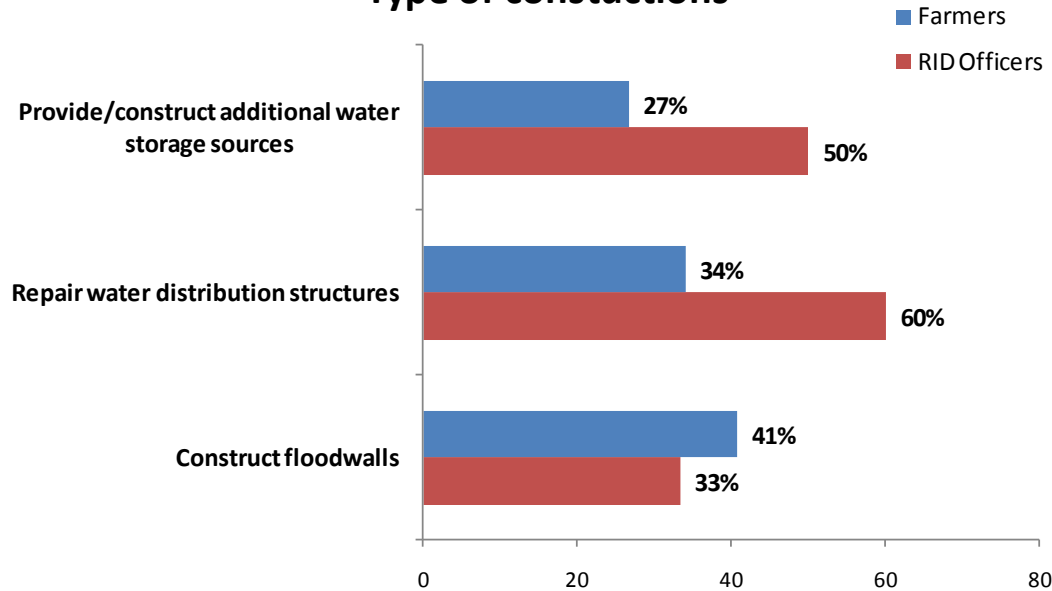


From the natural disaster events and their impacts in the areas under your responsibility, **what should be the roles of local administrative bodies?**

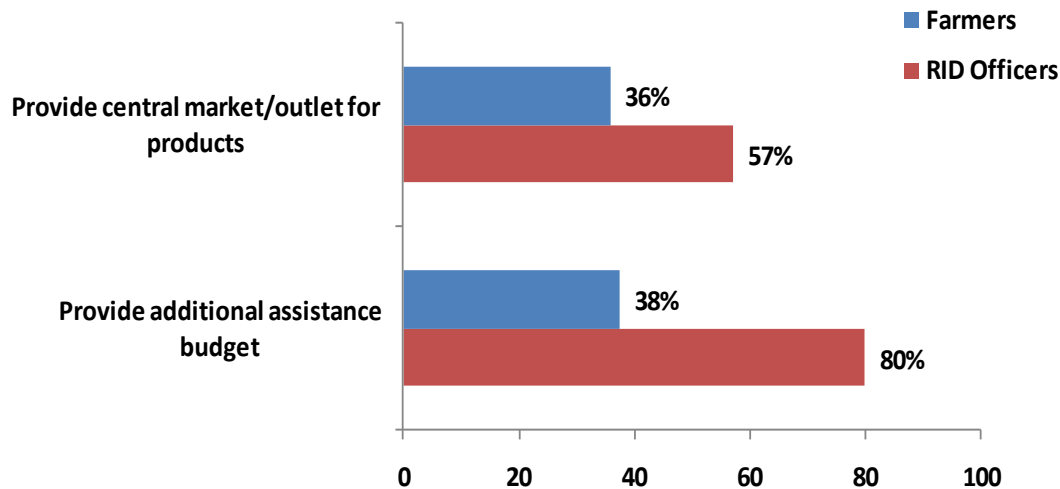


*** Specific questions of the farmers and RID officers

Type of constuctions



Type of economics



From the natural disaster events and theirs impacts in the areas under your responsibility, what should be the roles of local administrative bodies?

Recommendations to reduce impacts from natural disasters (floods, droughts, increase temperature etc.)

Issue	Farmers	Zonemen	RID Officers
Environment/Nature	• stop deforestation • increase reforestation • rehabilitate upper watershed areas • increase rubber plantation • planting trees on field dike • stop rice stubs burning practice • control chemical substance usage	-	• reforestation/ reduce deforestation • reforestation with high economic values trees

Recommendations to reduce impacts from natural disasters (floods, droughts, increase temperature etc.)

Issue	Farmers	Zonemen	RID Officers
Management	-	• encourage farmers to observe an agreed /planned cropping calendar • carry out regularly field survey and monitoring activities • replace cross drainage culvert in the secondary canal with gate structure • heighten canal bank and regularly dredge distribution canals	-
Public relation		• promote environmental conservation consciousness in younger generation • promote/encourage farmers to use organic substances instead of chemical ones • provide public information at the junction within the zone under responsibility • improve cross drainage structures in all main canals	• promote awareness among all concerned parties • provide local community with knowledge on natural disasters (their causes and impacts) • promote less resources uses/consumption in urban area/ population control

Additional recommendations to resolve or adapt to natural disasters such as droughts, floods, higher temperature etc.

Issue	Farmers	Zonemen	RID Officers
Environment/Nature	• reduce paddy crop/ replace paddy with corn • rotate crops • cut down deforestation • plant paddy variety that resist insects (jumping fleas) • plant shorter-period paddy variety		• plant crops that consume less water during dry-season • plant paddy variety that use less water and resist insects

Issue	Farmers	Zonemen	RID Officers
Management	• use electrical pumps instead of gasoline ones • conserve water uses	• monitor water situation regularly • maintain irrigation infrastructures and canals to be in useable condition • quickly and timely adapt to the real situation since at present majority of works are urgent	• plant crops that use less water • conserve water, organized meeting to discuss/ define alternatives with participation of users • use water efficiently or even consider reuse/ recycle options
Public relation		• prepare public relation plan on water, land and weather/ climate change	

Part 4: Impact towards Irrigation System

Objectives

- To study the impacts of climate change on irrigation system in Wang Bua Irrigation Project
- To study on approaches on the climate change adaptation

Project Framework

- Collected & studied meteo-hydrological & water management in Ping River basin & Wang Bua Project from TMD & RID gage stations
- Analyzed inflows into Bhumibol Dam from downscaling rainfalls from MRI GCMs (Japan) by HEC-HMS (SCS Method)
- Analyzed water management conditions of Bhumibol Dam & Wang Bua Project in “Present” & “Future Condition”
- Analyzed the impacts on water management in Wang Bua Project
- Test the appropriated adaptation approach for Wang Bua Project
- Summary & recommendations for water management

Simulation Conditions

Period

P - Present	2006-2010
N - Near Future	2015-2039
F - Far Future	2075-2099

Season

Rainy (June – October) / Dry (November – April)

Water year

Wet, Normal, Dry, Serious Dry

(based on Bhumibol capacity : from present data)
(considered only from agriculture water demand)

Simulation conditions (con.)

Adaptation Scheme

- Water rotation

 - U: unregulated

 - R: regulated

 - (all time for MC and 1L-MC and

 - every 7 days for 1R-MC and 2R-MC, 3R-MC)

- Cropping

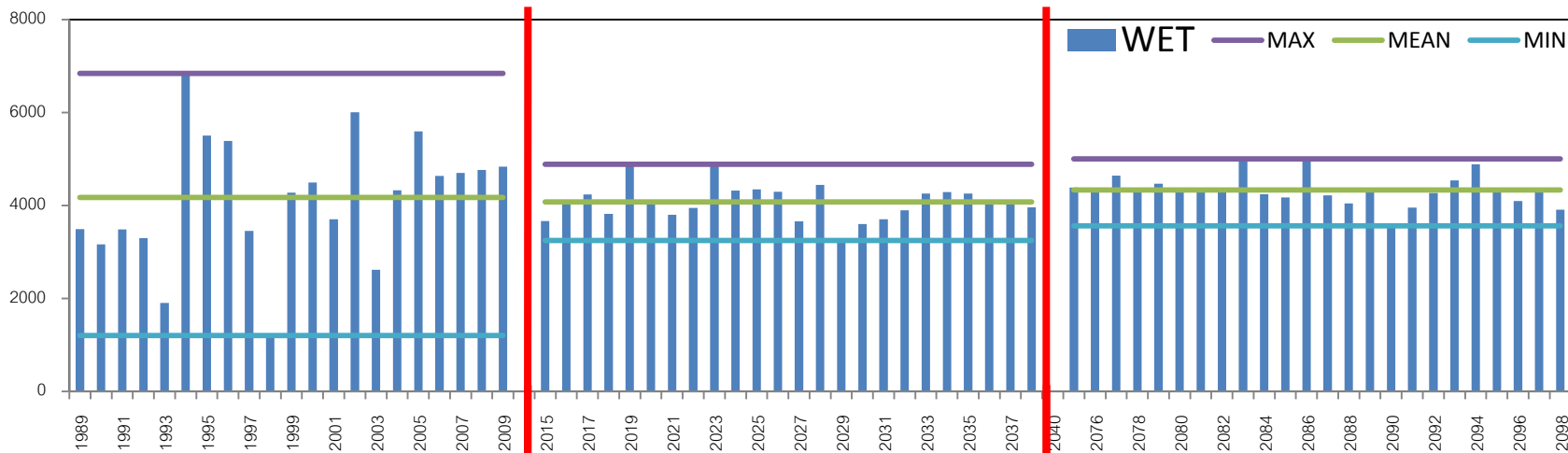
 - 2 times/year

- Cultivated Area

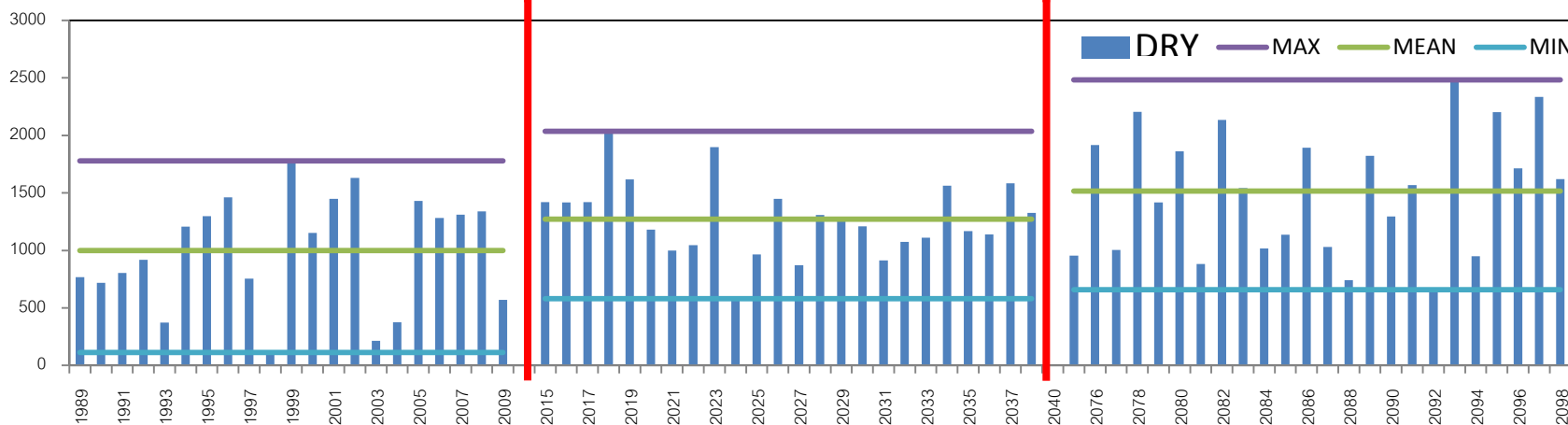
 - varied on water supply to the Project at each canal

Bhumibol Dam Inflow

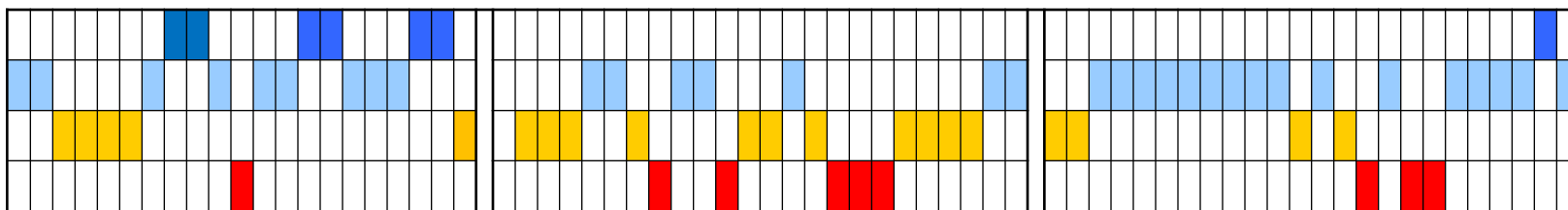
Bhumipol Inflow,MCM



Bhumipol Inflow,MCM

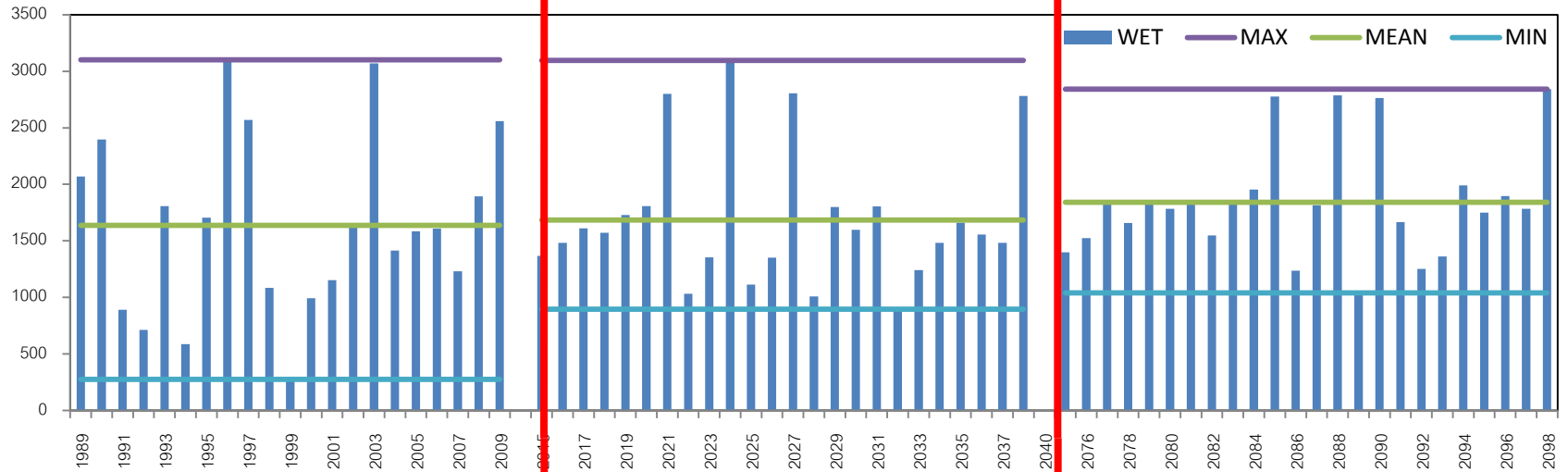


wet
normal
dry
ser dry

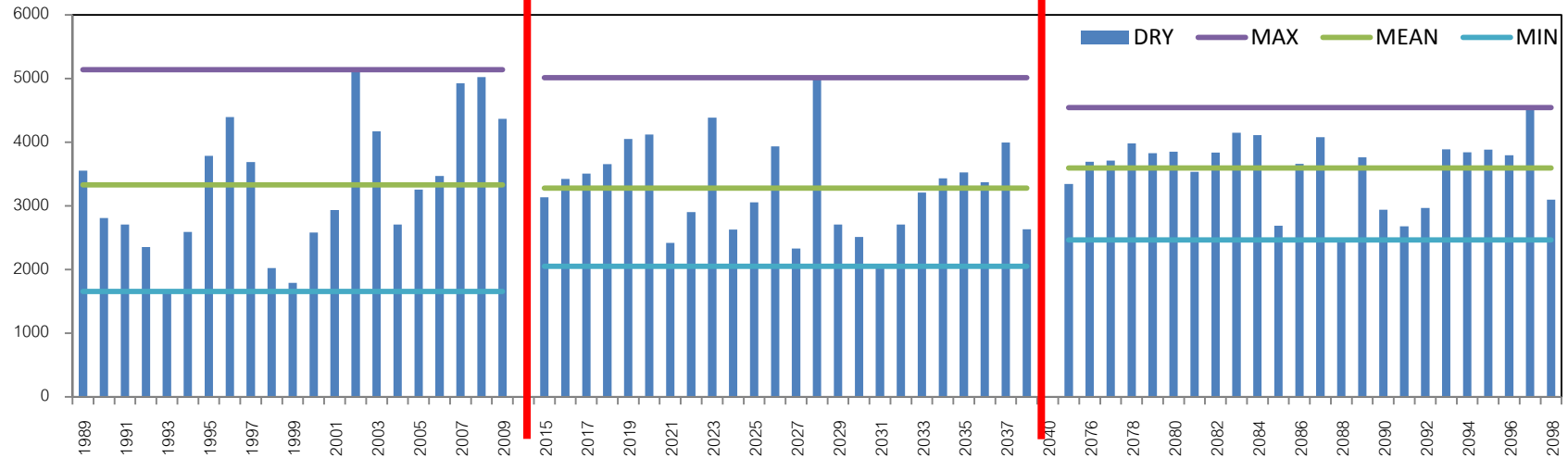


Bhumibol Dam Releases

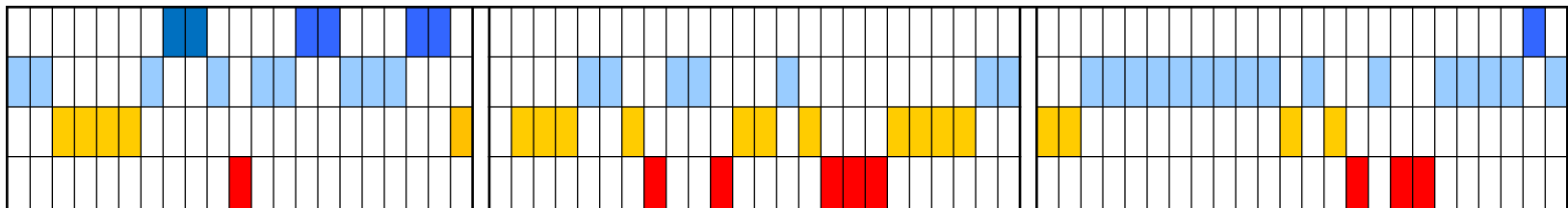
Bhumipol Release,MCM



Bhumipol Release,MCM

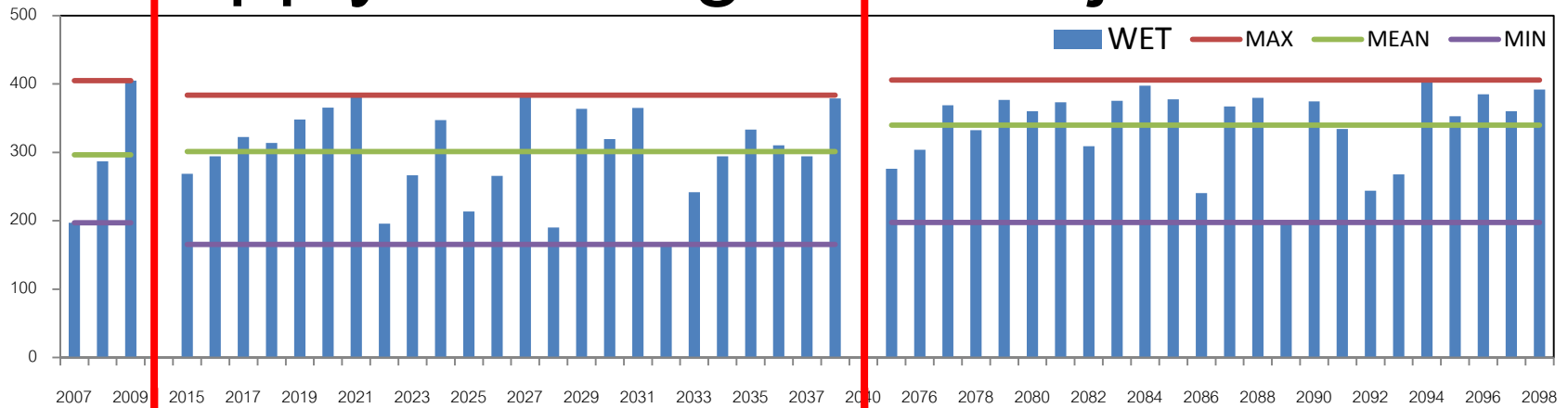


wet
normal
dry
Ser dry

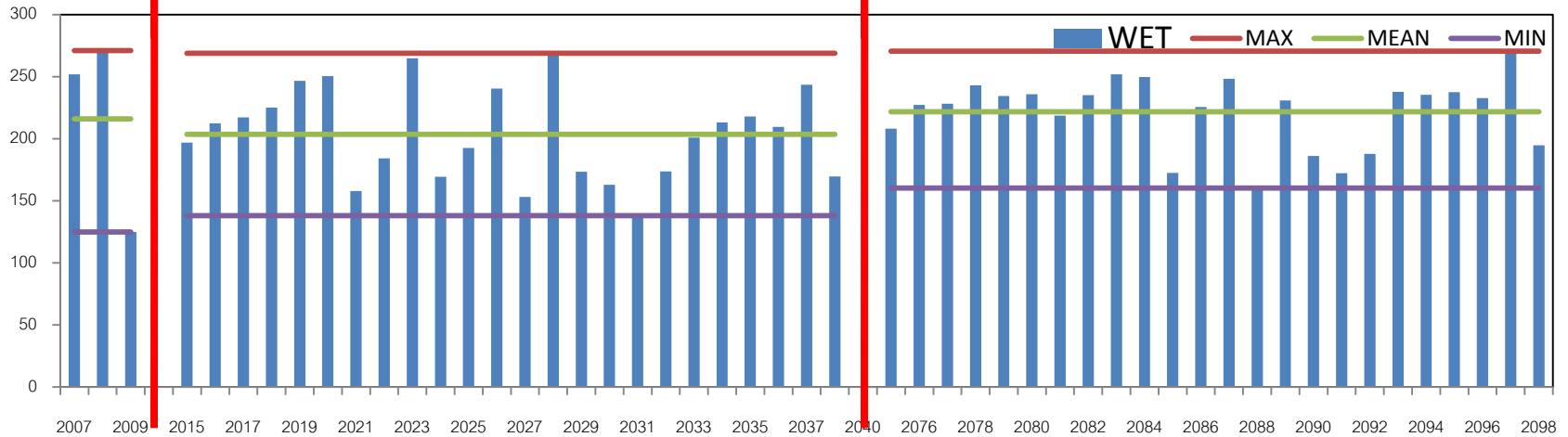


Supply to Wang Bua Project

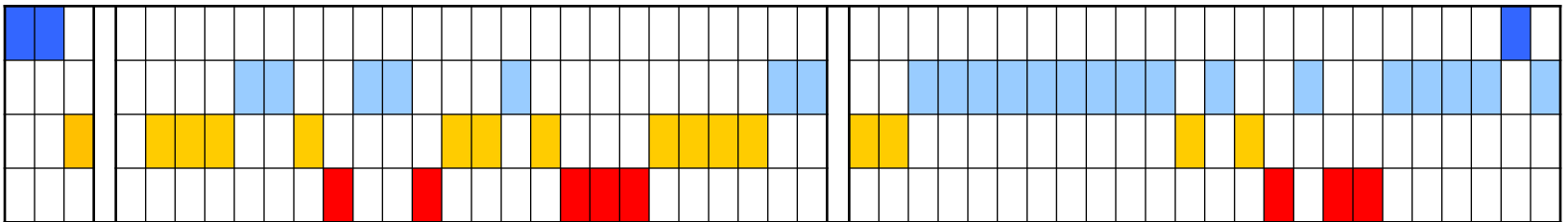
Supply to WangBau,MCM



Supply to WangBau,MCM



wet
normal
dry
ser dry



Canal MC,1L-MC delivery all time

Phichit

1R_MC

2R_MC

3R_MC

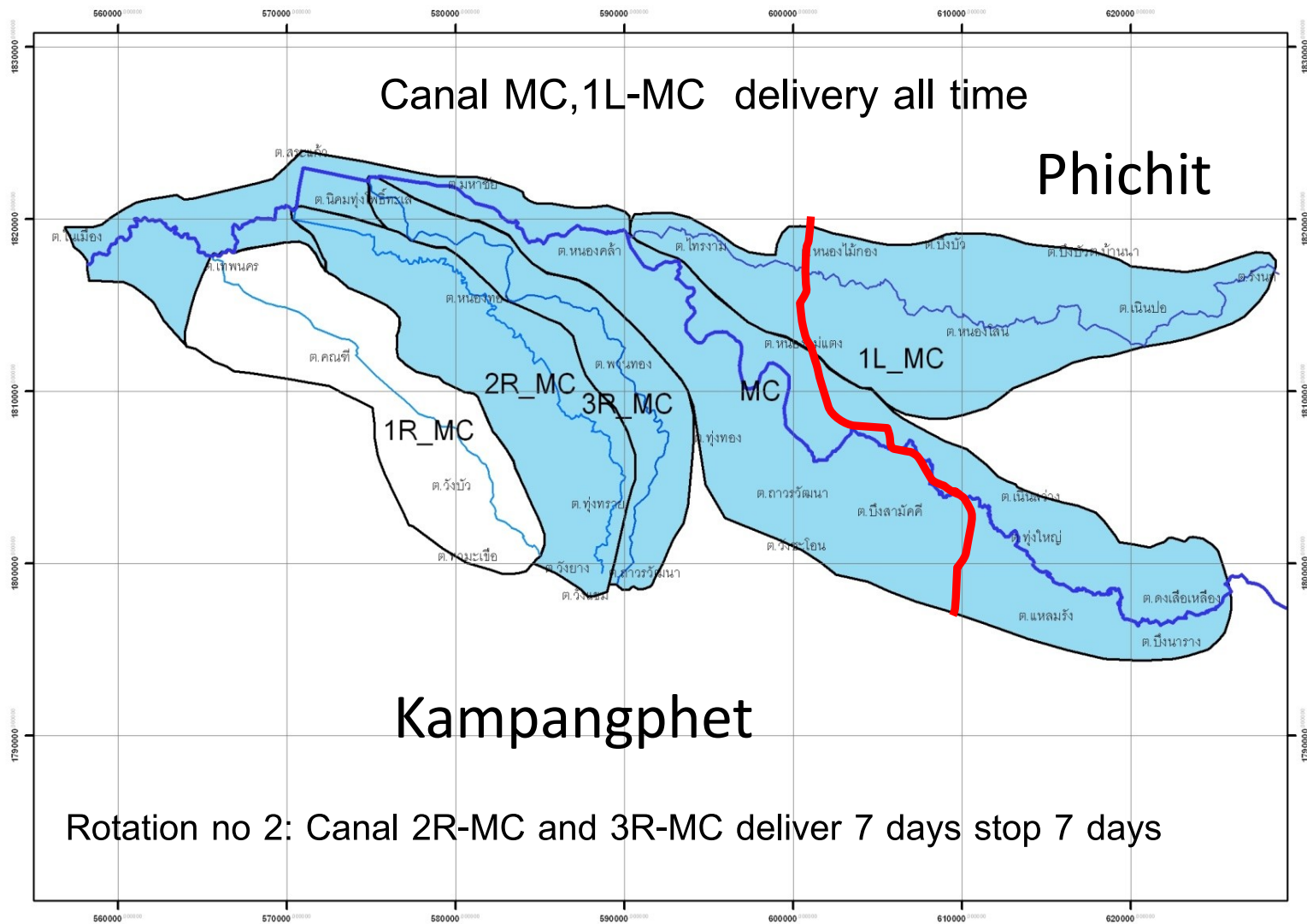
MC

1L_MC

Kamphangphet

Rotation no1: Canal 1R-MC deliver 7 days stop 7 days

Recent Rotation Scheme (con.)

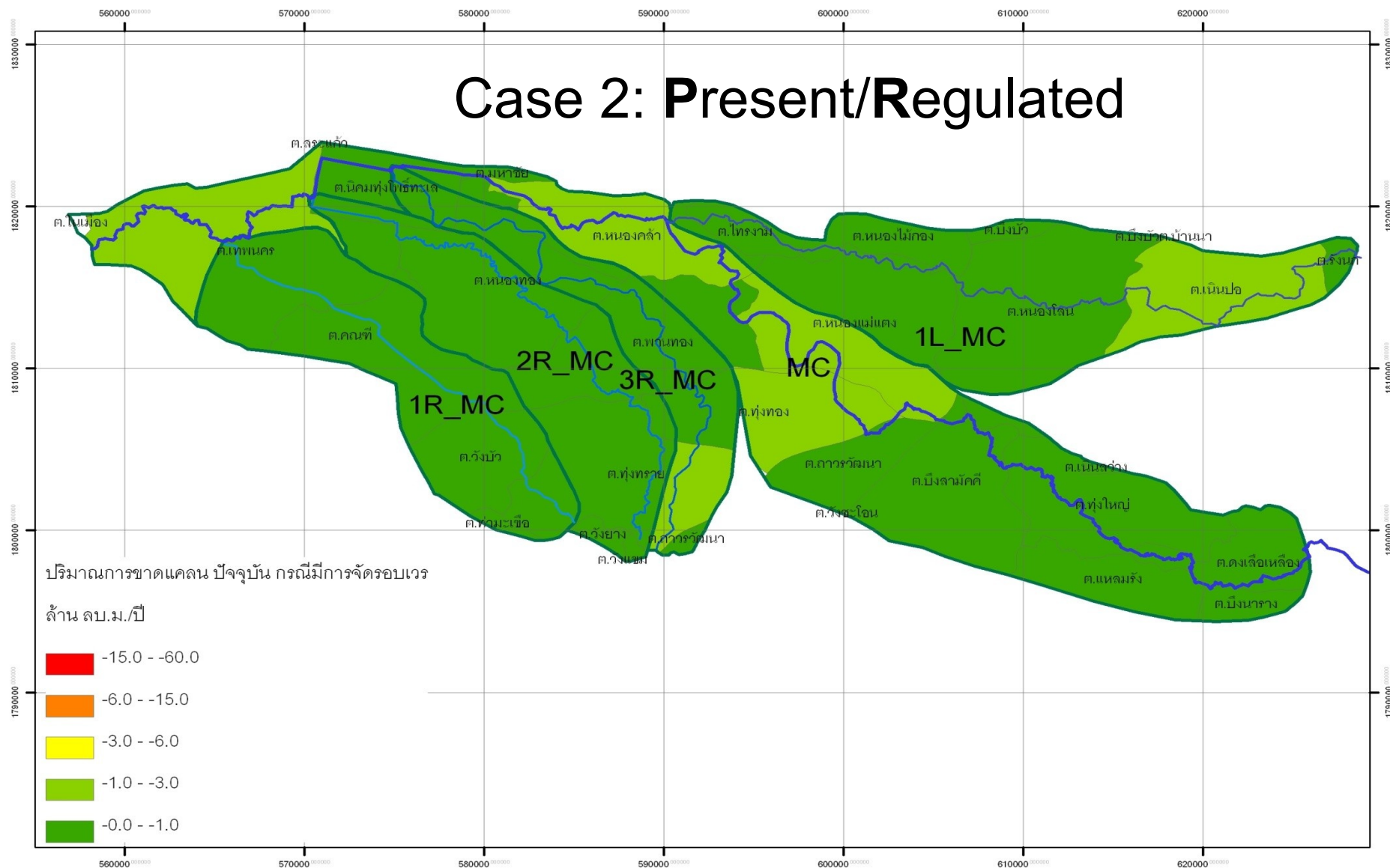


Simulation Case Study

1. Present (P) (year 2006-2010)
 - 1.1 Unregulated (PU)
 - 1.2 Regulated (PR)
2. Near Future (N) (year 2015-2039)
 - 2.1 Unregulated (NU)
 - 2.2 Regulated (NR)
3. Far Future (F) (year 2075-2099)
 - 3.1 Unregulated (FU)
 - 3.2 Regulated (FR)

[illegible]

Case 2: Present/Regulated



Case 3: Near Future/Unregulated

ปริมาณการขาดแคลน อนาคตอันใกล้ กรณีไม่มีการจัดรอบเวร
ล้าน ลบ.ม./ปี

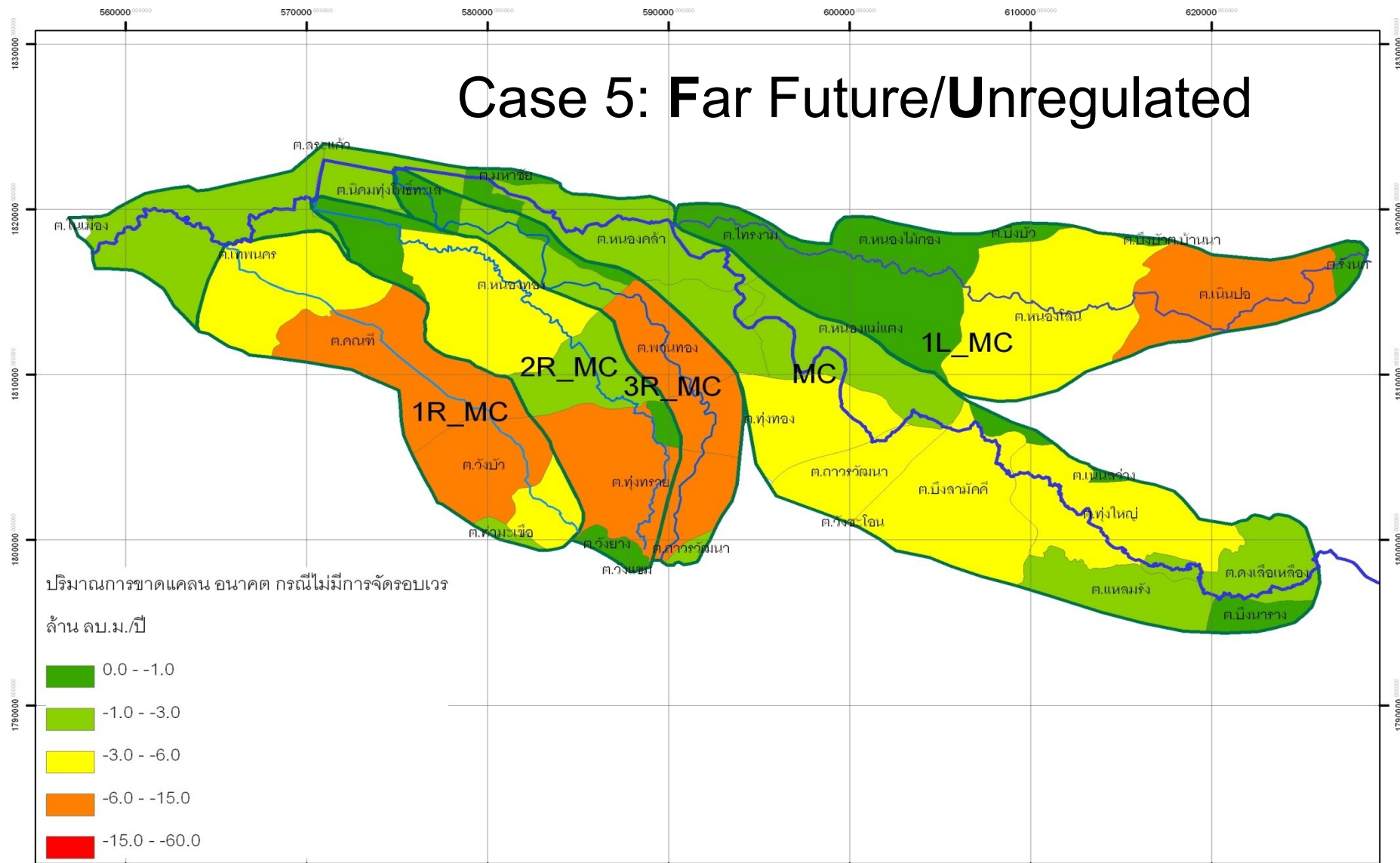
[Green]	-0.0 -- -1.0
[Light Green]	-1.0 -- -3.0
[Yellow]	-3.0 -- -6.0
[Orange]	-6.0 -- -15.0
[Red]	-15.0 -- -60.0

Case 4: Near Future/Regulated

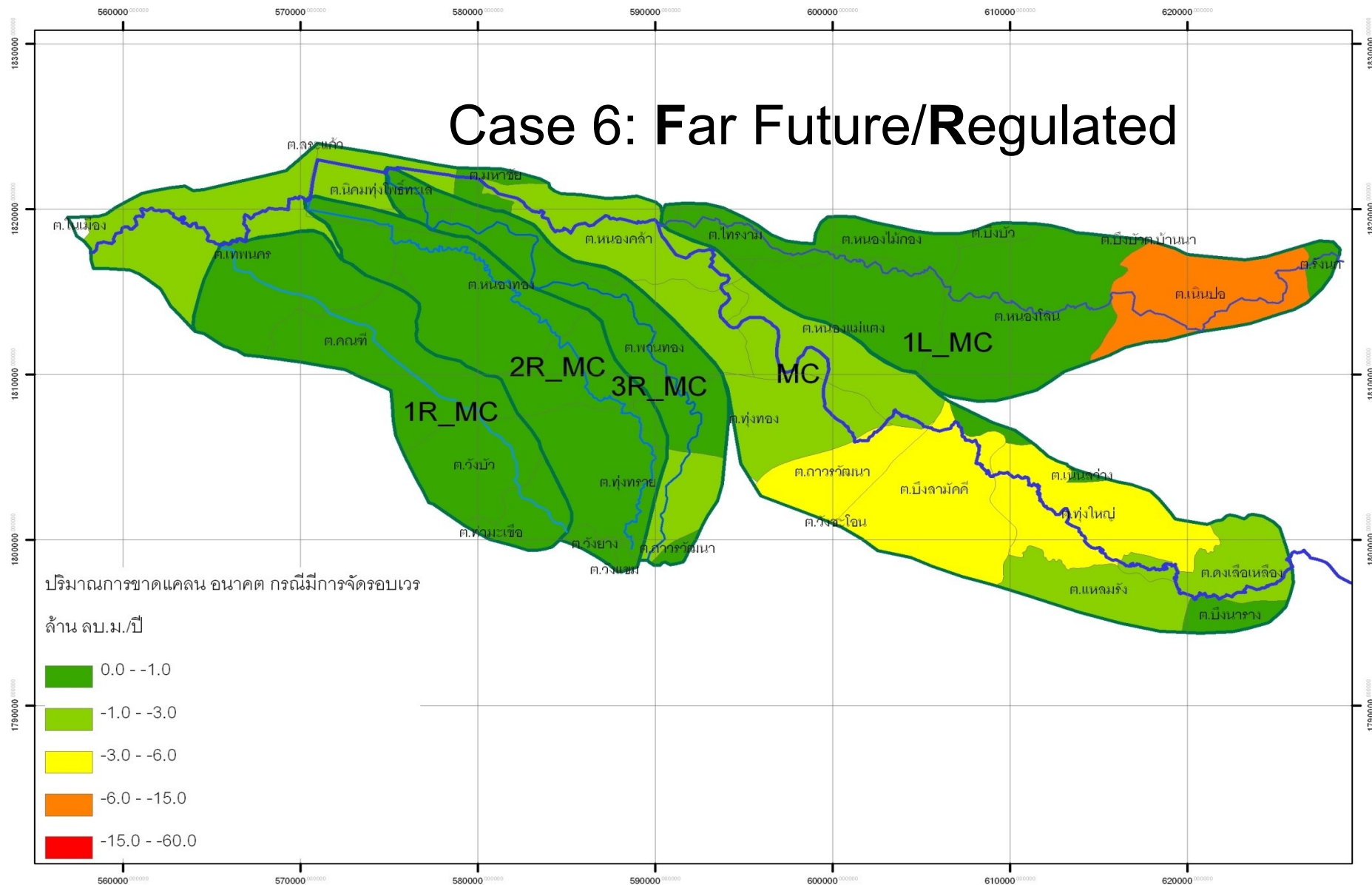
ปริมาณการขาดแคลน อนาคตอันใกล้ กรณีมีการจัดรอบเวร
ล้าน ลบ.ม./ปี

0.0 -- -1.0
-1.0 -- -3.0
-3.0 -- -6.0
-6.0 -- -15.0
-15.0 -- -60.0

Case 5: Far Future/Unregulated

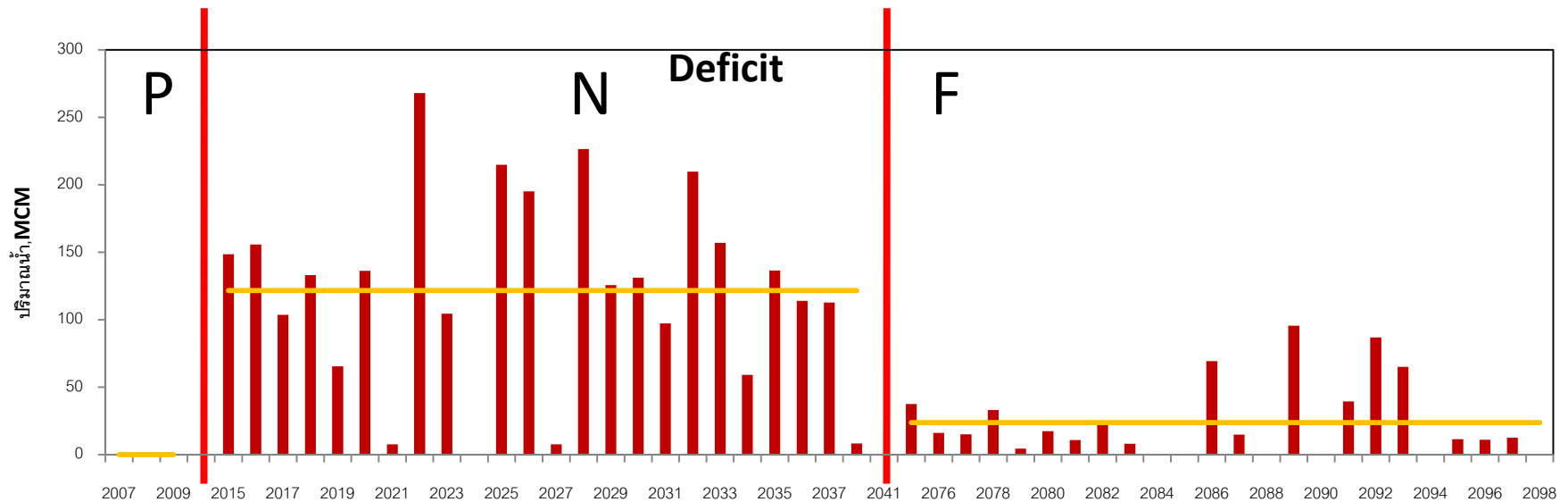
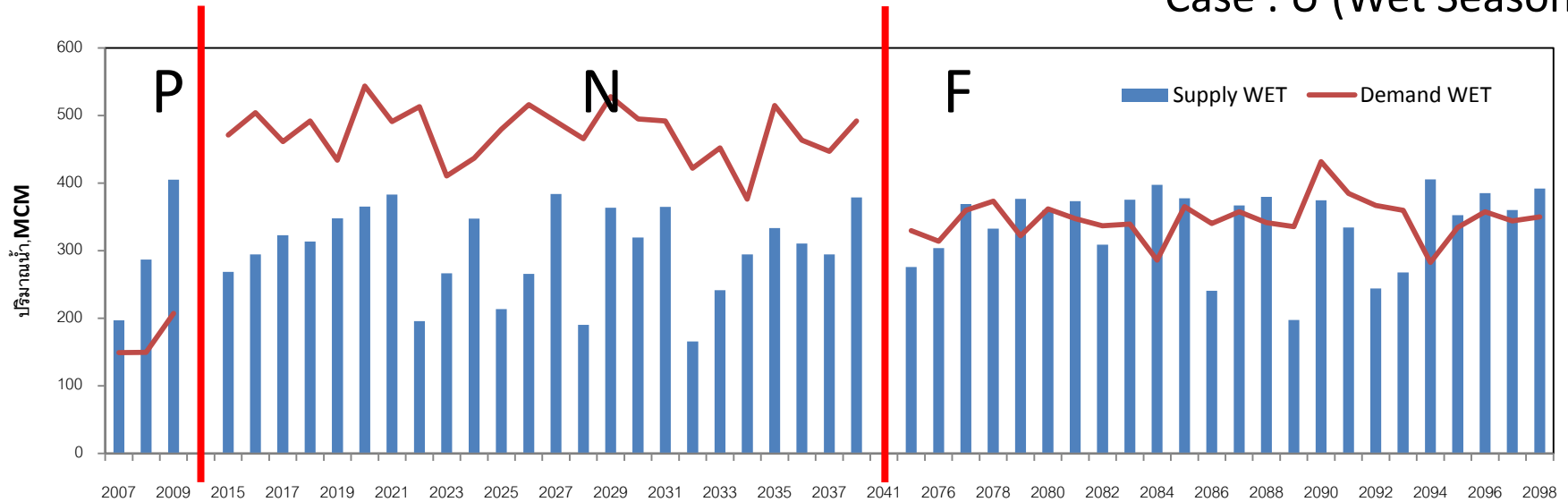


Case 6: Far Future/Regulated



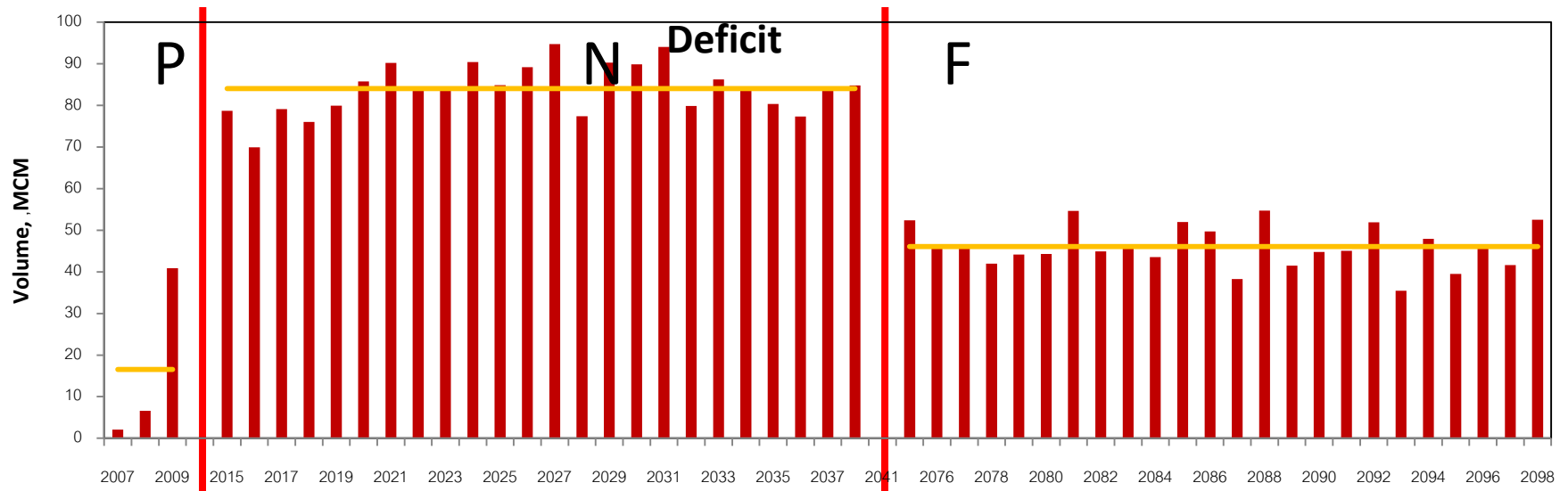
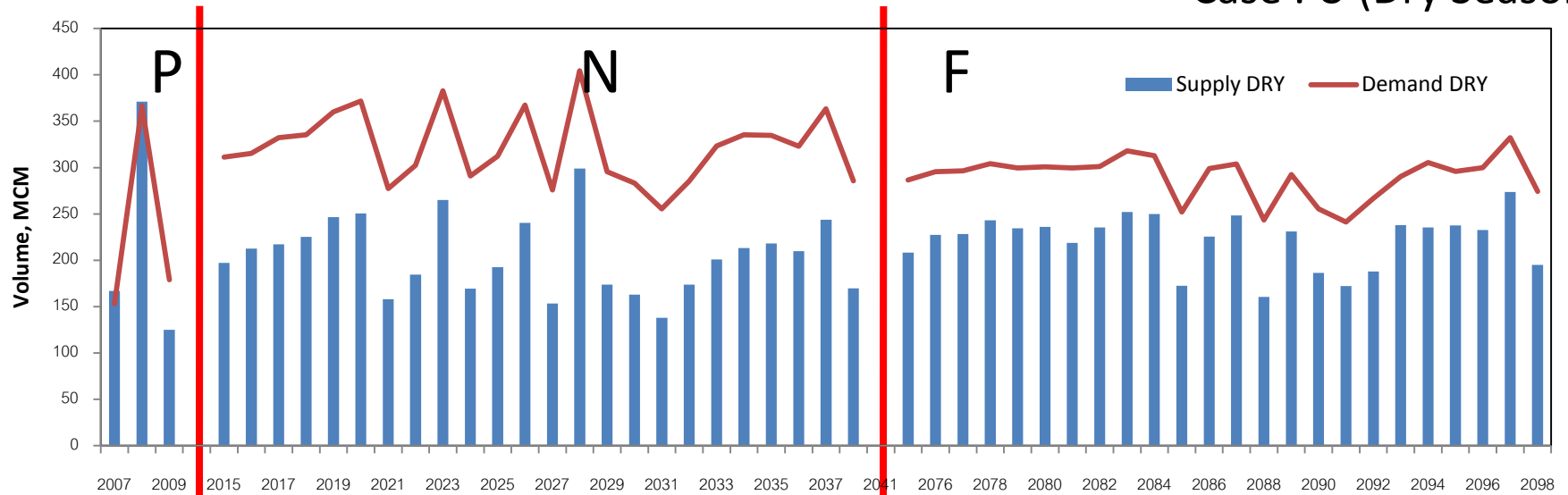
Demand and Supply for the Project

Case : U (Wet Season)



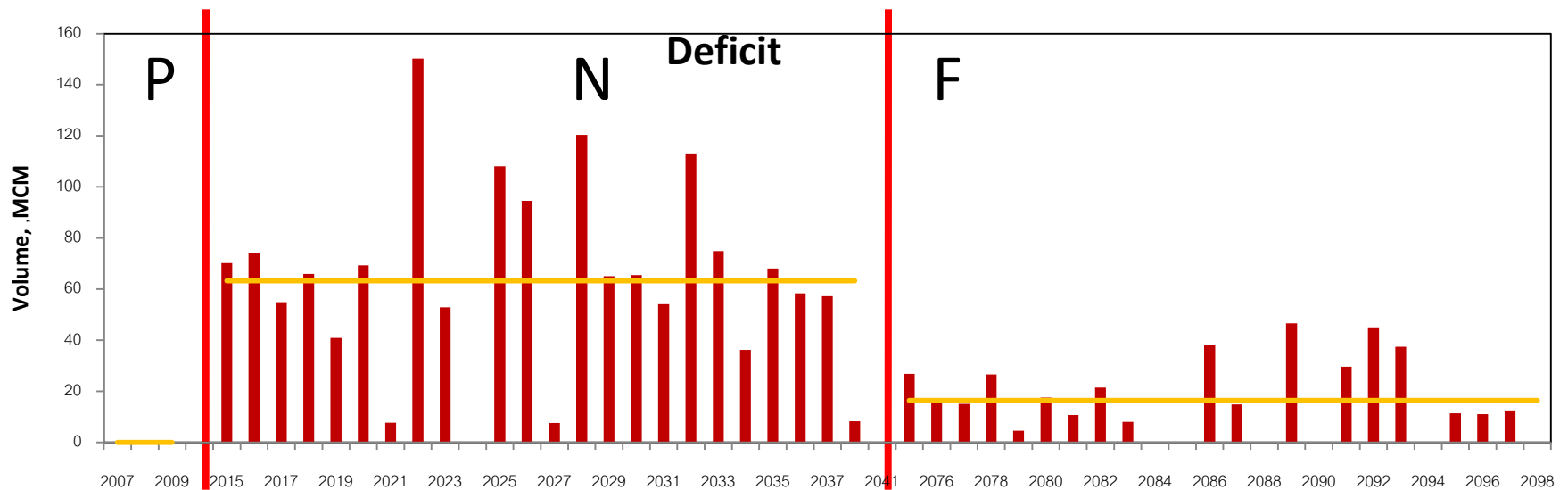
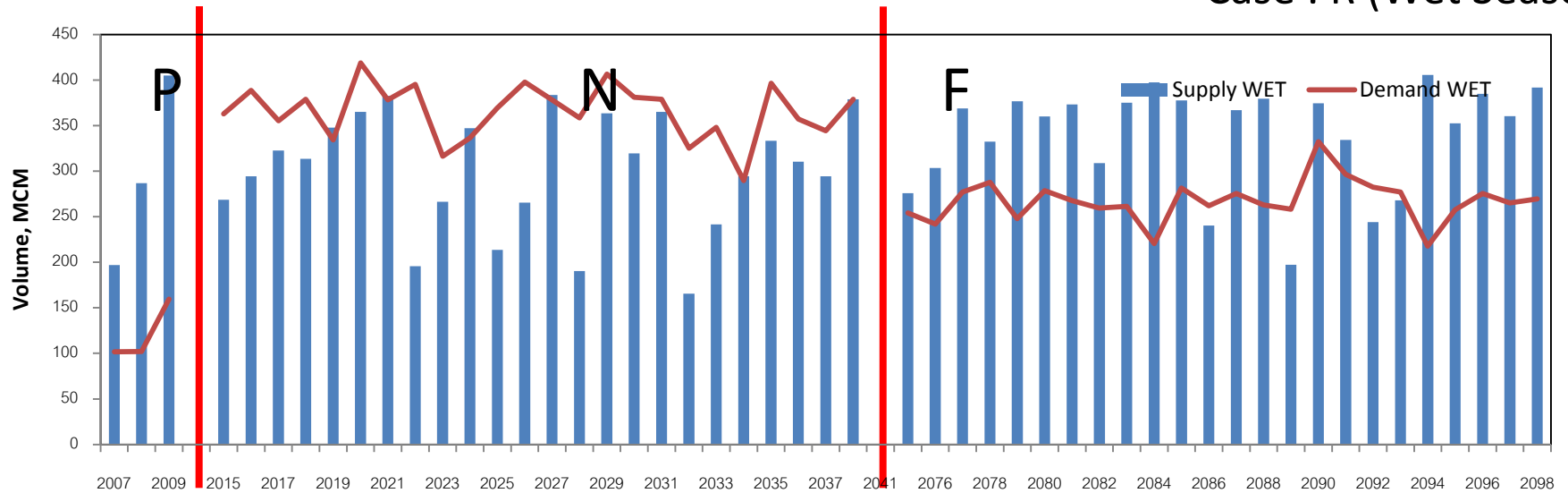
Demand and Supply for the Project

Case : U (Dry Season)



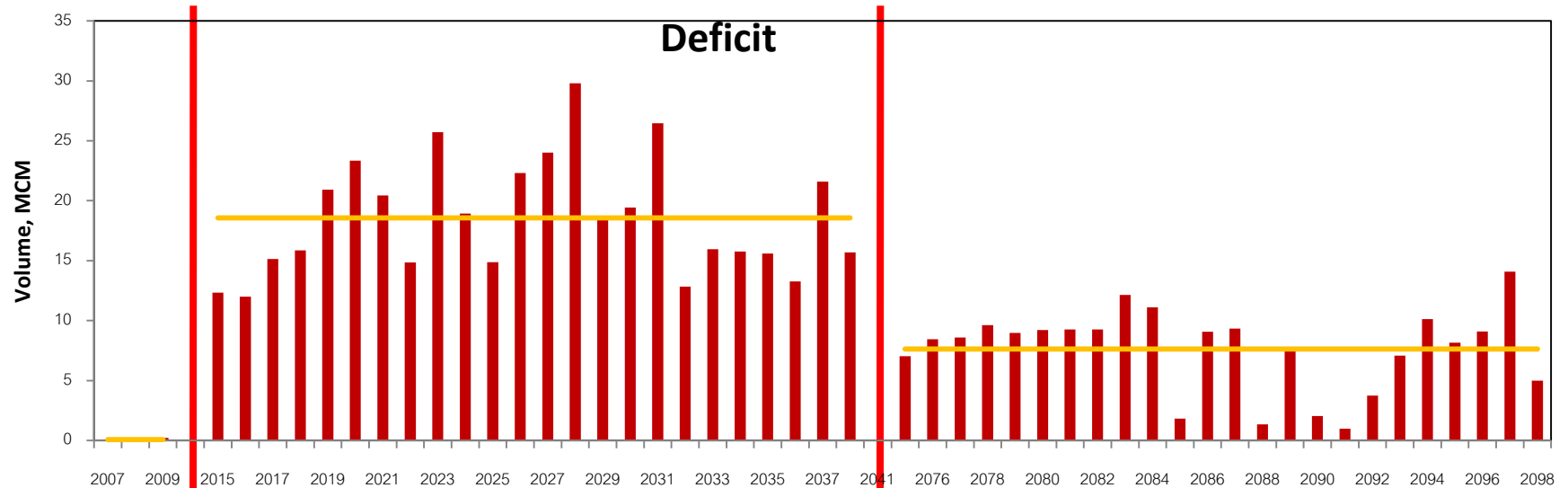
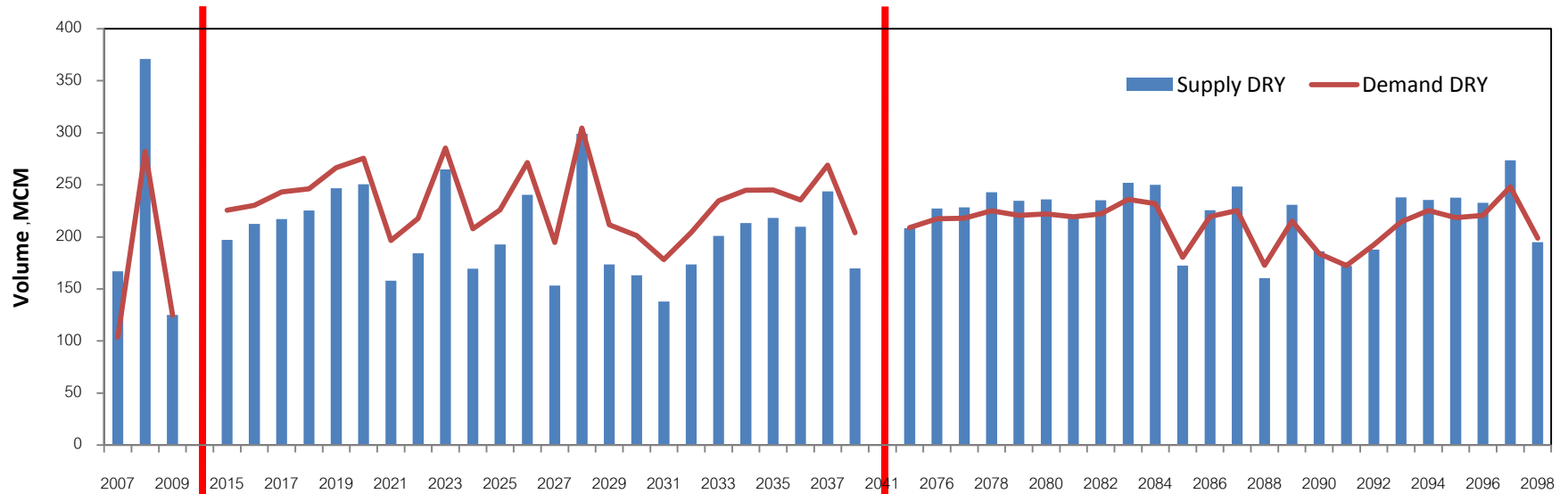
Demand and Supply for the Project

Case : R (Wet Season)



Demand and Supply for the Project

Case : R (Dry Season)



Water Deficit Summary in each Canal

			UP		UN		UF		RP		RN		RF	
			WET	Dry	WET	Dry	WET	Dry	WET	Dry	WET	Dry	WET	Dry
IN	MC	max	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
		mean	0.0	0.0	-5.3	-4.2	0.0	-0.0	0.0	0.0	-4.3	-3.2	0.0	0.0
		min	0.0	0.0	-37.1	-15.6	0.0	-0.0	0.0	0.0	-27.1	-14.6	0.0	0.0
	1L	max	0.0	0.0	0.0	-0.7	0.0	-0.1	0.0	0.0	0.0	-0.2	0.0	0.0
		mean	0.0	0.0	-2.1	-1.0	-0.2	-0.3	0.0	0.0	-1.1	-0.2	-0.2	-0.1
		min	0.0	0.0	-4.9	-1.3	-1.7	-0.5	0.0	0.0	-3.9	-0.3	-0.7	-0.2
	1R	max	0.0	-2.1	0.0	-13.2	0.0	-4.0	0.0	0.0	0.0	0.0	0.0	0.0
		mean	0.0	-3.6	-28.5	-15.8	-4.0	-6.8	0.0	0.0	-0.7	0.0	-0.7	0.0
		min	0.0	-4.7	-60.1	-18.6	-23.6	-9.1	0.0	0.0	-7.8	0.0	0.0	0.0
	2R	max	0.0	0.0	0.0	-11.6	0.0	-7.5	0.0	0.0	0.0	0.0	0.0	0.0
		mean	0.0	-5.0	-11.5	-20.4	-1.0	-12.1	0.0	0.0	-0.0	-0.3	-0.0	0.0
		min	0.0	-14.9	-28.7	-25.7	-9.4	-18.2	0.0	0.0	-1.1	-2.9	0.0	0.0
	3R	max	0.0	0.0	0.0	-20.1	0.0	-14.1	0.0	0.0	0.0	0.0	0.0	0.0
		mean	0.0	-8.0	-19.5	-30.7	-2.4	-19.6	0.0	-0.1	-0.4	-1.1	0.0	0.0
		min	0.0	-22.0	-42.6	-36.7	-16.1	-26.9	0.0	-0.2	-4.7	-6.0	0.0	0.0
OUT	MC	max	0.0	0.0	0.0	-1.2	0.0	-0.9	0.0	0.0	0.0	-0.2	0.0	-0.5
		mean	0.0	0.0	-23.8	-6.4	-5.8	-3.5	0.0	0.0	-13.8	-5.4	-4.8	-2.5
		min	0.0	0.0	-43.7	-12.5	-19.8	-5.7	0.0	0.0	-33.7	-11.5	-18.8	-4.7
	1L	max	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
		mean	0.0	0.0	-30.9	-5.6	0.0	-3.8	0.0	0.0	-20.9	-4.6	-9.4	-2.8
		min	0.0	0.0	-50.9	-16.1	-25.0	-8.1	0.0	0.0	-40.9	-15.1	-24.0	-7.1

Water Deficit Summary

	UP		UN		UF		RP		RN		RF	
	WET	Dry	WET	Dry	WET	Dry	WET	Dry	WET	Dry	WET	Dry
max	0.0	-0.3	0.0	-6.7	0.0	-3.8	0.0	0.0	0.0	-0.3	0.0	-0.1
mean	0.0	-2.4	-17.4	-12.0	-1.9	-6.6	0.0	-0.0	-9.0	-2.7	-2.5	-1.1
min	0.0	-5.9	-38.3	-18.1	-13.7	-9.8	0.0	-0.0	-21.5	-7.8	-6.7	-2.0

	UP	UN	UF	D(UN-UP)	D(UF-UP)	RP	RN	RF	D(RN-RP)	D(RF-RP)
max	-0.3	-6.7	-3.8	6.4	3.5	0.0	-0.3	-0.1	0.3	0.1
mean	-2.4	-29.4	-8.5	27.0	6.1	-0.0	-11.7	-3.5	11.7	3.5
min	-5.9	-56.4	-23.4	50.4	17.5	-0.0	-29.2	-8.7	29.2	8.7

Conclusions from the Simulation

- Less water into Bhumibol Dam
(in Near Future, but more in dry season)
- Need more water supply to Wang Bua Project
- More water deficit in dry season
- Adaptation Measures:
 - Rotation water management with water control facilities;
 - Control cultivation area based on resources;
 - More retention/intermediate storages needed
(including groundwater esp. outside irrigation area)

Thank you for your attention

For more information, please contact:

Water Resources System Research Unit

Chulalongkorn University

Email : watercu@eng.chula.ac.th

chaiyuth.S@chula.ac.th

Website : www.watercu.eng.chula.ac.th