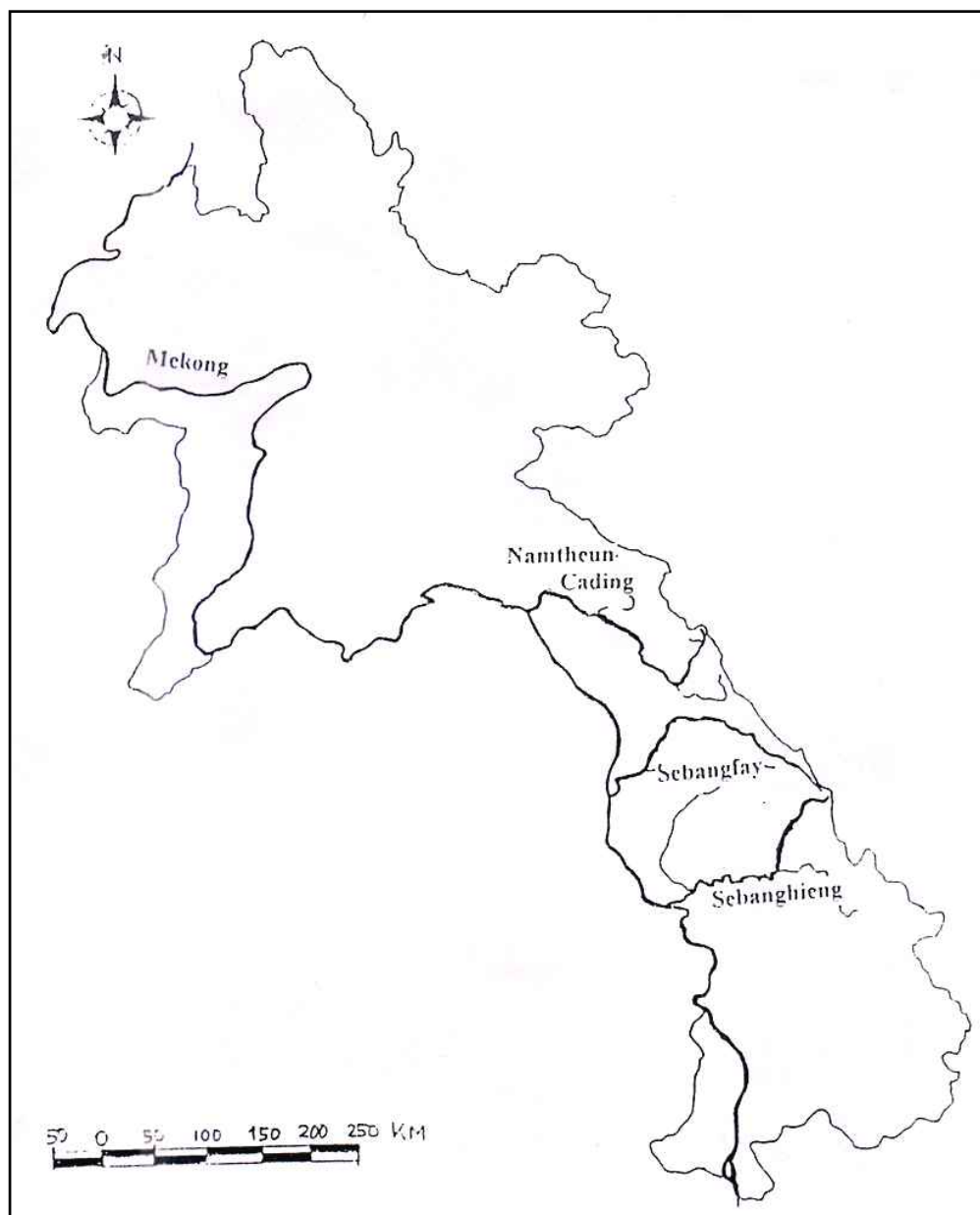


The Lao People's Democratic Republic

Lao-4: NamTheun

Lao-5: Nam Sebangfay

Lao-6: Nam Sebanghieng



Introduction

The Lao People's Democratic Republic is a land locked country situated in Southeast Asia, between the latitudes 13° 50' N ~ 22° 30' N and the longitudes 100° 00' ~ 107° 45' E with an area of 236 800 km². In the northwest - southwest direction, it has a length of more than 1 700 km and in the east-west direction the distance varies between 100 ~ 400 km. The topography is closely related to the geology with watershed highlands of granites and metamorphic, draining down to Jurassic, Cretaceous Indonesian sandstone and shale, then over piedmont slopes to low flat lands. Over 47 % of the land is covered by forests and the fertile flood plains embracing about 30 % of the land along the Mekong River. The climate is tropical monsoon with two distinct seasons: the wet season from mid April to mid October and the dry season from November to March. The average annual precipitation is 1 956 mm but it varies from less than 1 300 mm in the northern valleys to over 3 500 mm in the southern plateaus. The population in December 1998 was 4 938 596 with a distribution of 50.6 % female and 49.4 % male. The average population density is 20.86 persons/km² and the growth rate is about 2.6 % per year.

The three rivers catalogued in this volume are NamTheun/Cading, Sebangfay and Sebanghieng. The level of information content is different, especially on the hydrometeorological data, since the collection was started in 1960 for Sebangfay and Sebanghieng, and since 1985 for Namtheun /Cading.

In the central plains there are many rivers. Two important tributaries of the Mekong - Sebangfay and Sebanghieng - have streamflow data since 1960. The NamTheun basin, which is located in the north eastern part of Central Lao and stretching to the west at the end of the Nakai Plateau is chosen as Lao - 4. The basin often experiences floods in flashy conditions and droughts or low flows in some EL NINO years. The total area of the catchment is 14 810 km² near the confluent point with the Mekong. This study focuses on the area of 3 370 km² at Signo where data are available from 1985~1998. The Sebangfay and the Sebanghieng basins located in the flood prone-areas were chosen as Lao - 5 and Lao - 6, respectively. These two large river basins, where tropical forests cover about 59 % for Sebangfay and 55 % for Sebanghieng, have a periodic cycle of floods and droughts.

These three rivers have severe flooding conditions during the monsoon season from June to September. Inparticular, the lowland area of the Sebangfay and the Sebanghieng, located in the flood prone areas are suffering the heavy condition of back water effect from the Mekong mainstream.

Acknowledgements

For the preparation of the catalogue, a working group was established within the Department of Meteorology and Hydrology (DMH), the same group as for Volume 2. The following Organizations and Departments are thanked for their co-operation by providing data for the preparation of this work:

Department of Agriculture and Extension,

The Provincial Hydrometeorological Services of at Bourikhamxay, Khammouane, and Savannakhet for providing additional data until 1998,

MRC for providing some materials: Forest cover map 1996~97,

Inland Waterway Department (IWD) for additional discharge data from 1994~1997, and

The Computer personnel of the DMH.

Nam Theun/Cading

Map of River

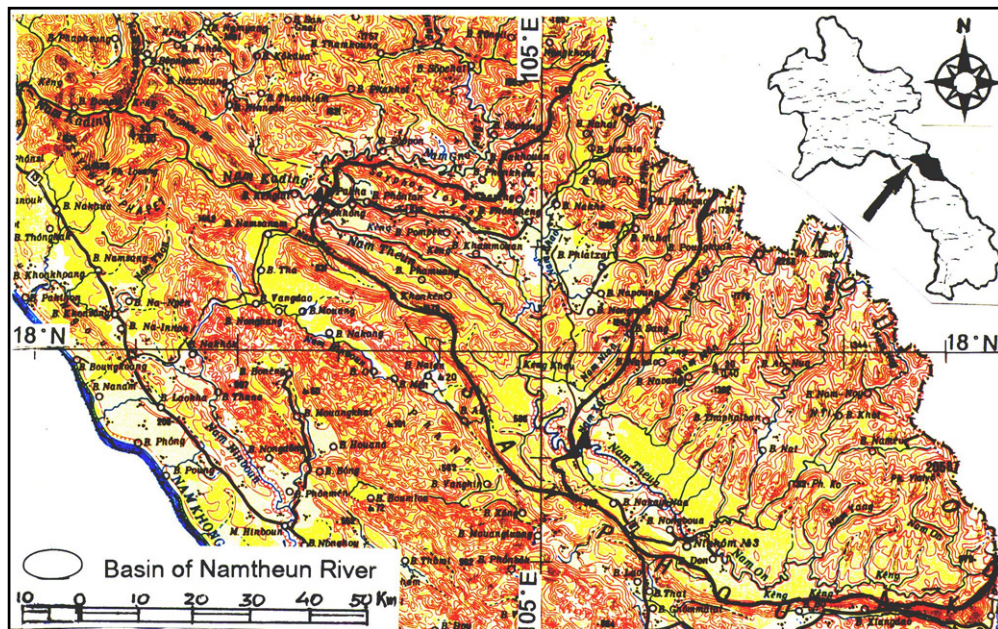


Table of Basic Data

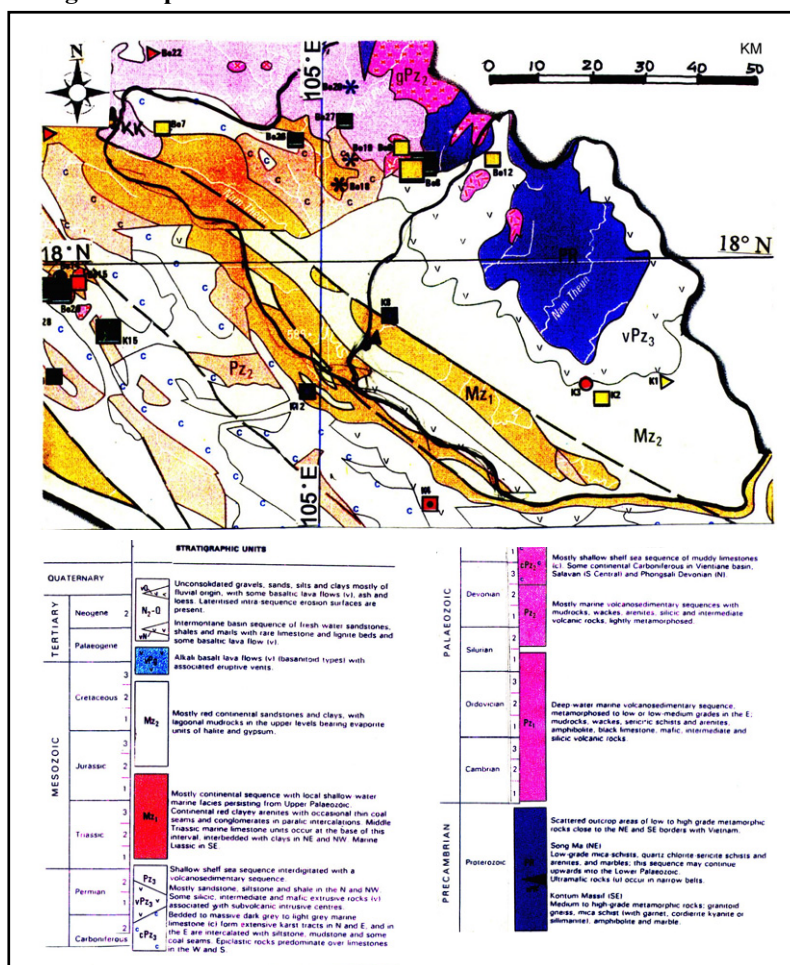
Name: Nam Theun/Cading (at Signo)		Serial No: Lao - 4
Location: Barikhamxay Province	N: 17° 50'42"	E: 105° 03'06"
Basin Area: 3 370 km ² (at Signo)	Length of main stream: 138 km	
Origin: Sayphoulouang (2 200 m)	Highest Pt. : 2 288 m	
Outet : Pakcading	Lowest Pt. : 155 m	
Main geological features : Mesozoic, Cretaceaus, Permiam and Proterozoic, Precambrian.		
Main tributaries: Nam One, Nam Noy, Nam Xot, Nam Kata		
Main Lakes : Nam Theun II project (on going) 450 km ²		
Main reservoirs : Nam Theun II (project)		
Mean annual precipitation: 2 500 mm (1986~1998)		
Mean annual runoff: 222.83 m ³ /s at Signo (3 370 km ²) (1985~1998)		
Population : 103 000 (1998)	Main cities: Nakai, Khamkheut	
Lands use: Forest (60 %), Agriculture (25 %), Urban (1.5 %), Wetland (0.48 %), River (8 %), Others (12.22 %) (1998)		

1. General Description

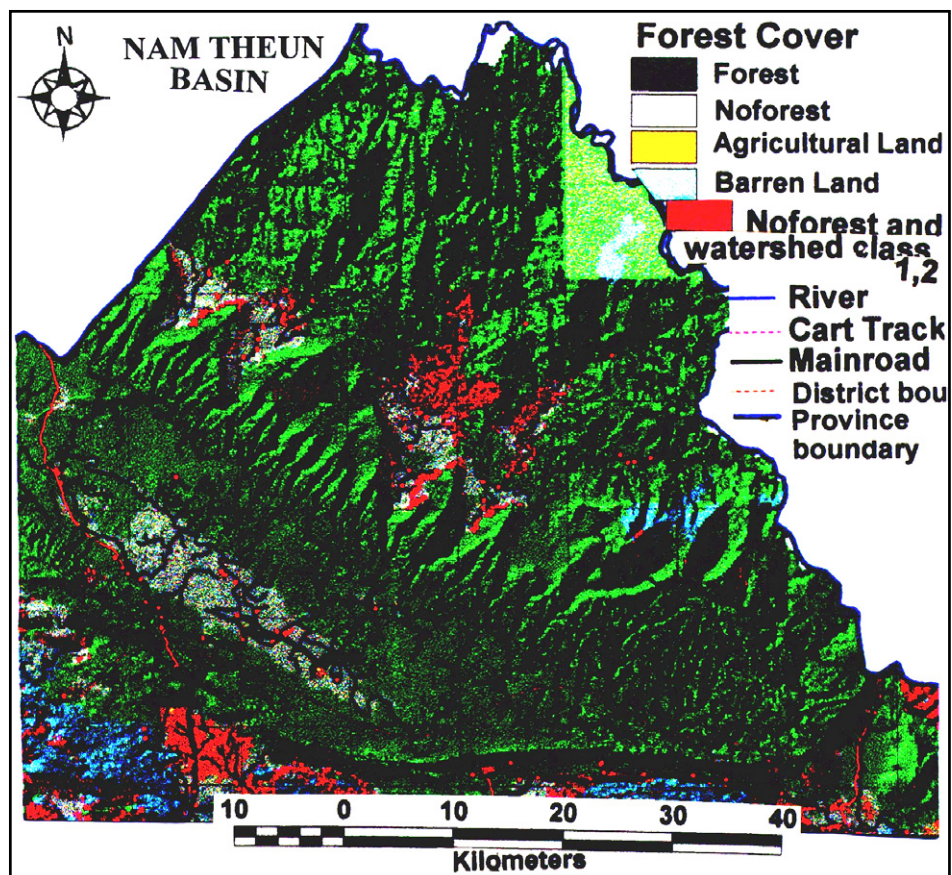
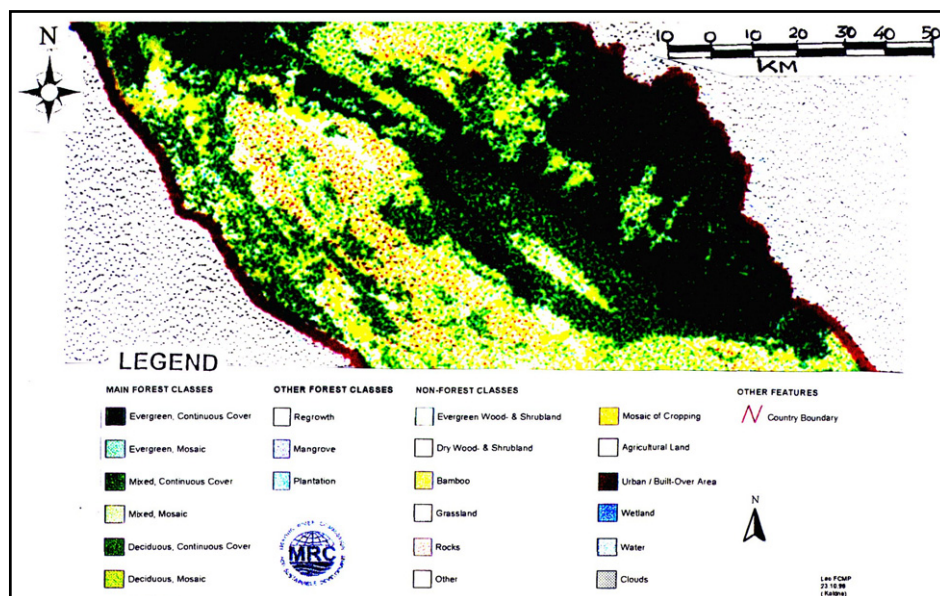
Nam Theun/Cading is the fourth largest tributary of the Mekong river. It flows from the Siaphou Louang (Lao- Vietnam border) at an elevation of 2 200 m to the Nakai plateau, 500 ~ 580 m in a north-northeast to south-southwest direction. From Nikhom 03 to Khamkeut (Kengkuan), the river flows in a southeast-northwest direction with an underground river system more than 300 m long. The Nam Theun leaves the plateau at its north-western end, turns to the west and joins the Mekong River as the Nam Cading through an elevation lower than 200 m. The total catchment area at the confluence point with the Mekong is 14 810 km² and the total length including tributaries is 2 047 km. The average annual precipitation is 2 500 mm with a little more than 3 000 mm along the mountain range. The annual discharge at Signo (3 370 km²) is 223 m³/s (1985~1998). At Ban Phonesy in the lower reach (14 200 km²), the annual discharge is 478 m³/s (1984~1986). The total population in the basin was estimated at 103 000 people in 1998. As the topography of the basin relates closely to the geology, the Nam Theun biogeographical sub-unit is Annam Trung Sun mountain chain with watershed highlands of granites and metamorphics, draining down to Jurassic and cretaceous Indonesian sandstones and shales, and most fertile area is in the lower Nam Cading.

2. Geographical Information

2.1. Geological Map



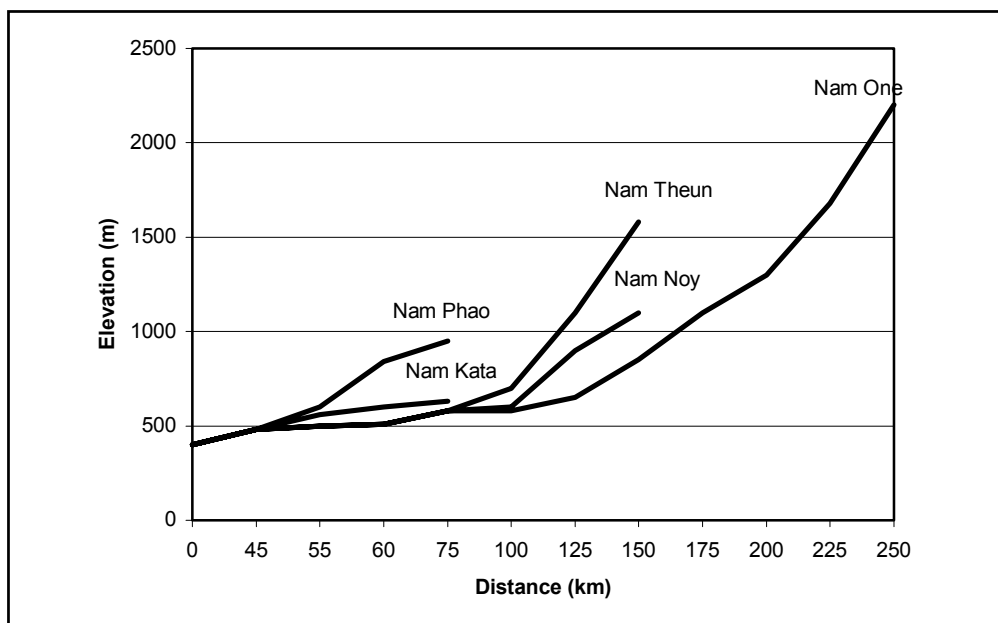
2.2. Land Use Map



2.3. Characteristics of the River and the Main Tributaries

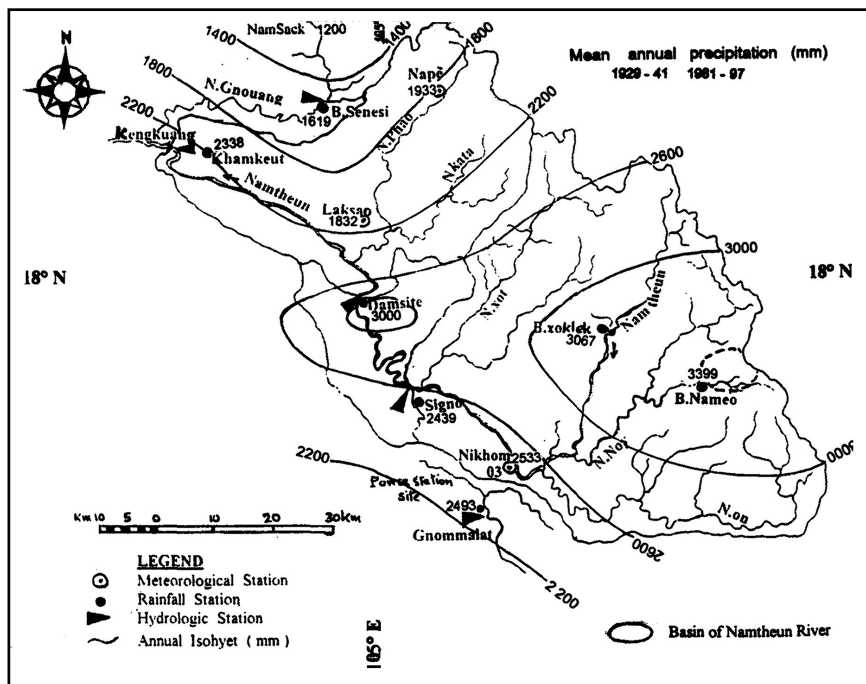
No.	Name of River	Length [km] Catchment area [km ²]	Highest peak [m] Lowest point [m]	Cities population (1998)	Land use [%]
1	Nam Theun/ Cading	138 14 810	2 280 157	Pakcading 25 000	Forest (64)
2	Nam One	912	2 058 530	Nakay 15 000	Forest (60)
3	Nam Noy	618	1 058 508		
4	Nam Xot	823	2 288 508		
5	Nam Kata	38	1 724 500		
6	Nam Phao	35 1 190	1 821 480	Lak Sao (KK) 20 000	Forest (65)
7	Nam Gnoung	111 2 830	1 689 470		

2.4. Longitudinal Profiles



3. Climatological Information

3.1. Annual Isohyetal Map and Observation stations



3.2. List of Meteorological Observation Stations

No	Station	Elevation [m]	Location	Observation period	Mean annual precipitation [mm]	Mean annual evaporation [mm]	Observation items ¹⁾
224*	Khongsedone	122	N 15°34' E 105°48'	1965~94 1929~90	1 658 1 716		P,E
225*	Pakse	101.5		1951~96	1 942	1 550~ 2 000	P,E,SR,DS
226*	Paksong	1 200		1965~94	3 403	Piche 550	
227*	Salavane	168		1960~94	1 999	Pan'A' 2 073	P(TB),E,SR, DS
242*	Selabam	117		1972~94	1 929		P
270*	LaoNgam	451		1991~95 1989~93	1 760 1 780		P
	Vangkaman	302		May~Dec 1995			P (TB)
260	Nonghine	1 280		1980~94	2 844		P
	Thateng	800		1993~95	2 123		P
	MuangVapi	160		1991~96	1 704		P
	KengSin	180		1993~96	2 416		P

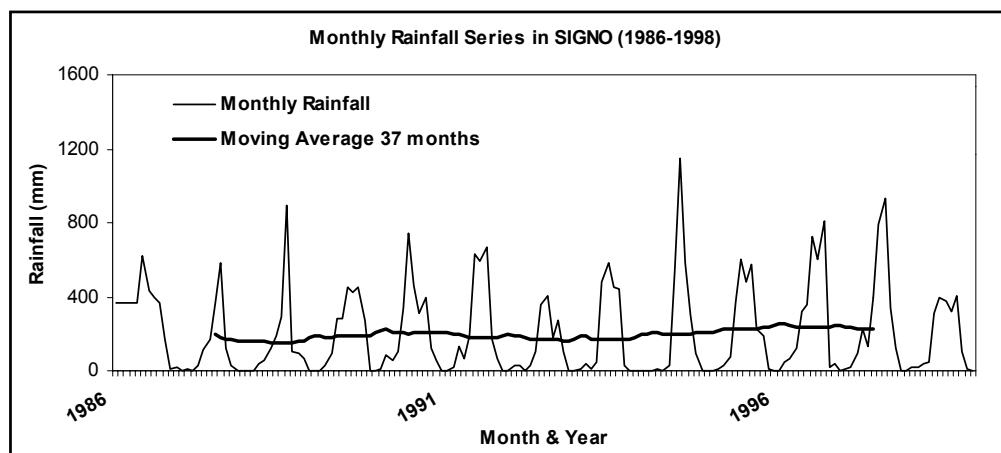
1) P: precipitation; E: evaporation; SR: solar radiation; DS: Duration of sunshine; P(TB): tipping bucket raingage

3.3. Monthly Climate Data

Station: Paksan

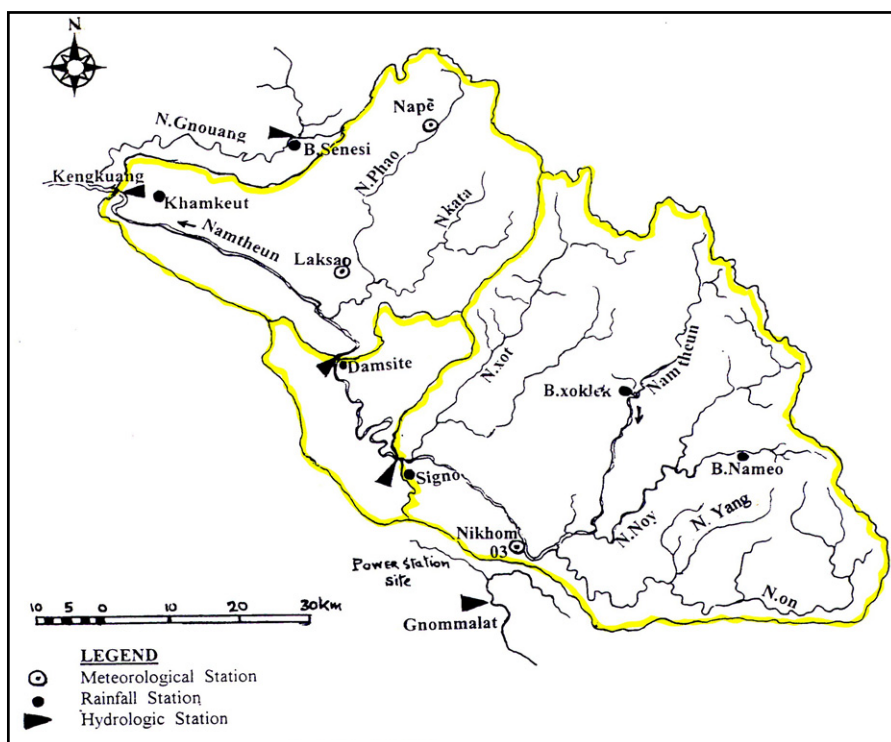
Observation item	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual	Period for the mean
Temperature [°C]	20.6	22.8	25.2	26.9	26.9	26.8	26.1	26.3	26.3	25.2	23.4	21.1	24.8	1933~44
Precipitation [mm]	3.8	30.8	75.9	120.9	431.2	599.2	674.1	479.3	389.3	146.8	31.7	2.8	2 986	1933~44
Evaporation [mm]	15.8	18.3	21.0	24.2	26.3	28.2	27.5	26.8	26	22.8	18.2	16.5	21.5	1933~44
Duration of sunshine [hr]	221.6	192.7	240.4	205.9	157.3	96.7	78.5	84.2	141.3	202.5	231.2	218.5		1938~44

3.4. Longterm Variation of Monthly Precipitation Series



4. Hydrological Information

4.1. Map of Streamflow Observation Stations



4.2. List of Hydrological Observation Stations

No.	Station	Location	Elevation [m]	Catchment area (A) [km ²]	Observation period	Observation items ¹⁾ (frequency)
1.	Singo	N 17° 50' 7" E 105° 03' 1"	500	3 370	1985~1998	H2
2.	Kengkuang	N 18° 14' 1" E 104° 39' 7"	470	5 560	1985~96 1992~92	Q(d)
3.	Phonsi	N 18° 18' 1" E 104° 05' 9"	157	14 200	1960, 1967~71 78~80, 86~93	Q(d)

No.	Q ²⁾ [m ³ /s]	Q max ³⁾ [m ³ /s]	Q max ⁴⁾ [m ³ /s]	Q min ⁵⁾ [m ³ /s/100 km ²]	Q/A [m ³ /s/ 100 km ²]	Qmax/A [m ³ /s/ 100 km ²]	Period of statistic
1	222.83	3 040	1 775	20.42	6.612	90.208	1986~98
2	385.0	2 490	3 172	16.80	5.044	56.142	1986,90~93
3	478.0	6 000	4 910	59.95	3.366	34.577	1986, 91~93

1) H2 (d): water level reading twice daily; Q(d): daily discharge;

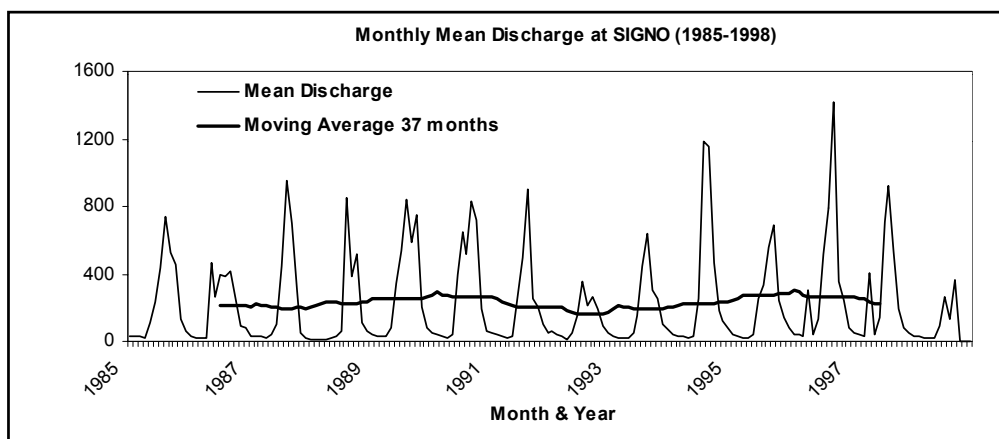
2) Mean annual discharge;

3) Annual maximum discharge;

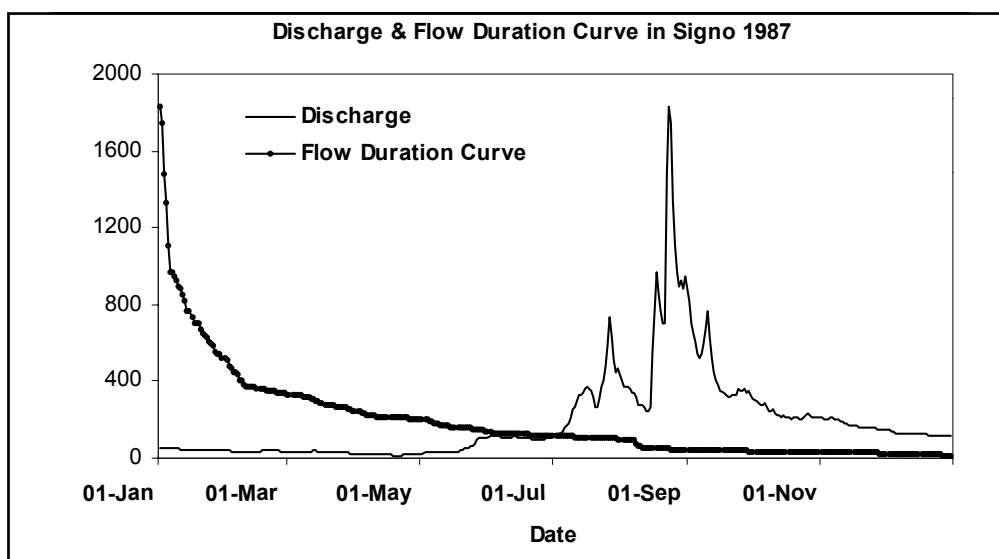
4) Mean annual maximum discharge;

5) Mean annual minimum discharge

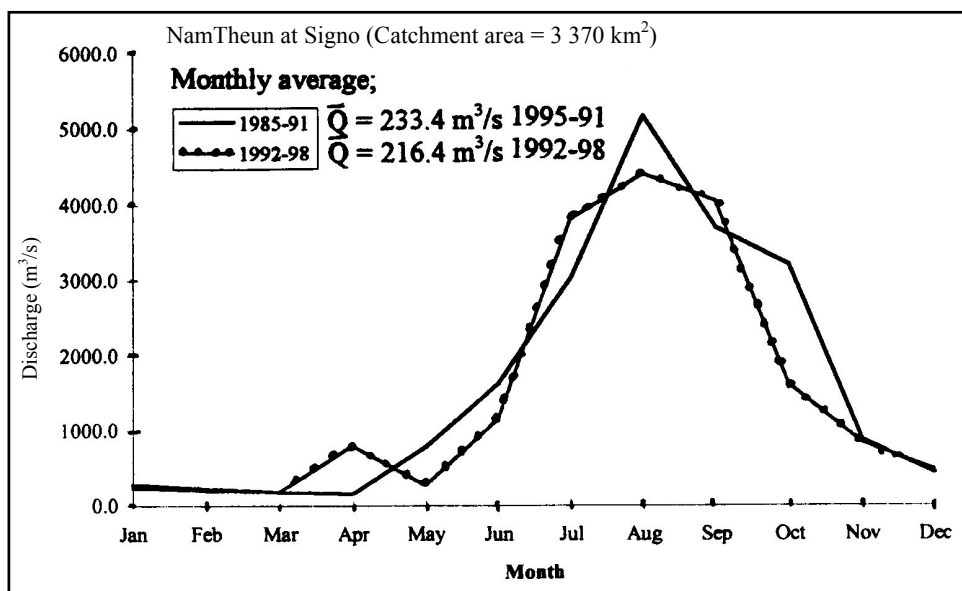
4.3. Longterm Variation of Monthly Discharge Series



4.4. Annual Pattern of Discharge Series



4.5. Unique Hydrological Features



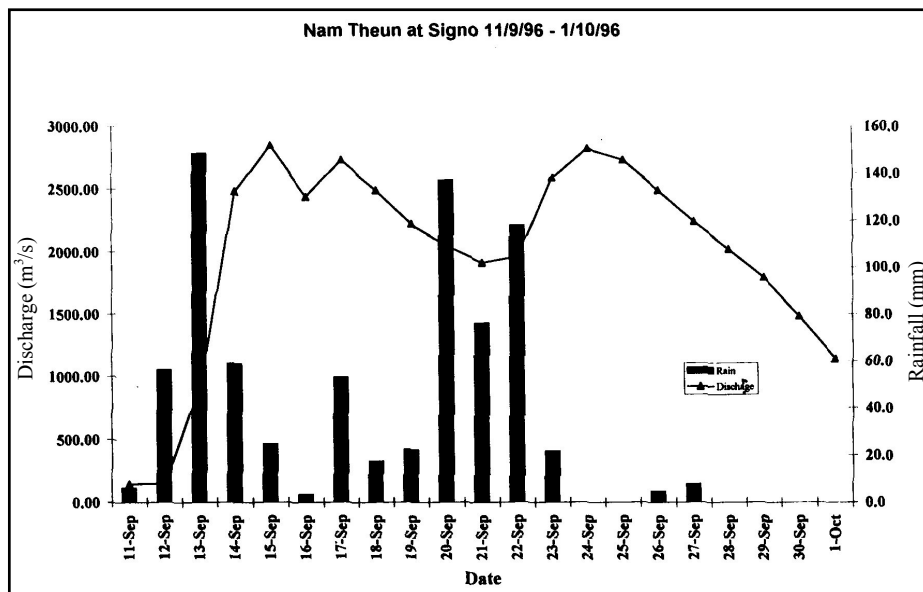
4.6. Annual Maximum and Minimum Discharges

Station: At Ban Signo

Catchment Area: 3 370 km²

Year	Maximum		Minimum	
	Date	Discharge ¹⁾ [m ³ /s]	Month	Discharge ²⁾ [m ³ /s]
1986	9.8	1 280	-	-
1987	8.22	1 890	4	14.4
1988	8.11	1 270	3	15.0
1989	7.25	1 770	4	38.4
1990	8.3	1 930	4	16.0
1991	8.2	2 060	6	14.0
1992	6.3	1 520	5	7.38
1993	7.14	1 480	3	16.4
1994	8.1	2 330	4	17.7
1995	9.2	1 696	5	16.6
1996	9.16	3 040	4	48.4
1997	8.17	1 787	4	23.6
1998	7.4	1 011	3	17.1
Sum		23 064		244.98
Mean		1 774.16		20.42

4.7. Hyetographs and Hydrographs of Major Floods



5. Water Resources

5.1. General Description

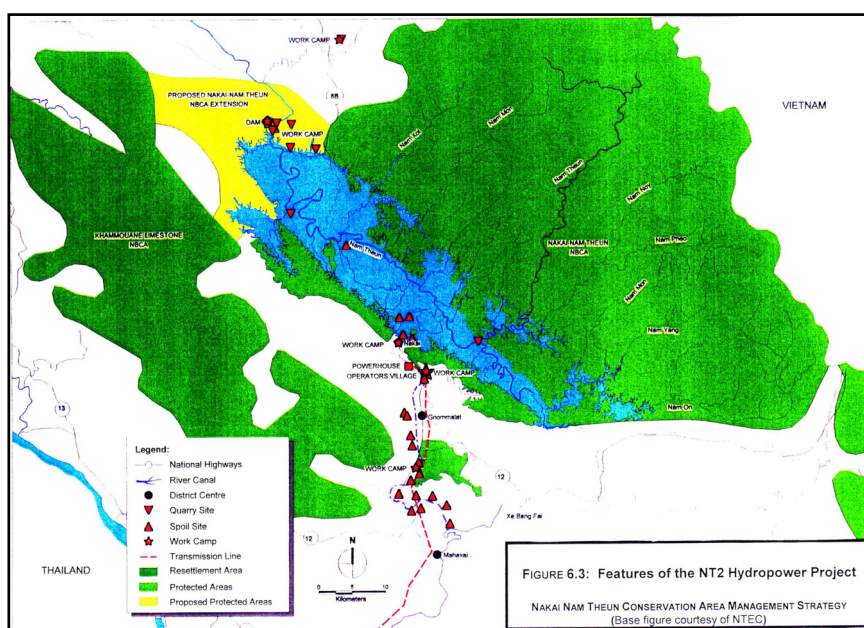
The Nam Theun / Cading, where the upper part is in Khammouane Province while the middle and the lower areas are in Bolikhamxay Province in Central Lao, has several tributaries: as illustrated on map of streamflow, the upper reaches in the plateau consist of Nam One, Nam Noy and Nam Theun that have total length of 138 km; the middle tributaries consist of Nam Xot, Nam Kata and Nam Phao with 38 km and 35 km long than they join the Nam Theun; and the lower tributary is Nam Gnoang of 111 km long and drainage area 2 800 km² joins the NamTheun downstream of KengKuang gauging station. In the middle reach of Nam Cading there is an important tributary (Nam Mouan), still an ungauged river.

The floods of more than 2 000 m³/s at Signo (3 370 km²) were frequently observed. On the 12th of September 1996, the water stage was 1.95 m than beginning the 14th September rise to 14.27 m as resulted from a tropical cyclone which corresponded to an increase in river discharge from 130 to 3 040 m³/s. These peak stage and discharge were the highest in the 10-year period of stream gauge operation. The second tropical storm on the 22nd of September caused a peak of 15.78 m water level (2 850 m³/s) on the 24th that same month. It was concluded that the 1996 was the wettest year in ten years. However, the interannual variability is of importance. During the EL NINO years, with less rainfall in 1987 (1 427 mm) or much rainfall in 1997 (3 050 mm) – the NamTheun and its tributaries have many promising projects for flood control and hydropower. The Nam Phao mini hydro is operational and supplies 2 MW to Laksao city, NamTheun 3 Power project (Nam Gnouang or Nam Nhoang) is under study, and NamTheun 0 - Hinboun Power project is a 210 MW Trans-basin run off river hydropower is already operational.

The NamTheun 2 Hydropower project involves the development of a hydroelectric scheme in Central Lao PDR (see Map of water resource systems in 5.2). The scheme involves constructing a dam on the

NamTheun approximately 160 km upstream of its confluence with the Mekong River. This would create a reservoir on the Nakai Plateau which would necessitate the relocation of about 900 families or 4 500 people who would be resettled at higher elevations on the Plateau. The catchment area near the dam is 4 013 km² and the reservoir is estimated to inundate 450 km² or 40 % of the Nakai Plateau when at full supply level. Water from the reservoir would drop more than 350 meters in a diversion tunnel to the powerhouse and then flows to another river system, the Sebangfay which also flows into the Mekong about 150 km south of NamTheun. A Transmission line to the Thai border and the construction or upgrade of more than 200 km of roads are additional components of the project and another water resources in the NamTheun Nakai Plateau. It constitutes a synclinal basin which varies in width from 15 to 35 km and which has an area of 1 618 km² where habitat for rare species exists in a rich natural environment. There are indications that the area support an uncommon diversity of habitats and wildlife natures, which will be dependent on the wetlands in some way, usually for water in the dry season. From this important hydropower project, the peak power is estimated to be 600 MW, four times the Nam Ngum I project power.

5.2. Map of Water Resource System



5.3. Major Flood And Drought Experiences

Major Flood

Date	Station Catchment area [km ²]	Peak discharge [m ³ /s]	Rainfall [mm] Duration	Meteorological causes	Major damages (District affected)
12/9/96	Signo 3 370	3 040	288.0 12~15 Sept.	Typhoon	Downstream of Kanang rice field flooded in lower Nam Cading

Major Drought

Period	Areas affected	Major damages and counteractions
1~16 July 1997	Lower Nam Cading	Rice crops

5.4. Water quality

Parameters	Unit	N.Theun Signo 30/06/95	N.Theun Damsite 30/06/95	N.Theun Signo 30/07/95	N.Theun Damsite 31/07/95	N.Theun Signo 30/08/95	N.Theun Damsite 31/08/95	N.Theun Signo 7/94	N.Theun Damsite 7/94	N.Theun Signo 30/09/94	N.Theun Damsite 30/09/94
Date		6.65	6.78	6.44	6.54	6.51	6.34	6.24	6.28	6.31	7.59
pH											
Conductivity	ms/m	2.7	2.6	1.9	1.7	1.39	1.32	1.3	1.4	2.2	27.1
Ca	meg/l	0.139	0.119	0.093	0.087	0.063	0.059	0.063	0.046	0.088	2.302
Mg	meg/l	0.071	0.079	0.076	0.061	0.068	0.068	0.071	0.055	0.058	0.679
Na	meg/l	0.048	0.027	0.047	0.031	0.028	0.029	0.045	0.013	0.055	0.022
K	meg/l	0.005	0.003	0.005	0.007	0.016	0.015	0.030	0.033	0.013	0.008
NH4-N	mg/l	0.105	0.041	0.042	0.046	0.088	0.070	0.024	0.023	0.011	0.005
Cl	meg/l	0.022	0.018	0.008	0.024	0.015	0.016	0.182	0.104	0.139	0.128
SO4	meg/l	0.070	0.223	0.006	0.043	0.079	0.055	0.056	0.060	0.110	2.950
Alkalinity	meg/l	0.143	0.121	0.098	0.085	0.078	0.099	0.126	0.063	0.051	0.035
NO3-N	mg/l	0.025	0.131	0.074	0.086	0.208	0.165	0.123	0.156	0.186	0.277
Total P	mg/l	0.179	0.020	0.034	0.049	0.121	0.107	0.047	0.156	0.052	0.035
Total Fe	mg/l	6.261	0.501	0.825	0.652	0.405	0.205	0.103	0.081	0.175	0.368
COD Mn		38.0	2.145	3.079	2.799	6.588	2.827	114	73	45	241
TSS	mg/l	0.001	19.0	67	79	14.8	92.4	0.783	0.930	1.593	0.458
Mn	mg/l		0.001	0.001	0.001	0.001	0.001	0.001	0.001	0	0

6. Socio-Cultural characteristics

The Ethno-economic context of the watershed is characterized by human population of the Nakai - Nam Theun conservation area and adjacent peripheries that can be grouped according to ethnolinguistic classes which, although not equivalent, represent useful anthropological categories for planning and management. The vietic branch of Mon Khmer (Austro Asiatic) Brou is a single language, Hmong, refers to a single language belonging to the Hmong-Mien family. Nevertheless, within the Nam Theun catchment there is a fascinating variety of people who still preserve distinct cultural traditions to a remarkable degree. In 1995 a UNESCO representative visited the Nakai Nam Theun Khammouane area and recommended that the Lao government seeks technical assistance available through World Heritage Fund to assess the suitability of the area for Natural Heritage nomination.

7. References, Databooks and Bibliography

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