Climate Change Impact on Groundwater and Farmers' response (The Wang Bua Irrigation Project, Kampheng Phet Province, Thailand: case study)

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Abstract

The climate change induced direct affect to irrigation area, e.g., Yom, Nan Basin or Chao Phraya Basin in the dry year when the storage amount is not adequate for summer rice and caused water deficit in many irrigation projects. The Wang Bua Irrigation Project is an area in Kampheng Phet Province, Thailand and in Ping River Basin which depends on both surface and groundwater sources (mostly in the dry year). Most farmers turn to use groundwater to supplement irrigation water. The objectives of the study are to analyze the impact of the climate change on groundwater and farmers' response to the change. The study comprised of the groundwater modeling by applying MODFLOW to study the impact on groundwater and collecting the farmers' responses on the adaptation towards climate change. The study found that there will be more fluctuations in precipitation pattern, less rainfall in wet season and more rainfall in dry season. Hence, groundwater pumping and water table will be more fluctuated, though in average, groundwater table will be higher in the selected period due to less rainfall in wet season and more rain in dry season. From the field interviews on the adaptation towards climate change, with the more fluctuated rainfall pattern and decrease of rainfall in wet season in near future duration, in generally, the farmers tend to control the cultivated area and dig the supplementing shallow wells to counter with climate change. From the study, it is found that farmers are ready to adapt to the changing situations with effective warning and communication system and with good cultivation area control and water rotation, the water deficit condition can be lessened.

Keywords: Climate Change, Impact, Groundwater, Farmer, Response

Introduction

Kamphaengphet Province was prosperous in the last 700 years ago when Sukhothai was Thailand's first capital. From monument stone study, it is found that Kamphanephet was important in the ancient time surrounding with various cities, e.g., Chakanloas, Nakornchum, Traitrung, Thepnakorn, Khonthi etc., which showed the wealth of the province from the old days. The province was located in the bank of Ping River and suitable for agriculture in the right side of the river. There is an evidence that in the year 1510, there was a water pipeline project (called Phrayaruang Water pipe) to divert water from Ping River to Parn City.

Kamphangphet is located in the southern part of north region at latitude 150 degree 51 lipda north till latitude 160 degree 54 lipda north and longtitude 90 degree east till longtitude 100 degree 3 lipda east with the height of 107 meter from mean sea level and 358 kilometers from Bangkok(see Figure 1). Kamphangphet has 8,607.5 sq. km or about 5,379,687 rai which is agricultural area of about 3,348,847 rai with developed irrigation area of about 582,000 rai.

Wangbua Irrigation Project is located at the left bank of Ping River and the project office is at Mu 13, Kamonghak village, T. Thepnakorn, A. Muang, Kamphaengphet Province and is in the south direction of Kamphaengphet-Tamadua Road and about 3 km from municipal area(see Figure 2). The irrigation project is overflow type (from Ping River) irrigation and the head work office has 21 rai 2 garn area (about 34400 sq m) with water gate (size 2.40 x 1.75 m with 9 gates) receiving water from Ping River at the rate of 50 cms. The Project area is

310,000 rai with irrigation area of 287,058 rai with following water structures.

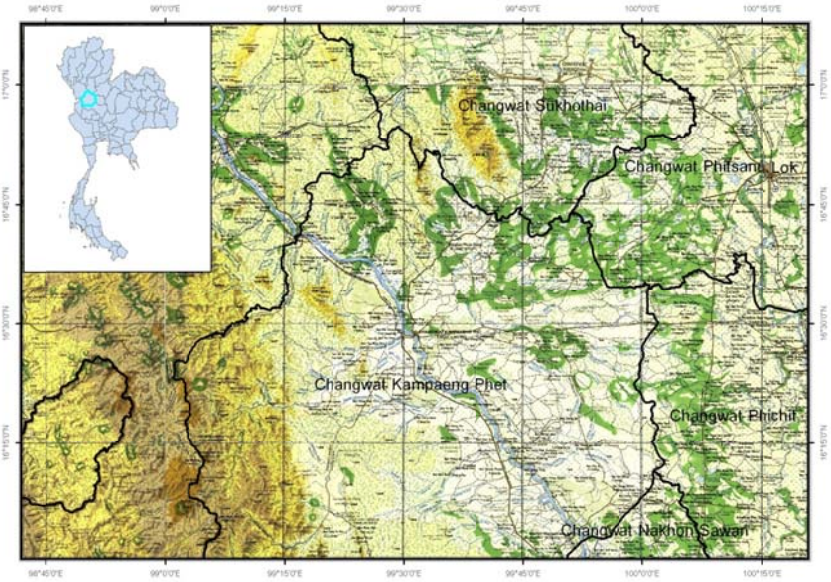


Figure 1 Location of Kampangphet Province

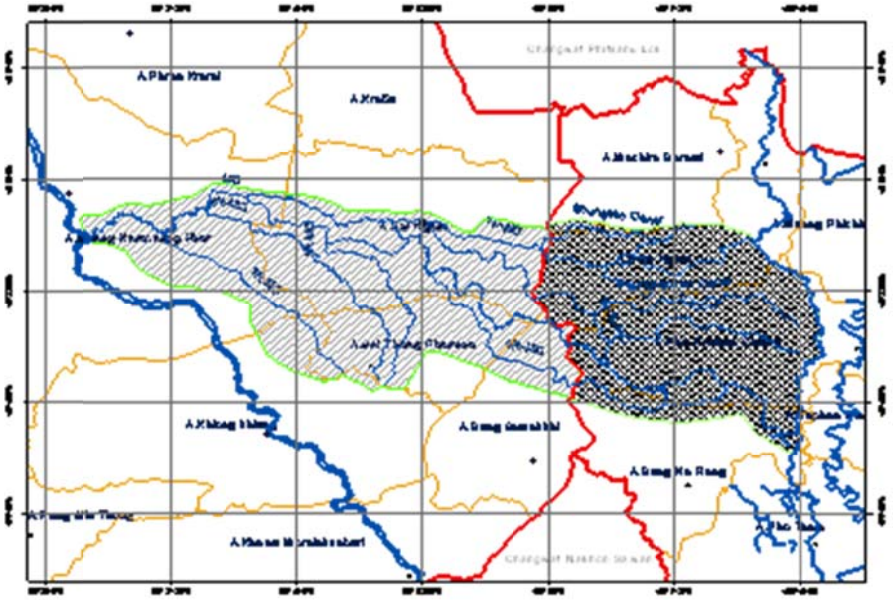


Figure 2 Wangbua Irrigation Project

Groundwater study in Kamphengphet area

Public Work Department (1996) explored the possibility of groundwater recharge in Kamphaengphet area of both well and pond type to raise groundwater Table in the area especially in the dry year. Field investigations were conducted to see the technical possibility and environmental impact from the recharge activities. The maintenance of recharge pond from sediment was found as an obstacle for continuous recharge activities

Sont C. (1997) developed groundwater model in the Kamphengphet area to simulate the groundwater movement and to estimate groundwater recharge rate both in the field and experimental scheme.

Groundwater Resources Department (2006) conducted the conjunctive use study in the north Central Plain to explore the present status of groundwater use, its potential and how to manage water with surface water conjunctively. The study revealed that the potential of groundwater in the study area was still high and the main users were for water supply in the municipal area though farmers used groundwater as supplementary irrigation water especially in the dry season and dry year. The study of the interaction of surface and groundwater (as groundwater recharge and discharge) is very important mechanism to keep groundwater potential in long term.

Weraphol B. (2006) developed the simulation model of surface coupled with groundwater in the north Central Plain and analysed the interaction between surface and groundwater movement in the Nan River. From the simulation, it was found that river water recharged into groundwater aquifer during rainy season and discharge water into Nan River during dry season

Hydrological data analysis

Rainfall

The average monthly rainfall data was analyzed from 12 stations. The results show that amount of average monthly rainfall in Kamphaengphet Province is 1,150.22 mm/year and separate in wet season (May – October) 1,021.02 mm and dry season (November – April) 129.20 mm. The distribution of monthly rainfall is shown as Figure 3. The average monthly rainfall could be summarized in Table 1

Table 1 The summary of average monthly rainfall (unit : mm/month)

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Wet	Dry	Total
2.05	11.76	27.97	44.65	173.24	144.70	137.25	164.33	237.28	162.22	38.70	4.07	1021.02	129.20	1150.22

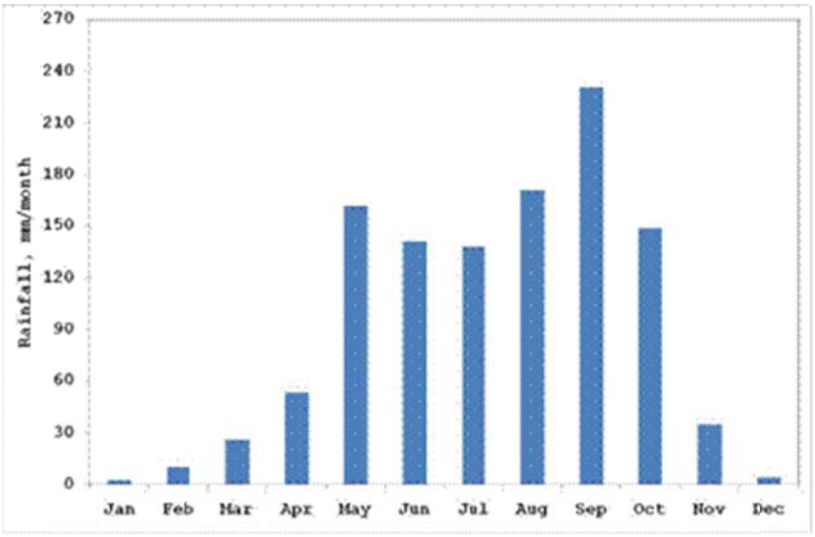


Figure 3 Average monthly rainfall in Kamphaengphet Province

Temperature

The average monthly temperature data was analyzed from 1 station. The results show that average monthly temperature in Kamphaengphet Province is 28.81 oC which separate in wet season (May – October) 28.81 oC and dry season (November – April) 27.24 oC. The distribution of monthly temperature is shown in Figure 4. The highest temperature is in April. The average monthly temperature could be summarized in Table 2.

Runoff

The average monthly runoff in the main Ping River was analyzed from station P.7A at Ban Huai Yang, A. Muang, Kamphaengphet which has coverage area about 42,700 Km2 . The results show that average monthly runoff at station P.7A is

6,934.6 MCM/year which separate in wet season (May – October) 4,099.60 MCM and dry season (November – April) 2,834.01 MCM. The distribution of monthly runoff is shown in Figure 5.

The average monthly runoff could be summarized in Table 3.

Table 2 The summary of average monthly temperature (unit : ^{o}C)

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Wet	Dry	Total
24.22	27.20	29.25	30.99	30.16	29.16	28.82	28.52	28.37	27.82	26.38	24.40	28.81	27.24	28.04

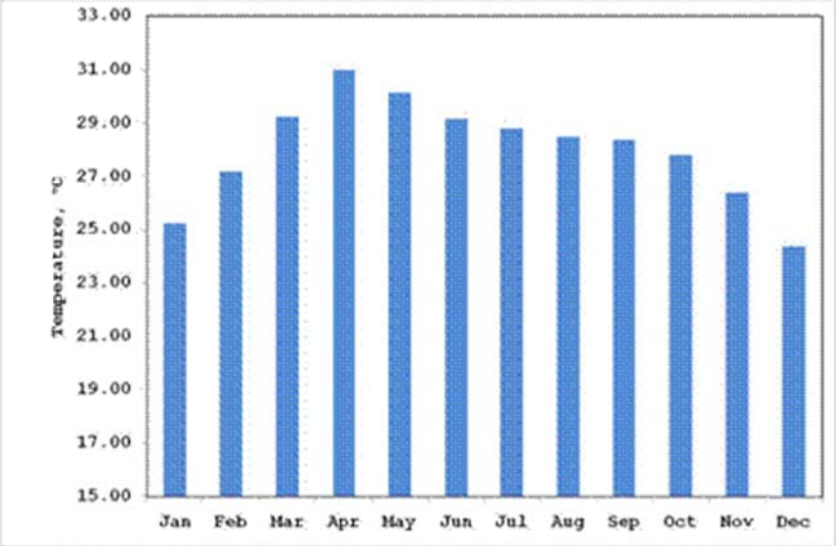


Figure 4 Average monthly temperature in Kamphaengphet Province

Table 3 The summary of average monthly runoff (unit : MCM/month)

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Wet	Dry	Total
327.56	413.64	567.53	501.62	507.03	464.71	521.40	633.37	1,093.81	878.27	656.18	368.48	4,099.60	2,834.01	6,934.61

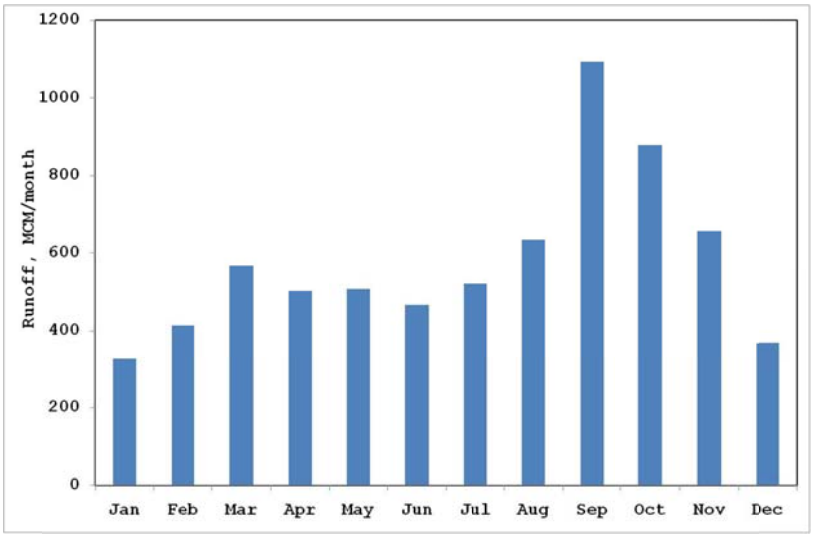


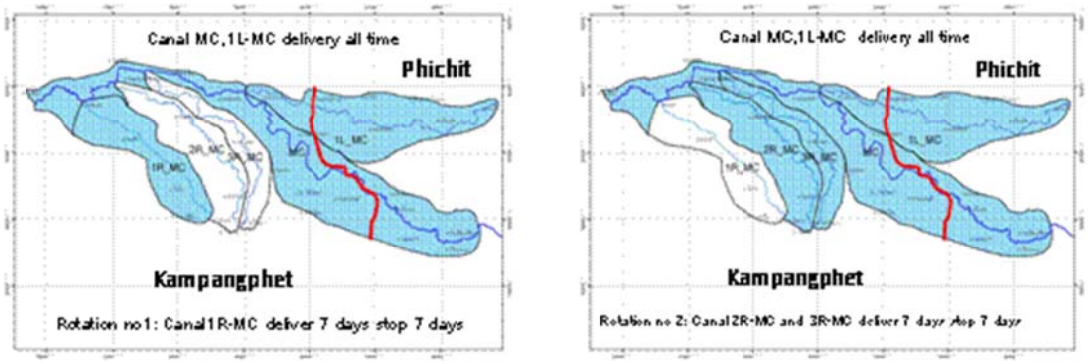
Figure 5 Average monthly runoff at station P.7A Ban Huai Yang, A.Muang, Kamphaengphet

Water balance analysis in Wangbua Irrigation Project

The water balance of Wangbua Irrigation Project could be calculated the water deficit in the study area that estimated from the water supply and irrigated water demand in the Wangbua Project. The condition of water balance simulation has duration, season, water year, water rotation and meaning of regulated 2 crops a year. The duration is present (2006 – 2010), near future (2015 – 2039) and far future (2075 – 2099). The seasonal are rainy (June – October) and dry (November – April). Water year include wet, normal, dry and serious dry (based on Bhumipol capacity). The Adaptation scheme was Water rotations include unregulated and regulated (all time for MC and 1L-MC every 7 days for 1R-MC and 2R-MC, 3R-MC). As shown in Figure 6. The case in this studied as 6 cases. As shown in Table 4.The results could be summarized as Table 4.

Table.4 Case study of simulation

CASE	Unregulated	Regulated
Present (2006 – 2010); P	PU	PR
Near Future (2015 –	NU	NR
Far Future (2075 –	FU	FR



a) Rotation No.1 **b) Rotation No.2**

Figure 6 Recent Rotation Scheme (after 2010)

Table 4 Summary of the water deficit of Wangbua Irrigation Project

year	Water deficit (MCM.)					
	Unregulated			Regulated		
	Wet	Dry season	Annual	Wet	Dry season	Annual
Present (2006-2009)	0.0	-2.4	-2.4	0.0	0.0	0.0
Near future (2015-2039)	-16.4	-12.0	-29.4	-9.0	-2.7	-11.7
Far future (2075 – 2099)	-1.9	-6.6	-8.5	-2.5	-1.1	-3.6

Groundwater pumpage analysis

The groundwater pumpage of Wangbua Irrigation Project in each period could be estimated from the water deficit multiply the groundwater usage ratio from the thesis report of simulation of groundwater condition in Kampheang Phet Province (Sont, 1997). The ratio is 50% and 20% in wet season and dry season. For the results of groundwater pumpage of groundwater province is 218×106 m3/year. In the present the pumpage in Wangbua Project is 49.7×106 m3/year in 2009 (in case regulate:PR) and 63.11×106 m3/year (in case un-regulate:PU). Results in each cases are summarized in Table 5.

Table 5 Summary of the groundwater pumpage in each cases

Case		Groundwater pumpage (MCM.)		
		Dry	Wet	Total
R	P	48.18	1.52	49.7
	N	41.69	1.79	43.48
	F	41.77	1.7	43.47
U	P	61.59	1.52	63.11
	N	50.32	5.32	55.64
	F	43.97	1.64	45.61

Groundwater Study

Groundwater flow simulation by using MODFLOW

From the previous groundwater study of the simulation of groundwater condition in Kampheangphet Province (Sont, 1997), the groundwater model was calibrated by adjusting the parameters in the unsteady state by using monthly groundwater levels 1995-1997 to verify the hydraulic coefficients and the pumpage coefficient. The calibration of this model gave the error with the mean error of 1.14 and the verification process gave error of 3.5.

The result of groundwater flow simulation gave the water level in represent wells. The simulated existing water level of Wangbua Irrigation Project are shown in Table 6.

In this study we considered groundwater level in each season and fixed the groundwater recharge such as recharge areas, river and ground surface as in the existing period.

Table 6 Summary of the existing groundwater level of Wangbua Irrigation Project

		Water level (m. MSL.)					
		Initial	Wet season	Difference	Initial	Dry season	Difference
Regulated	well 1	74.61	74.4	0.21	72.95	71.36	1.59
	well 2	74.74	74.2	0.54	72.66	68.02	4.64
	well 3	66.73	66.75	-0.02	64.42	56.7	6.72
Un-Regulated	well 1	74.61	74.08	0.53	72.95	71.29	1.66
	well 2	74.74	73.14	1.6	72.66	71.29	1.37
	well 3	66.73	65.19	1.45	64.42	56.51	6.91

For the near future, water level of Wangbua Irrigation Project was found that the Regulated case has the water level difference increases in all area for dry season 0.22 m, 2.6m and 3.2 respectively. In the wet season water level difference are 0.91 m, 2.33 m and 2.49m respectively. Moreover, the Un-Regulated case has the water level difference increases for dry season 0.58 m, 4.02m and 9.21m respectively. In the wet season, water level difference are 1.03m, 3.19m and 3.78m respectively. The results were shown as Table 7.

Table 7 Summary of the near future groundwater level of Wangbua Project

		Water level (m. MSL.)					
		Initial	Wet season	Difference	Initial	Dry season	Difference
Regulated	well 1	74.61	73.7	0.91	72.95	72.73	0.22
	well 2	74.74	72.41	2.33	72.66	70.06	2.6
	well 3	66.73	64.24	2.49	64.42	61.22	3.2
Un-Regulated	well 1	74.61	73.58	1.03	72.95	72.37	0.58
	well 2	74.74	71.55	3.19	72.66	68.64	4.02
	well 3	66.73	62.95	3.78	64.42	55.21	9.21

For the far future, water level of Wangbua Irrigation Project was found that the Regulated case has the water level difference increases in all area for dry season 0.02 m, 1.73m and 1.82m respectively. In the wet season water level difference are 0.33 m, 0.99 m and 0.66m respectively. Moreover, the Un-Regulated case has the water level difference increases for dry season 0.29m, 2.12m and 2.4m respectively. In the wet season, water level difference are 0.38m, 1.26m and 1.17m respectively The results were shown as Table 8.

Table 8 Summary of the far future groundwater level of Wangbua Project

		Water level (m. MSL.)					
		Initial	Wet season	Difference	Initial	Dry season	Difference
Regulated	well 1	74.61	74.28	0.33	72.95	72.93	0.02
	well 2	74.74	73.75	0.99	72.66	70.93	1.73
	well 3	66.73	66.07	0.66	64.42	62.6	1.82
Un-Regulated	well 1	74.61	74.23	0.38	72.95	72.66	0.29
	well 2	74.74	73.48	1.26	72.66	70.54	2.12
	well 3	66.73	65.56	1.17	64.42	62.02	2.4

Impact assessment on groundwater pumpage / level

Groundwater pumpage

From the comparison of each period, the impact assessment on the groundwater usage of the Wangbau Project can be summarized that the groundwater usage in the near future will increase in the wet season by 16.76% and decrease in the dry season by-13.47%. However the far future groundwater usage will increase in the wet by 11.84% and decrease in dry season by -13.30% respectively in Regulated case. In Un-Regulated case the groundwater usage in the near future will increase in the wet season by 250% and 4.44 % in dry season. However the far future water supply will increase in the wet season by 6.89% and decrease by -8.74% in dry season respectively, as shown in Table 9.

Table 9 The comparison of the groundwater usage in each cases

		Pumping (MCM.)			% Difference		
		Dry	Wet season	Annual	Dry season	Wet season	Annual
Regulated	Existing	48.18	1.52	49.7			
	Near	41.69	1.79	43.48	-13.47	16.76	-12.52
	Far future	41.77	1.7	43.47	-13.30	11.84	-12.54
Un-Regulated	Existing	61.59	1.52	63.11	26.83	0.00	26.98
	Near	50.32	5.32	55.64	4.44	250.00	11.95
	Far future	43.97	1.64	45.61	-8.74	6.89	-8.23

Groundwater level

From the comparison of each case, the impact assessments on the water levels of groundwater considerate at the each representative well in the Wangbau Project. Groundwater level (Figure 7) can be summarized that in Un-Regulated case, well 2 and well 3 both of near future and far future periods have critical area different from initial condition about 3.19m, 1.26m, 3.78m, 1.17m in wet season and 4.02m, 2.12m, 9.21m and 2.4m in dry season. The climate change impact on groundwater levels consider from change of groundwater levels. In well1, both near future and far future in Un-Regulated case has decreasing change of groundwater about 1.03m and 0.38m in wet season and increasing change about 0.58m and 0.29m in dry season, shown as Table 10, and Figure 8.

Table 10 The comparison of groundwater level in each zone.

			Water level m.		Difference (m)		Change (m)	
			Wet	Dry	Wet	Dry	Wet	Dry
Well 1 (thep-nacon)	Regulated	Initial	74.61	72.95	-	-		
		Existing	74.08	71.36	0.53	1.59		
		Near	73.7	72.73	0.91	0.22	0.38	-1.37
		Far future	74.28	72.93	0.33	0.02	-0.2	-1.57
	Un-Regulated	Initial	74.61	72.95	-	-	-	-
		Existing	74.4	71.29	0.21	1.66		
		Near	73.58	72.37	1.03	0.58	0.82	-1.08
		Far future	74.23	72.66	0.38	0.29	0.17	-1.37
Well 2 (nong-tong)	Regulated	Initial	74.74	72.66	-	-		
		Existing	73.14	68.02	1.6	4.64		
		Near	72.41	70.06	2.33	2.6	0.73	-2.04
		Far future	73.75	70.93	0.99	1.73	-0.61	-2.91
	Un-Regulated	Initial	74.74	72.66	-	-	-	-
		Existing	74.2	71.29	0.54	1.37		
		Near	71.55	68.64	3.19	4.02	2.65	2.65
		Far future	73.48	70.54	1.26	2.12	0.72	0.75
Well 3 (bung-sa-makee)	Regulated	Initial	66.73	64.42			-	
		Existing	65.19	56.7	1.54	6.72		
		Near	64.24	61.22	2.49	3.2	0.95	-3.52
		Far future	66.07	62.6	0.66	1.82	-0.88	-4.9
	Un-Regulated	Initial	66.73	64.42	-	-	-	-
		Existing	66.75	56.51	-0.02	6.91		
		Near	62.95	55.21	3.78	9.21	3.8	2.3
		Far future	65.56	62.02	1.17	2.4	1.19	-4.51

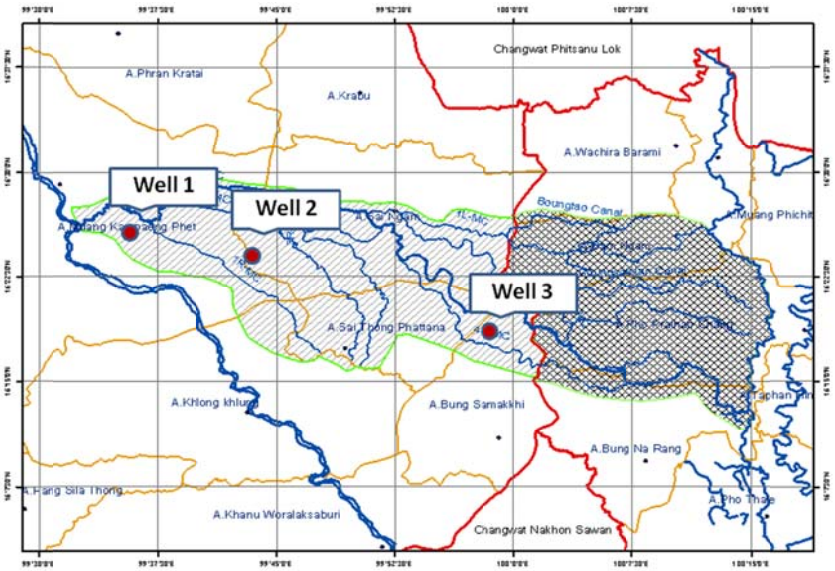
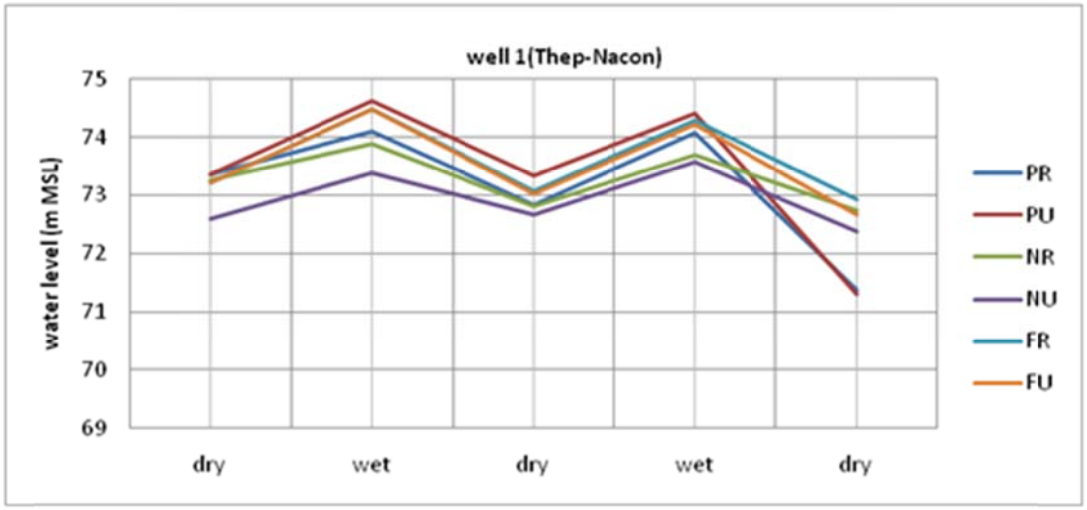
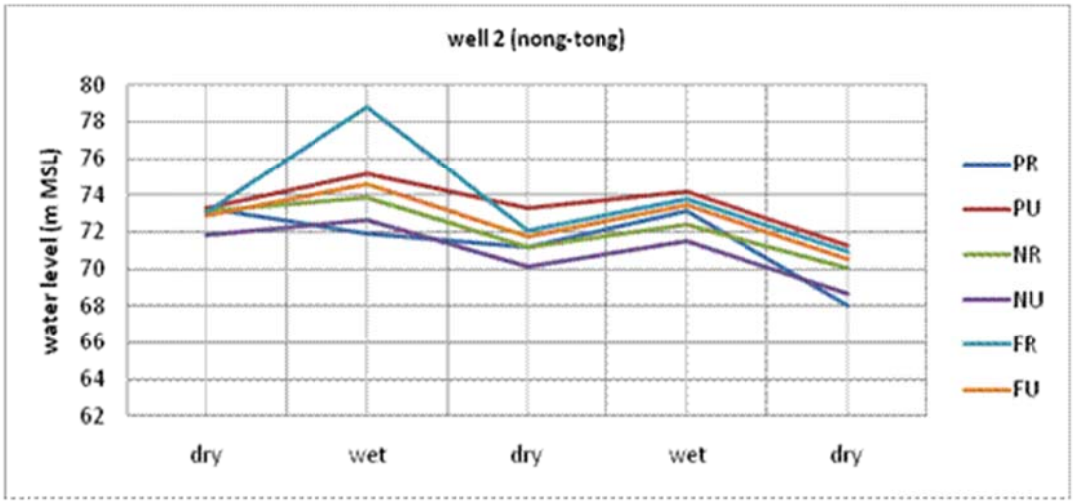


Figure 7 Location of representative wells





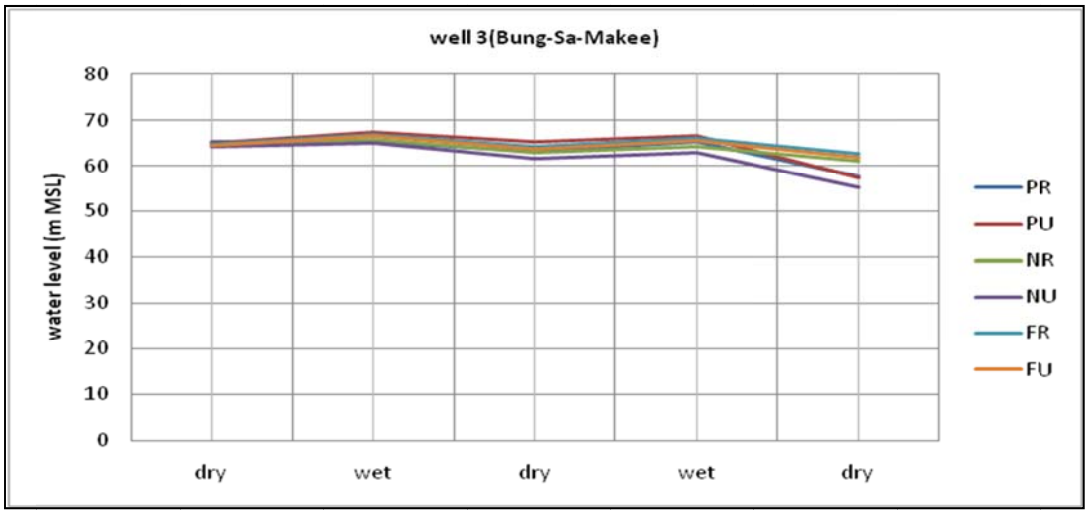


Figure 8 Groundwater level in 6 cases in each representative area

Farmer Responses

For the farmer response, at present, farmers seem to accept the change of the climate and implement self adaptation in farm level, i.e., farm pond or groundwater use, while the irrigation officers recognized the climate change condition and started to consider the measures under the two crop policy from the government. The planned adaptation scheme should consider the agreement and recognition between farmer and irrigation officer to agree on cultivated area, water rotation timing on plot level based on each year water and water allocation situation with other suitable support scheme for those who don't receive water. In the project level, water allocation, water rotation and water warning system should be considered more systematically and effectively. From the study, it is found that farmers are ready to adapt to the changing situations with effective warning and communication system and with good cultivation area control and water rotation, the water deficit condition can be lessened.

From interviews with farmers in each zone, farmers think about the trend in future climatic conditions will have longer prolonged gap, longer prolonged gap and more rain with higher temperature. The impacts from the past 2009 drought were the shortages of water due to insufficient irrigation water, damages in agricultural land area, lower price for products and more insects in the area. Farmers think to resolve the droughts by using groundwater as alternate water supply source, replacing with crops consuming less water, reducing the cultivated areas. In future, farmers tend to prepare for the drought by reducing cropping areas, excavating borrow pits to store supplementary water, changing cropping calendar and improving cropping techniques to save water.

Conclusions

There will be more fluctuations in precipitation pattern, less rainfall in wet season and more rainfall in dry season. Hence, groundwater pumping and water table will be more fluctuated, though in average, groundwater table will be higher in the selected period due to less rainfall in wet season and more rain in dry season. From the field interviews on the adaptation towards climate change, with the more fluctuated rainfall pattern and decrease of rainfall in wet season in near future duration, in generally, the farmers tend to control the cultivated area and excavate the supplementing shallow wells to counter with climate change impact. From the study, it is found that farmers are ready to adapt to the changing situations with effective warning and communication system and with good cultivation area control and water rotation, the water deficit condition can be lessened.

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