PROFILE OF THE STUDY AREA

1. Location and extent

The Pasak watershed covering an area of about 15,899.53 sq. km, is located in between 14^0 19′44′′ to 17^0 16′ 28′′ North Latitude and $100^0$34′ 45′′ to 101^0 30′ 23′′ East Longitude mostly at central part of Thailand and partially in North and Northeastern of Thailand. The watershed areas cover 7 provinces and 37 districts which are shown in Table 4 and Figure 5.

Table 4 List of Provinces and Districts belonging to Pasak Basin

Name of province	Name of Districts
Loei Province	Dan Sai
Phechabun Province	Lom Kao, Lom Sak, Num Nao, Khao Kho, Muag Phechabun, Nong Phai, Bung Sam Phun, Wachian Buri and Si Thep
Chiayaphum Province	Phakdi Chumphon and Thep Sathit
Lop Buri Province	Kok Charoen, Lom Sonthi, Chai Badan, Tha Luang, Phatthana Nikhom, Kok Sumrong, Muang.
Nakhon Ratchasima Province	Dan Khunthot, Si Khiu, Pak Chong, Thepharak
Sara Buri Province	Muang, Muak Lek, Kaeng Khoi, Chalaem Phakiea, Phraphut Thabat, Ban Mo, Sao Hai, Nong Don, Nong Saeng
Phra Nakhon Si Ayutthaya Province	Ayuttaya, Phachi, Nakhon Luang, Tha Rua

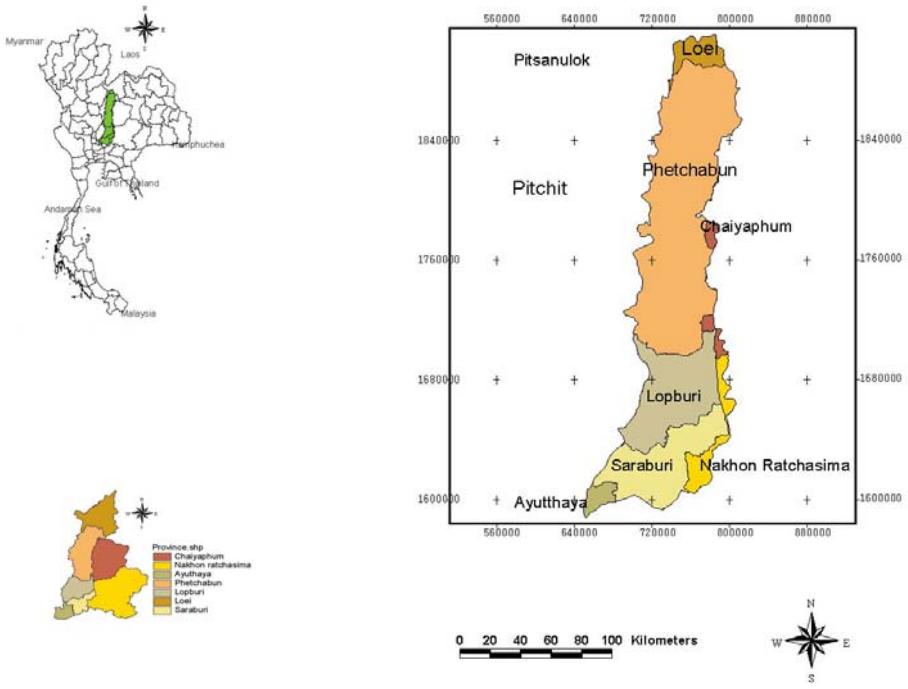

Figure 5 Location map of Pasak watershed

In the north the Pasak watershed is bounded by Khong River at Dan Sai districts, in the east by Khong River at Phu Luang district, Chi river at Nam Nao, Lom Sak, Muang, Nong Phai, Wachian Buri disticts, Phetchaboon Province and Nong Baodang, Pakdee Sumpon, Tep Satit districts, Chiayaphum Province, Moon river at Dan Khuntot, Si Keiw, Pak Chong, Tep Sathit districts, Nakhon Ratchsima Province, in the south by Bang Pakong watershed at Muang, Banna districts, Nakhon Nayok and Muang, Kang Khoi, Bhahan Dang district, Saraburi Province, Chaopraya watershed at Nhong Kha, Chaleom Pakeit, Nong Sang districts, Saraburi and Ayutthaya Province, Nakhon luang district, Ayuttaya province, in the west by Chaopraya watershed at Ayuttaya, Nakon luang, Bang Pahan district, Ayuttaya and Muang, Chaleom Pakeit, Phra Puttabat, Ban Mo, Nong Don districts, Saraburi province and Kok Charoen, Kok Sumrong, Sara Bot, Muang district, Lopburi province and Nong Phai, Bung Sam Phan, Wichian Buri, Chon Dan districts, Phetchaboon province and Phai Sali district, Nakonsawan and Nan watershed at Chon Dan , Khao Kho, Wang Pong districts, Phetchabun , Kong watershed at Lom Kao district, Phetchabun and Dan Sai district, Loei province.

Based on the availability of historical hydrologic records, the study area of Pasak Basin was divided into three parts namely: 1) Upper part at S4B gaging station 2) small catchments in the middle part (at S13 gaging station) as a representative of the middle part and 3) lower part of Pasak basin at S9 gaging station that include upper and middle part also (Figure 6). The sizes of each drainage area are given in the Table 5. The Pasak Basin has rectangle, narrow and long shape extending north-south direction. It stretches from north to south with 350 km long and 45 km wide. The drainage pattern in the area is controlled by geological structure and topography. Its main drainage system is dendritic i.e. the drainage lines are symmetrical. The dendritic drainage patterns together with the tributaries form a crooked pattern.

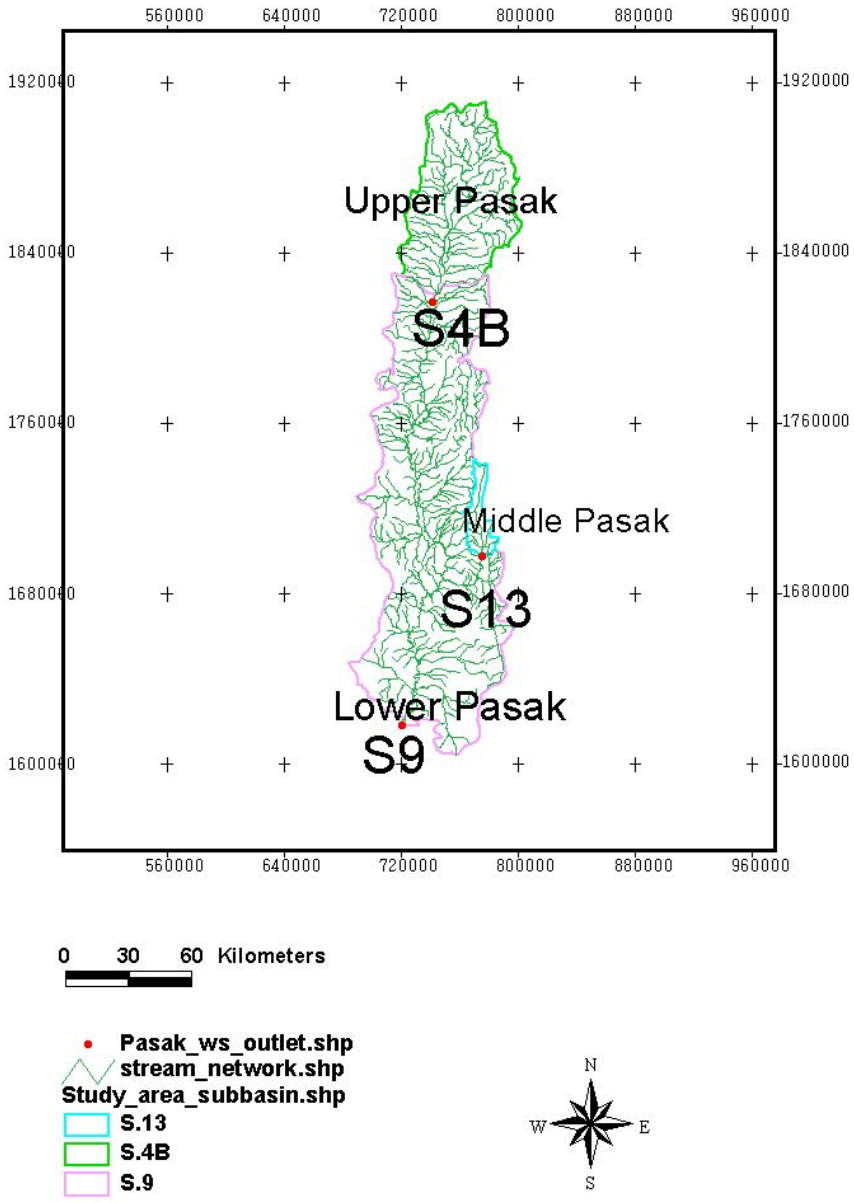

Figure 6 Study area of Pasak watershed showing three drainage areas

Table 5 Size and location of study area

Study area	size	Location of outlet *			
			Latitude		
	sq. km	At	(° N)	Longitude (°E)	Code**
		Muang, Phetchabun			
Upper part of Pasak	3480.43	(Map sheet No. 5241-IV)	160°-25′-12″	101°-10′-13″	S4B
		Ban Tha Yiam, Lom Santhi, Lopburi			
Middle part of Pasak	353.62	(Map sheet no. 5239-I)	15°-20′- 21″	101°-22′-30″	S13
		Ban Pa, Kaeng Khoi, Saraburi			
Lower part of Pasak	14236.69	(Map sheet no. 5238-III)	14°-37′-33″	101° -1′- 0″	S9

Note: * Stream gaging stations at outlet operated by Royal Irrigation Department (RID). ** Discharge station's code used by RID.

2 Climate and Meteorological Characteristics

The climate in the study area is tropical monsoon and characterized by wet and dry season, In general the wet season starts in May and extends to October. The dry period is from November to April. Rainfall varies considerably between years. Monsoon rains are unpredictable. Every 3-5 years rainfall may be so extreme that crops are damaged because of flooding or drought. . It is characterized by high humidity, moderately to high temperature and a distinct climatic variation between dry and wet seasons

According to the records of Lomsak (upper part of Pasak) climatic station of Royal Irrigation Department for the period of 23 years (1980-2003), the mean annual precipitation is 1091 mm with a mean maximum monthly rainfall of 217.4 mm in September (Table 6). The average number of rainy days is 102 per year. Maximum average rainfall is found to occur in September and minimum average rainfall in December.

From the data of temperature, humidity and evaporation during 1971-2000 collected by Meteorological department show Phetchabun station (upper Pasak) has average temperature of 26.9° C , average humidity 73%, and total evaporation 1,596.3 mm/year, while Lopburi station (Lower Pasak) has average temperature of 28.1° C , average humidity 71%, and total evaporation 1,905.8 mm/year. Average temperature is 18°C, through maximum temperature in April and minimum temperature in January.

Table 6 Monthly rainfall in mm observed at Lomsak climatic station during 1980-2003

Water Year	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Annual
1980	35.8	216.5	225.5	154.2	147	313.9	58.1	11.2	0	0	24.3	38	1224
1981	80.5	95.7	143.1	210.2	189.3	40.1	82.9	44.5	0.2	0	30.3	38	954.5
1982	29.2	31.4	220.6	26.1	129.2	388.1	32.1	26.3	1.5	8.1	0	0.4	893
1983	24.1	101.6	193.1	47.3	220.9	137.5	169	23.6	24	0	8	71	1021
1984	38.5	154.9	215.6	135	116.1	255.7	97.6	7	0	22	16.2	0	1058
1985	43.3	301.1	108.1	123	148.1	163.7	149	6.6	0	0	3	0	1046
1986	75.7	124.3	119.6	110.5	96	84.8	45.3	15.3	3	0	36.4	87	798.3
1987	38.4	118.6	127.8	59.6	267	263.9	94.3	3.1	0	0	9.6	54	1036
1988	84.6	233.4	92.7	77.1	142	85.8	141	0	0	0.4	0.5	90	947.8
1989	70.5	188.9	129.2	38.7	116.1	159.3	217	0	0	0	17.9	181	1119
1990	15.1	280.3	173.2	150	106.3	120.8	78.1	5.5	0	0	0	37	966.2
1991	53.2	130.1	163.9	143.3	358.6	231.4	16.6	0	23.2	17	10.1	1.9	1149
1992	63.6	52.6	118.3	171.4	202.7	153.1	56.5	0.3	15.9	0	0	69	902.9
1993	18.1	154	44.2	106.6	105.2	142.2	4.6	0	0	0	22.7	128	725.8
1994	2.1	206	273.4	171.8	300.7	259.5	9.5	3.1	10.6	16	4.2	18	1275
1995	64.3	128.9	81.9	276.7	319.7	121.2	49.4	0.7	0	0	84.6	28	1155
1996	186.5	79.1	82.9	71.4	277.1	400.7	150	103	0	0	0.1	41	1392
1997	120.7	144.7	69.9	243.1	266.3	222.4	110	4.5	0	0	60.2	24	1266
1998	105.4	200.8	75.1	143.3	171.8	103.7	75.4	33.6	0.8	1.1	0	6.9	917.9
1999	92.8	215.3	47.5	99.7	201.2	179.6	85.5	23.9	1.1	0	34.4	4.2	985.2
2000	178.8	227.8	187	98.9	322.2	253.8	74.1	0	0	0	0	65	1407
2001	7.4	197	102.6	155.6	156.6	68	74	2.7	15.5	7.7	0.4	10	797.7
2002	11.2	149.7	273.9	98.5	440.5	339.1	56.6	1.7	4.5	0.7	17	81	1475
2003	10.9	63.5	128.9	168.2	112.1	161.4	24	23.3	0	20	53.6	17	782.2
Average	63.4	154.7	151.8	140.7	194.1	217.4	81.8	11.5	4.5	4.9	19.6	47	1091
Rainy Days	6.8	12.8	14.3	15.6	17.3	16.4	8.8	1.9	0.7	1	2.1	4.3	102

Source: Royal Irrigation Department (2005)

3 Geology

The geological formation of the Pasak Basin comprised sedimentary, metamorphic and igneous rock from the Silurian – Devinian Period to the Quaternary Period laying from north to south consisting of 30 kinds of formation as shown in Figure 7.

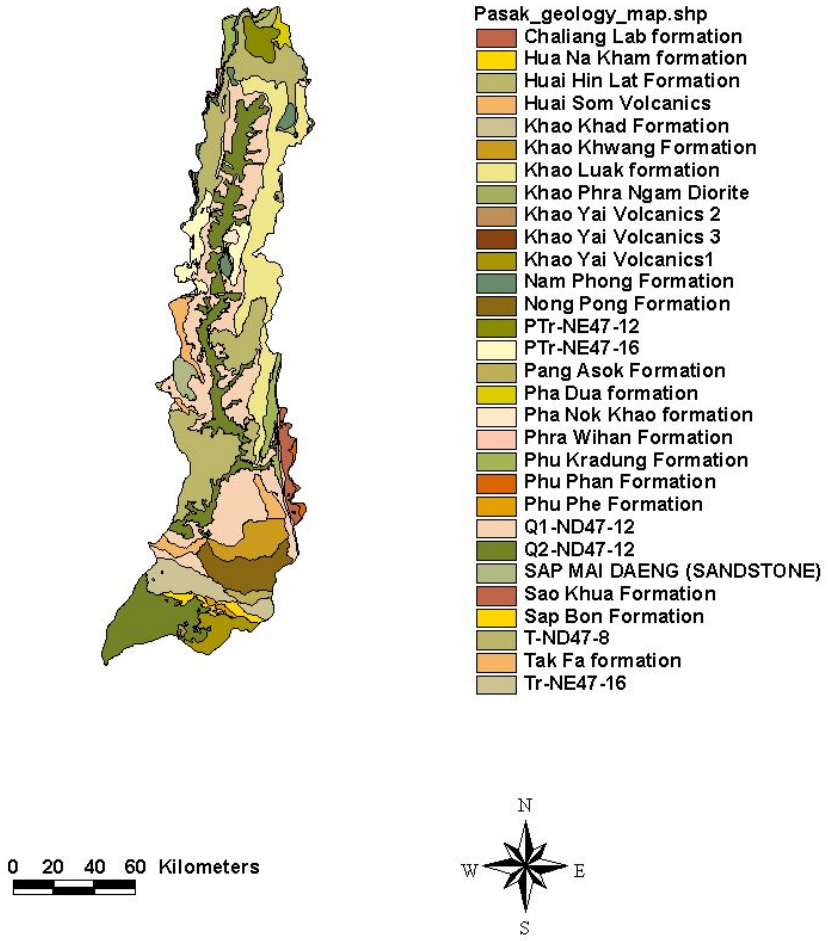

Figure 7 Geology map of Pasak watershed
Source: Department of Mineral Resources (1995)

4. Soil

According to the Department of land Development's soil data in 1991, soils in the study area consists of 39 soil groups. Their distribution by area is shown in Table 7 and Figure 8.

Table 7 Characteristics and areal distribution of soil group in Pasak watershed

Soil group	Characteristics of soil group	P^H	Hectare	Percent
1	Grey to black clay , vertisol	6.5 - 8.0	78246.98	4.92
2	Dark grey to red brown clay	4.5 - 5.5	2798.41	0.18
3	Dark grey to brown mixed grey clay, poor drainage	7.5 - 8.0	20631.53	1.30
4	Clay loam in the upper layer and brown clay in the lower	5.5 - 8.0	70941.21	4.46
5	Dark grey to brown mixed grey, consists of manganese and limestone	6.0 - 8.0	2275.31	0.14
6	Grey to brown mixed grey clay	4.5 - 5.5	20959.79	1.32
7	Brown mixed grey to dark brown or red	6.5 - 5.5	45595.53	2.87
15	Loamy clay or silt, brown mixed grey to pink mixed grey	6.5 - 7.5	29273.73	1.84
16	Brown loamy or loamy sand to loamy grey clay	6 - 7.5	23850.99	1.50
17	Sandy loam to clay loam mixed with sand, deep brown	4.5 - 5.5	10639.48	0.67
18	Dark brown or brown mixed grey loamy to loamy clay mixed with sand	5.0 - 7.5	5891.10	0.37
19	Dark brown mixed grey or dark brown loamy sand or sandy loam	4.5 5.5	9769.62	0.61
21	Brown mixed grey or light brown loamy sand or silt	5.5 - 7.0	1484.06	0.09
22	Brown mixed grey or light brown loamy sand or sandy loam	4.5 - 5.5	531.36	0.03
25	Shallow soil, brown mixed grey loamy sand to yellowish grey clay	4.5 6.5	19312.08	1.21
28	Black clay, suitable for crop	7.0- 8.0	173669.93	10.92

Table 7 (continued)

Soil group	Characteristics of soil group	P^H	Hectare	Percent
29	Brown, yellowish or red clay	4.5 5.5	57198.01	3.60
31	Deep soil, brown, yellowish or red clay	5.6 -6.5	55814.64	3.51
33	Very deep soil, brown or brown mixed silty loam,	5.5 -6.5	15060.72	0.95
35	Very deep soil, brown mixed grey or brown sandy loam to brown clayey loam, good drainage, suitable to crop, forest	4.5 – 5.5	14891.43	0.94
36	Dark brown or brown mixed grey sandy loam to brown red clayey loam	5.5 -6.5	29152.65	1.83
38	Very deep soil, light brown mixed grey loamy or loamy sand	5.0 – 7.0	5069.78	0.32
40	Sandy loam in the upper layer, brown mixed reddish sandy loam in the lower	5.5 6.5	11283.12	0.71
41	Dark brown loamy sand to sandy loam	7.0 – 8.0	146.01	0.01
44	Deep soil, light brown sandy loam	5.0 – 7.0	756.15	0.05
46	Shallow soil, brown mixed gravel	5.0 – 6.5	3109.58	0.20
47	Shallow soil, brown reddish loam, clay	5.5 – 7.0	177618.21	11.17
48	Shallow soil, brown red mixed yellow sandy loam	5.0 – 6.5	44075.57	2.77
49	Shallow soil, brown red mixed sandy loam to clay mixed gravel	5.0 – 6.5	8391.22	0.53
52	Soil depth 50 cm, dark brown claey loam to dark grey clay mixed marble	7.0 – 8.5	6379.01	0.40
54	Dark brown mixed reddish clay to red mixed yellow, good drainage	6.5 – 8.0	115201.49	7.25
55	Brown or red clay, soil depth 50 -100 cm	6.0 – 7.5	37154.63	2.34

Table 7 (continued)

Soil group	Characteristics of soil group	P^H	Hectare	Percent
56	Moderate to deep soil, sandy loam to clayey loam mixed with sand	5.0 - 5.5	7105.78	0.45
59	Many kinds of soil following parent material	6.0 - 7.0	5414.28	0.34
60	Deep, loamy with little sand due to flood before.	6.0 - 7.0	2733.73	0.17
61	Many kinds of soil following parent material		24.41	0.00
62	Many kinds of soil following parent material, mostly shallow soil		454247.51	28.58
70	Others		23253.998	1.44
Total			1589953.00	100.00

5. Topography

Pasak Watershed has rectangle shape, narrow and long, situated in north-south direction. Upper watershed has a abrupt Phetchabun mountain whereas in general the area is hilly with new flat lands. The middle part of the basin is flat land and hilly area between Lopburi and Saraburi. and lower part of the basin is the merging point of Chao Phraya River at Phranakhon Si Ayuthaya Province where the land is flat and 1,760 m above mean sea level.

6 River system

Pasak River is one of The Chao Phraya River's tributaries; it is narrow and long river with a number of tributaries, which are originated on the Phetchabun Range (200-1,000 m MSL) in Dansai district, flows down in north-south direction through Phetchabun, Lopburi, Saraburi, and Ayutthaya provinces, then meets The Chao Phraya River at Ayutthaya (Figure 9). The floodplain of Pasak Basin stretches from north to south with 350 km long and 45 km wide. The drainage pattern in the area is controlled by geological structure and topography. Its main drainage system is dendritic i.e. the drainage lines are symmetrical. The dendritic drainage patterns

together with the tributaries form a crooked pattern. On the other hands the drainage condition is controlled by seasonal climatic conditions and topography. During the rainy seasons the low glacis terraces and the wide valleys are over flooded and used for paddy rice cultivation.

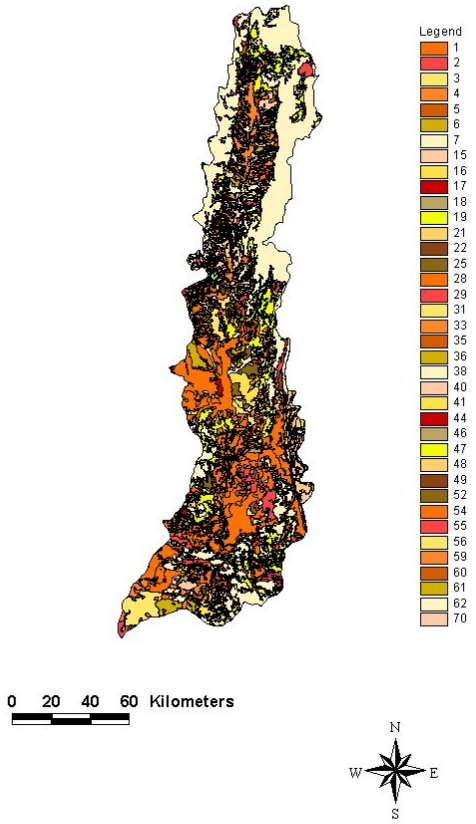

Figure 8 Soil map of Pasak watershed, Thailand

Source: Department of Land Development (1991)

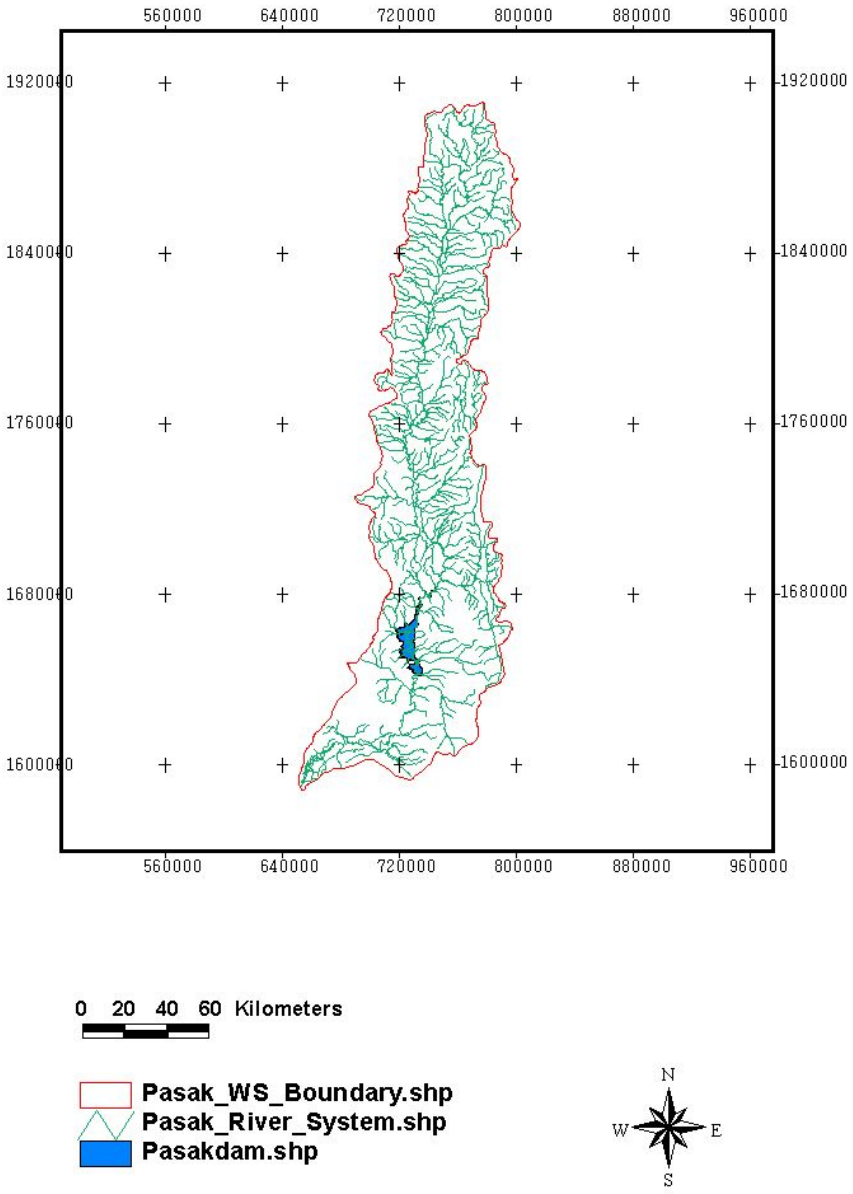

Figure 9 River system map of Pasak Basin

7. Forest resources

Based on the classification of forest types by Royal Forest Department as shown in Figure 10, the forest types in the study area can be identified as follows:

1). Dry Evergreen Forest: This forest type covering an area of about 46,186 ha (11.6%) occurs throughout the watershed area mostly in Dansai district of Loei province, Khao kho and east part of Muang Phechabun, Thep Sathit district of Chaiyaphum province and Kaeng Khoi and Pak Chong districts of Saraburi province. Trees consist of *Dipterocarpus alatus, Diptercarpus turbinatus, Hopes ferra, Shorea thorelii, Alstonia scholaris*, etc.

2). Hill Evergreen Forest: This forest type covered the least area of about 194 ha 0.05%) occurs on a ridge top of the mountain in the east of Khao kho district of Phechabun province. Floristic composition is quite low consisting of *Quercus spp, Lithocarpus spp, Podocarpus imbricatus,* etc.

3). Pine Forest: This forest type covered an area of about 1,782 ha (0.45%) found mainly in the Lomsak district of Phechabun province.

4). Mixed Deciduous Forest: This forest type covered majority of the area of about 240,072 ha (60%) compared to other forest types found scattered on the mountains over the basin area from Kaeng khoi of Saraburi, Chaibadan of Lopburi upto head watershed in the Lomkao of Phechabun province. Most of this forest type was found in the east part of Lomsak Muang districts of Phechabun province.

5). Dry Dipterocarp Forest: This forest type covering an area of about 34,341 ha (8.61%) found scattered on hill side of basin area. The height above mean sea level was between100 – 600 meters. Most of this type of forest was found in Lomkao, Lomsak, Muang distrcts of Phechabun province, Thep Sathit districts of Chaiyaphum and Muak lek districts of Saraburi province.

6). Others: It consists of Bamboo of about 4,342 ha, teak plantation of 20,897 ha (5.25%), eucalyptus plantation of 1624 ha (0.41%) and secondary growth forest of about 48225 ha (12.13%).

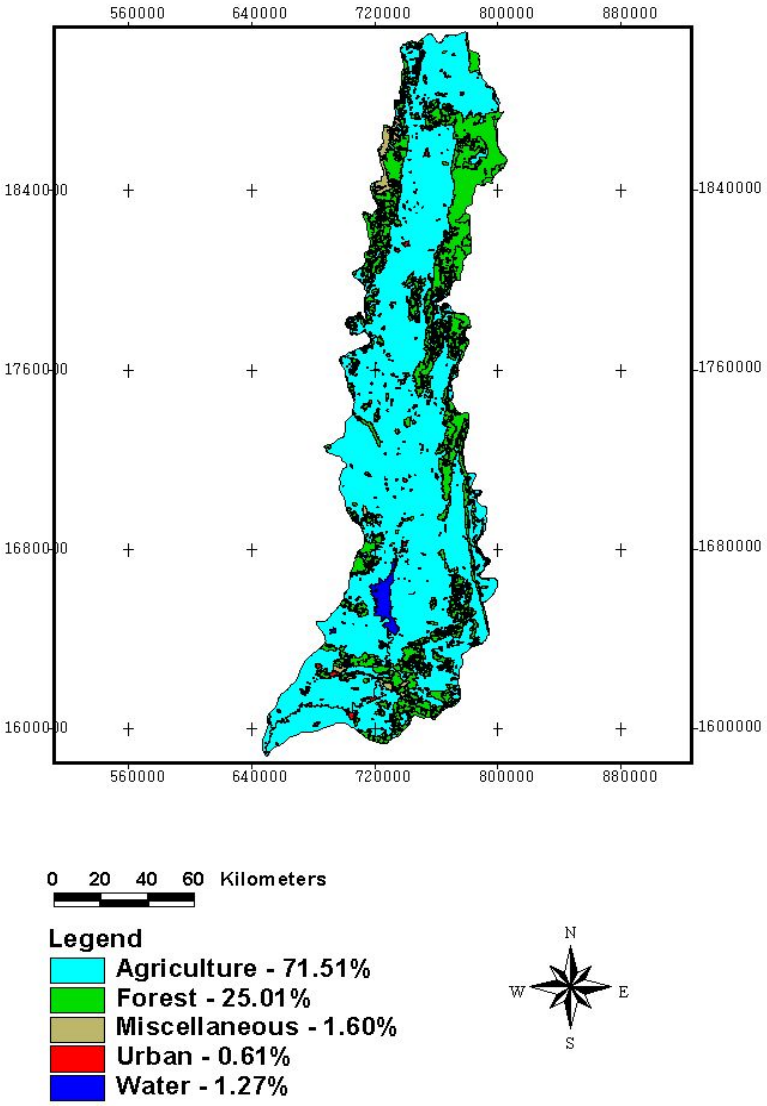

Figure 10 Land use map of Pasak watershed, 2000

8 Agricultural area

Agricultural area of Pasak watershed covering an area of about 1.14 million ha could be classified into 5 types namely paddy fields, field crop plantation, paddy field mixed with field crops, tree crop plantation and others.

Paddy field: Paddy fields were found in the plain area of both side of Pasak river stretching from north to south or in the valley areas where streamflow was available. Paddy fields were tremendously increased after the construction of Pasak Cholasid Dam in 1999. Paddy farming was practiced both in wet and dry seasons using water supply from this reservoir or small scale irrigation projects existing in the basin area by diverting streamflow into the paddy fields.

Field crop plantation: Field crop plantation were observed in the highlands between paddy field and forest area. Most of the crops growing were corn, cassava, maize, sugarcane, pineapple, etc.

Paddy fields mixed with fields crops: These were scattered in the plain area over the basin and mostly downstream of the basin as well.

Tree crop plantation: these were found in the upland areas throughout the basin including mango, tamarind, eucalyptus, mixed horticulture and orchard.

Others: This include paultry farm, fish farm, swine farm and pasture land. .

9 Water resource

Before the construction of Pasak Cholasid Dam water resource was scarce in the basin area, though there were some small scale irrigation projects that were not enough to meet the peoples need for agricultural and industrial demand. Pasak Cholasid is a large reservoir and located at Baan Nong Bua, Nong Bua sub-district, Pattana Nikom District, Lopburi province and Ban Kampran, Kampran sub-district, Wang Muang district, Saraburi province. The capacity of the reservoir is 785 million cu.m., which can irrigate the area of 143,700 rai and can deliver water to irrigated area of Klong Preaw-Sao hai Project as well as deliver water to support the east lower Chao Phraya project.

10. Population of the study area

The population density in the Pasak watershed has reached around two hundred thirty nine thousands five hundred in year 1993 to 2005 with 104/sq. km in 1993 to 119/sq. km in 2005 as shown in Table 8. The Figure 11 shows the increasing trend of population in different provinces of watershed area.

Table 8 Population of whole Pasak watershed during 1993 – 2005

Year	Number of Population (whole Pasak)
1993	1654469
1994	1669224
1995	1682251
1996	1703093
1997	1710114
1998	1734871
1999	1734183
2000	1733180
2001	1765351*
2002	1797522*
2003	1829693*
2004	1861865*
2005	1894036

Source: Modified from data of National Statistics Office, Thailand (2005)
* interpolated by linear regression

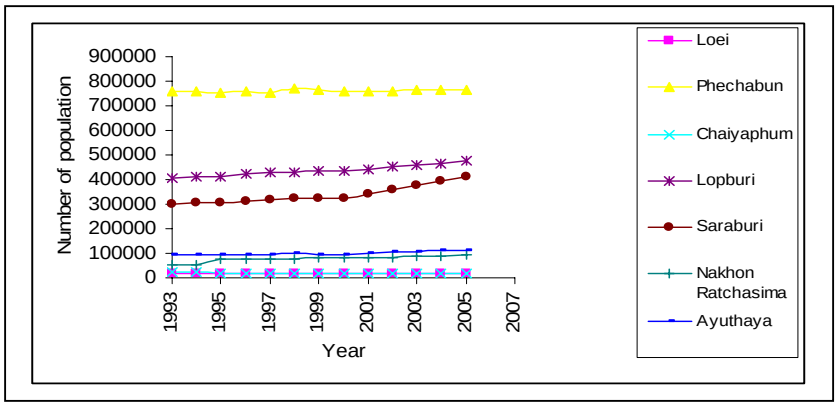

Figure 11 Province-wise population growth pattern of Pasak watershed.