7. The Role of Agro-environmental Education and Water Resources and Related Disasters in Thailand

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WATER RESOURCES REGIME OF THAILAND SURFACE WATER REGIME

There are 25 major watersheds that were accepted by the National Water Resources Committee of Thailand (Figure 1). Ping, Wang, Yom and Nam are the four main watersheds in Northern Thailand these watersheds drain the water to the central part of Thailand at Nakhon Sawan Province and join the Chao Praya River. Chi and Mun watersheds are the major watersheds in the Northeastern part these converge into the Mekong International River. The Mekong River is the main watershed in Western Thailand. Pasak watershed is located in between the Central and the Northeastern parts and converge into the Chao Praya River at Nakhon Sri Ayudhaya Province. The Tapi watershed is the major watershed in the Southern part that drains into the Gulf of Thailand. These watersheds have different rainfall amount ranging from 1,000mm to 2,000mm annually due to their differences in geographic location and differences in the climatic regions. The quantity/amount of surface water resources, climatic condition and runoff potential as well as rainfall runoff ratio of each watershed were tabulated in Table 1,2 and 3 respectively.

Annual runoff specific yield of the Southern watershed are quite greater than the others due to the higher rainfall amount of this area compared to the other areas.

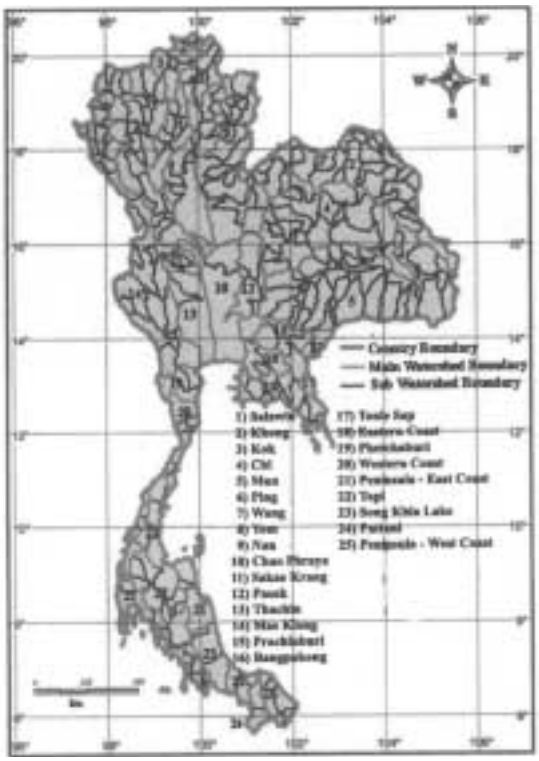

Figure 1 Major 25 watersheds in Thailand.

GROUNDWATER REGIME

Groundwater is another necessary water resource, which is highly influenced by the rainfall amount, topography and geology of the watershed. The groundwater resources regimes in Thailand may be divided into 6 major parts; the Northern, Northeastern, Central, Western, Eastern and Southern. The amount of groundwater in consolidated and unconsolidated sediment of each part of Thailand is shown in Table 4.

The comparison of groundwater recharge with average rainfall and surface runoff for each part of Thailand is presented in Table 5. The stor-

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Table 1 Average Runoff in Rainy Season Dry Season and Annual Runoff of other Main watershed.

Watershed Code	Main Watershed	Area (km^2)	Consolidated Area (km^2)			Annual Runoff Yield (liter/Second/km^2)
			High Aquifer	Medium Aquifer	Low Aquifer	
Watershed in Northern						
01	Salawin	17,920	8,622.89	83.39	16.61	15.26
03	Kok	7,895	4,710.32	80.86	19.41	18.92
06	Ping	33,898	9,001.96	84.55	15.45	8.42
07	Wang	10,791	1,658.03	92.87	7.13	4.87
08	Yom	23,616	4,247.09	92.73	7.27	5.70
09	Nan	34,330	11,508.12	92.65	7.35	10.63
Total Watershed in Northern		**128,450**	**39,748.41**	**87.43**	**12.57**	**9.81**
Watershed in Northeastern						
02	Khong	57,422	22,746.48	93.08	6.92	12.56
04	Chi	49,477	11,135.14	94.50	5.50	7.14
05	Mun	69,700	20,408.85	94.33	5.67	9.28
Total Watershed in Northeastern		**176,599**	**54,290.47**	**93.84**	**6.16**	**9.75**
Watershed in Central						
10	Chao Phraya	20,125	4,435.03	92.78	7.22	6.99
11	Sakae Krang	5,192	1,185.65	91.18	8.82	7.24
12	Pasak	16,292	3,560.49	90.63	9.37	6.93
13	Tha Chin	13,682	2,449.19	91.03	8.97	5.68
14	Mae Klong	30,837	12,379.41	90.02	9.98	12.73
19	Phetchaburi	5,603	1,337.91	89.85	10.15	7.57
20	Western Coast	6,745	1,576.51	88.85	11.15	7.41
Total Watershed in Central		**98,476**	**26,924.19**	**90.62**	**9.38**	**8.67**
Watershed in Eastern						
15	Prachinburi	9,821	4,569.44	96.29	3.71	14.75
16	Bangpakong	8,679	3,765.43	96.40	3.60	13.76
17	Tonlesap	4,150	2,409.60	91.16	8.84	18.41
18	Eastern Coast	13,830	12,690.90	93.19	6.81	29.10
Total Watershed in Eastern		**36,480**	**23,435.37**	**94.10**	**5.90**	**20.37**
Watershed in Southern						
21	Peninsula-East Coast	26,352	21,778.99	91.00	9.00	26.21
22	Tapi	12,225	12,528.12	94.96	5.04	32.50
23	Songkhla Lake	8,495	5,483.39	91.57	8.43	20.47
24	Pattani	3,858	3,320.02	88.59	11.41	27.29
25	Peninsula-West Coast	21,172	21,742.30	94.78	5.22	32.56
Total Watershed in Southern		**72,102**	**64,852.82**	**92.96**	**7.04**	**28.52**
Total		**512,107**	**209,251.28**	**91.96**	**8.04**	**12.96**

Remark :

1) Watershed Code 1 – 20 : Rainy Season is May to November
2) Watershed Code 21 – 25 : Dry Season is May to January

Table 2 Summary of Climatic Condition in 25 Main Watersheds.

Watershed Code	Main Watershed	Area (km^2)	Climatic Data					Average Annual Rainfall	
			Temperature (°C)	Relative Humidity (%)	Wind Velocity (knots)	Cloud Cove (0 – 10)	Evaporation (mm)	Range (mm)	Average (mm)
Watershed in Northern									
01	Salawin	17,920	25.4 – 32.4	67.0 – 76.0	1.0 – 2.9	5.4 – 6.2	1413.0-1955.0	1,114 – 2,137	1,368
03	Kok	7,895	24.0 – 25.4	72.0 – 77.0	1.6 – 2.2	5.3 – 5.4	1382.4-1627.0	1,358 – 1,666	1,482
06	Ping	33,898	25.4 – 32.4	67.0 – 75.0	1.6 – 3.7	5.4 – 6.6	1503.2-2073.0	940 – 1,394	1,143
07	Wang	10,791	25.9 – 27.3	68.0 – 74.0	1.4 – 2.8	5.6 – 3.2	1466.7-1955.0	1,023 – 1,132	1,076
08	Yom	23,616	25.5 – 28.3	70.0 – 73.0	1.5 – 3.7	5.2 – 6.0	1547.5-2073.0	995 – 1,298	1,146
09	Nan	34,330	25.7 – 28.3	70.0 – 78.0	1.0 – 3.7	5.4 – 6.0	1243.5-2073.0	623 – 1,481	1,244
Total Watershed in Northern		**128,460**	**24.0 – 32.4**	**67.0 – 780**	**1.0 – 3.7**	**5.2 – 6.0**	**1243.5-2073.0**	**623 – 2,137**	**1,217**
Watershed in Northeastern									
02	Khong	57,422	24.0 – 26.8	72.0 – 77.0	1.5 – 4.0	5.2 – 6.4	1382.4-2054.3	1,066 – 2,474	1,522
04	Chi	49,477	26.7 – 27.6	67.0 – 71.0	2.1 – 3.5	5.6 – 6.0	1773.2-2001.3	997 – 1,355	1,180
05	Mun	69,700	26.7 – 27.0	72.0 – 73.0	2.1 – 4.0	6.1 – 6.4	1873.5-2109.5	1,007 – 1,759	1,266
Total Watershed in Northeastern		**176,599**	**24.0 – 27.6**	**67.0 – 77.0**	**1.5 – 4.0**	**5.2 – 6.4**	**1382.4-2109.5**	**997 – 2,474**	**1,325**
Watershed in Central									
10	Chao Phraya	20,125	27.9 – 29.2	70.0 – 74.0	3.3 – 5.1	5.8 – 7.1	1861.7-2073.0	1,107 – 1,136	1,131
11	Sakae Krang	5,192	28.3	70.0	3.7	5.8	2073.0	1,148 – 1,414	1,295
12	Pasak	16,292	26.7 – 28.1	70.0 – 72.0	1.2 – 3.3	5.5 – 5.9	1621.0-1934.4	1,066 – 1,433	1,192
13	Tha Chin	13,682	25.3 – 29.2	70.0 – 72.0	3.7 – 4.2	5.8 – 6.1	1861.7-2073.0	1,080 – 1,111	1,084
14	Mae Klong	30,837	23.2 – 29.2	68.0 – 80.0	1.0 – 4.2	5.3 – 6.1	1362.8-1930.5	1,027 – 2,576	1,422
19	Phetchaburi	5,603	27.6	76.0	3.3	6.1	1651.5	1,035 – 1,174	1,071
20	Western Coast	6,745	27.0	78.0	4.7	6.3	1740.9	898 – 1,447	1,054
Total Watershed in Central		**98,476**	**23.2 – 29.2**	**68.0 – 80.0**	**1.0 – 5.1**	**5.3 – 7.1**	**1362.8-2073.0**	**898 – 2,576**	**1,223**
Watershed in Eastern									
15	Prachinburi	9,821	27.7 – 29.9	72.0 – 77.0	2.0 – 2.6	6.2 – 6.3	1674.2-1822.8	1,335 – 1,667	1,508
16	Bangpakong	8,679	27.7 – 28.4	72.0 – 77.0	2.0 – 4.0	6.0 – 6.2	1674.2-1728.2	1,212 – 1,662	,1365
17	Tonlesap	4,150	29.9	74.0	2.6	6.3	1822.8	1,174 – 1,951	1,522
18	Eastern Coast	13,830	26.8 – 29.3	73.0 – 80.0	1.7 – 6.2	5.9 – 7.2	1518.3-1893.9	1,307 – 3,289	2,188
Total Watershed in Eastern		**36,480**	**26.8 – 29.9**	**72.0 – 80.0**	**1.7 – 6.2**	**5.9 – 7.2**	**1518.3-1893.9**	**1,174 – 3,289**	**1,734**
Watershed in Southern									
21	Peninsula-East Coast	26,362	26.7 – 27.5	77.0 – 82.0	2.5 – 6.7	6.7 – 7.7	1399.0-1825.9	1,590 – 2,660	2,046
22	Tapi	12,225	26.4 – 30.2	76.0 – 81.0	1.9 – 5.4	6.9 – 7.1	1414.0-1823.9	1,611 – 2,629	1,689
23	Songkhla Lake	8,486	26.8 – 27.9	77.0 – 81.0	2.8 – 6.7	7.1 – 7.7	1414.0-1825.9	1,744 – 2,093	1,931
24	Pattani	3,858	26.9	81.0	4.3	7.4	1762.2	1,791 – 1,933	1,865
25	Peninsula-West Coast	21,172	26.7 – 28.3	75.0 – 82.0	2.5 – 5.0	6.4 – 7.3	1281.4-1851.6	1,975 – 4,059	2,513
Total Watershed in Southern		**72,102**	**26.4 – 30.2**	**75.0 – 82.0**	**1.9 – 6.7**	**6.4 – 7.7**	**1281.4-1851.6**	**1,590 – 4,059**	**2,133**
	Total	**512,107**	**23.2 – 32.4**	**67.0 – 82.0**	**1.0 – 6.7**	**5.2 – 7.7**	**1243.5-2109.5**	**623 – 4,059**	**1,421**

Table 3 Comparison Runoff from Natural Flows and Runoff from Rainfall Calculate (100%)

Watershed Code	Main Watershed	Area (km^2)	Annual Runoff (mcm	Annual Rainfal (mm)	Runoff Potential (From 100% Rainfall (mcm)	% Rainfall to Runoff (%)
Watershed in Northern						
01	Salawin	17,920	8,622.87	1,367.64	24,508.09	35.18
03	Kok	7,895	4,710.33	1,481.72	11,698.22	40.27
06	Ping	33,898	9,001.97	1,143.09	38,748.41	23.23
07	Wang	10,791	1,658.03	1,075.67	11,607.66	14.28
08	Yom	23,616	4,247.08	1,145.70	27,056.80	15.70
09	Nan	34,330	11,508.15	1,244.11	42,710.12	26.94
Total Watershed in Northern		**128,450**	**39,748.43**	**1,217.04**	**156,329.30**	**25.43**
Watershed in Northeastern						
02	Khong	57,422	22,746.47	1,522.43	87,421.04	26.02
04	Chi	49,477	11,135.13	1,179.86	58,376.06	19.07
05	Mun	69,700	20,408.86	1,266.41	88,268.65	23.12
Total Watershed in Northeastern		**176,599**	**54,290.46**	**1,325.41**	**234,065.74**	**23.19**
Watershed in Central						
10	Chao Phraya	20,125	4,435.03	1,130.68	22,754.87	19.49
11	Sakae Krang	5,192	1,165.65	1,235.86	6,416.53	18.48
12	Pasak	16,292	3,560.50	1,191.96	19,419.40	18.33
13	Tha Chin	13,682	2,449.19	1,084.32	14,835.65	16.51
14	Mae Klong	30,837	12,379.40	1,422.25	43,858.35	28.23
19	Phetchaburi	5,603	1,337.91	1,071.02	6,000.94	22.30
20	Western Coast	6,745	1,576.51	1,053.53	7,106.09	22.19
Total Watershed in Central		**98,476**	**26,924.19**	**1,222.55**	**120,391.83**	**22.36**
Watershed in Eastern						
15	Prachinburi	9,821	4,569.44	1,507.95	14,809.63	30.85
16	Bangpakong	8,679	3,765.43	1,365.48	11,851.08	31.77
17	Tonlesap	4,150	2,409.60	1,522.32	6,317.62	38.14
18	Eastern Coast	13,830	12,690.90	2,188.45	30,266.22	41.93
Total Watershed in Eastern		**36,480**	**23,435.37**	**1,733.68**	**63,244.55**	**37.06**
Watershed in Southern						
21	Peninsula–East Coast	26,352	21,779.00	2,046.37	53,925.93	40.39
22	Tapi	12,225	12,528.14	1,888.82	23,090.78	54.26
23	Songkhla Lake	8,495	5,483.39	1,930.82	16,402.36	33.43
24	Pattani	3,858	3,320.02	1,864.71	7,194.04	46.15
25	Peninsula–West Coast	21,172	21,742.29	2,512.64	53,197.78	40.87
Total Watershed in Southern		**72,102**	**64,852.84**	**2,133.24**	**153,810.89**	**42.16**
Total		**512,107**	**209,291.28**	**1,421.27**	**727,842.31**	**28.75**

Table 4. Unconsolidated rocks areas and Consolidated rock area in Thailand

Region	Area (km^2)	Unconsolidated Area (km^2)	Consolidated Area (km^2)		
			High Aquifer	Medium Aquifer	Low Aquifer
Northern	169,640	41,300	32,210	49,490	46,640
Central	30,130	18,100	3,500	4,100	4,430
Northeastern	168,840	9,200	56,000	85,000	18,640
Eastern	34,280	5,690	5,160	6,750	16,480
Western	39,840	9,150	14,334	1,400	14,956
Southern	70,140	17,600	12,450	24,200	15,890
Total	512,870	101,240	123,651	170,940	117,036

age safe yield, of groundwater in each sediment basin of the flood plain area are summarized in Table 6.

The area of unconsolidated aquifer in the Northern, Central and Southern parts are larger than the other parts but the consolidated aquifer in the Northeastern and Northern parts are greater than the others.

Table 5 Groundwater Recharge (compare with runoff) of other regions in Thailand.

Region	Average Rainfall		Runoff (mcm)	Groundwater Recharge (mcm)
	(mm)	(mcm)		
Northern	1,280	217,140	65,140	11,000
Central	1,270	38,270	7,650	2,800
Northeastern	1,460	246,500	36,680	9,700
Eastern	2,140	73,360	22,000	3,000
Western	1,520	60,560	18,170	3,500
Southern	2,340	164,130	49,240	8,000
Total	10,010	799,960	198,880	38,000

Remark mcm : million m^3

Table 6. Groundwater Storage and Safe Yield for Other Basin in Thailand

Groundwater Basin	Groundwater Storage (MCM)	Save Yield per Year (MCM)	Save Yield per day (MCM)
1. ChiangMai – Lamphun Basin	485	97	0.265
2. LamPang Basin	295	59	0.161
3. Chiang Rai – Phayao Basin	212	42	0.115
4. Phrae Basin	160	32	0.087
5. Nan Basin	200	40	0.110
6. North Chao Phraya Basin	6,400	1,280	3.500
7. South – Chao Phaya Basin	6,470	1,294	3.500
8. Tha Chang Basin	320	64	0.175
9. Nakhon Sri Thamarat Basin	420	84	0.230
10. Ranot – Songkhla Basin	400	80	0.200
11. Hat Yai Basin	175	35	0.096
12. Pattani Basin	340	68	0.186
Total	15,877	3,175	8.625

ATMOSPHERIC WATER REGIME

The atmospheric waters are important resources that should be known for both the spatial distribution and time distribution in order to initially assess the rough amount of precipitation and evaporation of each of the watershed. Spatial distribution was carried out in terms of the climatic regions.

The overall climate in Thailand was classified into four main regions A, B, C and D. The main idea for classification was modified from Van Der Eelaart, which comprised of the influence on monsoons period, rainfall amount evaporation amount and temperature. Zone A : The Equatorial Climate include two sub zone A_1 and A_2. Sub zone A_1 is in region of high rainfall during long Southwest Monsoon comprise of the area on the West Coast of the Southern Thailand (along Phuket Mountain Range) and on the coast of the Eastern Thailand (along Bantud Mountain Range) as shown in Figure 2. Sub zone A_2 is in the region of high rainfall during long Northeast Monsoon Season on the East Coast of the Southern Thailand (Nakhorn Sri Thammarat and San Kala Khiri Mountain Range). The zone B is in the Tropical Monsoon Climate with long rainy season. There are five sub zone, B_1 (high rainfall : windward of San Kham Phaeng Mountain Range to the Southwest Monsoon), B_2 (moderate rainfall : windward of Phetchabun and San Kham Phaeng Mountain Range and leeward of Tennessarim Mountain Range to the Southwest Monsoon), B_3 (low rainfall area : leeward of Tennessarim Mountain Range to the Southwest Monsoon), B_4 (moderate to high rainfall and cool dry season : Chiangrai Valley) and B_5 (mountainous with cool dry season in valleys : all mountain range in the Northern and Western of Thailand). Zone C were identified as Tropical Monsoon Climate with Rainy and Dry season (5.5 to 6.6 humid months) and were classified into three sub zone C_1, C_2 and C_3. Sub zone C_1 implied moderate to high rainfall area on the east of the Khorat Plateau in the Northeast of Thailand, subzone C_2 exists low rainfall : in the Central of Thailand and the Southern of the Khorat Plateau. The Zone D is the Tropical Monsoon Climate with long dry season (4.5 to 5.5 humid months) comprise of

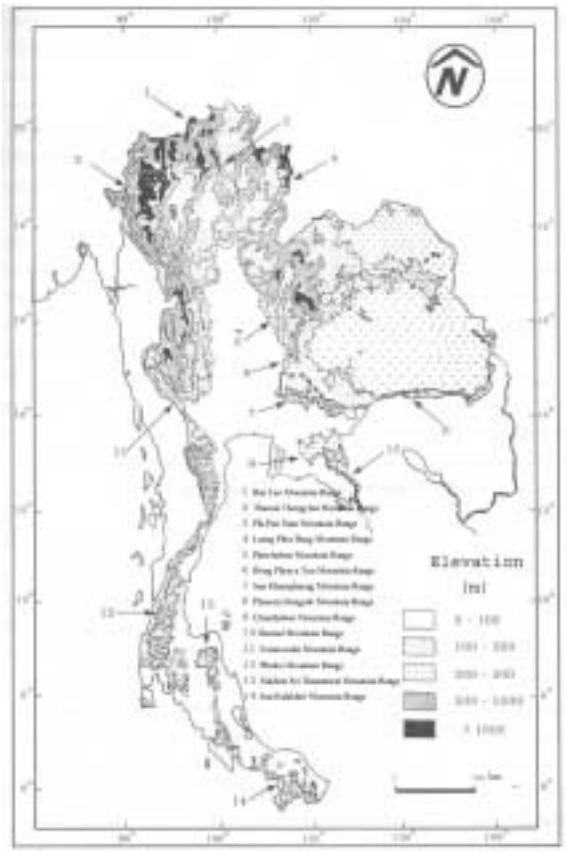

Figure 2 Topographic Map of Thailand Showing the Orientation of Mountain Ranges

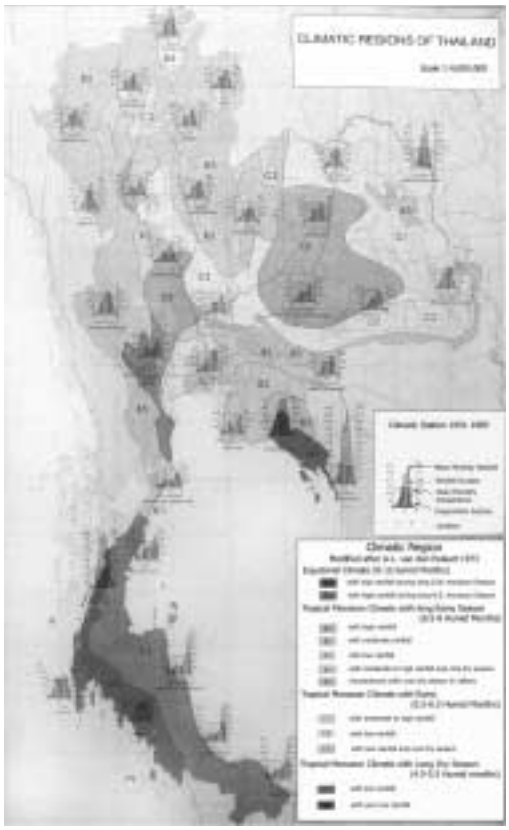

Figure 3 Climatic Regions Map of Thailand

low rainfall sub zone (D_1 along leeward of Tennessarim Mountain Range and on the Khorat Plateau in the Northeastern Thailand) and very low rainfall sub zone (D_2 leeward of Tennessarim Mountain Range). The Climatic Regions of Thailand is mapped as shown in Figure 3.

Time distribution of the precipitation of the overall climatic region was carried out/analyzed in terms of the synoptic climatic condition. Three kinds of air mass move over Thailand every year. Warm and moist marine time air mass from South China Sea during the rainy season as well as warm and moist marine time air mass from Andaman Sea and warm and moist air mass from Pacific Ocean. Another cool and dry air mass from the upper part of Asia Continent. This air mass and the Intertropical Convergence as well as the Monsoon exist and play an important role in the climatic conditions of Thailand as shown in Figure 4. Frequency and duration analysis on the Synoptic Climatic Conditions of Thailand yielded nine Climatic Influents that will conduct heavy rainfall, drought and flooding. The criteria on frequency and duration analysis are the three years group of the same behaviour of rainfall amount such as in high rainfall amount (WET) medium rainfall amount (MED) and low rainfall amount (DRY). Five seasons are classified for each topographic and physiographic feature of Thailand. The seasons are the Northeast Monsoon Season (NM, during JAN, FEB, NOV, DEC), Summer Intermonsoonal Season (SIM, during JAN, FEB, NOV, APR), on set Southwest Monsoon Season (OSM, during MAY, JUN), Southwest Monsoon Season (SW, during JUL, AUG, SEP) and winter intermonsoonal Season (WIM, during OCT).

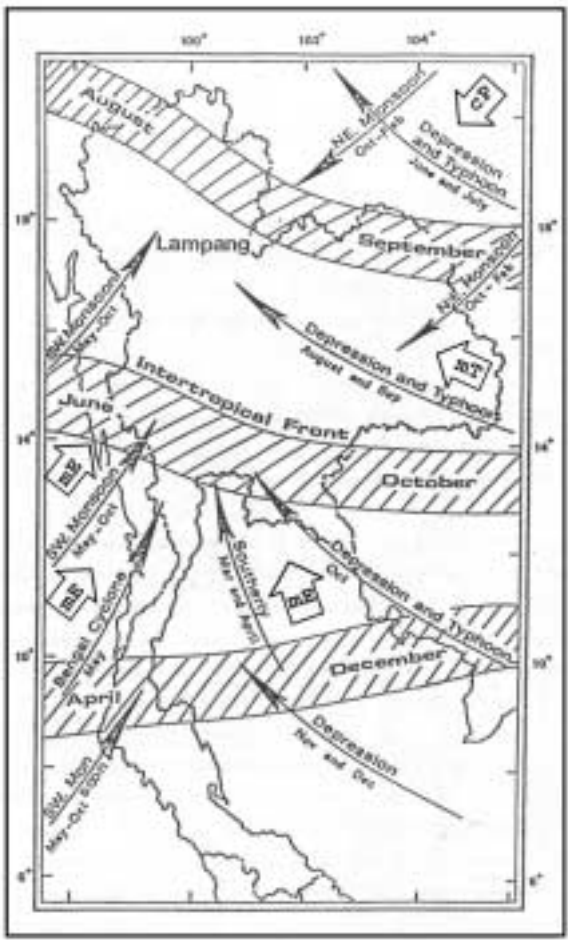

Figure 4 Monsoon and Cyclone Storms dominating the Climatic Condition in Thailand

The details of nine Climatic Influences are as follows :

1. The Active High Pressure (AH) and Heat Low (HL) condition (Active High Pressure (AH) and Heat Low (HL) condition
2. Convergence (Con) between warm and moist air mass from South China Sea join with warm and very moist air mass from Andaman Sea
3. Westerly Trough (WT) of warm air mass in the temperate climate under the influence of Westerly Wind
4. The influential movement of Tropical Storm (LOW & DEP) from Andaman Sea and South China Sea
5. The influence of Active Intertropical Convergence Zone (AITCZ)
6. The influence of Weak Intertropical Convergence Zone (WITCZ)
7. The Active Southwest Monsoon (ASW)
8. The Easterly Wind (EWIND) from South China Sea to the continental low-pressure area
9. The Southerly Wind (SWIND) from the Gulf of Thailand to the continental low-pressure area

The summary of these climatic influences and their activities on each climatic region of Thailand is presented in Table 7.

Table 7 Summary on Synoptic Situation of Climatic Influents on five Conventional Season over 8 Parts and 4 Climatic Regions of Thailand.

	NM	SIM	OSM	SM	WIM
Up-N (B_4-B_5)	AH+HL and CON	AH+HL and CON	AITCZ and LOW+DEP	AITCZ and LOW+DEP ASW	AITCZ and LOW+DEP
Up-NE (C_1)	AH+HL LOW+DEP	AH+HL, CON and S-WIND	AITCZ and LOW+DEP and CON	AITCZ and LOW+DEP ASW	LOW+DEP AITCZ
Lo-N (B_2-C_3)	AH+HL	CON	AITCZ	AITCZ LOW+DEP ASW	AITCZ and LOW+DEP
Lo-NE (D_1)	AH+HL and CON	AH+HL and CONS-WIND	AITCZ ASW and CON	AITCZ ASW	AITCZ and LOW+DEP
CEN (C_2-D_1)	AH+HL LOW+DEP	AH+HL and CON	AITCZ ASW	AITCZ ASW	AITCZ AH+HL
EAST (B_2 and B_5)	AH+HL LOW+DEP (Nov.)	AH+HL and CON	AITCZ CON	AITCZ and ASW	AITCZ and ASW
SSE A_2	AH LOW+DEP	AH and CON	ASW	ASW, WSW	AH and AITCZ
SSW A_1	AH LOW+DEP	AH and CON	AITCZ ASW	WITCZ and LOW+DEP	AH and LOW+DEP

HYDROMETEOROLOGICAL DISASTER IN THAILAND

The natural disaster in Thailand predominantly related with the hydro meteorological factors such as severe flooding and landslide due to long heavy rain, severe drought due to lack of rainfall and severe windstorm due to Tropical Storm and Cyclone. Heavy rain accompany with windstorm when they are generated by the Tropical Storm (Figure 5). Droughts in the Dry Season and in Wet Season are caused by lack of rainfall for long period.

Flooding and Wind Storm

The nine climatic influences conduct both smooth and vigorous rhythm of the weather especially the Tropical Storm. The numbers of the regional Tropical Storm that generated in between Latitude 0-25 °N and Longitude 90-115 °E during 1975 to 1990 are summarized and tabulated in Table 8. The numbers of Tropical Storm that moved over Thailand during 1951 to 1990 are also shown in Table 9. The hydro-meteorological disaster in Thailand can be explained in term causes, lost of life and economic as lost follows : (Table 10)

In 1962 ; The Tropical Storm (LOW & DEP), Hariat, moved over the Talumpuk Spit at Nakhon Sri Thammarat Province and conducted Storm Surge to destroy 870 peoples lost of lives and 16,170 peoples lost their houses.

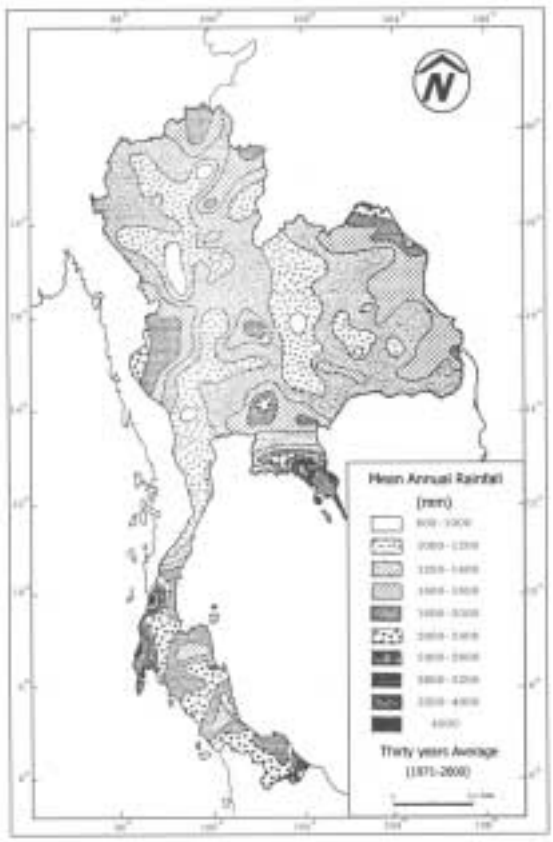

Figure 5 Mean Annual Rainfall During 1971-2000 Thailands

Table 8 The Numbers of Regional Tropical Cyclone Originated in between Latitude 0 - 25 N and Longitude 90 - 115 E during 1975 to 1990

Originating Area / Year	Pacific Ocean	South China Sea	Gulf of Bengal	Andaman Sea	Philippines Islands	Gulf of Thailand	Total
1975	4	8	1	1	1		15
1976	1	7	3	2			13
1977	4	5	2				11
1978	11	4	1		2		18
1979	4	5			1		10
1980	8	6	2	1			17
1981	7	8	2	1		1	19
1982	6	3	4	1			14
1983	4	9	3		2	1	19
1984	5	6	2				13
1985	8	12	3				23
1986	6	8	1	1	1		17
1987	6	3		2			11
1988	7	6	3	2			18
1989	9	8		1		1	19
1990	4	12	1	2			19
Total	94	110	28	14	7	3	256
Percent	37	43	11	5	3	1	100

Source : Dhammasaroch (1999)

In 1975, Typhoon (LOW & DEP) passed over the Northern Thailand yielded severe flooding in Chao Phraya Basin in the Central and Mun Basin in the Northeast.

In 1983, Depression Herbert and Depression Kim (LOW & DEP) passed over the Eastern and the Central Thailand and caused very long term flooding in Bangkok for 4 months.

In 1988, the strong Northeast Monsoon (AH) moved to the Active Inter Tropical Convergence Zone (AITCZ) in the Southern Thailand and caused severe flooding and landslide all over the South of Thailand leaving 415 people dead and 61,334 persons badly affected not to mention an economic loss of US $ 340 million.

In the year 1989, Typhoon Gay (LOW & DEP) originated in the Gulf of Thailand and caused the lost of 615 peoples, destroyed 46,958 houses and sunk 639 ships as well as US $ 230 million economic loss.

In 1995, many depression (LOW & DEP) and AITCZ move over the North and Northeast of Thailand continually that created heavy rain in the Ping, Wang, Yom and Nan Basin. Two months of flooding over the Lower Northern and the Central Thailand cause the economic loss of US $ 250 million and many people died.

In 2000, heavy rain (AITCZ) about 440 mm during November 20 to 21 in the Southern Thailand conducted severe flooding in Haadyai District, Songkhla Province and caused lost of 26 lives and US $ 50 million economic loss.

In 2001, heavy rain about 281 mm due to Active Intertropical Convergence Zone (AITCZ) situated over the Northern Thailand and caused flash flood and debris flow to Wang Chin District, Phrae Province, then 36 people die and US $ 5 million of economic lost. The Uzangi Tropical Storm moved over the Northeastern and the Lower Northern Thailand cause flash flood and landslide at Ban NamKho, Lom Sak District, Phetchabun Province and 45 peoples dead, US $ 15 million economic lost.

In this year 2002, heavy rain during August 2 to 3 from strong Active Intertropical Convergence Zone (AITCZ) passed over The Northern caused flash flood and Landslide at Ban Sop Yuam, Mae Sa Riang District, Mae Hong Son Province, 15 people dead and 10 people lost.

Heavy rain from AITCZ and the influence of Tropical Storm in China Sea and South China Sea

Table 9 Tropical Storm Move Over Thailand for Forty Years Period during 1951 - 1990

Year \ Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
1951							1		1				2
1952								1	1	4			6
1953					1								1
1954										1			1
1955									1				1
1956											1		1
1957										1			1
1958							1	1	1	1			4
1959									1	1			2
1960									1	1	1		3
1961				1	2			1		2			6
1962							1		1	1	1		4
1963							1		2	1	1		5
1964									2	4	2	1	9
1965								3	5			1	9
1966						1				2	2	1	6
1967									1	3	1		5
1968								2		1	1		4
1969						1	1	1	1	1	1		6
1970								1	2	2	2		7
1971							2			2			4
1972						1			2	1		1	5
1973							1	1	1	1	2		6
1974								1		1	1	1	4
1975					1				2				3
1976													0
1977									1		1		2
1978							1	1	2		1		5
1979								1	1				2
1980					1				2		1		4
1981										1			1
1982					1				1				2
1983						1				3	1		5
1984						1				1	1		3
1985									1	2			3
1986									1	1			2
1987								1					1
1988										1			1
1989					1					2	1		4
1990								1		2			3
Total				1	6	6	9	16	34	44	22	5	143
Average				0.03	0.15	0.15	0.23	0.40	0.85	1.10	0.55	0.13	3.58
Frequency (%)				1	4	4	6	11	24	31	15	4	100

Source : Meteorological Department (2001)

Table 10 Economic Lost, Dead and Impact on Hydo - meteorological Disaster during 1962 to 2001

Year	Economic Lost (US $ Million)	Dead (Persons)	Impact (Persons)	Commentary
1962	*	870	16,592	Nakorn Sri Thamarat
1972	*	7	*	
1973	*	55	*	
1974	*	30	*	
1975	*	314	*	
1978	0.5	*	*	
1980	*	61	70,106	
1981	*	77	2,025	
1982	*	32	18,051	
1983	*	57	9,829	
1984	*	35	1,556	
1985	*	6	43	
1986	*	37	343	
1987	*	60	9,821	
1988	340	415	61,334	
1989	*	615	11,687	Chumporn
1990	*	41	6,867	
1991	7	*	*	
1992	5	*	*	
1994	1	*	*	
1995	236	*	*	
1997	150	*	665 villages	Chumporn
2000	50	26	*	Songkhla
2001	5	36	*	Phrae
2001	15	156	200,000 families	31 provinces

Commentary : * no report
Source : Ministry of Interior (2001)

conducted heavy rain continually in the Northern and Northeastern and caused flooding over all the Lower Northern, Central and Northeastern of Thailand same as in the year 1995. Forty-nine Province was submerge under water and 41 peoples died and US $ 30 million economic lost.

DROUGHT

Long-term drought in Thailand were analyzed under the criteria on Rainfall Decile (RD), Generalized Monsoon Index (GMI), Annual Rainy Day (ARD), Dry Period (DP) and in term of Low Flow (LF). The Rainfall Decide comprise of ten Decide Ranges (DR) those move around the mean annual rainfall of the study site. The Decide Range between 4 to 7 or $\pm$ 5% from the mean annual rainfall imply normal rainfall year (Table 11), DR between 3 to 1 or annual rainfall amount less than mean annual rainfall 5.1 to 15.0%, 15.1% to 25.0% and > 25.0% mean moderately drought, drought and severely drought respectively. DR between 8 to 10 or annual rainfall amount greater than mean annual rainfall 5.1 to 15.0%, 15.1 to 25.0% and > 25.0% mean moderately wet, wet and severely wet respectively.

The Generalized Monsoon Index (GMI) was suggested by the Meteorological Department on the total rainfall amount during the Southwest Monsoon season compare with mean annual rainfall in term of GMI percentile range (GMIpct) as shown in Table 12. The GMIpct range between 0 to 20, 21 to 30, 31 to 40, 41 to 60, 61 to 90 and 91 to 100 imply severely drought, drought, moderately drought, normal, higher than normal and

Table 11 Decile Range, Total of Rainfall higher and lower than normal rainfall and Rain Condition

Decile Range	The Quantity of rain per year High - Low more than (average, usual, normal) (%)	Rain Condition
1	Lower than usual 25	Severely drought
2	Lower than usual 15.1-25.0	Drought
3	Lower than usual 5.1-15.0	Moderately drought
4 - 7	More than or lower than usual 5.0	Normal
8	More than 5.1-15.0	Moderately Wet
9	More than 15.1-25.0	Wet
10	More than usual 25.0	Severely Wet

Source : Dhammasaroch (1999)

Table 12 Generalized Monsoon Index (GMI) in term of Percentile Range (GMIpct)

GMIpct	Moisture Requirement of Plant
91 - 100	Higher than Plant Requirement
61 - 90	Higher than Normal
41 - 60	Normal
31 - 40	Moderately Drought
21 - 30	Drought
0 - 20	Severely Drought

Source : Dhammasaroch (1999)

higher than requirement of plant.

The number of Annual Rainy Day (ARD) marks at 100 days a year, lesser than 100 days a year mean drought year, but greater than 100 days a year mean wet year. The Dry Period (DP) mean the time period with rainfall less 1 mm in fifteen days. The Low Flow (LF) demark on the flow in dry season if no LF imply drought if LF available mean normal condition.

Droughts in Thailand were recorded in 1967, 1968, 1973, 1977, 1979, 1982, 1983, 1986, 1997 and 2002. From the record, two drought patterns were identified. Drought due to no rain in the Wet Season during July to August up to September and drought due to long period of no rain in the dry season during December to June up to July were analyzed in term of repeated pattern. Droughts in wet period (during July to August or September) were recorded in 1968, 1972, 1979, 1982, 1986, 1990, 1994, 1998 and 2002. Droughts in dry period (during December to June) are in 1967, 1973, 1977, 1983 and 1997. Drought in wet period always causes very large economic lost due to damage of agricultural products that farmers plant them in this season. Drought in dry period always less economic lost than in the wet period because of seldom field crop plant in the dry period.

AGRO-ENVIRONMENTAL EDUCATION

More than hundred thousand have graduated from the Kasetsart University in the branch of agro-environment and related area during the early 60's ; this was the first institute who initiated agro-environmental education. Many academies created this kind of curriculum as well during the past two decades up to the present. The curriculums on the agro-environmental area are agricultural science, water resources science and engineering, forestry and watershed management, environmental science and engineering. At present, there are more than two hundred thousand of people who studied in this program and in related fields. Next year, 2003, Thai government will ask all schools to create a new curriculum for students adding the earth science studies in one of the six basic sciences and computer subjects, that all student have to study from primary level (level 1-6) up to secondary level (level 7-12) in order for them to understand the relationships and interactions between water resources, meteorological resources, geological resources prior to the profession studies in the university level. The Ministry of Environmental Resources will also use new strategies for the villagers who live within and nearby the watershed area. The participatory education or approaches will be implemented engaging the people living within the

watershed area and the government officers who are in-charge of taking care of the watershed together with the non-government organizations and also the people living within the town will intensify the care of the watershed area. The watershed area and the forest were established as a natural laboratory for them and the students. Within this strategy the forest and the watershed area practically belong to nature and to everyone, which, is the major educational objective, which hopefully will lead to sustainable use of resources aiming at having only minor disaster in the future.

SUMMARY

The twenty-five major watersheds in Thailand are the important water resources for both surface water and groundwater. The amount of precipitation in Thailand ranges between 1,000 mm to 4,000 mm and the average is 1,200 mm. The natural disaster in Thailand was generated by the effect of atmospheric water resources, as well as the physiogeography of the watershed area. Two main N - S trending mountain ranges in the Western and in between the Central and the Northeast are the major obstructers to the effect of the Northwest Monsoon and Northeast Monsoon on the climate of Thailand. Four major Climatic Regions were classified from the rainfall amount, evaporation, annual mean temperature and topography. There were the Equatiorial Climate, the Tropical Monsoon Climate with long rainy season, the Tropical Monsoon Climate with rainy and dry season (5.5 to 6.5 humid months) and the Tropical Monsoon Climate with long dry season.

The frequency and duration analysis of the influential factors on the climate in all seasons were carried out. Five seasons were distinguished as the Northeast Monsoon Season (NM) during Jan, Feb, Nov and Dec). Summer Intermonsoonal Season (SIM) during Mar and Apr, On Set Southwest Monsoon Season (OSM) during May and Jun, Southwest Monsoon Season (SW) during Jul, Aug and Sep and Winter Intermonsoonal Season (WIM) during October. The Climatic Regions and Climatic Seasons were intently related with the Climatic Influents that comprise of 9 components such as the Active High Pressure (AH) and Heat Low (HL) condition, (Active High Pressure (AH) and Heat Low (HL) condition, Convergence (Con) between warm and moist air mass from South China Sea join with warm and very moist air mass from Andaman Sea, Westerly Trough (WT) of warm air mass in the Temperate climate under the influence of Western Wind, the influential movement of Tropical Storm (LOW & DEP) from Andaman Sea and South China Sea, the influent of Active Intertropical Convergence Zone (AITCZ), the influent of Weak Intertropical Convergence Zone (WITCZ), the Active Southwest Monsoon (ASW), the Easterly Wind (EWIND) from South China Sea to the continental low pressure area and The Southerly Wind (SWIND) from the Gulf of Thailand to the continental low pressure area. These Climatic Influents are the outstanding on the Synoptic Climatic in both regional and seasonal of Thailand.

The major natural disaster in Thailand comprise of flooding, windstorm and drought. Tropical storms, Active Southwest Monsoon and the Active Intertropical Convergence Zone. They play the major role on windstorm and flooding disaster. The long-term stationary situation of Tropical Convergence Zone over the Southern of China and the Northern of Thailand cause severe drought in the wet period of the Central and Southern Thailand as well as very wet in the Northern and Northeastern. Whenever the Active Intertropical Convergence Zone moves down to the Central and the Southern, The heavy rain will be created and flooding and landslide will be occurred. Drought in the dry period always depends on the effect of El - Nino and Southern Oscillation (ENSO) the very strong activity of ENSO will cause the severe drought for long dry period. In 1962 Tropical storm, Hariat, move over the Talumpuk Spit of the Southern Thailand as well as Typhoon Gay move over the Upper Pant of the Southern. These two windstorms caused many lost of many lives and abundant economic losses. Severe flooding and landslide over all the Southern in November 1988 conducted by AH and AITCZ as well as severe flooding overall the Lower Northern, the Central and the Northeastern in 1995 and the same event are happening in 2002. Severe drought in wet

periods occurred in 1968, 1972, 1979, 1982, 1986, 1990, 1994, 1998 and 2002 whereas dry period drought were exhibited in 1967, 1973, 1977, 1983 and 1997.

The agro-environmental education in Thailand is initially started nearly 60 years ago, the beginning of Kasetsart University. Many curricula on the natural resource development and conservation, land-use and sustainability, watershed management and development with sustainable yield were created extensively in many universities and colleges during the previous decade. The Thai government plans to educate the students from primary school up to secondary school (12 levels) in earth science in terms of three categories; geological resources, hydrological resources, meteorological resources these are the major base sciences for agro-environmental studies in the future. The participatory education will be in placed with the idea of putting together the people living within the watershed area and the government officers in charge of taking care of the watershed area to work hand in hand towards the sustainable use of water resources with the aim of having minor disasters in the future.

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THAILAND : DISCUSSION

Question : What agricultural and environmental education programs are being implemented in Thailand to increase public awareness of the importance of the flood and drought control?

Answer : We have started the idea of the participatory approach where the villagers accompanied by the sub-district committee and the government officers, who are in charge of taking care of the environment, work hand in hand. The villagers themselves selected the sub-district committee. The teachers have to take care of the curriculum at the school level and then they work together with the sub-district committee, the forester and the agricultural extension officers in protecting their environment setting a good example for the next generation.

Question : Although there have been several floods and droughts in Thailand as you presented, they seem to be not in large-scale in Thailand's crop production, it seems that it is not seriously affected. Is this right?

Answer : The crop production is still affected by the occurrence of floods and droughts, but yes, they are in small scale when compared to the gross production. This is due to the fact that major droughts always occur in summer and major flood always exits in rainy season that we have enough time and chance to do replanting again in the dry season through irrigated water.

Question : Could you explain the education system for agriculture, forestry and environmental protection in Thailand?

Answer : The education on agriculture and forestry in terms of environmental protection in Thailand are mainly done in the Kasetsart University and in some universities that started within this decade. The government asks all students in school for all 12 levels to study the earth science which are divided into four categories; space resources, geological resources, atmospheric resources and hydrologic resources. These are the basic sciences geared towards sustainable utilization of the environmental resources in the future.

Question : How to determine the GMI?

Answer : The GMI (Generalized Monsoon Index) is the percentile range of the rainfall during the monsoon season compared with the mean annual rainfall and the set criteria as shown in Table 7.

Question : What kinds of non-structural countermeasures are being done in your country during droughts.

Answer : Check dams are the non-structural countermeasures we have which are very efficient

for watershed areas where the severe situation of erosion and land use change often occurs. We also have large pounding area for water storage in the rainy season, whereas the shallow ground waters are available for some places, which are not severely affected by droughts.

Question : Could you explain the range of variation for the precipitation in a year in Thailand?

Answer : The range of variation of rainfall in all year is differentiated into 3 seasons and 2 in between those three seasons. The main rainstorms are in rainy season in the southwest monsoon during July, August and September, whereas the winter season during November to February shows no more rain as well as the summer season during March to April. The season prior to the rainy season during May to June is characterized by very low occurrence of rain as in the rainy season as well as in October prior to the winter period.

Question : What are the criteria of your climate classification system? What are the value ranges of each of the parameters considered? How do you decide the region and the sub-region divisions?

Answer : The main criteria for climatic zone classification are the monsoonal season, topography, rainfall amount as well as evaporation and the temperature variation of each zonal area. The humid months are the major parameters to be considered for the climatic zoning as shown in Figure 2 and the topography of the area as well as the rainfall amount are the main key subjects to distinguish the sub-region division.

Question : Is the monsoon season different from the nine climatic influences as you indicated in your paper? How do they connect? And what is its connection also to the climate region mapping?

Answer : The connection between the climatic region mapping and the climatic influence are the seasons and locations. They are of the same objectives, but the climatic influence conducts the synoptic event to the mapping area, which influences each synoptic condition for both space and time during the year.

Question : Can you clarify and give reason for Table 1?

Answer : Table 1 shows the synoptic condition in terms of climatic influence for all year round for a period of twenty years climatic data for each location and each season and sub-seasons in terms of frequency and duration of occurrence in the wet and dry and the season in between.