Impact of Climate Change towards Irrigation Operations in Central and Northeast Thailand and its adaptation towards SDG

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Abstract

In the recent years, Thailand had suffered from both floods and drought which caused huge damages to the country's socio economics. Irrigation management in the country has different characteristics by area due to the topographical, meteorological and water demand conditions, i.e., wet area in the central plain (with 6 dams and annual rainfall of 1100-1500 mm) and dry area in the north east area (with 10 dams and annual rainfall of 800-1200 mm), which make each irrigation dam's operation rule different. In future, the climate change will induce more fluctuations to the hydrological parameters, the impacts of climate change to irrigation operation in the changing meteorology were explored comparatively in the area of wet and dry area on both project and farm levels.

The study investigated the hydrological change and the impact of climate change towards irrigation dam operations (inflow, release, storage) of the selected irrigation projects in the central and northeast area of the country. Due to the higher temperature and more fluctuated precipitations in the future, the study found that in the central plain, inflow to the main dams will change while in the northeast, inflow will reduce due to rainfall decrease and the irrigation demand will increase due to higher temperature, hence there will be more water shortage in the northeast area than that of the central plain.

Hence, in the irrigation project level, the dam release rule modifications with seasonal forecasting tools are essential to determine appropriate cultivation area in each year especially in the northeast area in order to cope with irrigation water shortage in the changing climate environment in the future. The field survey with farmer responses to such the change was conducted and found that the different responses among wet and dry area and irrigation and rainfed areas. In farm level, farmers prepared for adaptation measures, i.e., stop farming with other job creation scheme or do farming with supplementary water from other sources in the dry year such as pumping water from drainage canal, farm ponds, tube well and shallow groundwater or grow less water consumed plants in the rainfed area. Proper adaptation measures are needed to prepare for farmers to be more sustained with changing climate situations within SDG's framework of the country.

Keywords: climate change, irrigation, operation, water shortage, adaptation

1) Introduction

Thailand suffered from the big floods in 2011 and has faced with the consecutive droughts during 2014-2016. Such events caused huge damages to the socio-economic condition of the country. Irrigation management in the country has different characteristics by area due to the topographical, meteorological and water demand conditions particularly for rice cultivation, i.e., wet area in the central plain (with 6 dams and annual rainfall of 1100-1500 mm) and dry area in the northeast area (with 10 dams and annual rainfall of 800-1200 mm), which make the different

rules of irrigation dam operation. Recent meteorological patterns show more fluctuations of rainfall pattern and dam storage (Central: Bhumibol and Sirikit, NE: Ubolratana and Lam Pao) as shown in Figure 1. In future, the climate change tends to induce more fluctuations to the hydrological parameters, the impacts of climate change to irrigation operation in the changing meteorology needed to be explored comparatively in the wet and dry area to prepare appropriate adaptive measures of rice cultivation in both project and farm levels.

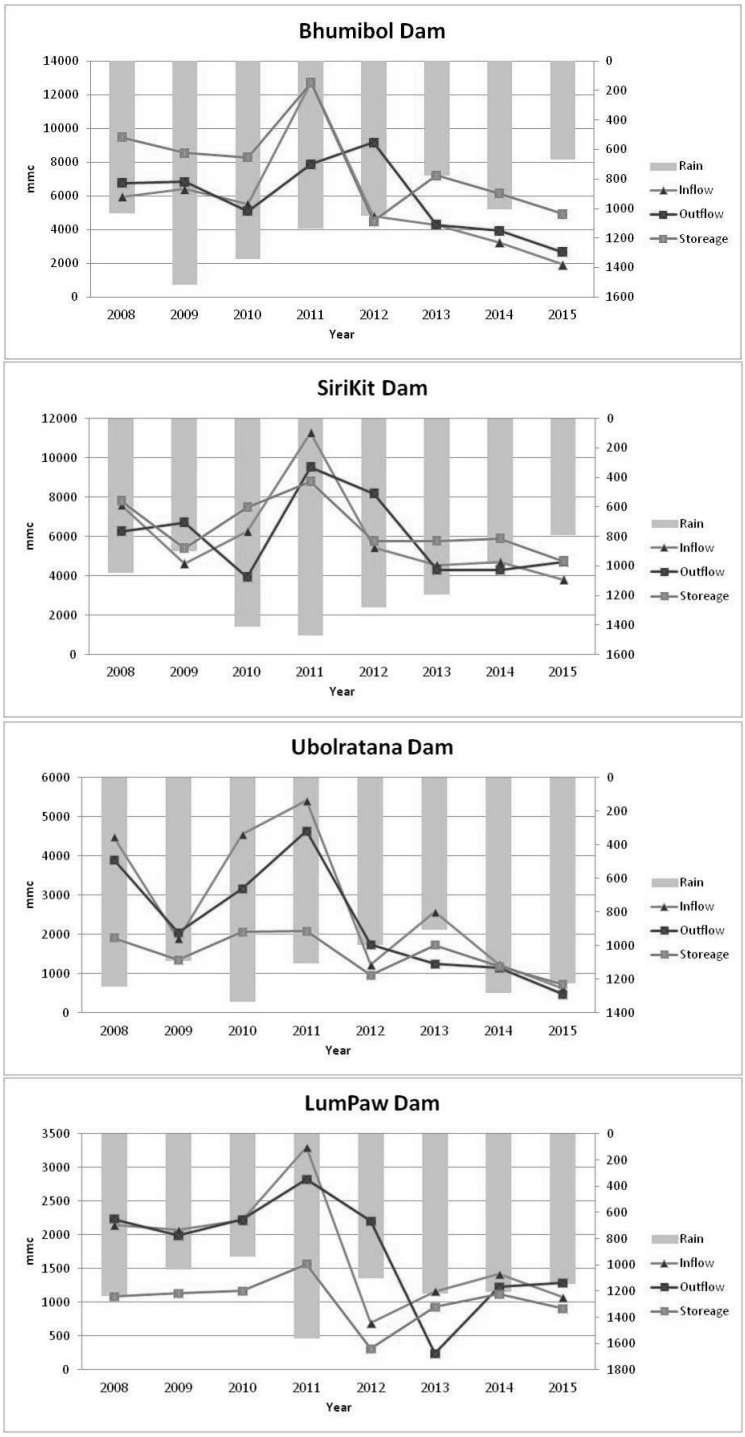

Figure 1 Fluctuation of meteorological conditions and dam operations

The study of impact of climate change to irrigation system had been conducted in various types of irrigation projects, dam and regional operations (Chulalongkorn University and RID, 2010: Sucharit K., 2013) and in the basin planning in the Nan River Basin (Sucharit K., 2012). The use of groundwater as supplementary water for irrigation was also explored (Sucharit K, 2015). The government had set the water resources management strategic plan (2015-2026) to provide water supply to villages and cities, to reduce water disaster risk, to improve water quality in the natural streams, to foster integrated water management scheme, and to improve water management structure of the central functions and community level (Ladawan Kampa, 2016). Besides, the country is now committed with UN's SD policy and is on the way to set the SDG including water sector.

2) Study area

The study selected the central plain area as a wet area and the northeast area as a dry area to compare the irrigation operations and adaptive measures on rice cultivation under the climate change situations. . The background information for irrigation in the central and northeast area is described in Table 1. The total area and agricultural area of the northeast is larger than the central area with similar precipitation though the irrigation area, number of dam and total storage in the northeast are less. Figure 2 shows the location of dams selected from each area. The Bhumipol and Sirikit Dams are selected for the central area, and the Ubolratana and Lampao Dams were selected for the northeast area. Two pilot irrigation projects in each region are selected, i.e., Plaichumpol (central and wet area) and Lam Pao (northeast and dry area) Irrigation Projects.

Table 1 General conditions for irrigation management in central and northeast areas

	Central	**Northeast**
1 Total area (km^2)	91.8	168.9
2 Population (M)	24.4	21.7
3 Precipitation (mm)	1100-1500	800-1200
4 Temperature (Celsius)	33.5	32.7
5 Agricultural area (km^2)	24.4	57.7
6 Irrigation area (M ha)	1.47	0.22
7 Number of dam	6	10
8 Total storage (Mm^3)	26.6	11.8

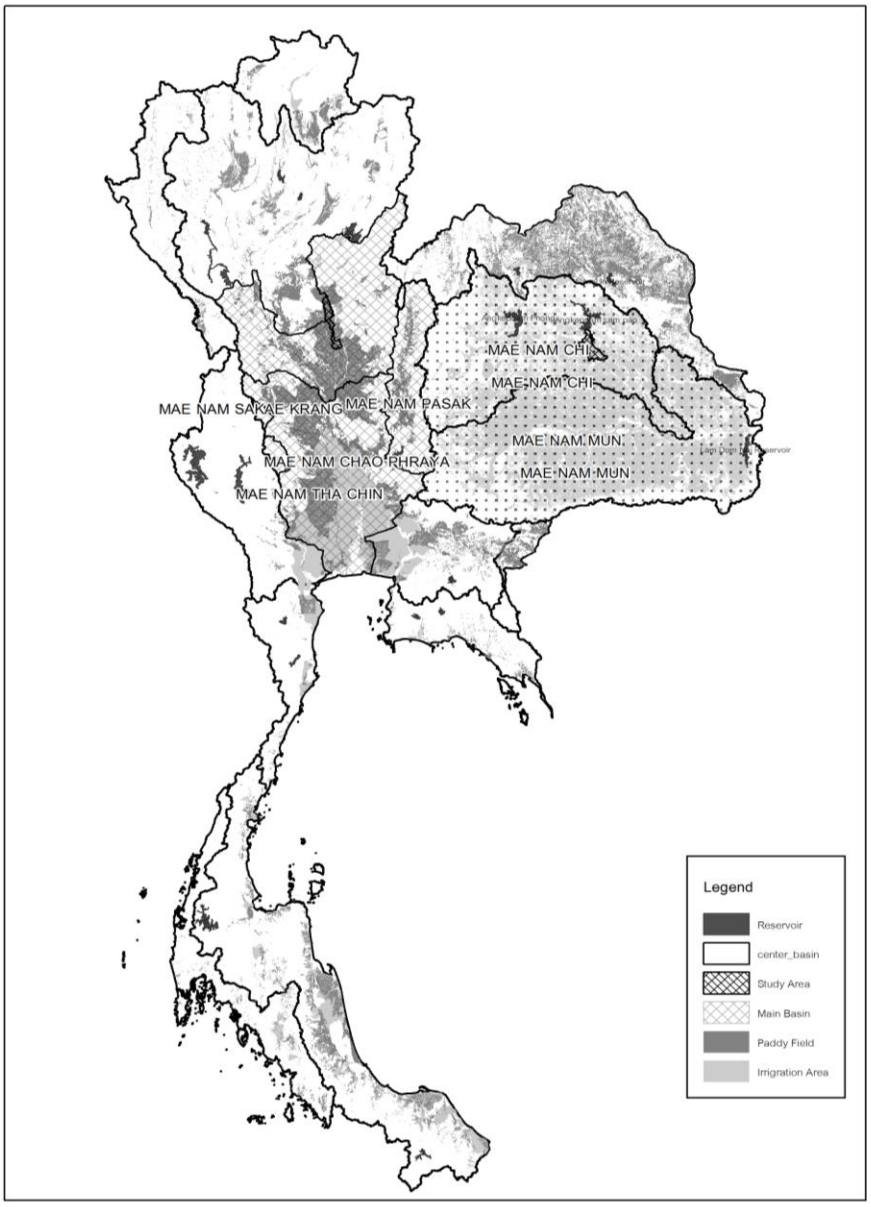

Figure 2 study area and dam locations

3) Objectives and approach

The objectives of the study are set as follows:

1. To investigate the hydrological change due to climate change,
2. To assess the impact of climate change towards irrigation dam operations,
3. To project the water shortage due to climate change in the future,
4. To survey with farmers on the adaptation means for rice cultivation.

The study approach started with the review on bias corrected climate data of present (1979-2012) , near future (2015-2039) and far future (2075-2099) periods (using MRI-GCM , scenario A1B). The inflows of the four main dams were estimated using the present monthly rainfall-

runoff relationships. The dam releases were computed using present monthly inflow-release ratios. The storages of the dam were computed from release and inflow volumes. The irrigation demands were estimated from the future climate and cultivation area which were determined from the water year (dry, moderate, wet) situations in the present. Water shortages were then computed from the dam releases and irrigation demands.

To explore the adaptation for rice cultivation at farm level, field surveys were conducted in the Plaichumpol Irrigation Project (in the central area as a wet case) and the Lam Pao Irrigation Project (in the northeast area as a dry case) during July 2016 which is at the end of critical drought period (Sucharit K., 2016). The questionnaires were distributed to 40 farmers in each irrigation project area and in nearby rainfed area for comparison. The interviews of irrigation engineers were also conducted to explore the adaptation scheme at the project level. From the impact study and field survey, the recommendations of future more sustainable management are suggested.

4) Results

The bias corrected climate data of present, near future and far future of temperature, rainfall of four main dams in the central plain and northeast areas were collected and compared. Water inflows, water release and water storage were computed and shown in Table 2. The overall temperature tends to increase higher in the northeast (dry) area. The rainfall in the central (wet) plain will increase while the rainfall in the northeast (dry) area will decrease. The inflows into the dam in the central plain will change -4.9-5.5 % while in the northeast, inflow will reduce about 1.0-18.4 % due to rainfall decrease.

Table 2 Hydrological change towards dam inflows due to climate change

	Central		**Northeast**	
	Bhumipol	**Sirikit**	**Ubolratana**	**Lam Pao**
1 Temperature, Celsius				
Present	33.54	33.41	32.72	32.11
Near Future	34.52	34.53	33.84	33.29
Far Future	36.68	36.95	36.64	35.9
2 Annual rainfall, mm				
Present	1038	1256	1297	1243
Near Future	1104	1248	1207	1190
Far Future	1169	1322	1266	1281
3 Inflow, Mm^3 (dry season)				
Present	5187(1078)	5554(798)	2374(288)	2097(129)
Near Future	5474(1019)	5281(793)	1937(262)	2081(147)
Far Future	5956(1249)	5609(823)	2089(267)	2357(141)

The impact from climate change was determined from water shortage volume estimated from dam release and irrigation demand. The irrigation demand was determined from the cultivation area (based on the past records for each water year (dry, moderate, wet), then water

release and water storage were estimated. The irrigation demand will increase due to higher temperature which will induce more water shortage in the northeast area more than that of the central plain. The water shortages in rainy and dry seasons in the main dams were shown in Table 3. In the central plain (wet area), the water shortage will reduce due to more rainfall even with higher temperature. The water shortage in the northeast (dry) area will increase in dry season due to less rainfall and higher temperature.

Table 3 Water shortage estimate due to climate change

	Central		**Northeast**	
	Bhumipol	**Sirikit**	**Ubolratana**	**Lam Pao**
1 Area (M ha)				
total area	1.26	0.11	0.04	0.05
max cultivation (rainy/dry)	1.18/1.14	0.09/0.10	0.04/0.02	0.05/0.04
min cultivation (rainy/dry)	0.88/0.70	0.08/0.08	0.04/0.01	0.05/0.03
2 Demand, Mm^3 (rainy, dry)				
Present	5249(2900)	107.4(542)	374(226)	587(373)
Near Future	5896(3089)	851(305)	373(218)	582(304)
Far Future	5429(2923)	782(289)	427(222)	534(368)
3 Release				
Present	1915/3311	2275/3097	1825/702	1687/693
Near Future	1678/2991	2272/2921	1696/723	1579/732
Far Future	2329/3864	2269/3233	1806/696	6877/730
4 Storage, Mm^3 (Rainy/Dry)				
Present	6778/9176	4982/7414	1659/2207	760/1283
Near Future	7266/9883	4818/7042	1661/2193	696/1352
Far Future	3876/10647	4931/7503	1673/2218	677/1356
5 Water shortage, Mm^3 (rainy/dry)				
Present	60.7/168	129/48	0/5.3	0.51/42
Near Future	195/128	88/20	0/6.5	0/26
Far Future	52/12	33/9	0/13.2	0/34

From field questionnaires, the farmers in the central plain in the irrigation area were impacted from droughts in the year 2015-16. The impacts were from damages of agricultural product and worsen quality of product. Farmers in the rainfed area were impacted from water shortage and product damages. The farmers in the northeast area mainly affected from water shortage in both irrigation and rainfed areas and the farmers in the rainfed area in the northeast got effect from more insects due to the drought.

Farmers in the central plain in the irrigation area adapted themselves by reducing cultivation area, growing less water crop, using shallow groundwater wells and using loan to solve their problems. Farmers in the rainfed area changed to crops that use less water, reduce cultivation area as counter measures

Farmers in the northeast area in the irrigation area adapted themselves by decreasing cultivation area and growing drought tolerance crops. Farmers in the northeast and rainfed area adapted by growing less water consumed crops and reducing cultivation area. From the field survey, there are numbers of farmers in the rainfed area who decided not to grow anything in these drought years due to low paddy price and had to find other jobs to do instead.

Irrigation engineers in the field informed that farmers in the central plain seek for other supplementary water such as shallow groundwater (88.9 %) and pond water (55.6%), while farmers in the northeast used pond water (62%) and shallow groundwater (25 %). Irrigation engineers introduced alternative wetting and drying farming method to farmers in order to save water, improve irrigation system to reduce water loss. They also had to create additional jobs for farmers who decided not to do farming such as weir construction. It is noticed that dam release rules also affected the drought conditions. The determination of cultivation area in each dry season will control irrigation demand to match with available water storage. Water release in the rainy season is vital for water storage in the next dry season especially in the case of Lam Pao Dam (in the dry area) where there are fewer choices of supplementary water sources in this dry area.

Table 4 Farmer responses from field survey

	Central (Plaichumpol Project0			Northeast (Lam Pao Project)		
	irrigation area	**rainfed area**	**irrigation officers**	**irrigation area**	**rainfed area**	**irrigation engineers**
1 Impacts from Drought			most drought year			most drought year
(percentage of responses)			preparation works :			preparation works :
1.1 Agr water shortage	68.2	75	a) inform situations to farmers	54.5	66.7	a) warning for appropriate
1.2 Water supply shortage	20.5	13.6	b) repair gates	4.5	16.7	cultivation area
1.3 Agricultural damages	68.2	36.6	c) canal maintenance	18.2	11.1	b) gate repair
1.4 Product downgraded	54.5	22.7	d) prepare water allocations	29.5	22.2	c) canal maintenance
1.5 More insects	25	4.5		25	44.4	
2 Drought counter measures			measures recommended :			measures recommended:
2.1 Agricultural area decrease	54.5	34.1	a) farmers use gw 88.9 %	34.1	33.7	a) farmers used pond water 62.5%
2.2 Use less water crop	38.6	40.9	c) farmers used pond water 55.6%	29.5	44.4	b) farmers used shallow gw 25 %
2.3 Select water tolerance crop	27.3	6.8	c) find other water sources	34.1	11.1	c) recommended suitable crops
2.4 use shallow gw	36.4	15.9	d) recommended suitable crops	6.8	11.1	d) reduce cultivation area
2.5 Dig new wells	27.3	6.8		4.5	0	
2.6 loan to solve problems	50	13.6		13.6	22.2	

5) Conclusions

The study found that the overall temperature tends to increase with higher increase in the northeast (dry) area and the rainfall in the central (wet) plain will increase while the rainfall in the northeast (dry) area will decrease. The inflows into the dam in the central plain will change -4.9-5.5 % while in the northeast, inflow will reduce about 1.0-18.4 % due to rainfall decrease while the irrigation demand will increase due to higher temperature which will induce more water shortage in the northeast area (dry area) more than that of the central plain (wet area).

In farm level, farmers prepared with two choices of adaptation measures, i.e., stop farming and find other jobs or do farming with supplementary water such as pumping water from drainage canal, farm ponds, and tube well and shallow groundwater and selected plants.

From the project level, the water release control is important to cope with water shortage in the drought year. The dam release rule in the rainy season with suitable control of cultivation area in the dry season matching to each type of climate (dry/wet) will vitally affect to water shortage situations as learned from the Lam Pao Irrigation Project.

6) Recommendations

The government is planning for the long term sustainable development. The issues of appropriate rice cultivation area, application of agro-map for suitable agricultural production as new planning tools are under planning. In the irrigation project area, more integrated, sophisticated and adaptive water management scheme should be adopted to cope with the change. The modification of dam release rule with the consideration of flood risk and introduction of new technology on seasonal forecasting tools are essential to cope with the changing of climate in the future. In the rainfed area, more supplementary water sources and other supportive job options should be systematically prepared. Proper adaptation measures are needed and prepared for farmers in each climate zone to be more sustainable with changing climate situations within SDG's country framework

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