United Nations
Educational, Scientific and
Cultural Organization

Program for Generation of Climate Change Risk Information (SOUSEI Project)

SOUSEI

Research project/plan by ICHARM (i-e)

Development of the basic technology for affect evaluation in the river basin scale

Development of the methodology for the local application of the predicted values of flood/drought hazard

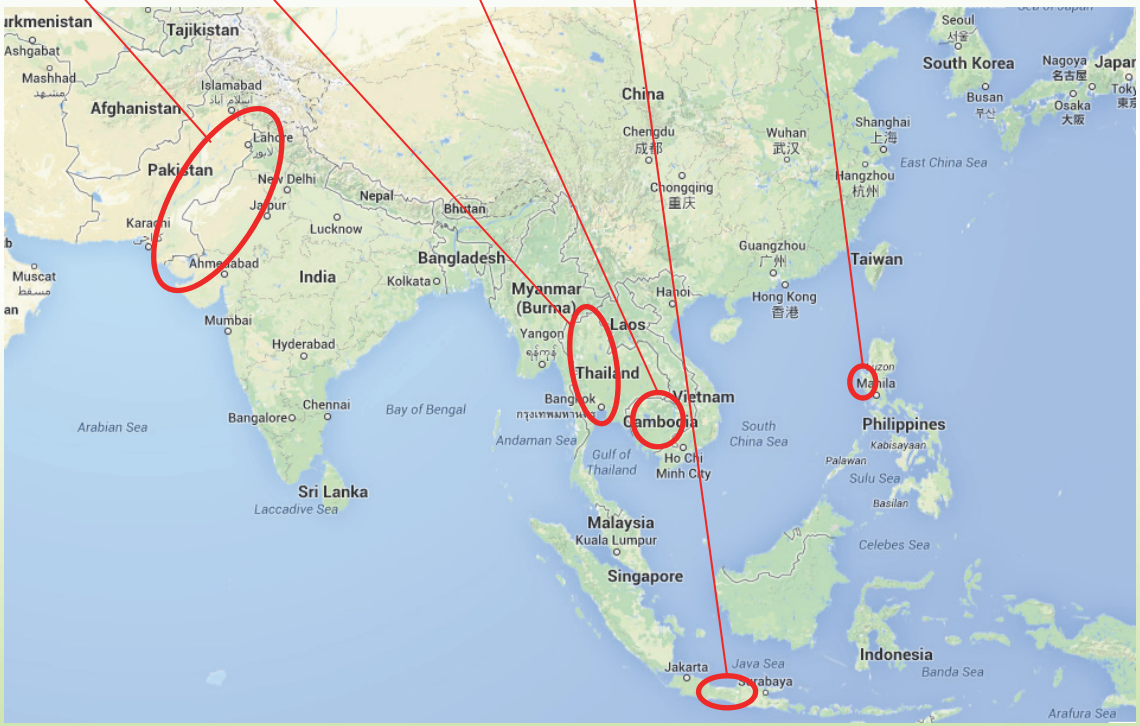
- Local customizing with hazard assessment
- Uncertainty assessment（CMIP5）
- Socio-economic impact assessment (Flood and drought)
- Vulnerability monitoring system

Development of the basic technology for the socio-economic risk assessment

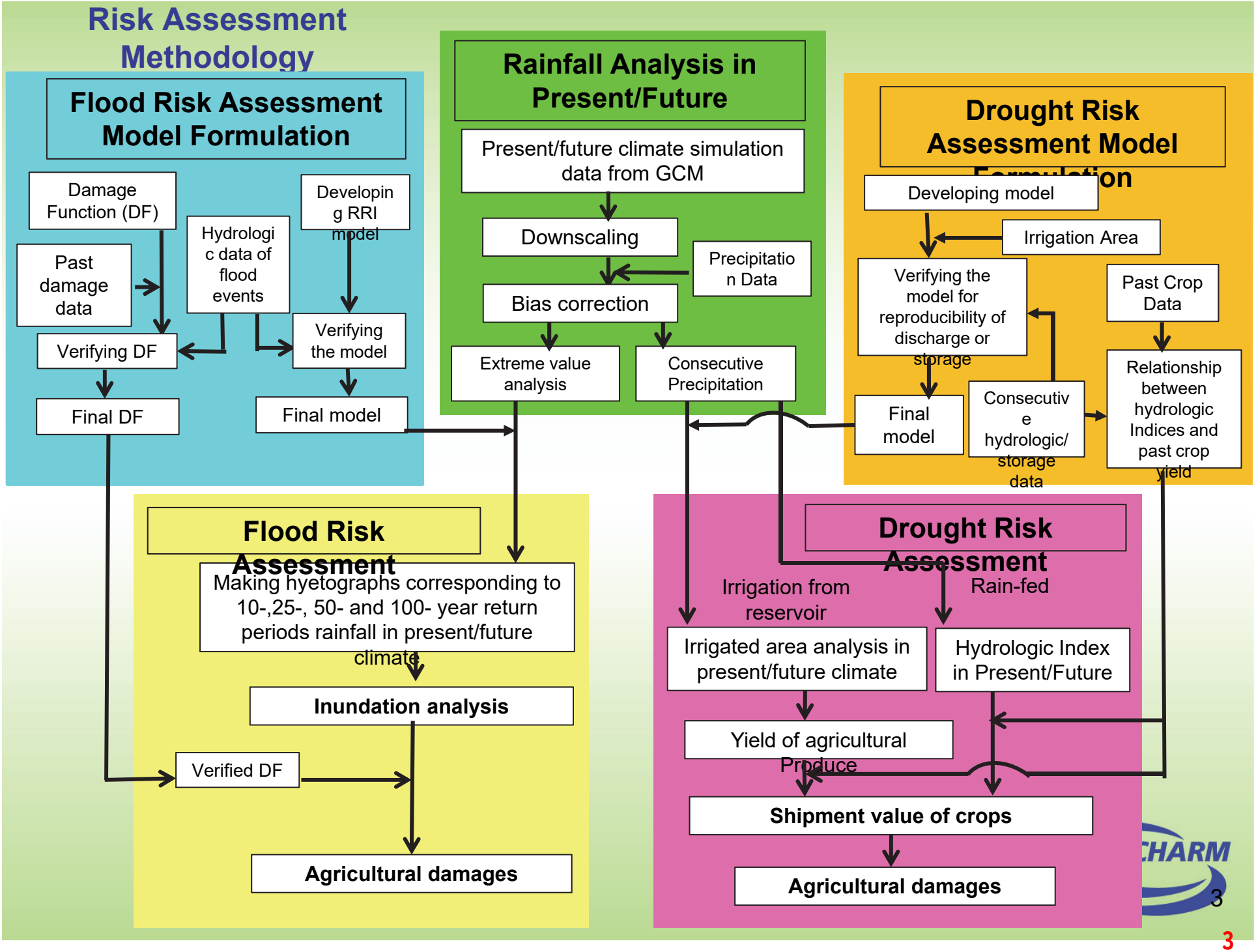
- Response framework of hazard, socio-economic impact
- Socio-economic impact assessment including uncertainty
- Necessary information for local adaptation

Affect evaluation in the special prone area

Indus | Chao Phraya | Mekong | Solo | Pampanga



Collaborative organization	Kyoto Univ.	Yamanashi Univ.	Government of Pakistan	Government of Thailand	Government of Cambodia	Government of Indonesia	Government of the Philippines


Risk Assessment Methodology
Flood Risk Assessment Model Formulation
Damage Function (DF)
Developing RRI model
Past damage data
Hydrologic data of flood events
Verifying DF
Verifying the model
Final DF
Final model
Rainfall Analysis in Present/Future
Present/future climate simulation data from GCM
Downscaling
Precipitation Data
Bias correction
Extreme value analysis
Consecutive Precipitation
Drought Risk Assessment Model Formulation
Developing model
Irrigation Area
Verifying the model for reproducibility of discharge or storage
Past Crop Data
Final model
Consecutive hydrologic/ storage data
Relationship between hydrologic Indices and past crop yield
Flood Risk Assessment
Making hyetographs corresponding to 10-,25-, 50- and 100- year return periods rainfall in present/future climate
Inundation analysis
Verified DF
Agricultural damages
Drought Risk Assessment
Irrigation from reservoir
Rain-fed
Irrigated area analysis in present/future climate
Hydrologic Index in Present/Future
Yield of agricultural Produce
Shipment value of crops
Agricultural damages
CHARM

3

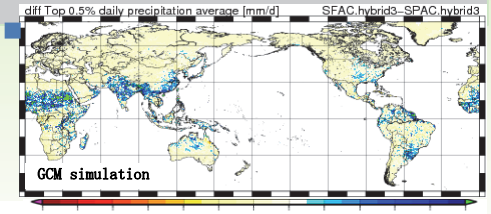
Flood Risk Assessment in Climate change (Sosei project by MEXT)

Various GCM experimental on future/current climate

Various scenarios

Downscaling/ Biais

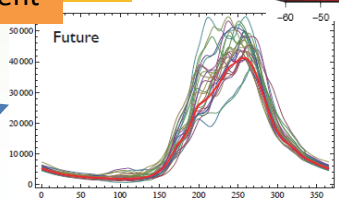
Uncertainty assessment

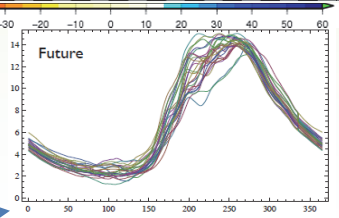


Basin scale rainfall information

Hydrological models
IFAS / BTOP / RRI

Projection of discharge variation





Uncertainty assessment

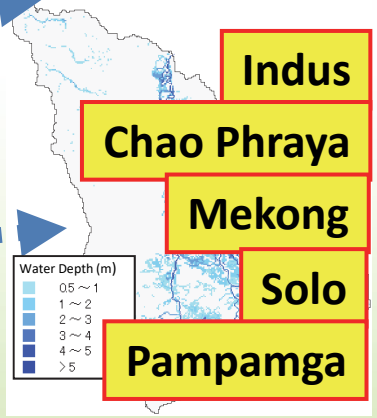
Projection of water level variation

Uncertainty assessment

Projection of water depth variation

1/10,1/25,1/50

Flood frequency map



Socio-economic impact assessement

agricultural damages

es assessment, water stress, risk partition

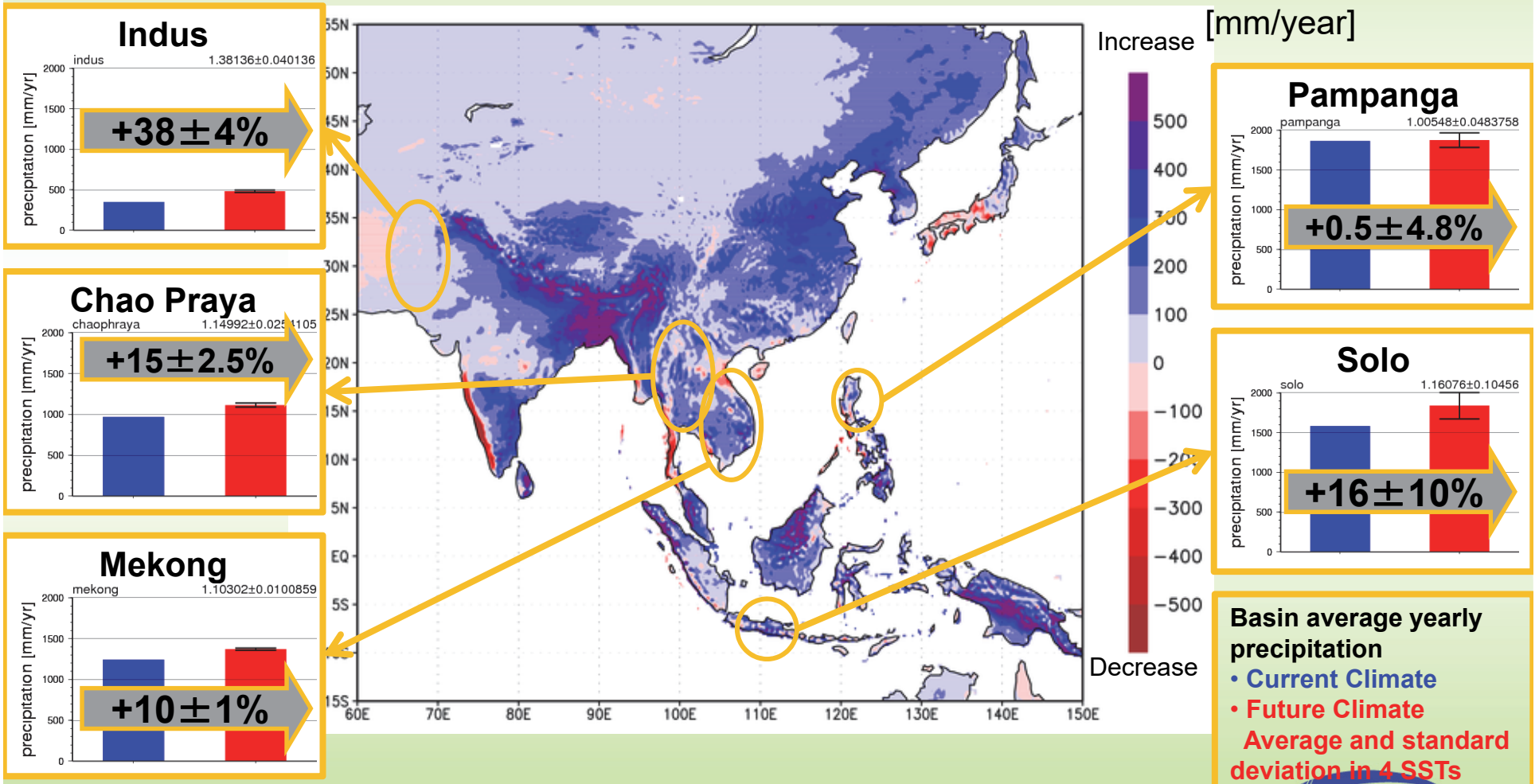
Uncertainty assessment

Disaster Risk monitoring indices

SOUSEI Program for Risk Information on Climate Change
気候変動リスク情報創生プログラム

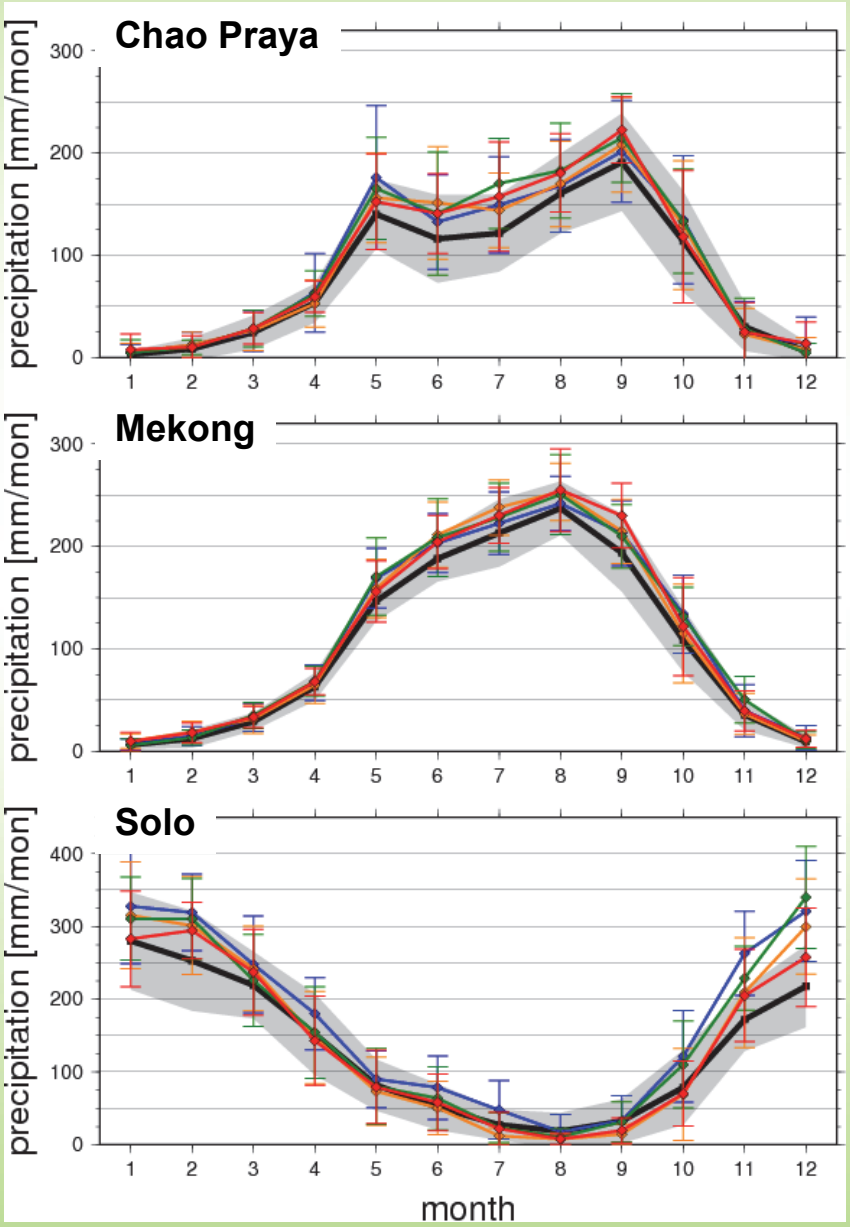
ICHARM

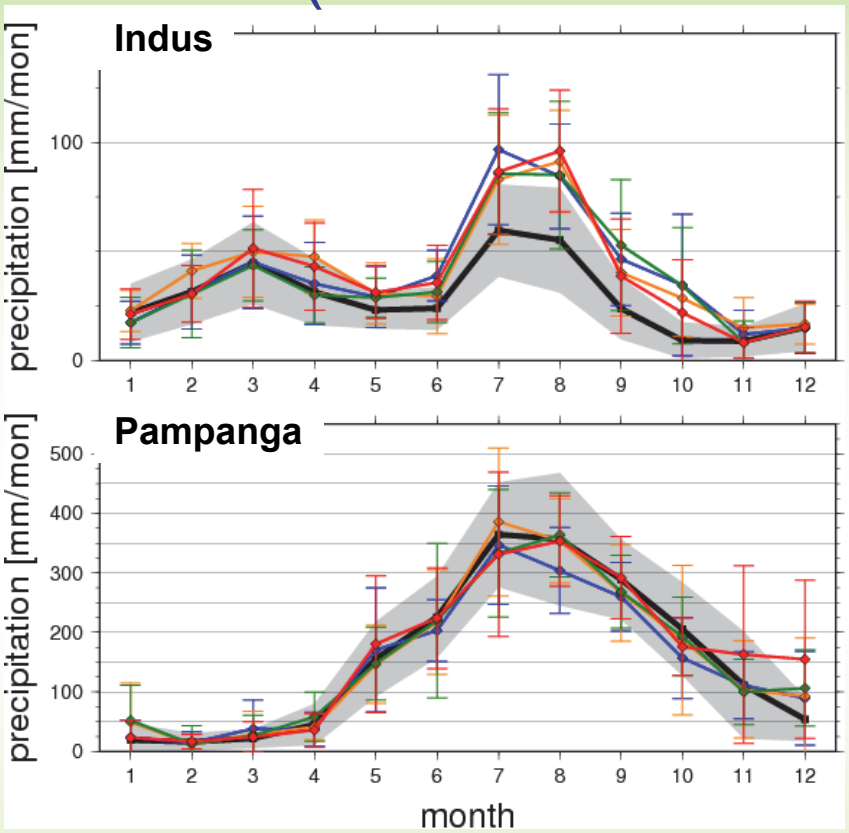
Difference in average yearly precipitation between present and future climate by MRI-AGCM3.2S for 4 Sea Surface Temperature (SST)patterns,



5

Comparison of average monthly precipitation between present and future climate for 4 SSTs (MRI-AGCM3.2S)





MRI-AGCM3.2S after B.C.

present
RCP8.5 MME
RCP8.5 c1
RCP8.5 c2
RCP8.5 c3

Iwami et al (2016) HRL, accepted

Progress of SOUSEI Drought Assessment in the Chao Phraya River basin -Bhumibol Dam and Sirikit Dam-

ICHARM

Contents

- 1. Introduction
- 2. Water resources management in Chao Phraya River basin
- 3. Simulation method
- 4. Simulation Results
- 5. Conclusion

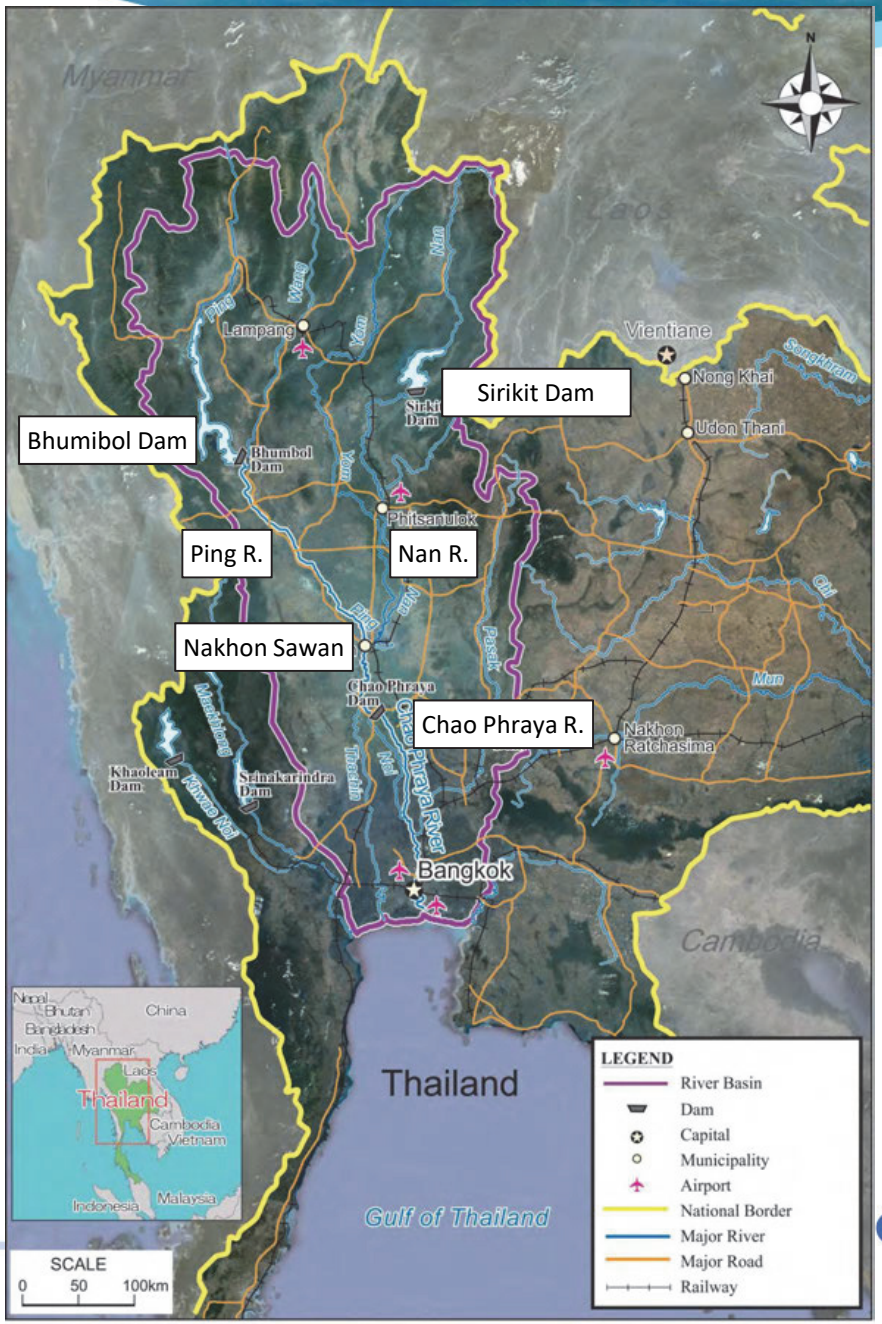
1. Introduction

Objectives of Drought Assessment

Our drought assessment has the following aims:

1) To select drought assessment methodology for characterization of natural and socio-economic droughts
2) To improve the BTOP model for the drought characterization
3) To apply our drought assessment of local and global scales under climate change

Study Area of the Chao Phraya River Basin



Source:
Japan International Cooperation Agency: Project for the Comprehensive Flood Management Plan for the Chao Phraya River Basin in the Kingdom of Thailand, 2013. 9.

2. Water resources management in Chao Phraya River basin

Specification of Bhumibol and Sirikit Dam-

Specification	Bhumibol Dam	Sirikit Dam
Type	Concrete arch -Gravity	Rockfill
Height (m)	154.0	113.6
Crest length (m)	486.0	800.0
Catchment area (km^2)	26,386	13,130
Reservoir area (km^2)	316.0	260.0
Crest level (m M.S.L)	261.0	169.0
Max. reservoir water level (m M.S.L)	260.0	162.0
Minimum water level (m M.S.L)	213.0	128.0
Storage at high water level (MCM)	13,462	9,510
Storage at minimum water level (MCM)	3,800	2,850
Effective storage (MCM)	9,662	6,660
Maximum design flood (m^3/sec)	Total 6,000 (Radial Gate x 4)	Total 3,250 (Radial Gate x 2)
Crest of spill way (m M.S.L)	242.9	150.5
Maximum discharge of intake pipe (m^3/sec)	Total 784.4 (8 sets)	Total 732.0 (2 sets)
Center elevation of intake pipe (m M.S.L)	207.0	110.0
Power generation (MW)	Total 779.2 (8 set)	Total 500.0 (4 set)

Source:
Japan International Cooperation Agency:
Project for the Comprehensive Flood Management Plan for the Chao Phraya River Basin in the Kingdom of Thailand, Supporting Report, Sector G, p3, 2013. 9.

Operation Rules of Bhumibol and Sirikit Dam

(a) Dry season / Wet season

・up to 2005

Dry: Jan 1 - June 30　Wet: July　1 - Dec 31

・from 2006

Dry: Nov 1 - April 30　Wet: May 1 – Oct 31

（Biggest demand term of irrigation water is from December to February.
Irrigation water supply is finished by April 30.）

(b) Minimum discharge from dams

Minimum discharge from Bhumibol and Sirikit Dam is determined to 8 m^3/s and 35 m^3/s respectively for the purpose of ecosystem management.

(c) Discharge plan for dry season

・Water demand for dry season is composed of irrigation, ecosystem management. domestic water use and etc.

・Regional offices of RID calculate water demand based on cropping estimation.

・Discharge plan for dry season is based on the reserved water volume on November 1.

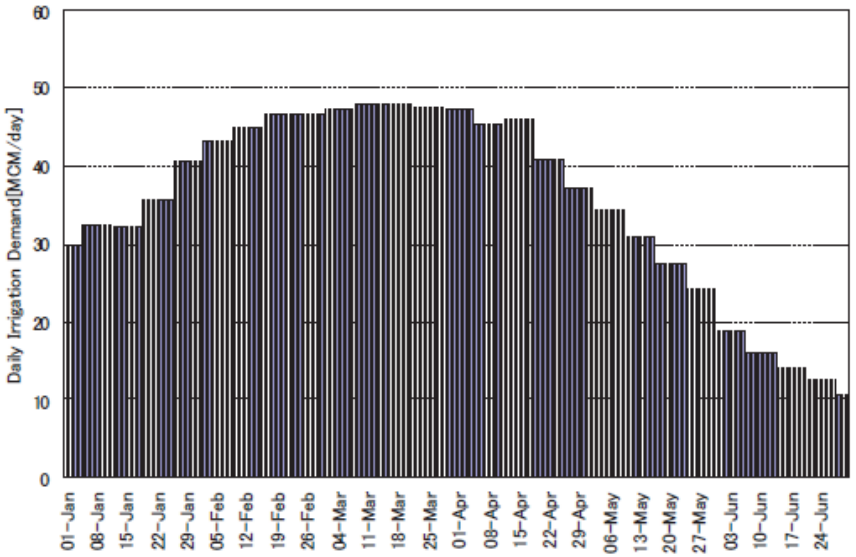
・Discharge plan for dry season is different for each year.

・Discharge plan is decided as the summation of discharged volume from both dams.

Scheduled Release from Two Dams

An Example of Irrigation Water Demand
In Chao Phraya River basin

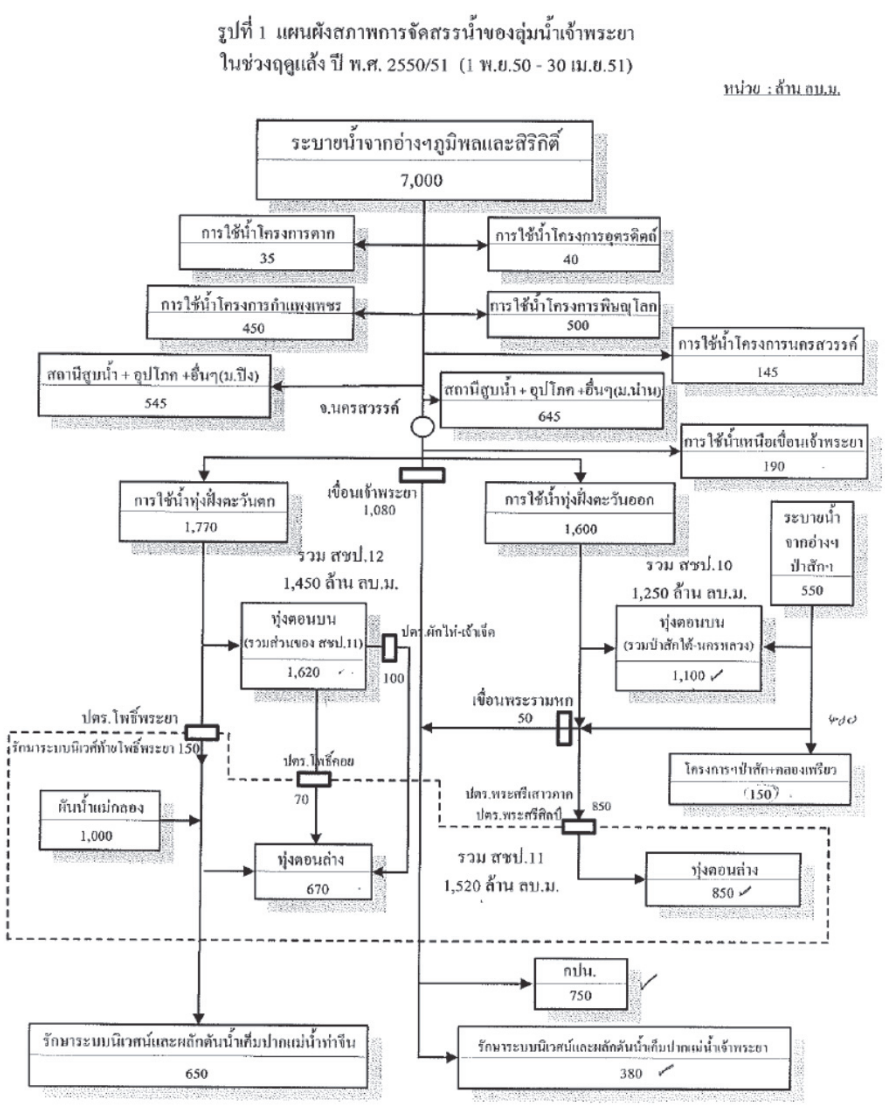
Week	Date		Irrigation Demand			Monthly Demand	
	from	to	m3/sec	MCM/day	MCM/week	Month	Demand(MCM/month)
1	01-Jan	04-Jan	345	29.81	119.23	January	1,146.2
2	05-Jan	11-Jan	375	32.40	226.80	February	1,321.1
3	12-Jan	18-Jan	372	32.14	224.99	March	1,474.3
4	19-Jan	25-Jan	410	35.42	247.97	April	1,279.2
5	26-Jan	01-Feb	470	40.61	284.26	May	872.9
6	02-Feb	08-Feb	497	42.94	300.59	June	406.0
7	09-Feb	15-Feb	523	45.19	316.31	Total	6,500
8	16-Feb	22-Feb	539	46.57	325.99		
9	23-Feb	29-Feb	540	46.66	326.59		
10	01-Mar	07-Mar	547	47.26	330.83		
11	08-Mar	14-Mar	553	47.78	334.45		
12	15-Mar	21-Mar	553	47.78	334.45		
13	22-Mar	28-Mar	551	47.61	333.24		
14	29-Mar	04-Apr	546	47.17	330.22		
15	05-Apr	11-Apr	526	45.45	318.12		
16	12-Apr	18-Apr	531	45.88	321.15		
17	19-Apr	25-Apr	473	40.87	286.07		
18	26-Apr	02-May	429	37.07	259.46		
19	03-May	09-May	398	34.39	240.71		
20	10-May	16-May	356	30.76	215.31		
21	17-May	23-May	316	27.30	191.12		
22	24-May	30-May	279	24.11	168.74		
23	31-May	06-Jun	220	19.01	133.06		
24	07-Jun	13-Jun	185	15.98	111.89		
25	14-Jun	20-Jun	164	14.17	99.19		
26	21-Jun	27-Jun	143	12.36	86.49		
27	28-Jun	30-Jul	125	10.80	32.40		
Total					6,500		



An Example of
Daily Irrigation Demand

Tebakari et al.:
Dam operations in Chao Phraya River basin and effects to river regeme in Thailand,
Proceedings, Annual Lecture Meeting of JSCE, Vol. Ⅱ,
pp125-126, 2004.

Water Distribution Plan of Chao Phraya River Basin



กิจกรรมการใช้น้ำ		2543	2544	2545	2546
ปริมาณน้ำต้นทุนสำหรับใช้น้ำฤดูแล้ง		11,930	13,585	14,068	15,300
1. การใช้น้ำเหนือเขื่อนเจ้าพระยา จังหวัดชัยนาท		1,300	1,300	1,300	1,700
- โครงการ ฯ พิษณุโลก		500	500	500	800
- อื่นๆ		800	800	800	900
2. การใช้น้ำในเขตโครงการฯเจ้าพระยาใหญ่		3,300	4,300	4,300	5,500
3. การรักษาระบบนิเวศน์และผลักดันน้ำเค็มปากแม่น้ำ		650	650	650	650
4. การประปานครหลวง		750	750	750	750
รวมระบายท้ายเขื่อนภูมิพลและสิริกิติ์	แผน	6,000	7,000	7,000	8,500
	ระบายจริง	6,513	6,879	6,709	9,722
5. เขื่อนป่าสักชลสิทธิ์	แผน	500	500	500	500
	ระบายจริง	762	600	695	709
6. พื้นที่นาปรัง (ล้านไร่) ในเขต	แผน	3.10	3.35	3.50	4.10
ชลประทานลุ่มน้ำเจ้าพระยา	ปลูกจริง	4.90	4.39	4.72	4.98

หมายเหตุ : 1) พื้นที่เป้าหมายนาปรังปี 2550 จำนวน 5.50 ล้านไร่

- Outflow from Pa Sak Dam ($500 \times 10^6 m^3$), Demand for ecosystem management ($650 \times 10^6 m^3$), Demand for Metropolitan Waterworks Authority ($750 \times 10^6 m^3$) are constant through 2000 to 2003.

Source:
Royal Irrigation Department:
Management and cultivation plan of dry season, Irrigated year 2550/2551, p33-34, November 2007.
11.

Scheduled Release from Two Dams (2)

Discharge plan for dry season

Unit: MCM

Activities for Water Use		2004	2005	2006	2007	2008	2009	2010	2011	2012
Water Demand										
Water Resource Volume for Water Use in Dry Season		9,250	9,450	12,024	16,099	12,224	10,849	8,720	9,628	16,239
1. Water Use of Upstream of Chao Phraya Dam, Chainat Province		1,300	1,500	2,340	2,905	2,550	2,800	2,350	2,345	3,870
2. Water Use in Project of Chao Phraya Yai		4,350	3,250	3,750	5,140	3,770	4,520	3,370	4,375	6,955
3. Ecosystem Maintenance and Salt Water Drive at the Mouth of River		600	500	600	405	480	480	480	480	1,590
4. Metropolitan Waterworks Authority		750	750	750	600	750	750	800	800	800
Total		7,000	6,000	7,440	9,050	7,550	8,550	7,000	8,000	13,215
Water Supply										
Outflow from Bhumibol and Sirikit Dams	Plan	6,500	5,500	6,890	8,500	7,000	8,000	6,000	6,800	11,865
	Actual	6,469	7,228	7,662	9,648	9,530	9,152	7,678	6,867	13,274
Outflow from Kwae Noi Dam	Plan	-	-	-	-	-	-	400	600	750
	Actual	-	-	-	-	-	-	655	732	
Outflow from Pa Sak Dam	Plan	500	500	550	550	550	550	600	600	600
	Actual	673	460	544	546	779	1,023	876	543	
Total	Plan	7,000	6,000	7,440	9,050	7,550	8,550	7,000	8,000	13,215
	Actual	7,142	7,688	8,206	10,194	10,309	10,175	9,209	8,142	

Source : Operational Plan for Water Allocation in Dry Season 2011/12, RID, Water Management Division
Note : Dry season 11/1~4/30(After 2006), 1/1~6/30(Before 2005)

Source:
Japan International Cooperation Agency:
Project for the Comprehensive Flood Management Plan for the Chao Phraya River Basin in the Kingdom of Thailand, 2013. 9.

3. Simulation method

BTOP model cell-by-cell calculation

From Takeuchi et al. (2008)

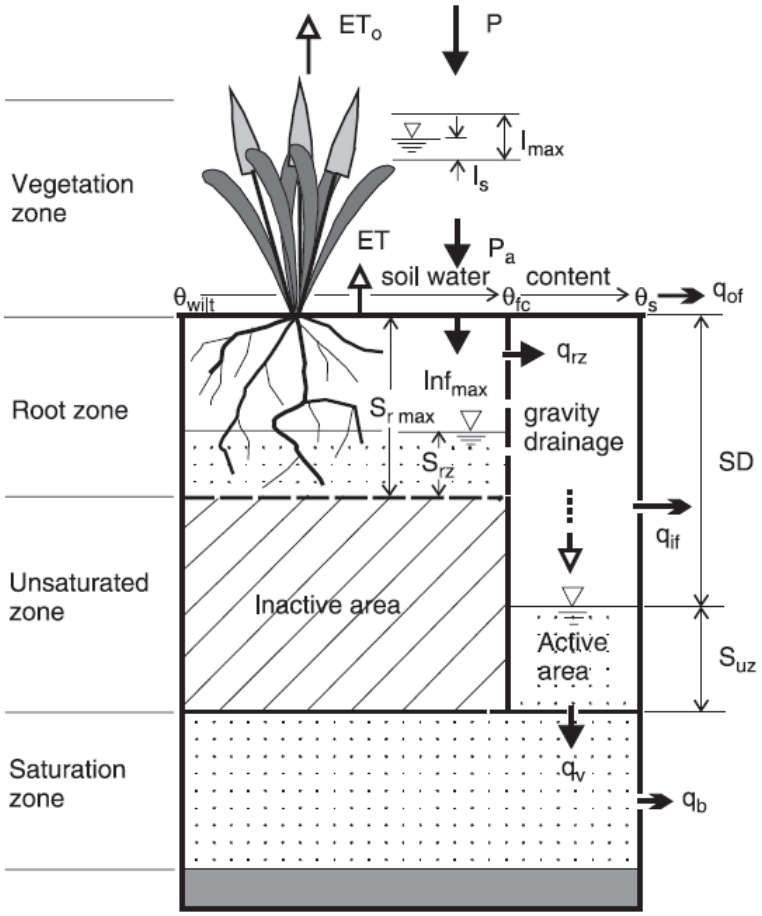
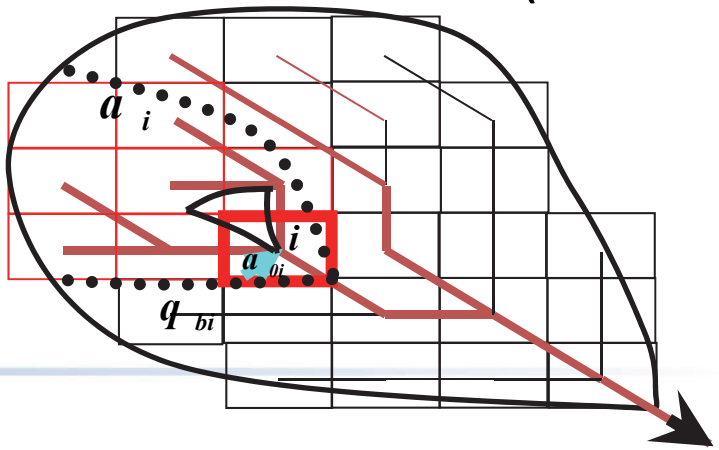


Figure 3. Runoff generation in a grid cell in the BTOP model (the vertical profile). P is the gross rainfall, ET_o is the interception evaporation, I_{max} is the interception storage capacity, I is the interception state, Inf_{max} is the infiltration capacity, P_a is the net rainfall on the land surface, ET is the actual evapotranspiration, $S_{r\,max}$ is the storage capacity of the root zone, S_{rz} is the soil moisture state in root zone, SD is soil moisture deficit in unsaturated zone, S_{uz} is the soil moisture state in unsaturated zone, q_{of} is the overland runoff, q_{if} is the saturation excess runoff, q_v is the groundwater recharge, and q_b is groundwater release. θ_{wilt}, θ_{fc}, θ_s are soil water content at wilting point, field capacity and saturation respectively

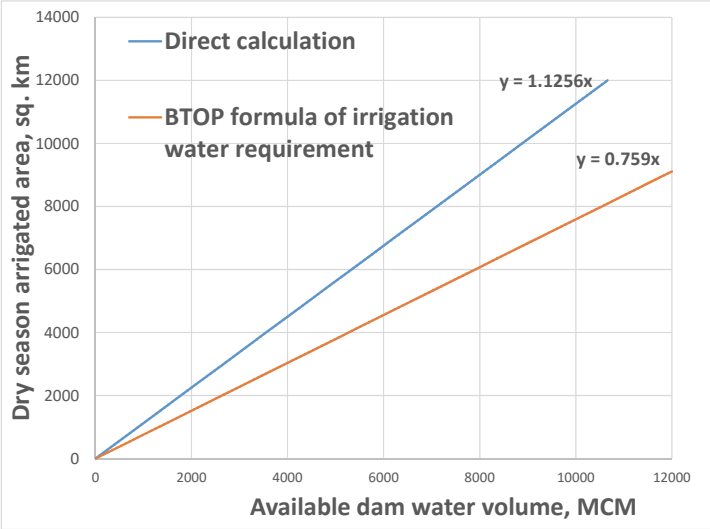
The BTOP model processes are:

- 24 hourly simulation using rainfall
- temperature input for snow module
- calculates Actual Evapotranspiration
- cell-by-cell variable properties
- root and unsaturated soil moisture
- saturated flow using Darcy's law

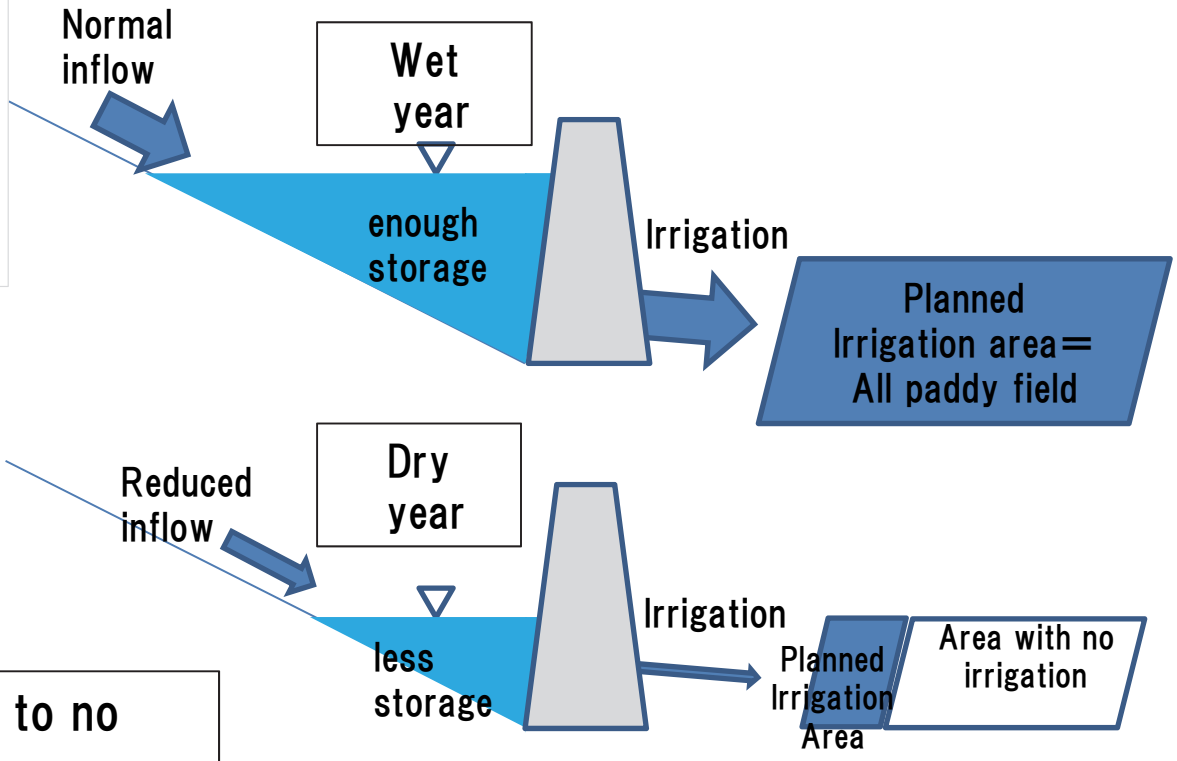
New research: river water diversion points (developed by Jun Magome at UY), Irrigation water release from dams, and Irrigation Water Module (started)



Proposed Method for Drought Risk Assessment



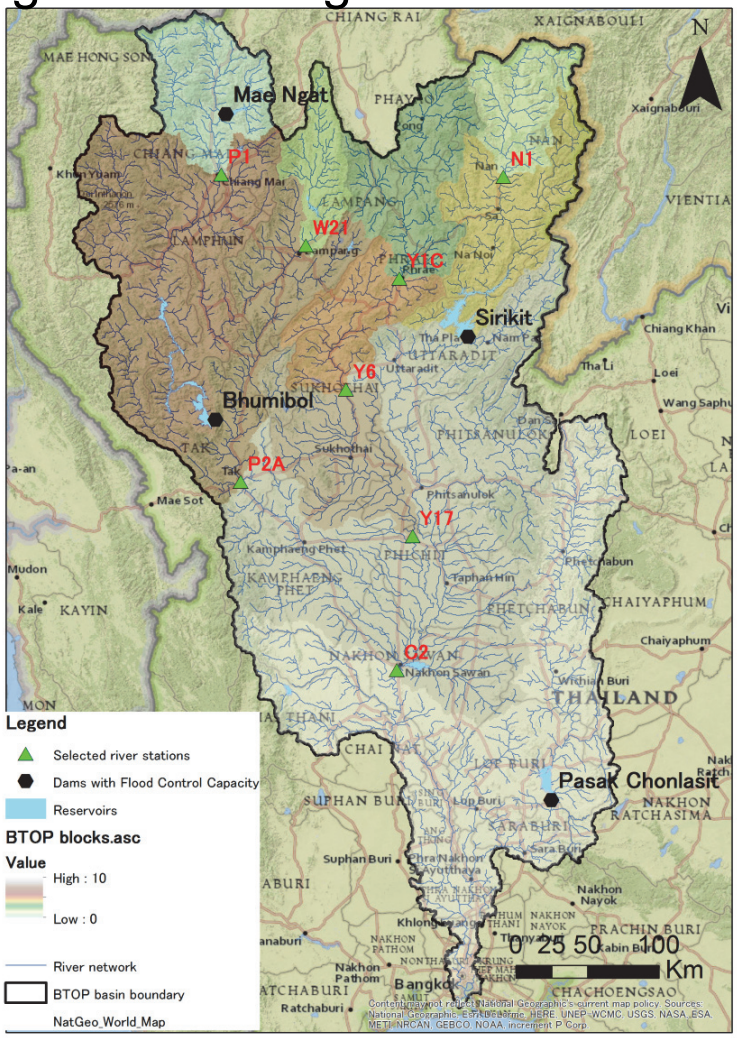
Irrigated area in dry season is decided with considering the reservoir water level at the beginning of dry season.

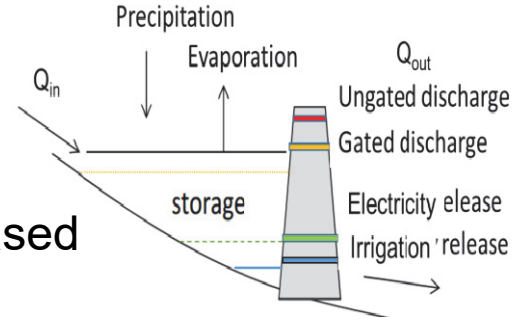


Drought Risk= Crop Loss due to no irrigation

Irrigated area of Bhumibol and Sirikit Dams are determined by BTOP model

Sirikit and Bhumibol Dams are simulated using Pantabangan Dam rule of gated and ungated flood control operation.





The BTOP Dam module determines irrigated area based on reservoir water volume and calculates daily discharge using

Irrigated Water Requirement (IWR) with FAO (1998):

$$IWR = IA \times (Kc \times PET - ER)/IE$$

where $IA[m^2]$ is the irrigated area
$K_c[-]$ is the cropping coefficient
$PET[m/day]$ is the potential evapotranspiration
$ER[m/day]$ is the effective rainfall
$IE[-]$ is the irrigation efficiency.

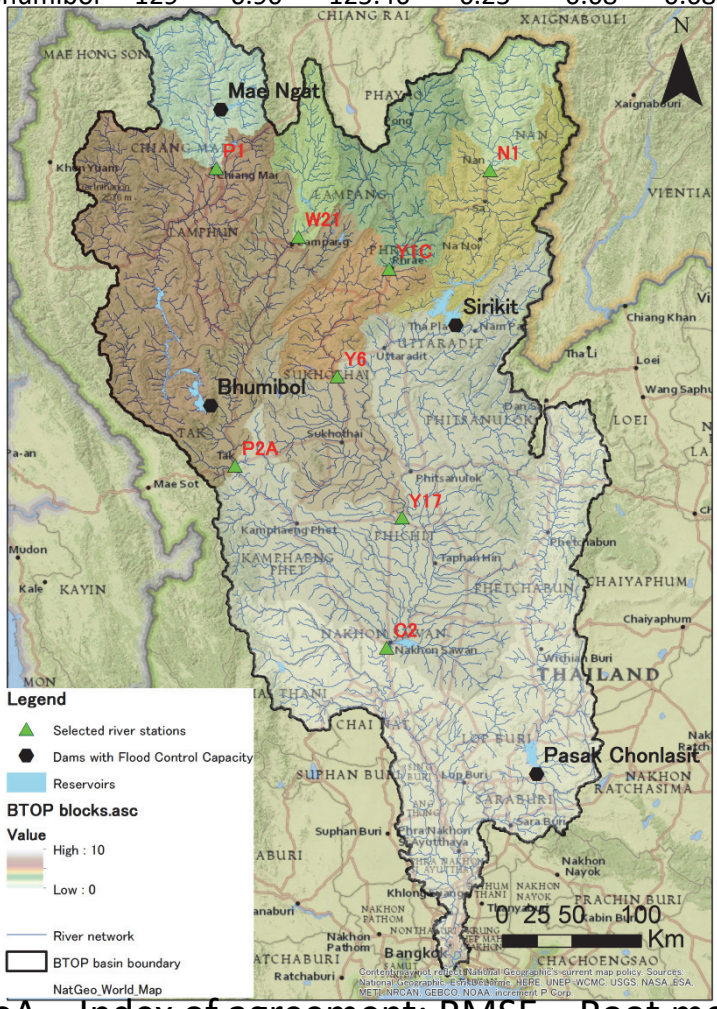
The available dam water volume – irrigated area relationship was constructed based on JICA (2013) report.

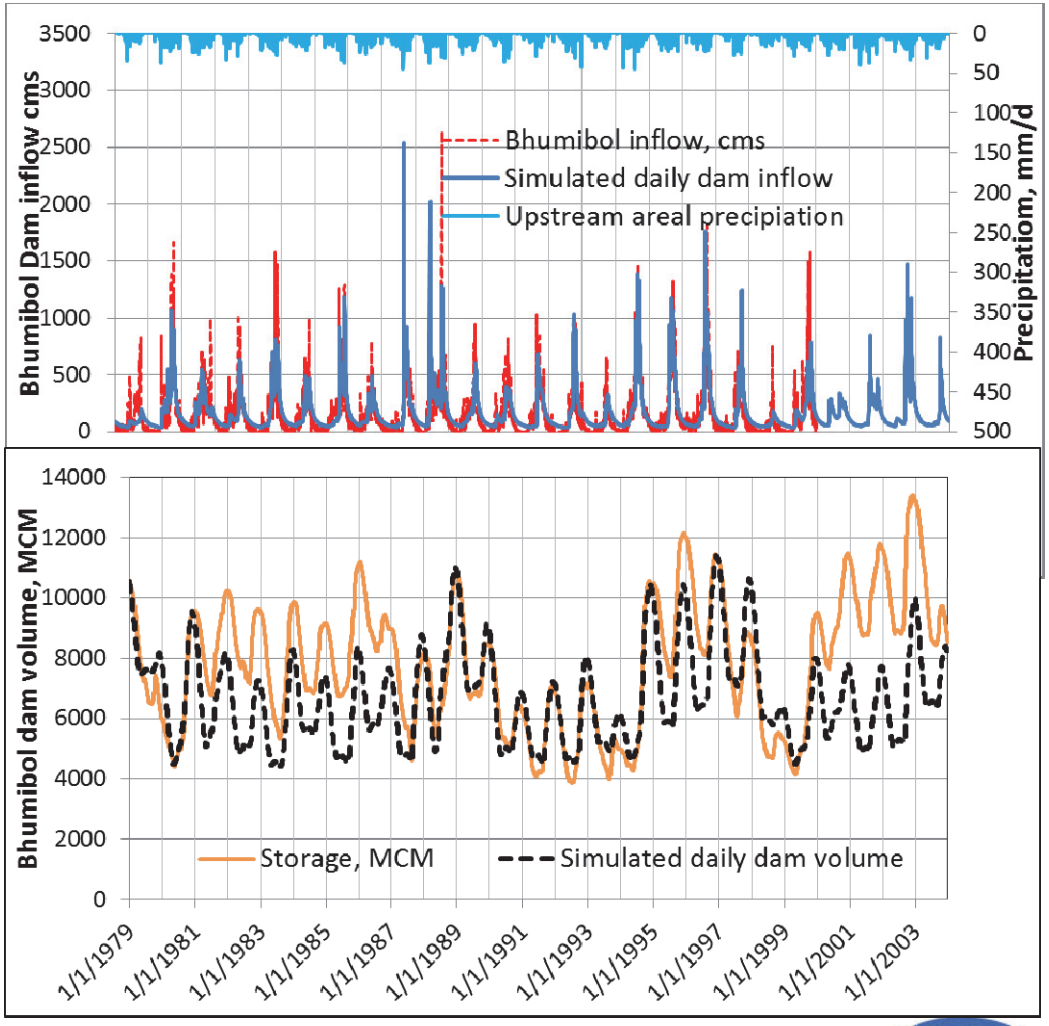
4. Simulation Results

Measured and BTOP simulated Bhumibol Dam inflows with APHRODITE precipitation

BTOP demonstrated good statistical performance in simulating Bhumibol inflows and volume

Location	Run	IoA	RMSE	MBE	R2	NSE
Bhumibol	129	0.90	125.46	6.25	0.68	0.68



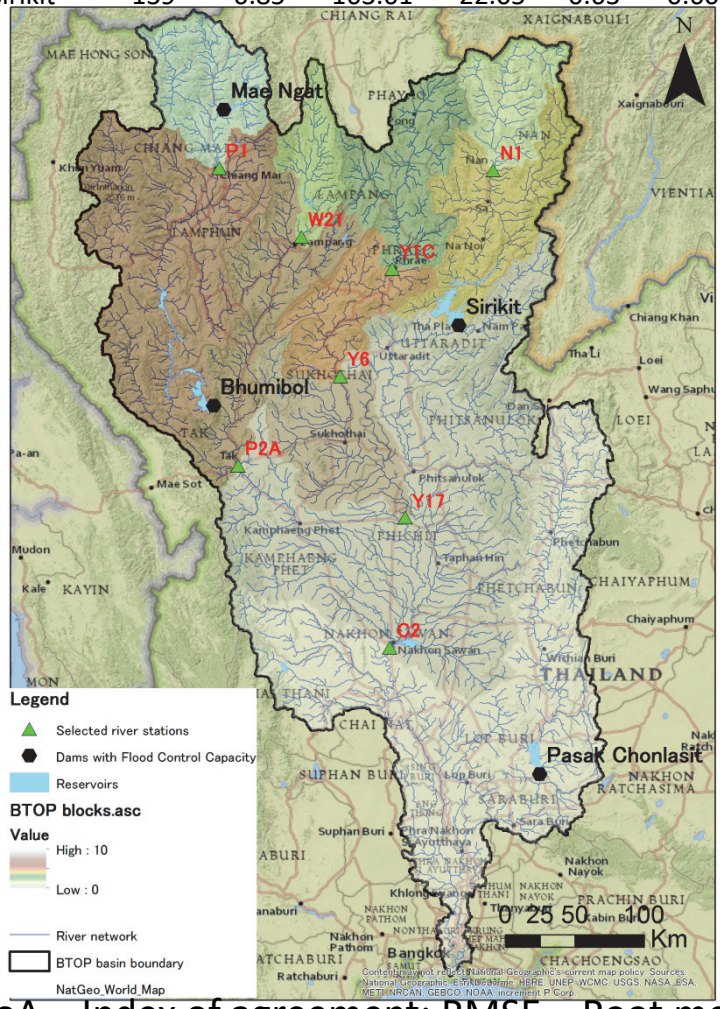


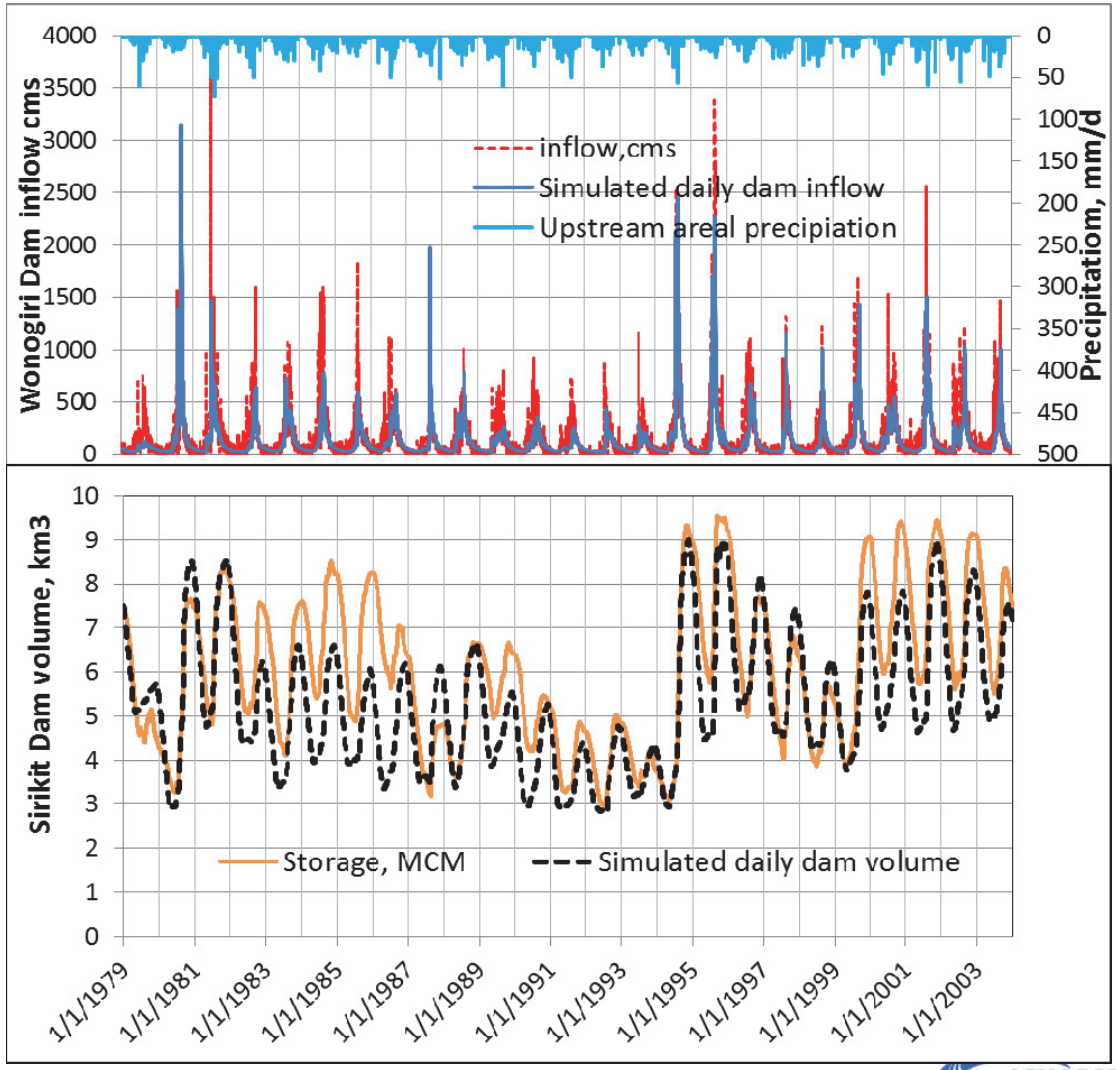
IoA = Index of agreement; RMSE = Root mean square error; MBE=mass balance error; R2 = R-squared; NSE= Nash-Sutcliffe efficiency

Measured and BTOP simulated Sirikit Dam inflows with APHRODITE precipitation

BTOP demonstrated good statistical performance in simulating Sirikit inflows and volume

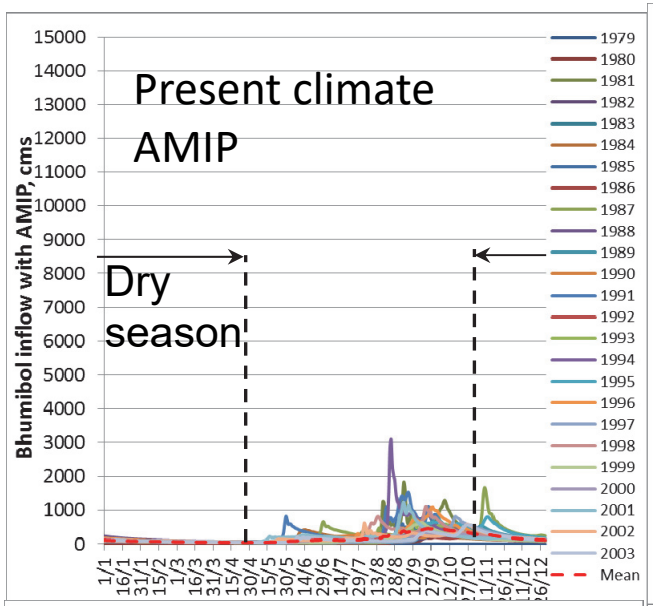
Location	Run	IoA	RMSE	MBE	R2	NSE
Sirikit	139	0.85	163.61	-22.05	0.63	0.60

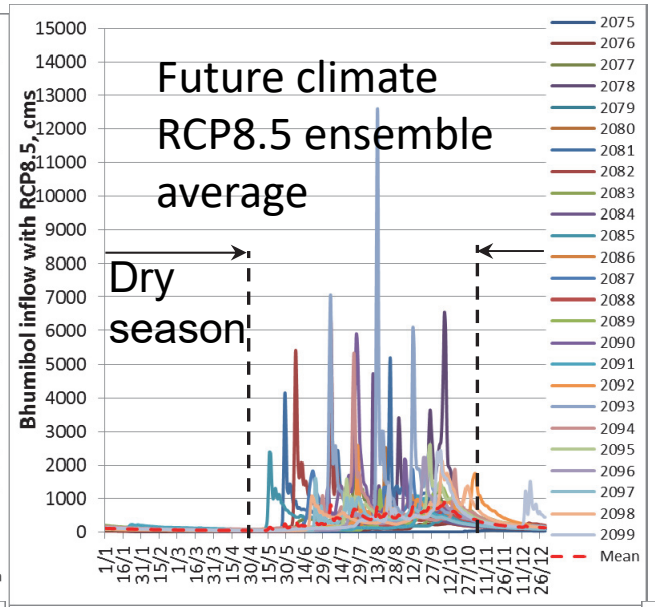




IoA = Index of agreement; RMSE = Root mean square error; MBE=mass balance error; R2 = R-squared; NSE= Nash-Sutcliffe efficiency

Comparison of inflow discharge into Bhumibol Dam for the present and the future climate

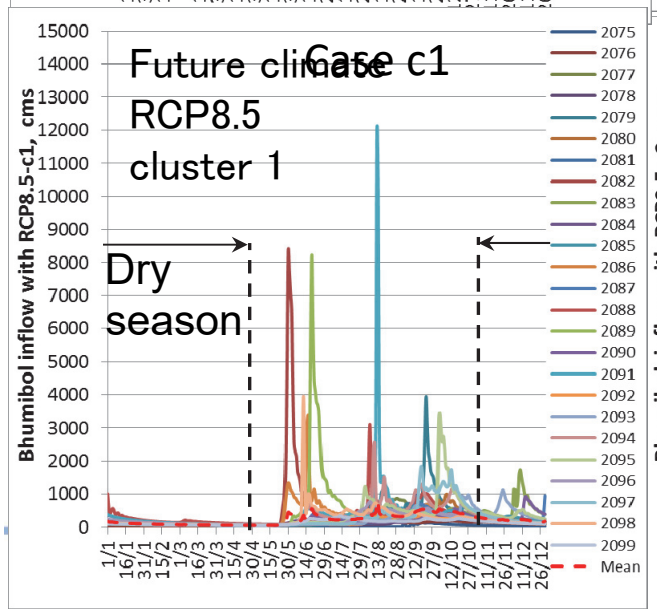


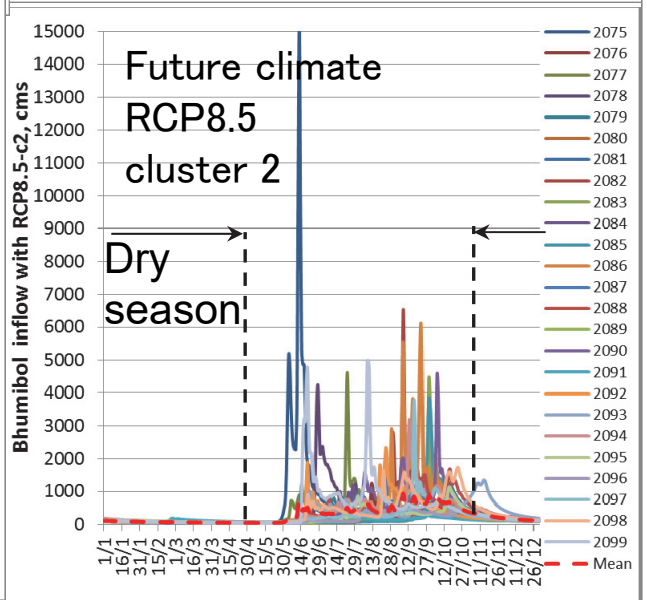


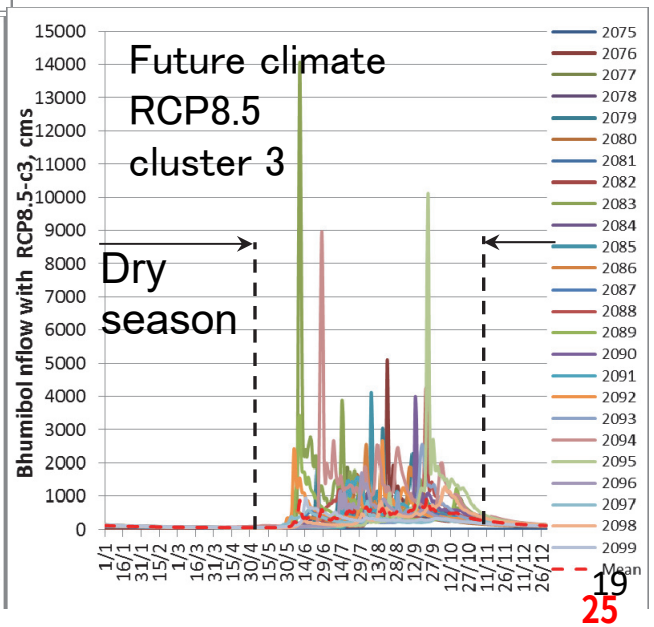
【Characteristics of the future climate】

-There is a possibility that a very large inflow may occur in the rainy season and there is a danger of becoming a large water related disaster.

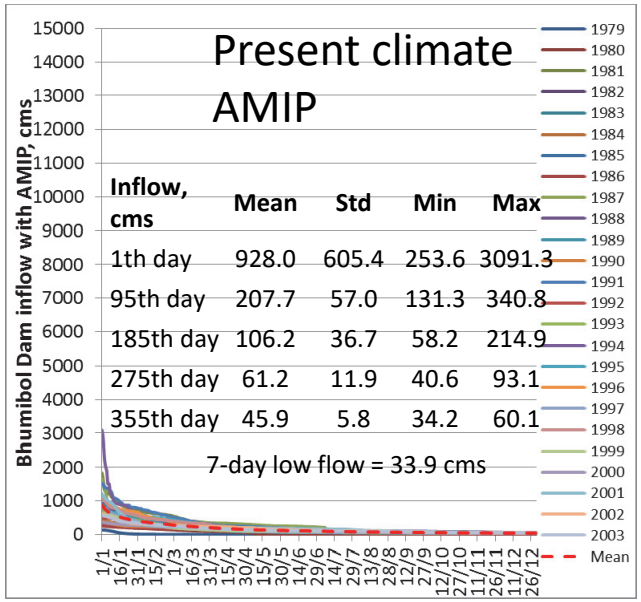
-Therefore, it is necessary to secure the flood control capacity as much as possible during the rainy season by changing the operation of the dam.



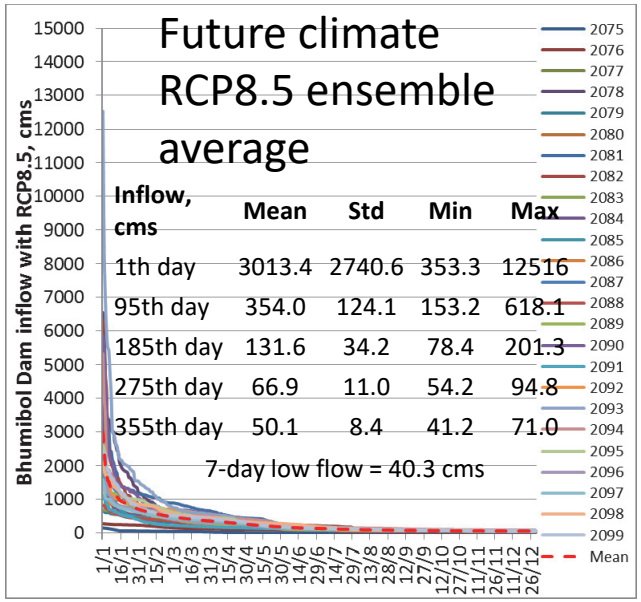




Comparison of inflow regime of Bhumibol Dam for the present and the future climate



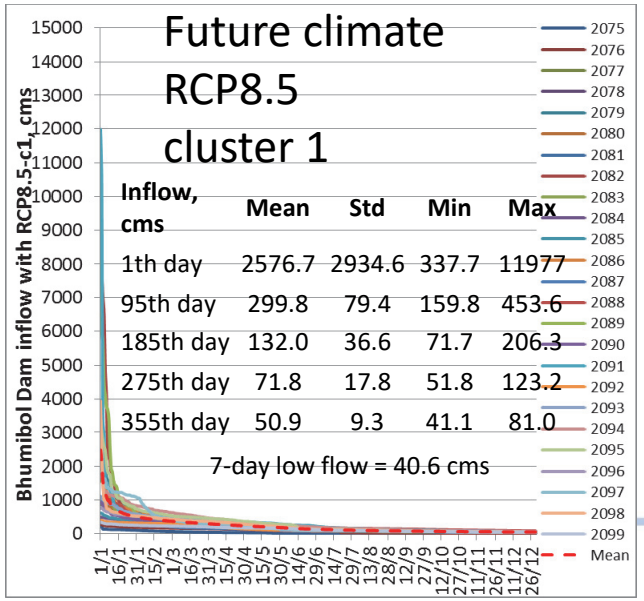
Inflow, cms	Mean	Std	Min	Max
1th day	928.0	605.4	253.6	3091.3
95th day	207.7	57.0	131.3	340.8
185th day	106.2	36.7	58.2	214.9
275th day	61.2	11.9	40.6	93.1
355th day	45.9	5.8	34.2	60.1



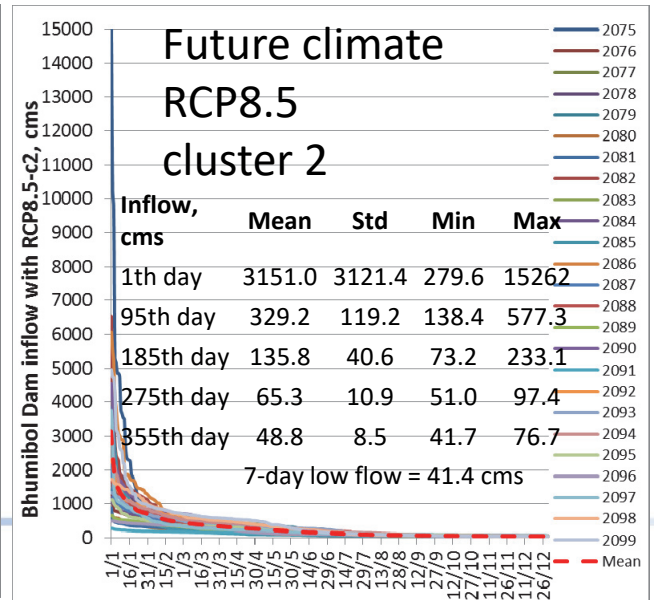
Inflow, cms	Mean	Std	Min	Max
1th day	3013.4	2740.6	353.3	12516
95th day	354.0	124.1	153.2	618.1
185th day	131.6	34.2	78.4	201.3
275th day	66.9	11.0	54.2	94.8
355th day	50.1	8.4	41.2	71.0

【Characteristics of the future climate】

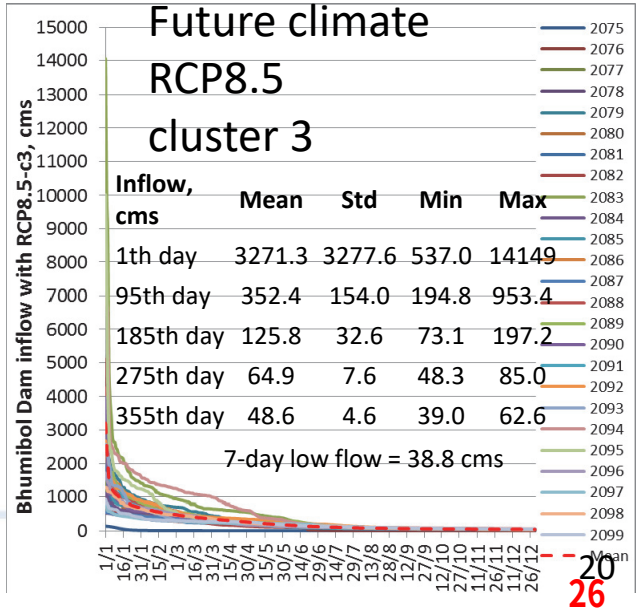
- The averaged annual maximum inflow tends to increase greatly..
- The averaged 95th inflow also tends to increase.
- The standard deviation also tends to increase in the future.
- The averaged 355th inflow slightly increase, on the other hand, the standard deviation increases greatly, so that there is a concern of frequency increase of severe drought situation.



Inflow, cms	Mean	Std	Min	Max
1th day	2576.7	2934.6	337.7	11977
95th day	299.8	79.4	159.8	453.6
185th day	132.0	36.6	71.7	206.3
275th day	71.8	17.8	51.8	123.2
355th day	50.9	9.3	41.1	81.0

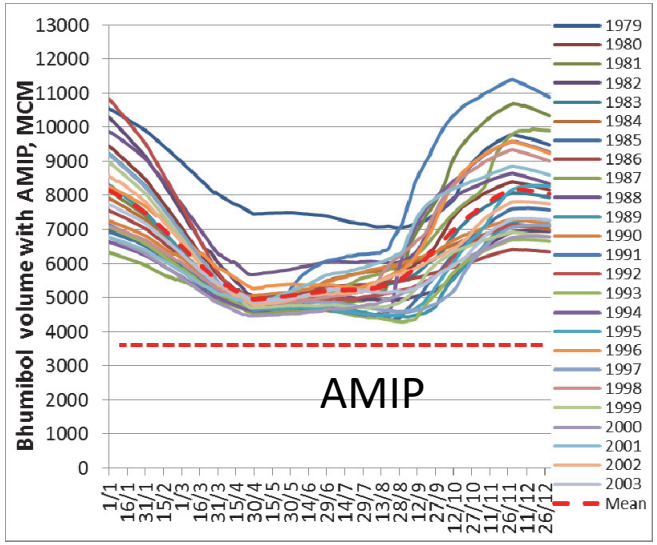


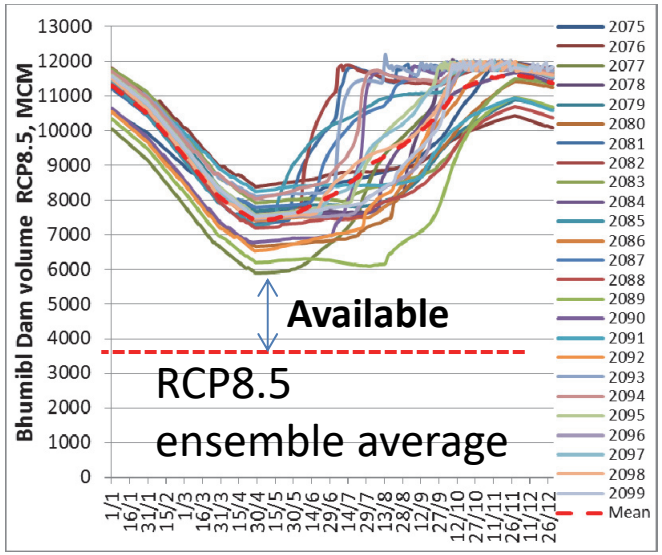
Inflow, cms	Mean	Std	Min	Max
1th day	3151.0	3121.4	279.6	15262
95th day	329.2	119.2	138.4	577.3
185th day	135.8	40.6	73.2	233.1
275th day	65.3	10.9	51.0	97.4
355th day	48.8	8.5	41.7	76.7



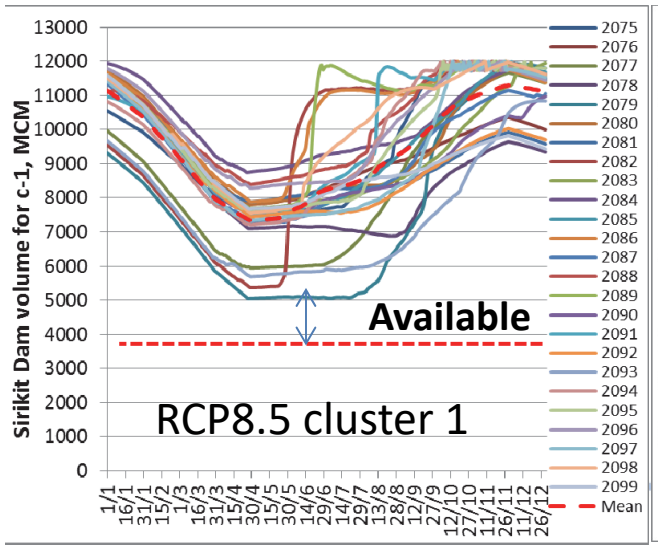
Inflow, cms	Mean	Std	Min	Max
1th day	3271.3	3277.6	537.0	14149
95th day	352.4	154.0	194.8	953.4
185th day	125.8	32.6	73.1	197.2
275th day	64.9	7.6	48.3	85.0
355th day	48.6	4.6	39.0	62.6

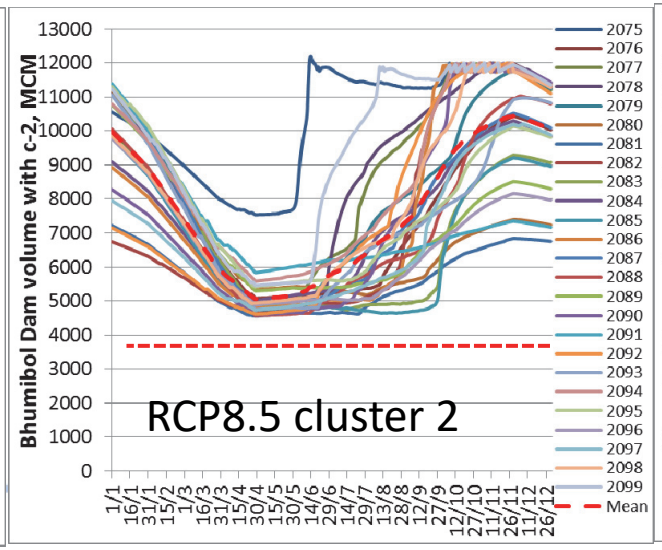
Prediction of the future change of Bumipol Dam Storage

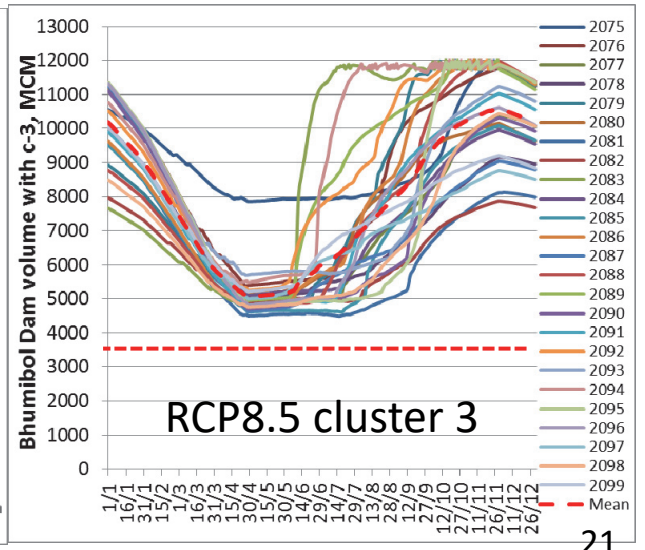




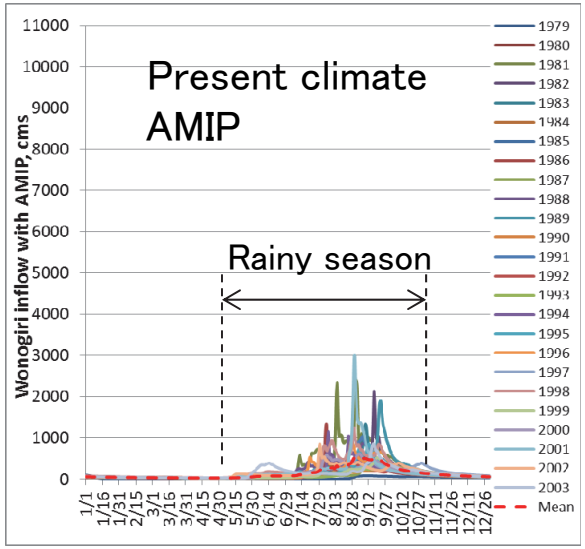
- In all cases of present and future climate the dam will not be empty.
- In the present climate, there is no ineffective release from reservoirs, but in future climates there will be a period of ineffective release in each case.
- It is possible to raise the release for water use by changing the dam operation rule, moreover it raises flood control function.

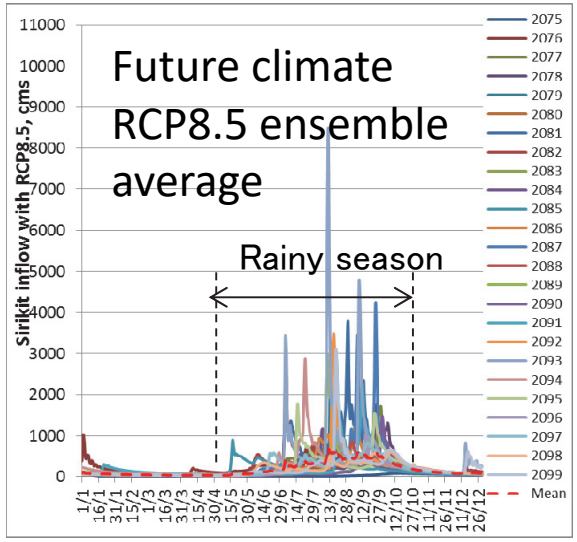






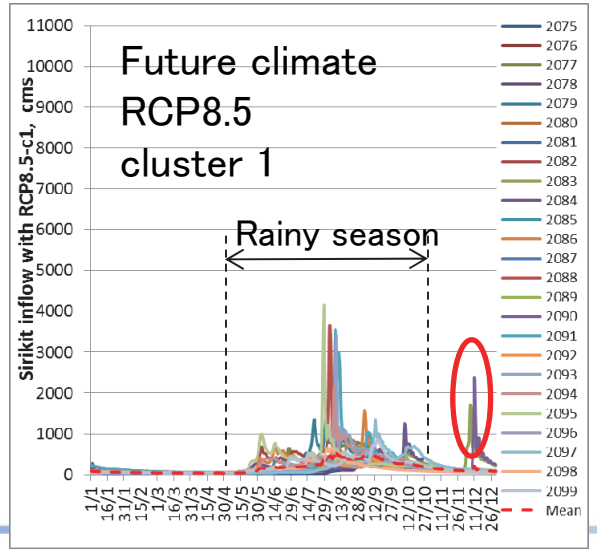
Comparison of inflow discharge into Sirikit Dam for the present and the future climate

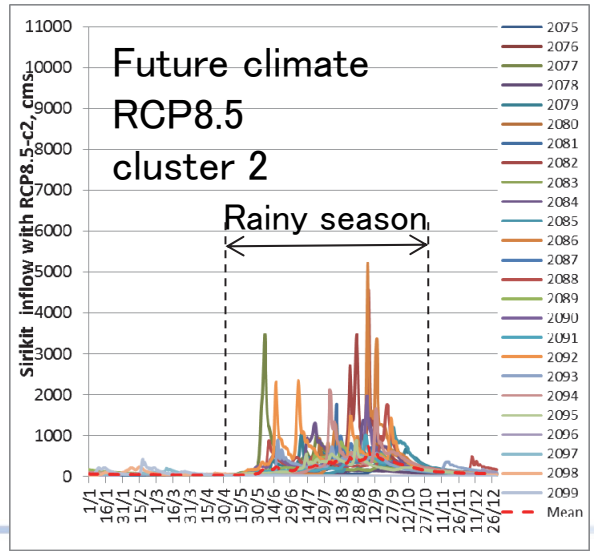


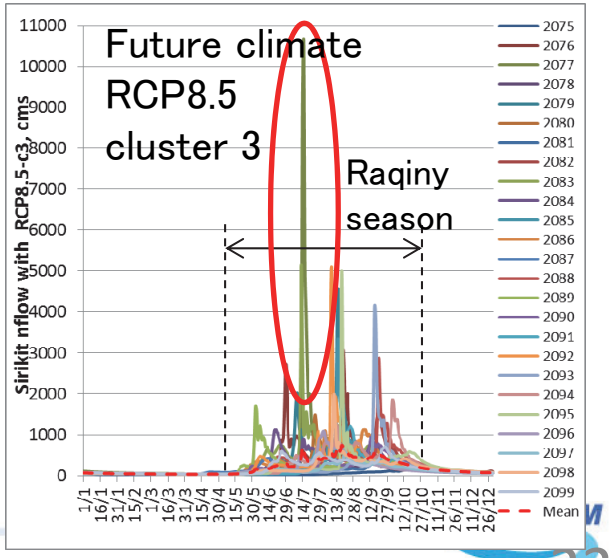


【Characteristics of the future climate】

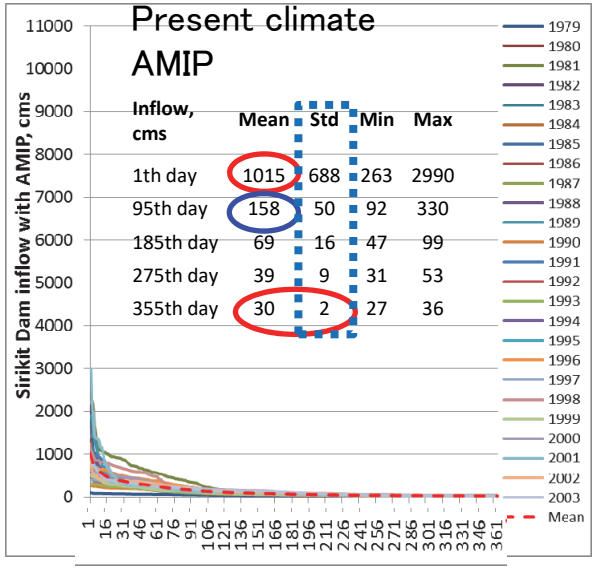
- Compared to the present climate, the climate in the future has a tendency to early start of the rainy season and to prolong it.
- In the future climate, there is a possibility of large rainfall and flooding even in the dry season (especially c-1).
- There is a possibility that a very large inflow may occur in the rainy season and there is a danger of becoming a large water related disaster (especially c-3).

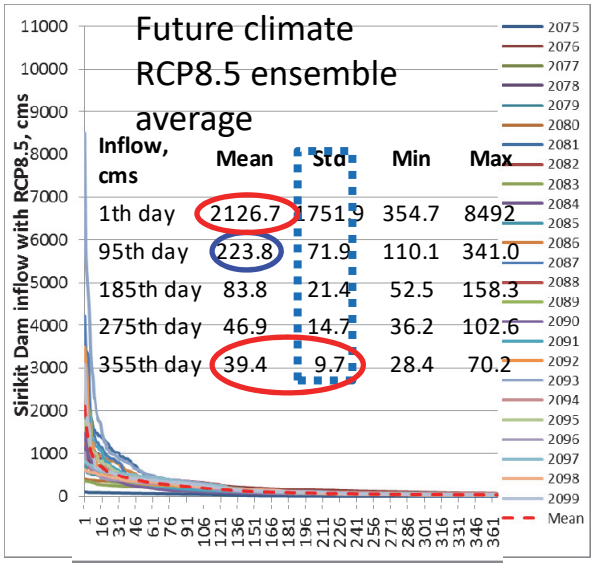






Comparison of inflow regime of Sirikit Dam for the present and the future climate





【Characteristics of the future climate】

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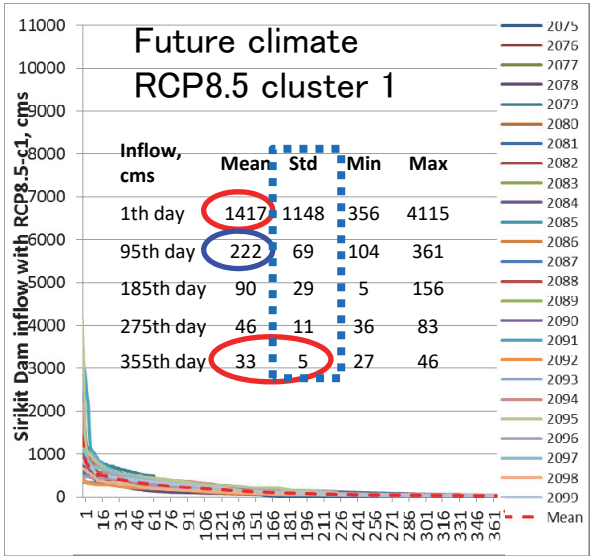
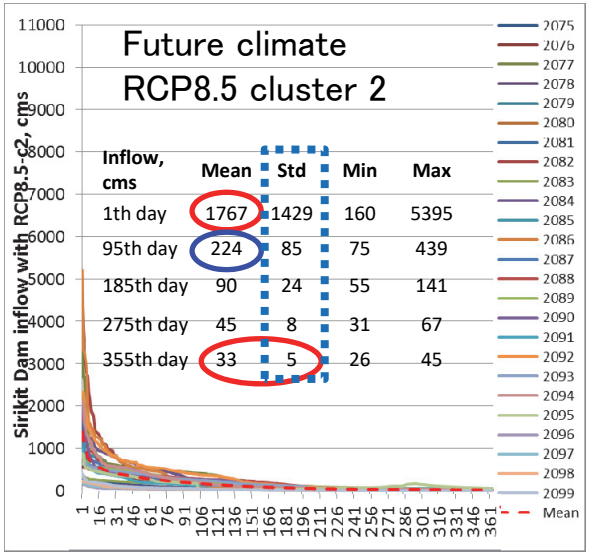
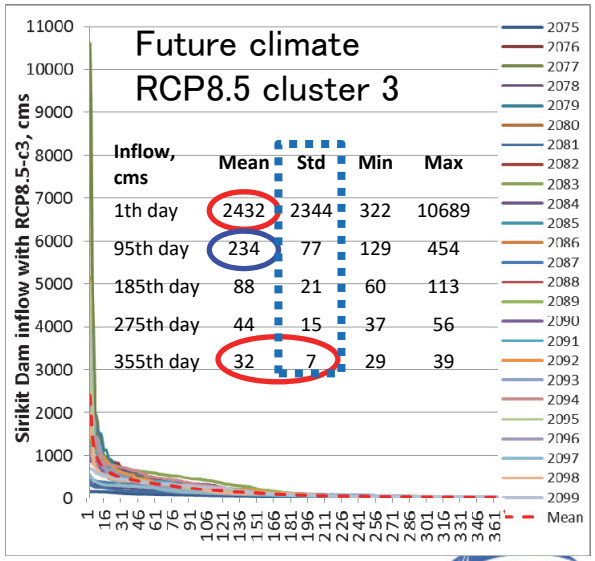
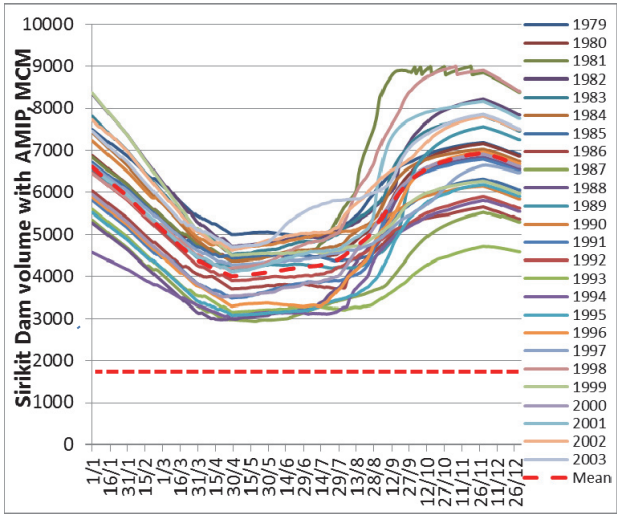
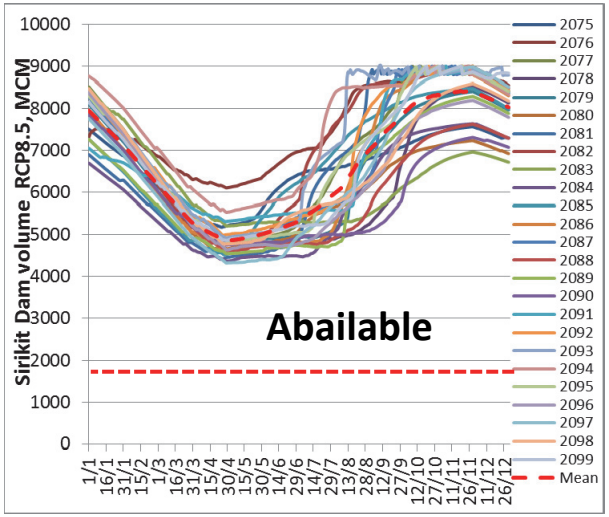






Comparison of inflow regime of Sirikit Dam for the present and the future climate





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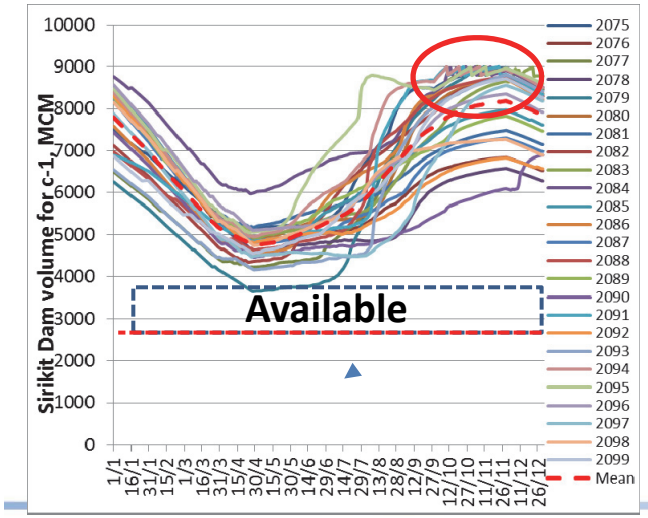
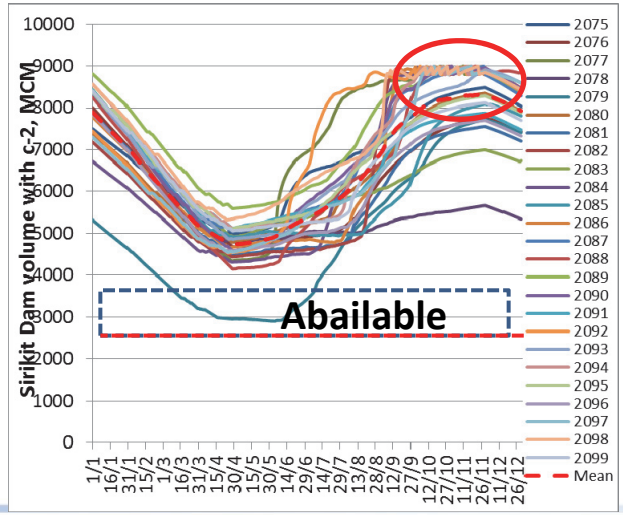
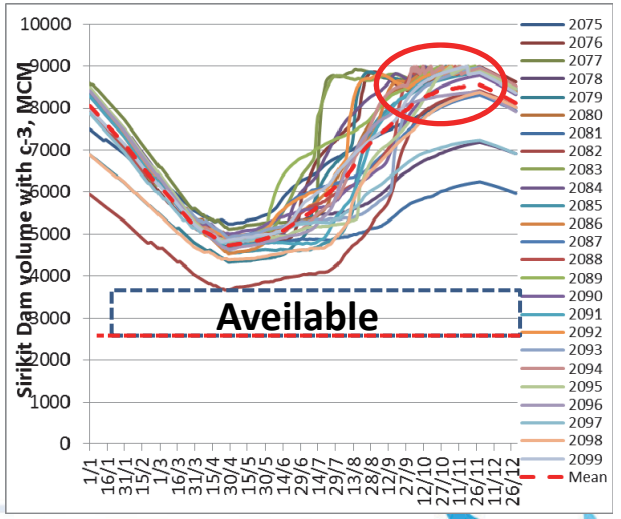
- It is possible to raise the release for water use by changing the dam operation rule, moreover it raises flood control function.







Calculation of irrigated area by Bhumibol Dam and Sirikit Dam (Irrigated Rice Crop in Dry Season)

Sirikit Dam

Sirikit Dam Scenario	Average, km^2	25%, km^2	75%, km^2	Maximum km^2	Minimum km^2
Local	4928.3	4500.0	5817.2	6601.7	3000.0
AMIP	4761.2	3714.7	5448.4	6583.9	2916.6
RCP8.5	6070.4	5809.3	6576.6	6729.2	4426.2
RCP8.5-c1	5819.0	5011.6	6623.4	6732.9	3460.7
RCP8.5-c2	6008.1	5701.3	6598.9	6730.2	2974.2
RCP8.5-c3	6253.7	6035.3	6667.8	6721.0	3629.3

Bhumibol Dam

Bhumibol Scenario	Average, km^2	25%, Km^2	75%, km^2	Maximum km^2	Minimum km^2
Local	4835.1	4041.1	5555.5	8075.6	1285.6
AMIP	4912.3	3683.4	6214.8	8528.3	2929.6
RCP8.5	7568.2	6307.6	9019.4	9202.7	4708.5
RCP8.5-c1	6899.7	5400.2	8686.8	9182.8	3707.7
RCP8.5-c2	7440.9	6151.0	8960.7	9206.3	3409.6
RCP8.5-c3	7637.8	6913.5	9025.4	9212.1	4570.3

Summation of two dams

Climate Scenario	Average, km2	25%, km2	75%, km2	Maximum km2	Minimum km2
AMIP	9673.4	7398.1	11663.2	15112.2	5846.2
RCP8.5	13638.6	12116.9	15596.1	15931.9	9134.7
RCP8.5-c1	12713.7	10406.1	15303.4	15911.1	7161.3
RCP8.5-c2	13448.9	11852.4	15559.6	15936.5	6383.8
RCP8.5-c3	13891.5	12948.7	15693.2	15933.2	8199.6

The future / current irrigation area ratio, combined of 2 dams,
it is 1.41 times (13638.6 / 9673.4) on average with RCP 8.5.
Furthermore, the overall increase greatly in any SST.
Further increase in irrigation area is anticipated by changing dam operation rules and effectively utilizing water resources.

5. Conclusion

1) In the future climate, there is a possibility of large rainfall and flooding even in the dry season.
2) There is a possibility that a very large inflow may occur in the rainy season and there is a danger of becoming a large water related disaster.
3) In the present climate, there is no wasteful release of water resources, but in future climates there will be a period of wasteful discharge.
4) In the future climate, it is possible to raise the release for water use by changing the dam operation rule, moreover it raises flood control function.
5) Further increase in irrigation area is anticipated by changing dam operation rules.

Reference

1) Gusyev M.A., Hasegawa A., Magome J., Sanchez P., Sugiura A., Sawano H. and Y. Tokunaga (2016). Evaluation of water cycle components with standardized indices under climate change in the Pampanga, Solo and Chao Phraya basins. Journal of Disaster Research 11(6): 1091-1102, doi: 10.20965/jdr.2016.p1091

2) Hasegawa A., Gusyev M. A., and Y. Iwami (2016). Meteorological Drought and Flood Assessment using the Comparative SPI Approach in Asia under Climate Change. Journal of Disaster Research 11(6): 1082-1090, doi: 10.20965/jdr.2016.p1082

Feb. 25, 2017

Drought Risk Analysis of Mekong River Basin
(North East Thailand)

ICHARM

Strategy for Analysis

Object :

- Predict Rice production in future in North East Thailand to investigate socio-economic impact of drought

Difficulty :

- There is not an appropriate reservoir related to irrigation area downstream. So, we need to build or find a predicting model for rice planted area.

Methodology :

- Apply Prediction model of IRE [*2] for Rice Planted Area Prediction[*1] and validate with Past Rice Planted Area data and Rainfall data.
- After validation, apply IRE model to predict Rice Planted Area using future rainfall data.

*1) TANIGUCHI, MASUMOTO et al: Development of a Distributed Water Circulation Model Incorporating Various Paddy Water Uses, PART1: A Model for Estimating Cropping Area and Pattern, Journal of Japan Society of Hydrology and Water Resources, Vol. 22, No.2 Mar.2009

*2) Institute of Rural Engineering, National Agriculture and Food Research Organization(NARO)

Obtained Data for Analysis

Item	Resolution	Duration	Reference
Planted Area of Rice	Each Province, every year, Major(Wet season) and 2nd Rice(Dry season)	1980-2013	Agriculture Economic Agency, Ministry of Agriculture and Cooperation
Harvested Area of Rice	Each Province, every year, Major(Wet season) and 2nd Rice(Dry season)	1980-2013	Agriculture Economic Agency, Ministry of Agriculture and Cooperation
Rice Production	Each Province, every year, Major(Wet season) and 2nd Rice(Dry season)	1980-2013	Agriculture Economic Agency, Ministry of Agriculture and Cooperation
Rainfall	15 arc minute 20km	Past(1950-2007) Future	APHRODITE(for Past) MRI-AGCM3.2(for Future)
Land Use for Crops	5 arc minute Each month, Rainfed area and Irrigate area	Average of Duration from1998 to 2000	MIRCA2000

THAILAND Source: Agricultural Statistics of Thailand

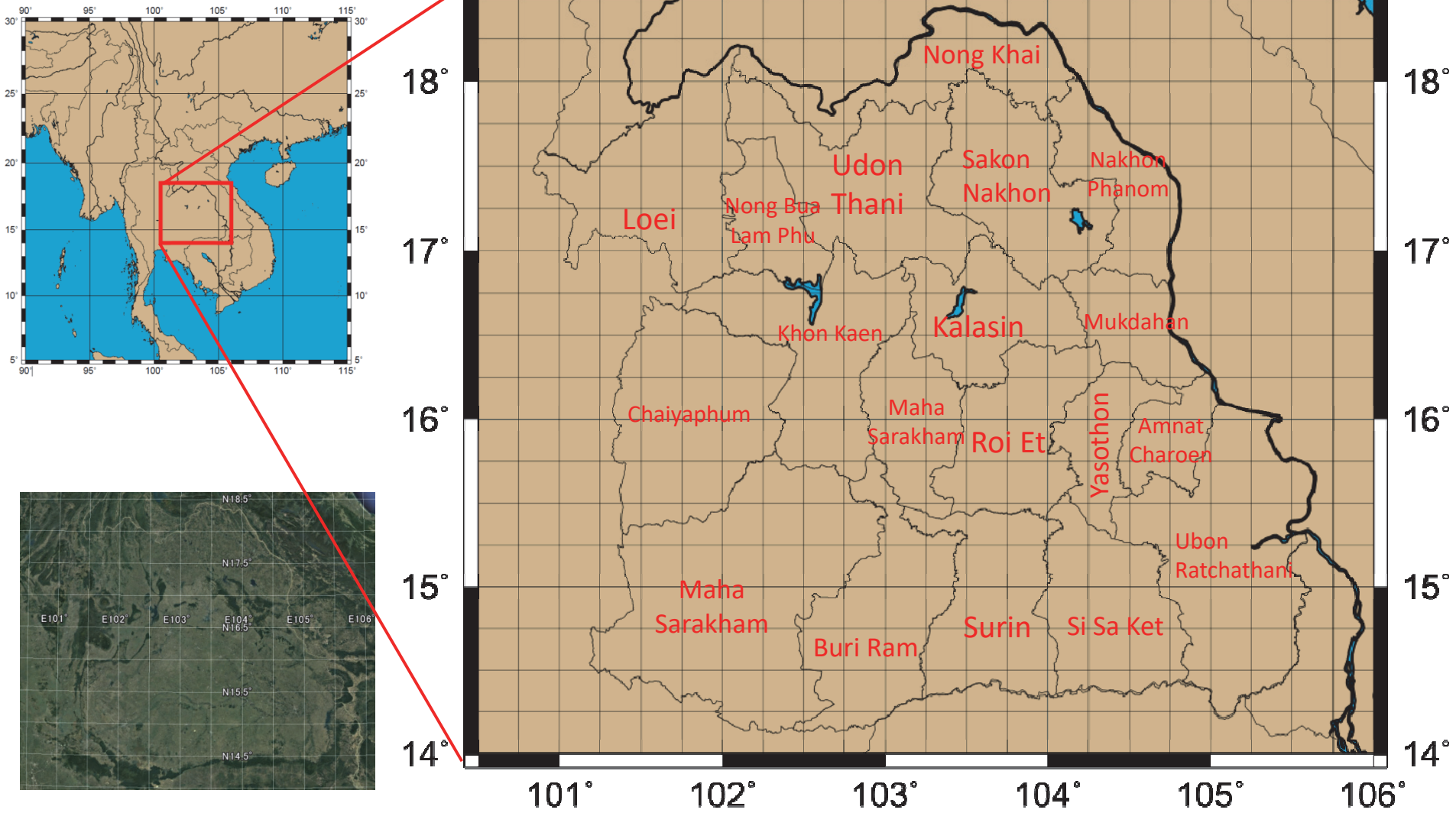
Irrigated crop calendar **2007**

Irrigated crops	Area	Crop area as percentage of the full control actually irrigated area by month											
	1000 ha	J	F	M	A	M	J	J	A	S	O	N	D
Rice one SECOND RICE(Dry Season)	2 327	46	46								46	46	46
Rice two MAJOR RICE(Wet Season)	3 941					78	78	78	78	78			

References

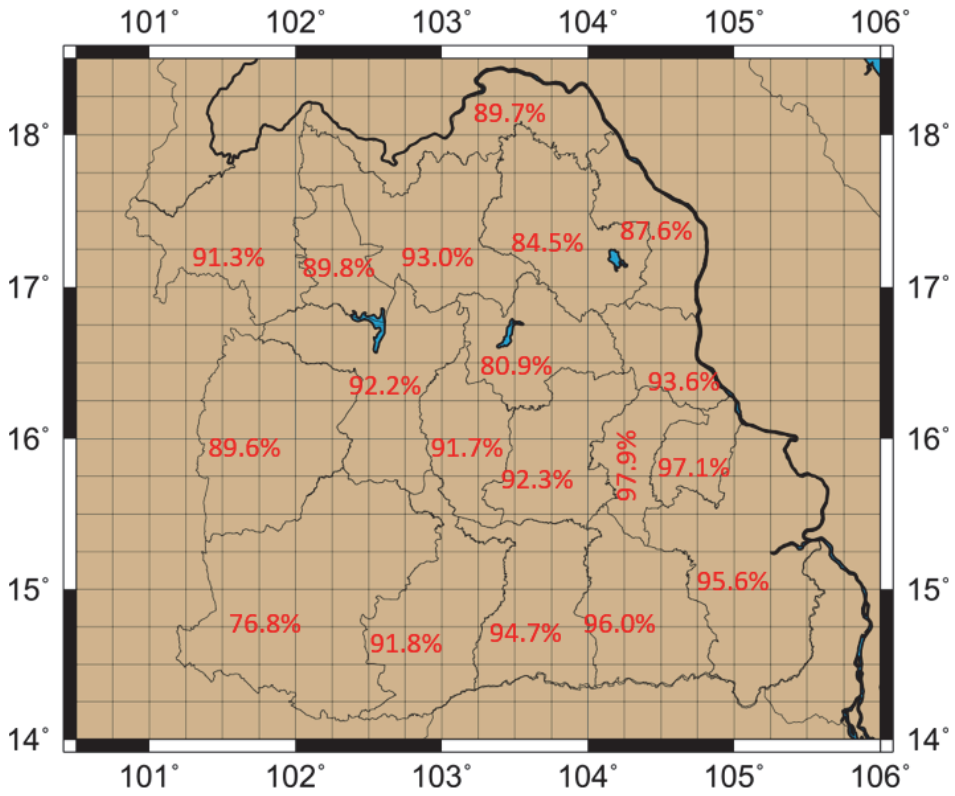
FAO. 2012. AQUASTAT, FAO's global information system on water and agriculture. http://www.fao.org/nr/aquastat

Overview of Target Area(Location)



Northeast Thailand (19 Provinces)

Overview of Target Area(Type of Rice Field)



Proportion of Area of Rainfed Rice Field in Rice Filed in each province

Rainfed Rice field dominates in this area compared to irrigated Rice field.
That is why we focus on Wet Season.

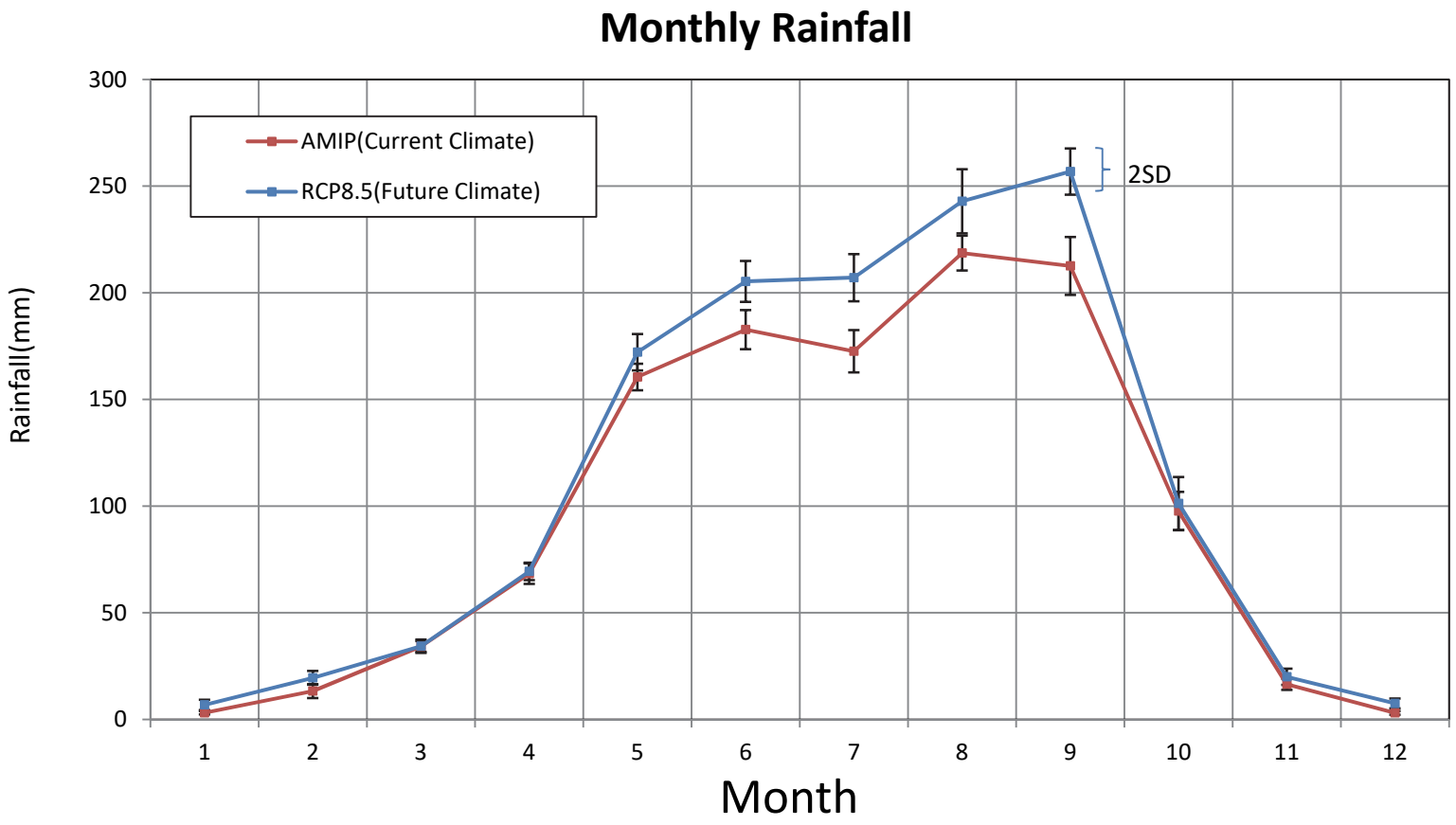
THAILAND
Irrigated crop calendar **2007**

Irrigated crops	Area	Crop area as percentage of the full control actually irrigated area by month											
	1000 ha	J	F	M	A	M	J	J	A	S	O	N	D
Rice one	2 327	46	46								46	46	46
Rice two	3 941					78	78	78	78	78			

References

FAO. 2012. AQUASTAT, FAO's global information system on water and agriculture. http://www.fao.org/nr/aquastat

Overview of the Target Area(Rainfall)

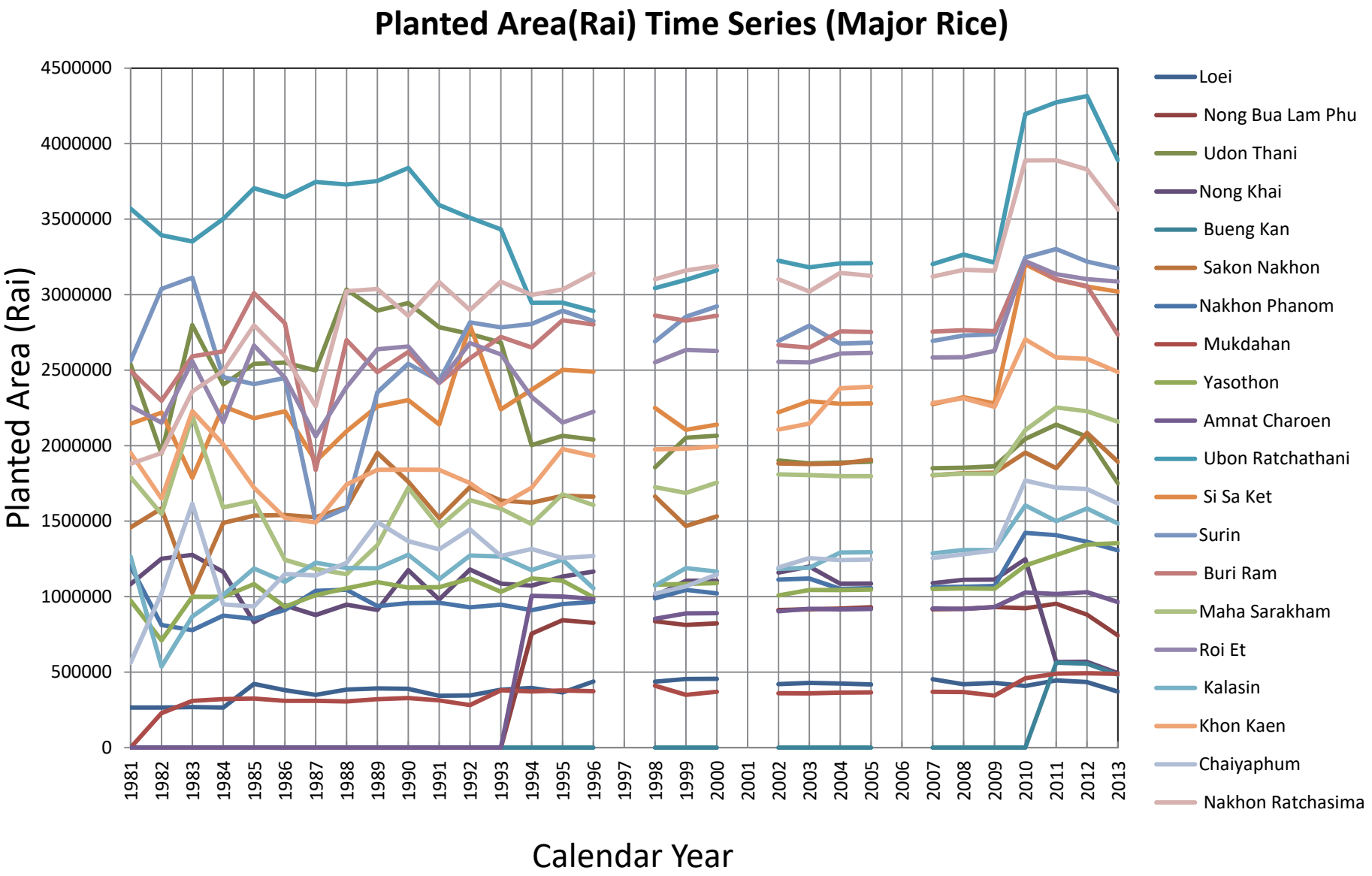


Annual Average Rainfall

AMIP(Current Climate)	1183 mm
RCP8.5(Future Climate)	1343 mm

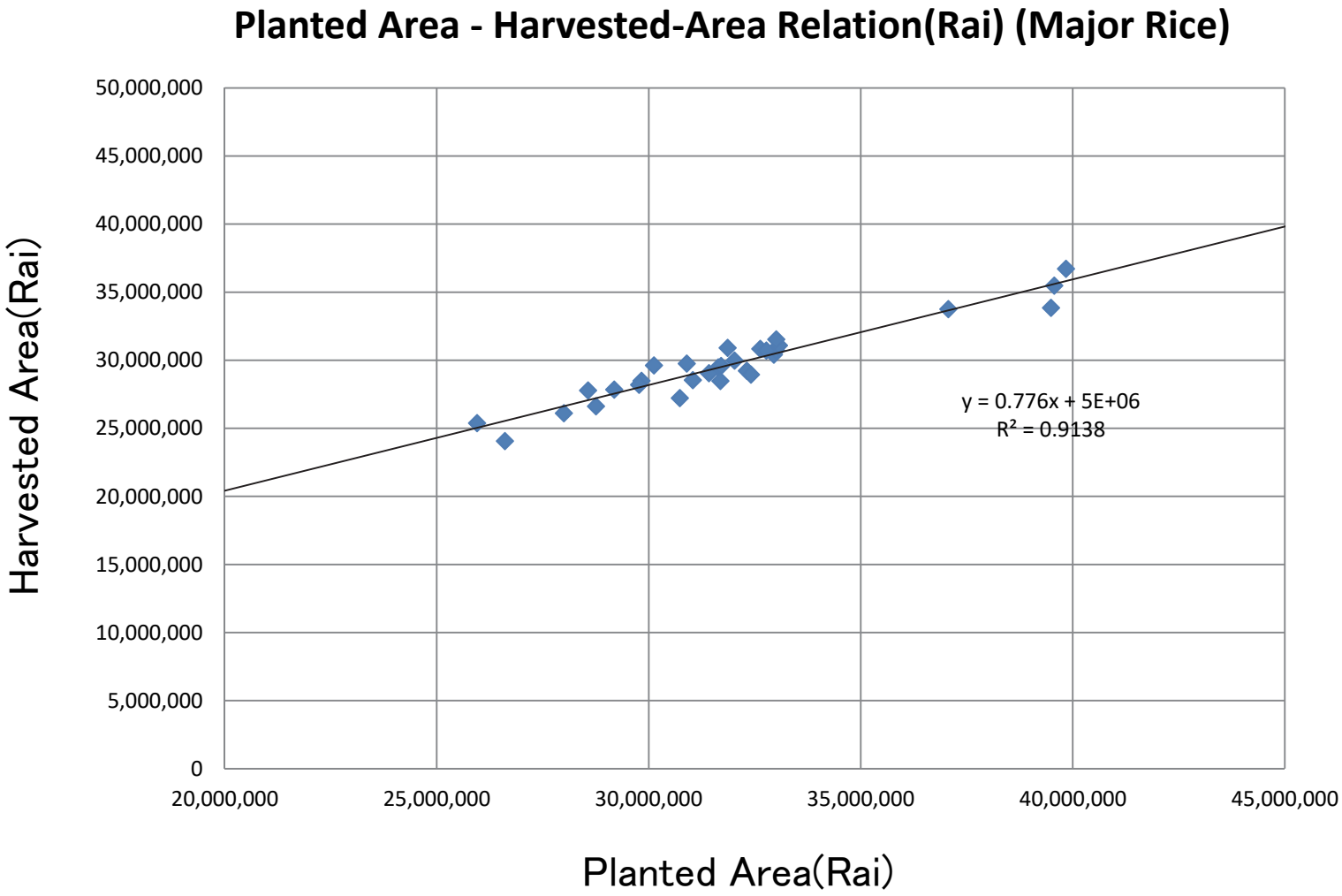
Average Rainfall in Mekong River Basin (North East Thailand)

Time Series of Planted Area of Rice in Wet Season



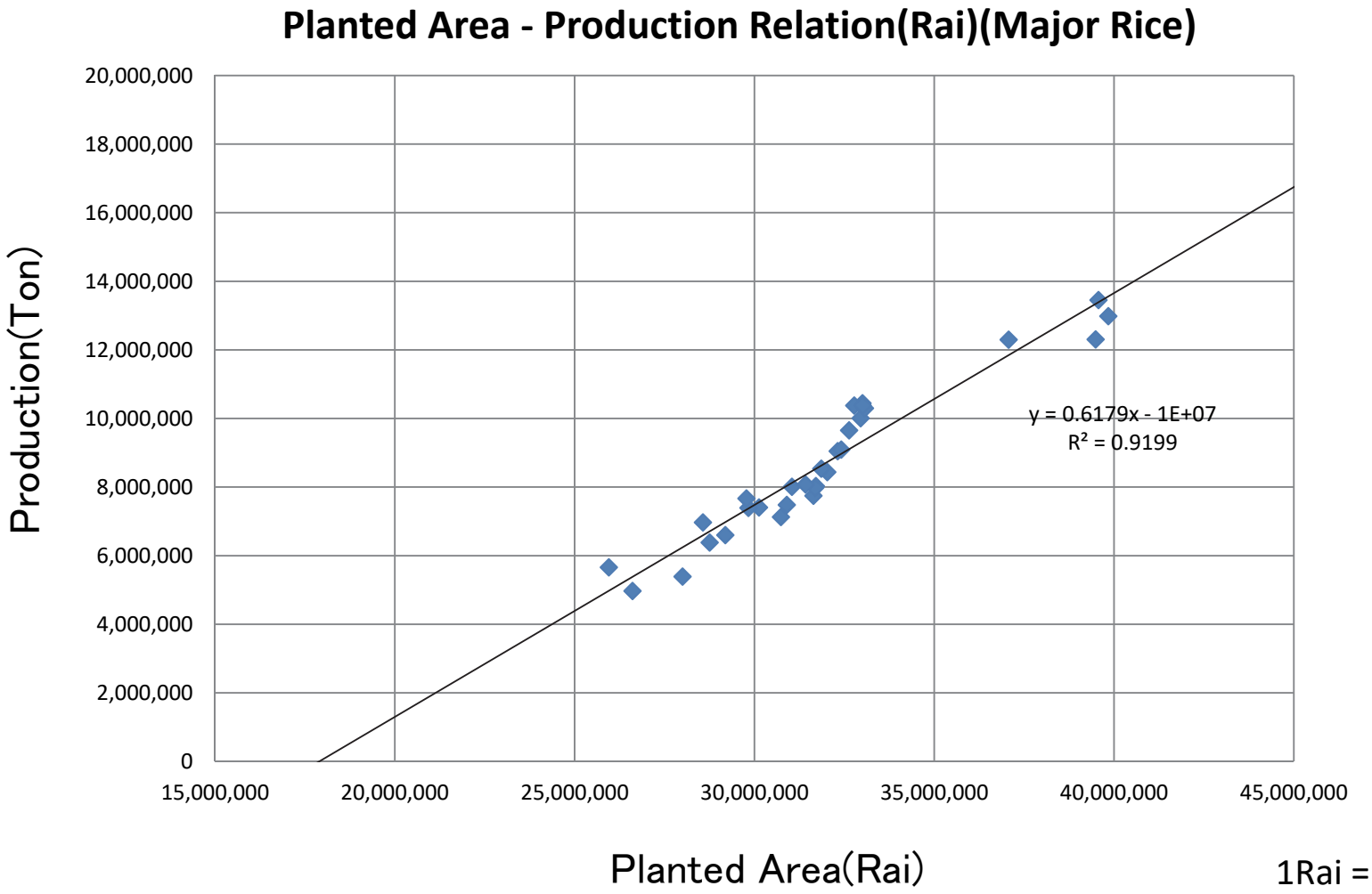
1 Rai = 0.16ha

Relationship between Planted Area and Harvested Area in Wet Season



1Rai = 0.16ha

Relationship between Planted Area and Rice Production in Wet Season



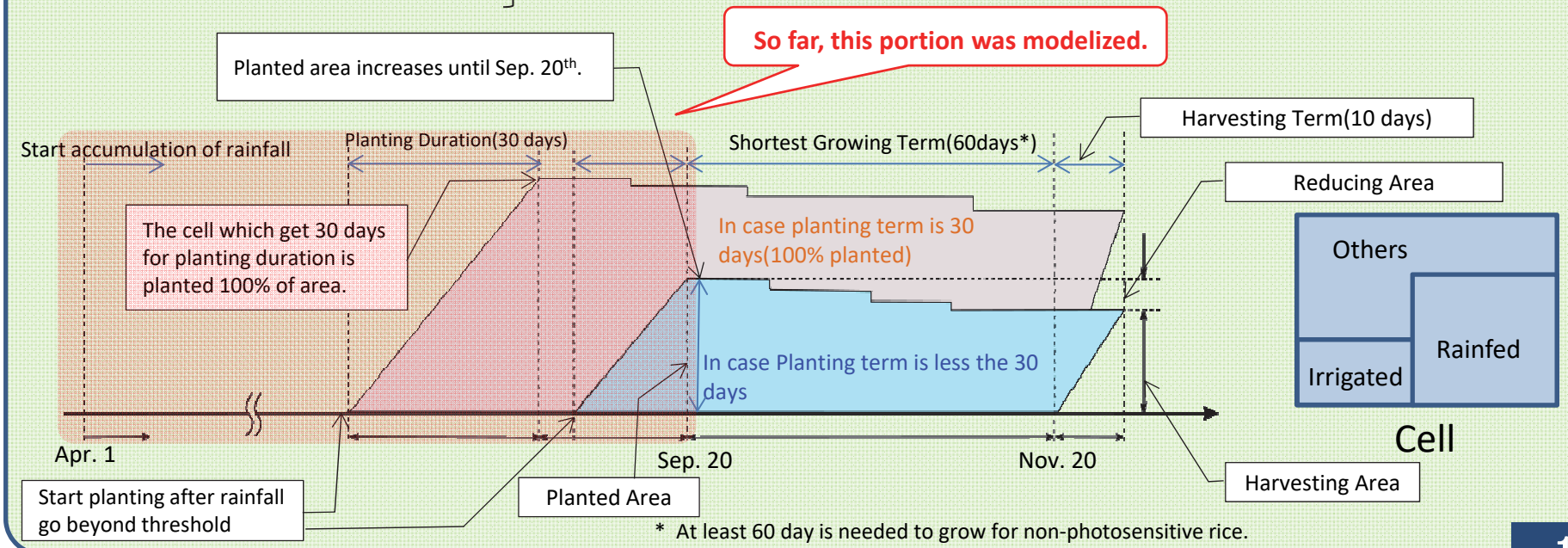
1Rai = 0.16ha

High correlation between planted area and rice production was found.

Applied IRE Model (Wet Season)

- Divide whole basin into cells. Allocate area of irrigated field and rainfed field to each cell.
- Calculate accumulation of rainfall from Apr. 1st. Set threshold of accumulated rainfall for start planting for each type of filed(Irrigated, Partial Rainfed Full Rainfed). In case accumulation of rainfall surpass the threshold, it start planting.
- Planting term for 100% planting is 30 days.
- Planted area increases by 1/30 area per day until Sep 20th. Planting stop on Sep 20th to ensure growing time -60 days. So that Planted Area at the date of Sep. 20th is the planted area in that year.
- Threshold of Accumulated Rainfall for Start Planting

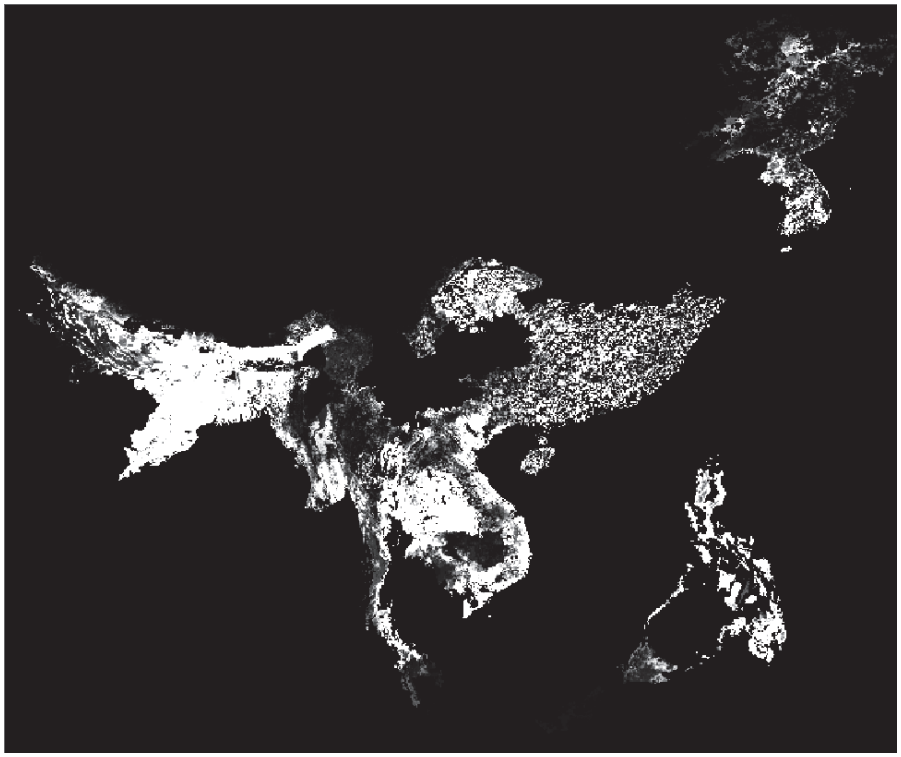
Irrigated:	500mm	Set by existing survey
Partial Rainfed:	341mm	Set based on threshold value of Irrigated rice filed using ratio of Partially Rainfed and Full Rainfed.
Full Rainfed:	625mm	



Land Use Classification(Allocation of Maximum Planted Area)

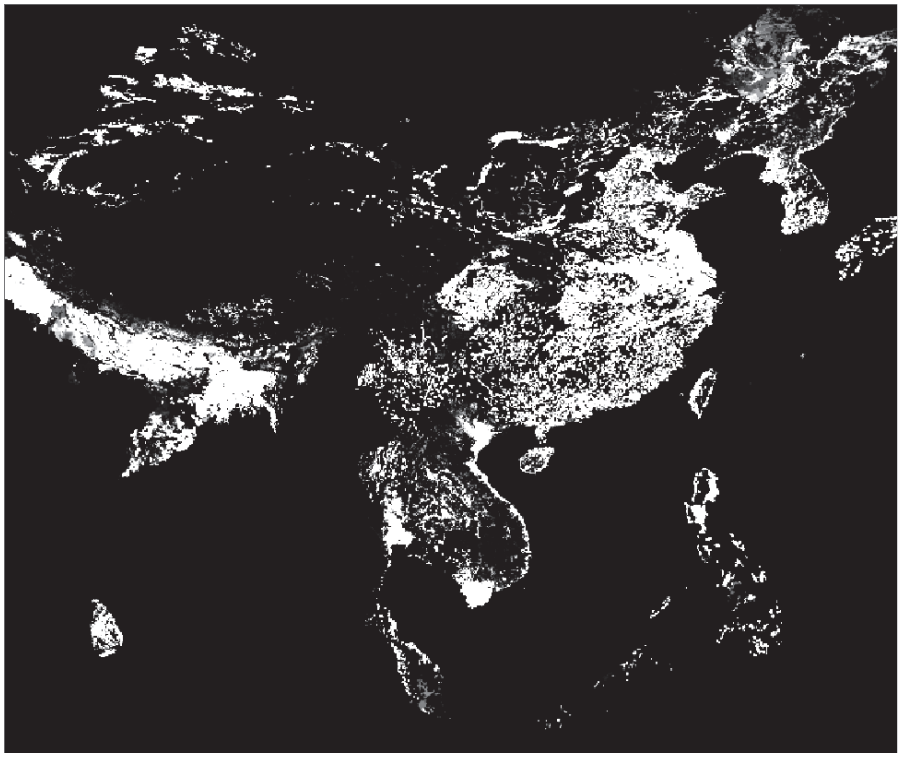
MIRCA2000 :

Resolution: 5 arc sec (9.2km on equator)
Each sell store irrigated rice field and rainfed rice field of each month around year 2000(average of 1998-2002)
Calculate Maximum Planted Area for irrigated and rainfed rice field.



Distribution of Rainfed (June)

Value
High : 7206
Low : 0 (Hectare)



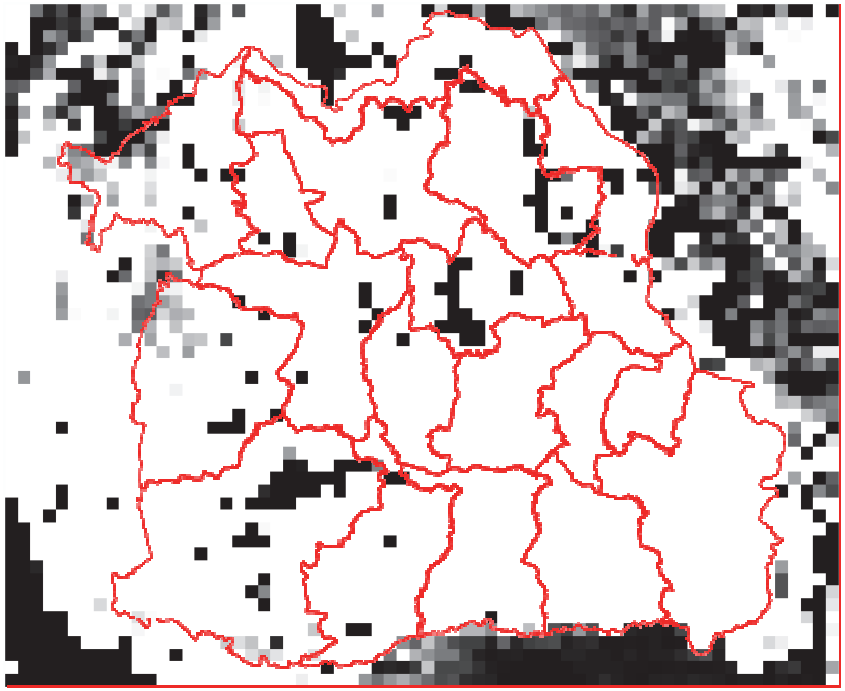
Distribution of Irrigated(June)

Value
High : 8227
Low : 0 (Hectare)

Land Use Classification(Allocation of Maximum Planted Area)

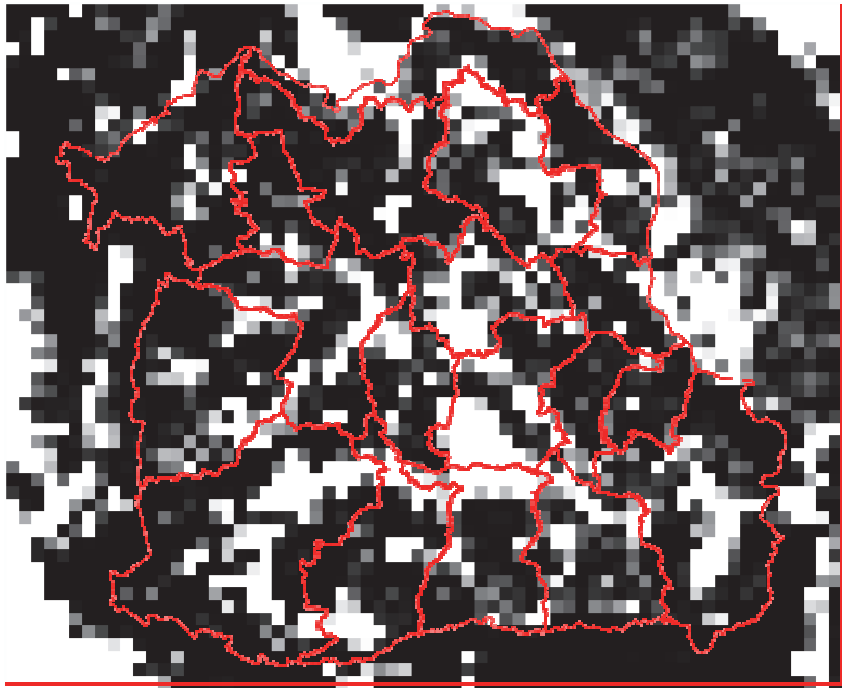
Allocating Rainfed Area and Irrigated Area for each cell

Allocate Maximum Planted Area of Each Province so as to fit calculated planted area with observed average planted area from 1981 to 2013. Use proportion of irrigated area and rainfed from MIRCA2000 to allocate irrigated and rainfed area each.



Value
High : 7206
Low : 0 (Hectare)

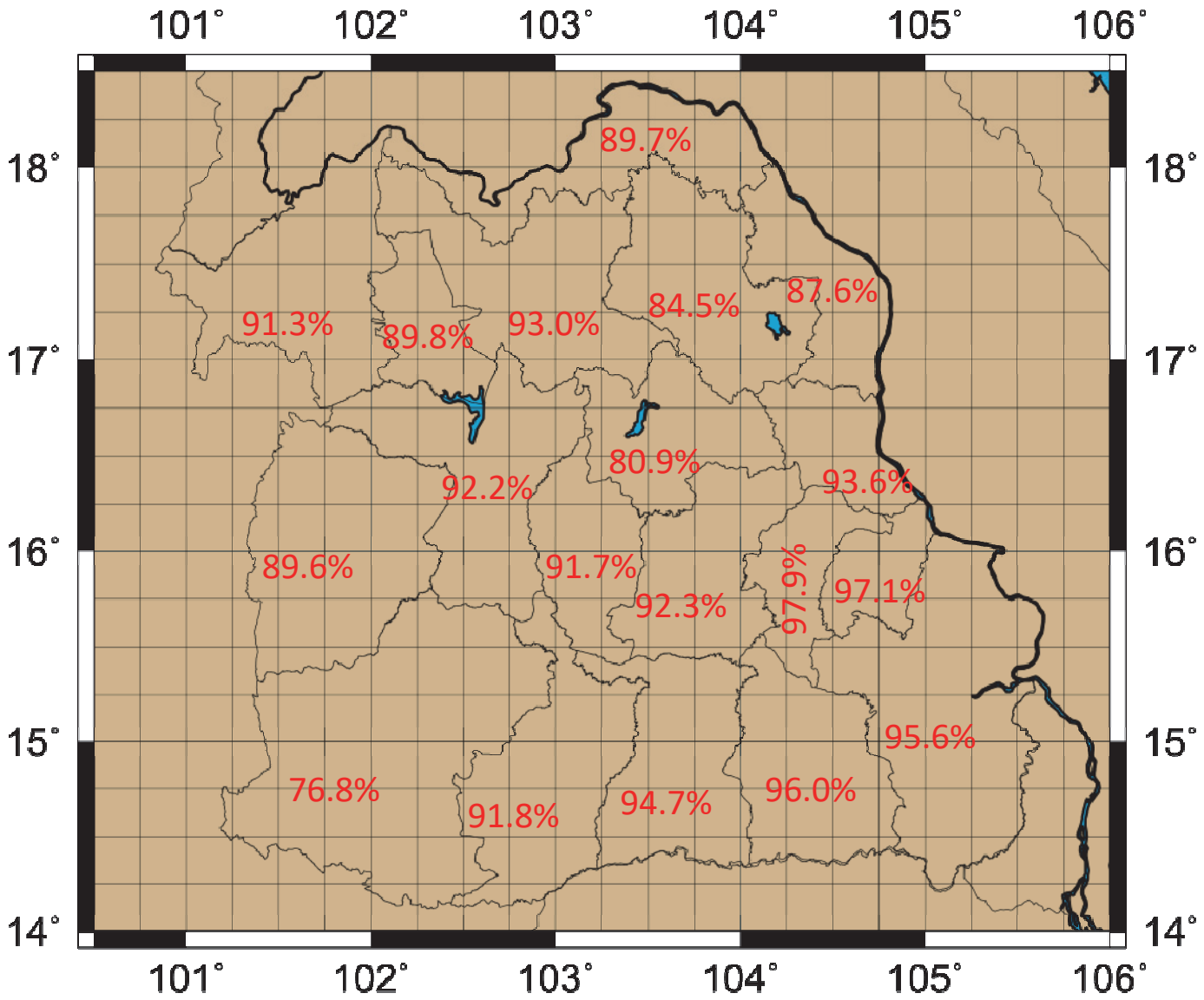
Distribution of Rainfed(June)



Distribution of Irrigated(June)

Value
High : 8227
Low : 0 (Hectare)

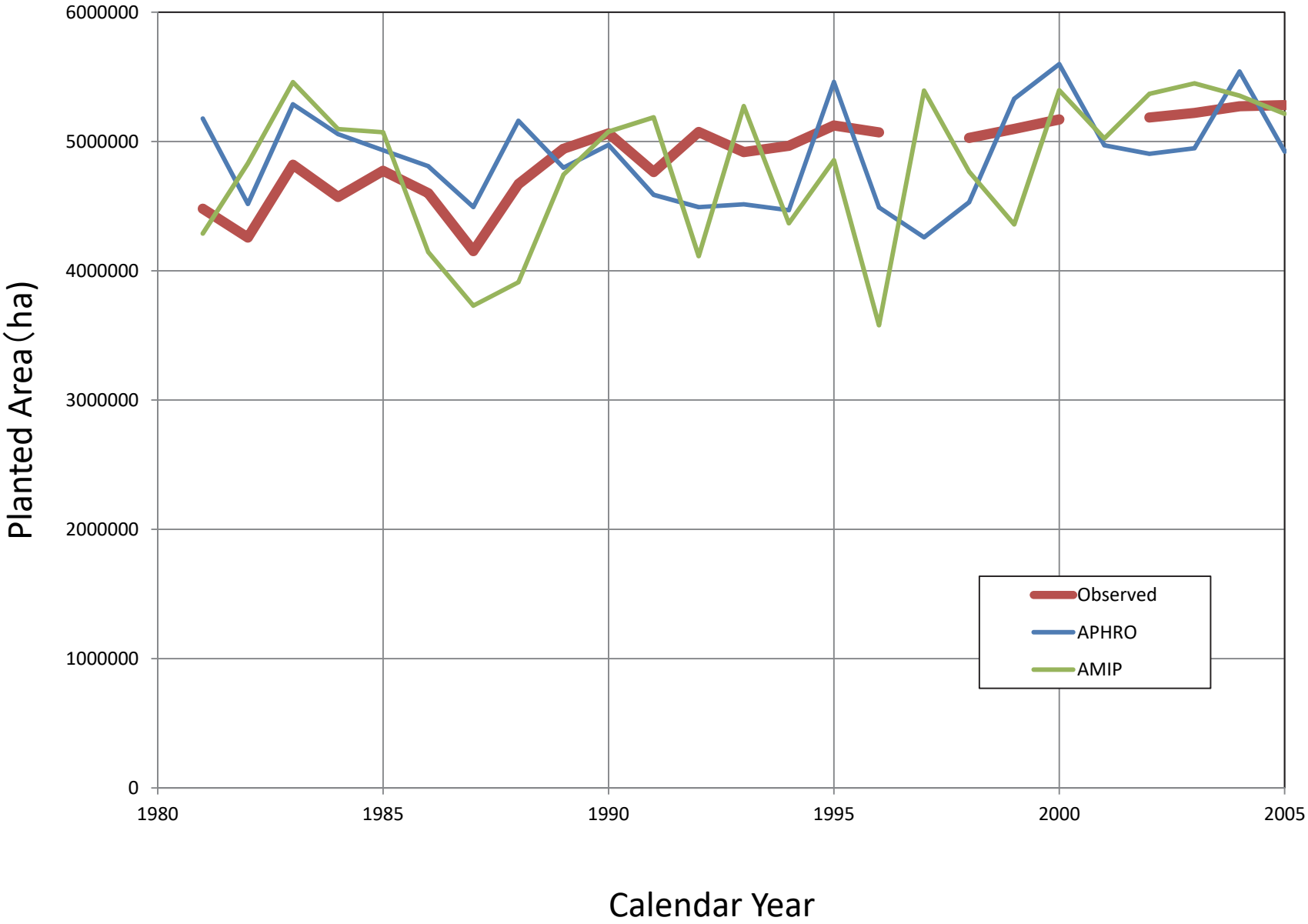
Land Use Classification(Allocation of Maximum Planted Area)



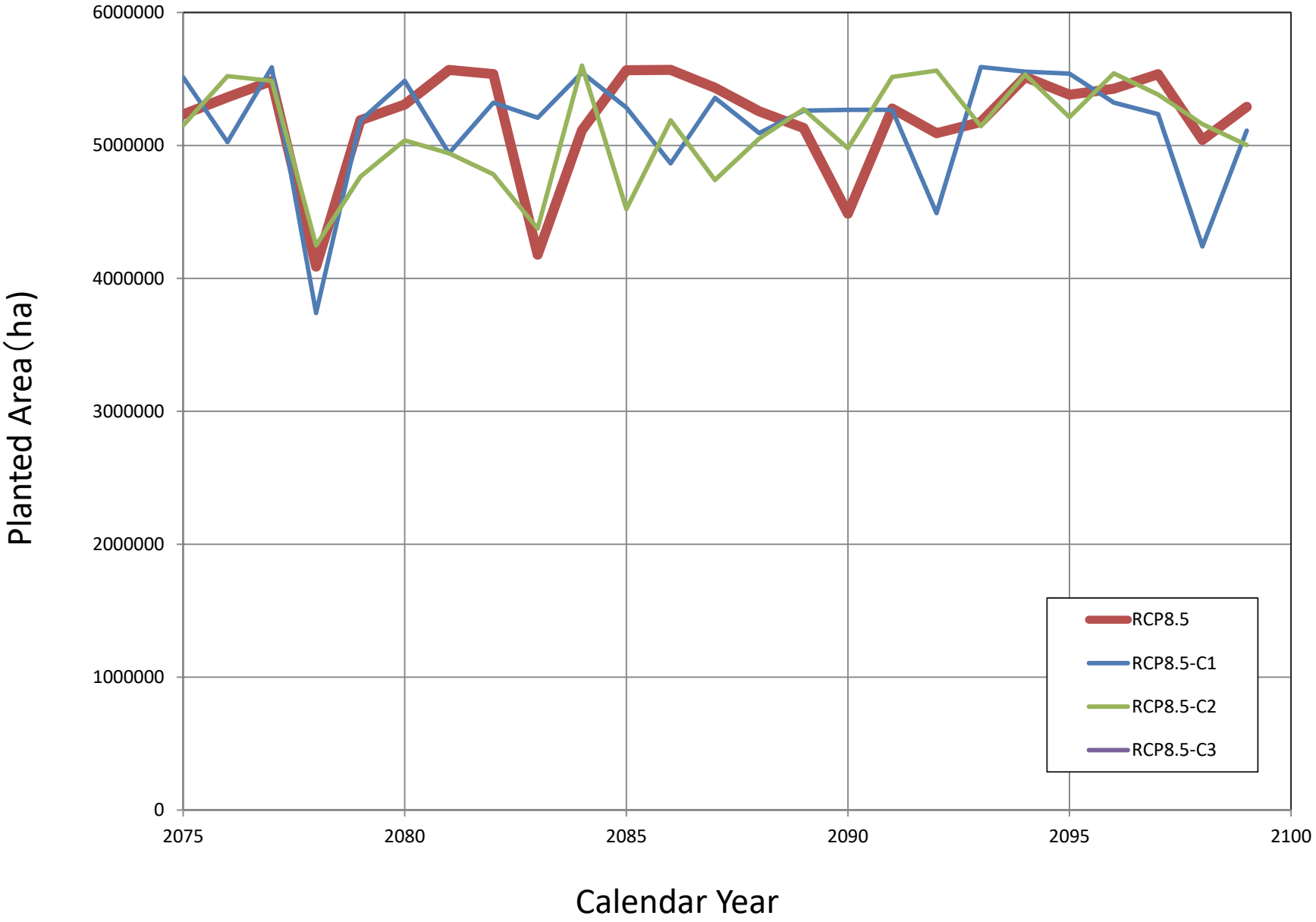
Proportion of Area of Rainfed Rice Field in Rice Filed in each province

Interval of meridian is 15' same as resolution of rainfall data. Resolution of Land Use data is 3 times finer than that of rainfall data.

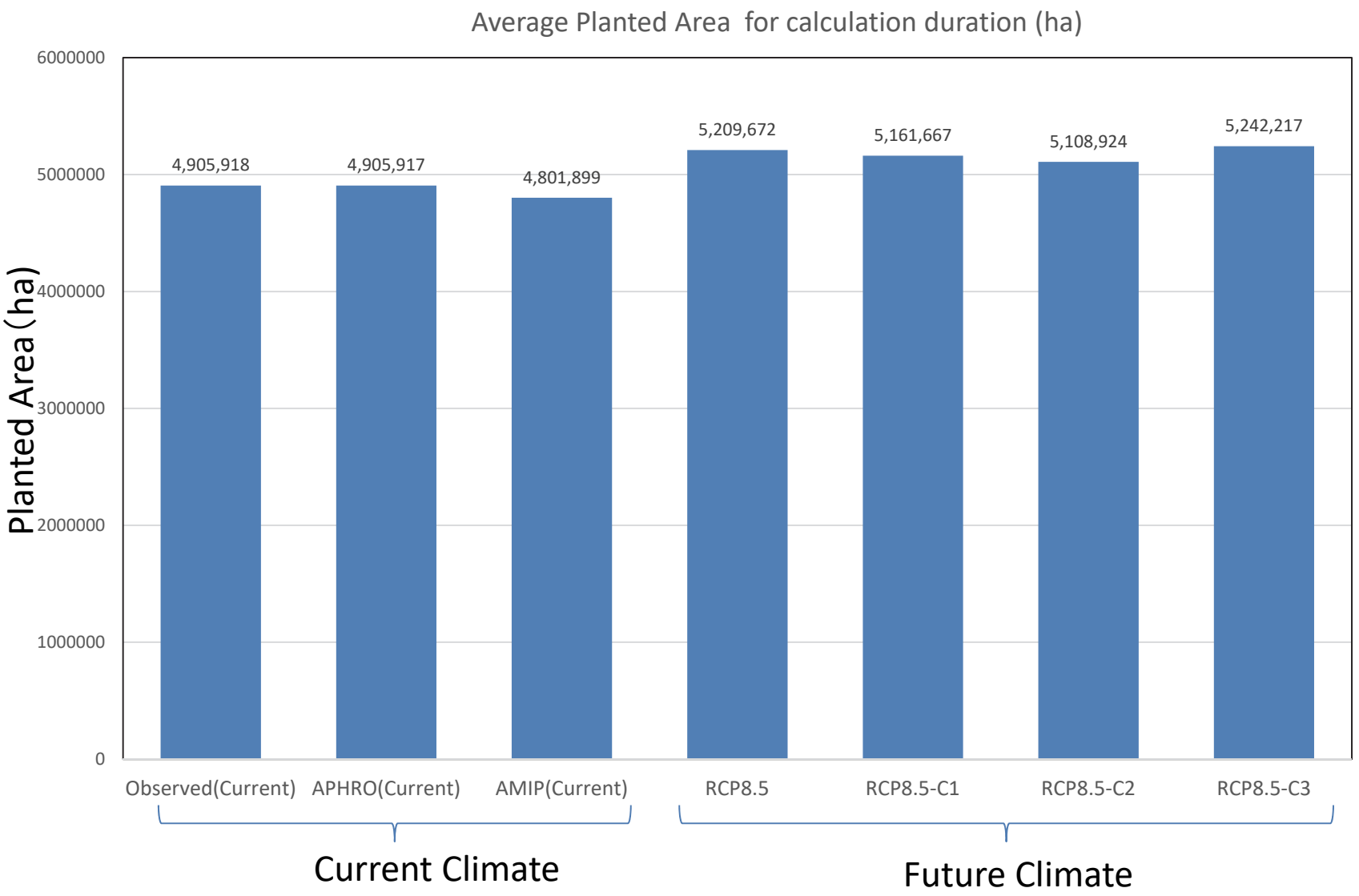
Calculation Result (Wet Season - Current Climate)



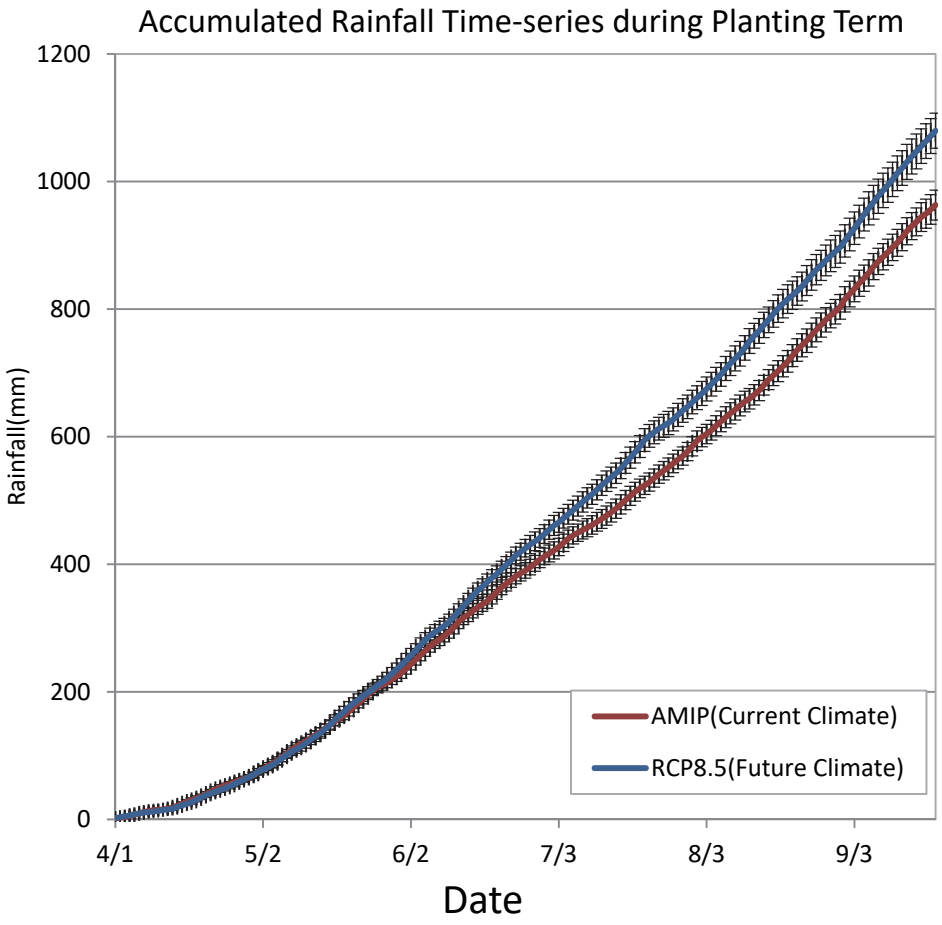
Calculation Result (Wet Season – Future Climate)

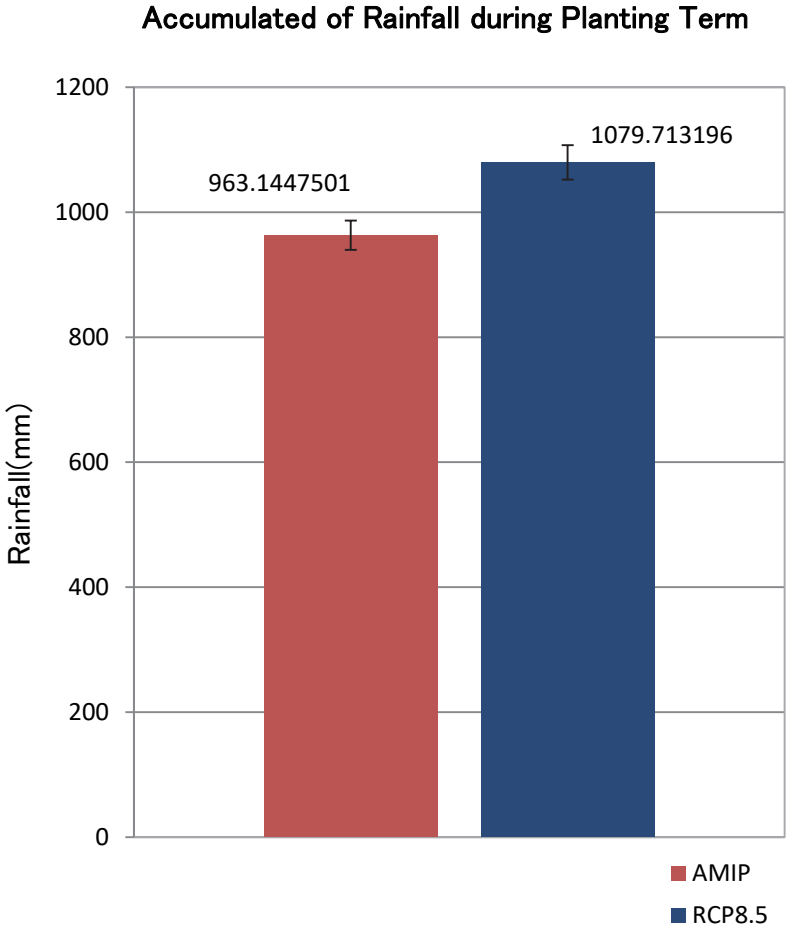


Calculation Result (Present– Future Comparison)



Difference of Rainfall between Current Climate and Future Climate





Conclusion

1. We applied IRE Model for Rice Planted Area Prediction. In case of the current climate, it turned out that this model reproduces current annual rice planted area time series well.

2. We got the result that Rice Planted Area will increases by approximately 6 to 9 % in future.

3. The reason why planted area will increase in future is that rainfall in planting duration increases so that farmers get to start planting early compared to current climate.

4. Above shown results are based on the assumption that reducing proportion of planted area after complete of planting is not changed.

Next Step

1. Calculation harvesting Area of Rice. It needs to build a model for reducing paddy area after planted.

2. Calculation harvesting Area of Rice in Dry Season.