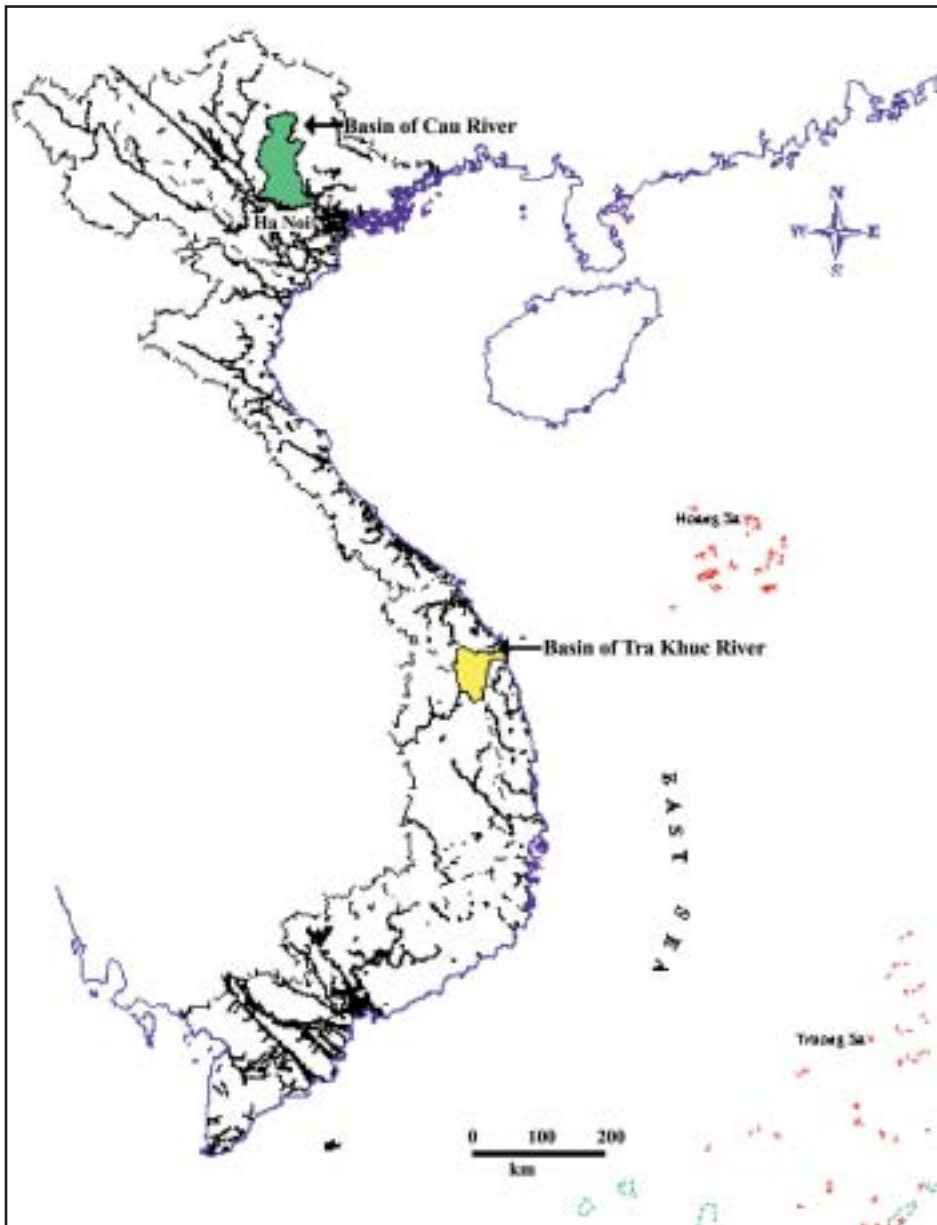


Vietnam

Vietnam-5: Cau River

Vienam-6: Tra Khuc River



Introduction

Vietnam is located in the inter-tropical zone, on the eastern part of the Indochina Peninsula. The total area of the country is 331,000 km², three quarters of which consist of mountains and hills, and the remainder alluvial plain, most of which lies in the Red River and Mekong Deltas.

The country is influenced by a tropical monsoon climate with two distinct seasons: a wet season from April/May to October/November, and a dry season. The mean annual precipitation is 1,960 mm varying from 4,760 mm in Bac Quang (in the northern part of Vietnam) to 650 mm in Phan Rang (in Central Vietnam). The annual river runoff volume in Vietnam is 880 km³ of which 556 km³ is generated outside Vietnam and only 324 km³ is generated in Vietnam (or equivalently, 980 mm/y of runoff, 4,630 m³/y per capita). The annual urban flow for Vietnamese territory is 980,000 m³/km² or 0.031 m³/s/km².

Most Vietnamese Rivers are of small and medium size, except for the Red River and the Mekong River. Forest covers about 26% of the country (1992, Ministry of Forestry). The urban population makes up about 15% of the nation's total.

The two rivers introduced in this volume, the Cau and Tra Khuc Rivers, are medium-sized Vietnamese river basins. The Cau River is in the North and the Tra Khuc River is in Vietnam's Central Coastal area.

The water resources of the Cau River are not large with a long-term annual specific discharge of 0.235 m³/s/km², which is smaller than the long-term average runoff value for Vietnamese rivers. In contrast, the Tra Khuc River is located in a region of high rainfall and so has plentiful runoff. However, the runoff is very irregularly distributed in a year; with frequent floods and droughts that cause disasters with great loss of human life and property.

The main water problems in the Cau River basin are protection of the water resources from over use and pollution, flash floods in upper and middle reaches, and flooding in the lower part of the basin. For the Tra Khuc River basin the most important issues are ones of water supply in the dry season and flood protection, especially from flash floods.

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Professor Nguyen Viet Pho, Chairman, Vietnam National Committee for IHP (NCIHP),
Mr. Le Van Sanh, Secretary, Vietnam NCIHP, Technical Secretary of the group,
Dr. Ass. Prof. Tran Thanh Xuan, Dr. Tran Thuc, Mrs. Tran Bich Nga, Mr. Doan Thanh Hang, Mr. Nguyen Thi Thanh Ha (Institute of Meteorology and Hydrology).

The organisations that have contributed to the work are:
The Hydro-Meteorological Data Center,
The Institute of Meteorology and Hydrology (Vietnam HMS).

Cau River

Map of River

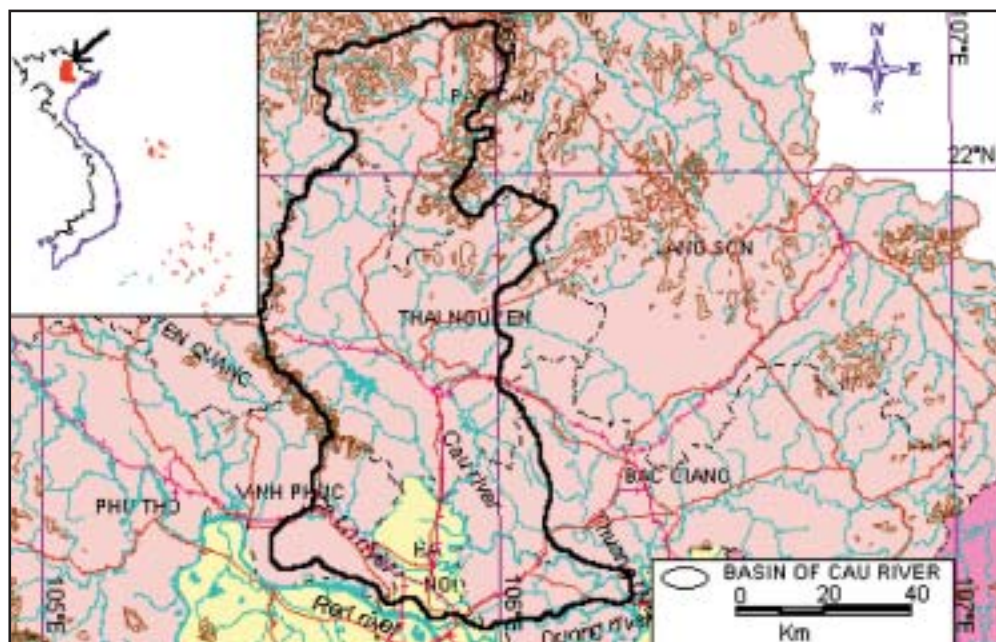


Table of Basic Data

Name: Cau River		Serial No. : Vienam-5
Location: Thai Nguyen, Province, Viet Nam	N 21° 07' - 22° 18'	E 105° 28' - 106° 08'
Area: 6,030 km ²	Length of main stream: 288 km	
Origin: Mt. Phia Deng 1,527 m	Highest point: Mt. Tam Dao (1,592 m)	
Outlet: Pha Lai	Lowest point: 3.8 m (confluence with the Thai Binh River at Pha Lai)	
Main geological: Quaternary, Ordovician - Silurian, Lower - Middle Devonian, Lower - Middle Jurassic		
Main tributaries: Ca Lo River (881 km ²), Du River (361 km ²), Chu River (437 km ²), Nghinh Tuong River (465 km ²), Cong River (951 km ²)		
Main lakes: Nui Coc (175 x 10 ⁶ m ³), Dai Lai (30.5 x 10 ⁶ m ³)		
Main reservoirs: None		
Mean annual precipitation: 2,063 mm at Thai Nguyen (1915 ~ 2000)*		
Mean annual runoff: 51.7 m ³ /s at Thac Bui (2,220 km ²) (1960 ~ 2000)		
Population: about 3,000,000 (1999)	Main cities: Thai Nguyen	
Land use: Forest (19.9%), Rice paddy (29.6%), Grass (0.3%), Other agriculture (50.6%)		

Note: * Indicates missing data in some years.

Detail of missing data for each station are: 1946 ~ 1956;

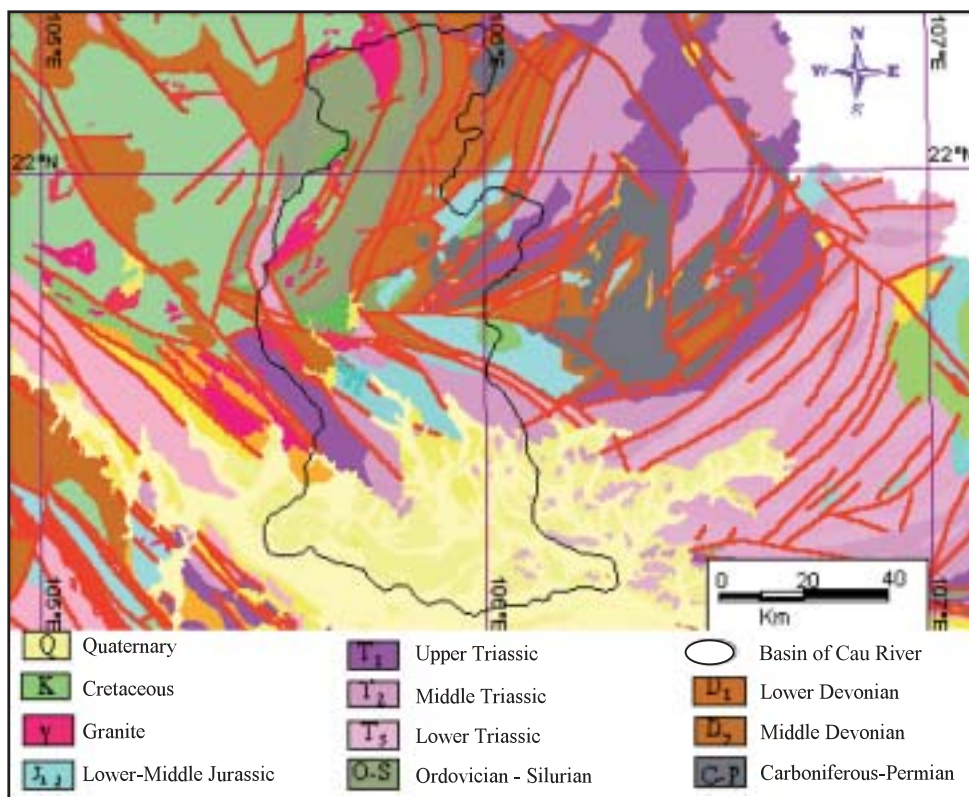
1. General Description

The Cau River is the mainstream of the Thai Binh River system. It originates from Phia Deng mountain (1,527 m) in the southeast of the Piabioc mountains. The length of the Cau River mainstream is 288 km (up to its confluence with the Thai Binh River at Pha Lai). The river network in the Cau River basin is relatively dense with tributaries evenly distributed along the mainstream. However, the significant tributaries, such as: the Cho Chu, the Du, the Cong, and the Ca Lo, are mostly on the right bank. The catchment area is 6,030 km², located from 21° 07' to 22° 18' N and 105° 28' to 106° 08' E.

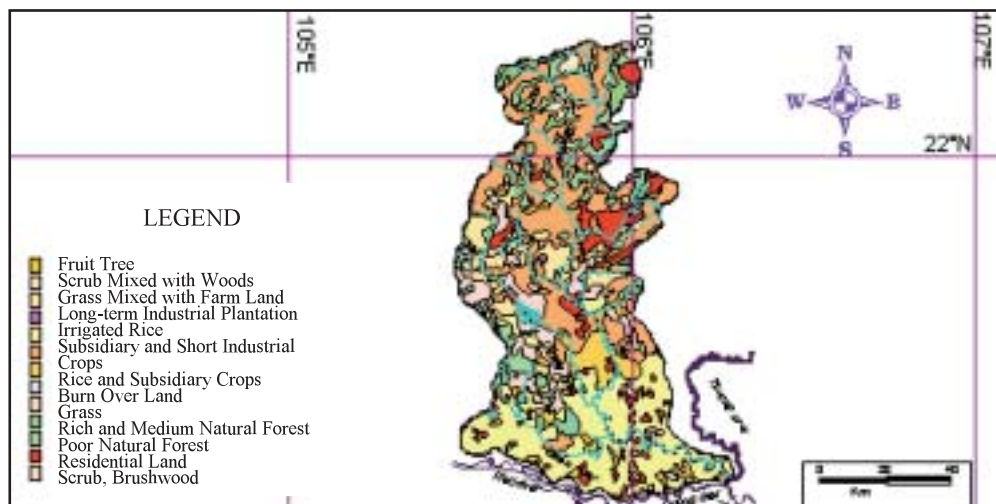
The annual rainfall in the Cau River basin varies from 1,400 to 2,700 mm (with an average of 1,680 mm). The highest value occurs at Tam Dao Mountain with an annual rainfall of more than 2,700 mm. The lowest value is at the Bac Can valley and in the basin of the Ca Lo River where the values are in the range 1,400-1,500 mm. The rainy season in the Cau River basin usually occurs from May to September in the upper part, extending to October, in the middle and lower parts of the basin. Rainfall in the rainy season contributes about 65-85% of the annual rainfall.

2. Geographical Information

2.1 Geological Map



2.2 Land Use Map

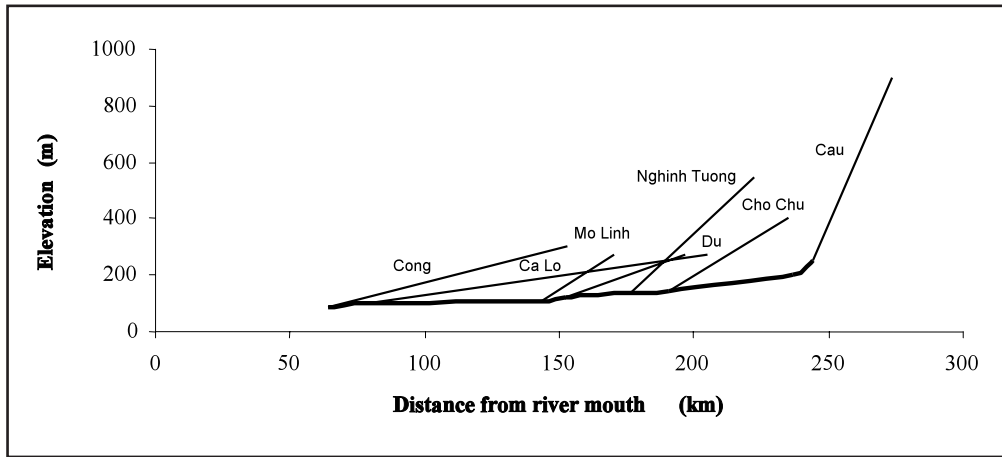


2.3 Characteristics of River and the Main Tributaries

No.	Name of river	Length [km] Catchment area [km ²]	Highest peak [m] Lowest point [m]	Cities Population	Land use [%]
1	Cau (Main river)	288 6,030	1,175		A (50.3) F (19.9)
2	Cong (Tributary)	96 957	275	Thai Nguyen	G (0.3) P (29.6)
3	Ca Lo (Tributary)	89 881	300		
4	Nghinh Tuong (Tributary)	46 465	550		
5	Chu (Tributary)	36.5 437	400		
6	Mo Linh (Tributary)	27 168	275		
7	Mu (Tributary)	27 112	900		
8	Kloung Lao (Tributary)	25 160	1,075		
9	Du (Tributary)	24.5 361	275		

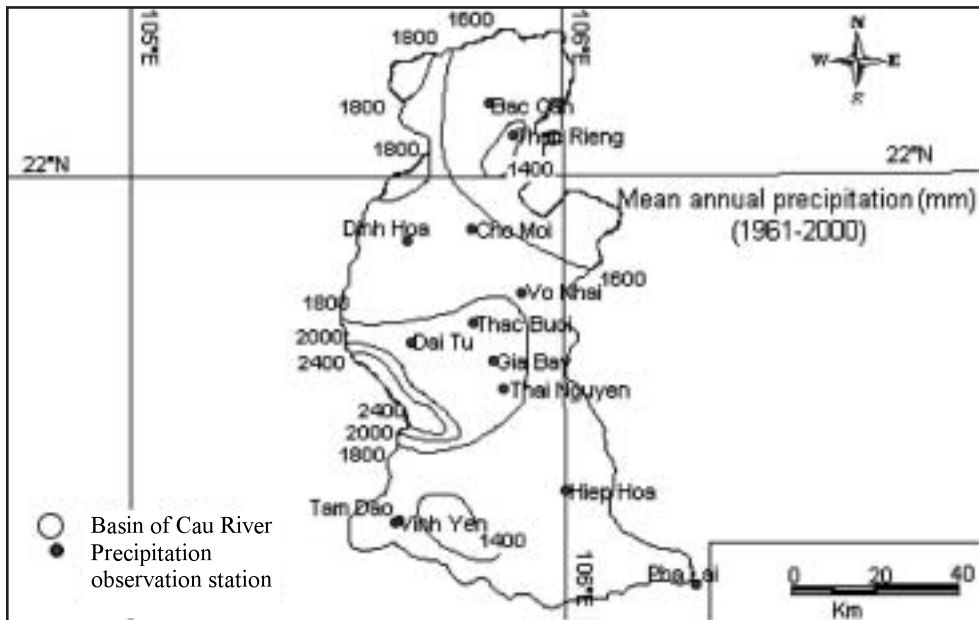
A: Other agriculture land F: Forest G: Grass P: Paddy field

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
48810	Bac Can	174	N: 22° 09' E: 105° 50'	(P) 1957 ~ (E) 1960 ~	1,580.2	763.6	DS, E, P
48/44	Dinh Hoa	107	N: 21° 54' E: 105° 38'	(P, E) 1961 ~	1,655.9	765.7	DS, E, P
48831	Thai Nguyen	35	N: 21° 36' E: 105° 52'	(P) 1915 ~ * (E) 1959 ~	2,062.6	969.8	DS, E, P
48/52	Tam Dao	934	N: 21° 37' E: 105° 39'	(P) 1931 ~ * (E) 1962 ~	2,491.4	543.7	DS, E, P
48814	Vinh Yen	10	N: 20° 59' E: 105° 50'	(P, E) 1960 ~	1,543.3	958.4	DS, E, P
488/53	Hiep Hoa	21	N: 21° 21' E: 105° 58'	(P) 1961 ~ (E) 1971 ~	1,581.2	936.9	DS, E, P

DS: Duration of sunshine observed by Helioscope

E: Evaporation by Piche tube

P: Precipitation observed by Pluviometer

Note: * Indicates missing data in some years.

Details of the missing data for each station are: 48831: 1946 ~ 1956; 48/52: 1945 ~ 1960

3.3 Monthly Climate Data

Station: Bac Can

Observation item	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual	Period for the mean
Temperature [°C]	14.8	16.1	19.4	23.1	26.1	27.3	27.4	27.1	25.8	23.0	19.3	16.0	22.1	1957 ~
Precipitation [mm]	21.4	32.7	54.1	103.3	206.6	267.7	292.6	289.2	158.2	99.0	38.7	16.7	1,580.2	1957 ~
Evaporation [mm]	55.4	56.4	62.5	63.7	79.6	67.5	60.7	59.7	64.2	69.0	62.9	62.0	763.6	1960 ~
Duration of sunshine [hr]	69.1	52.3	58.8	92.8	168.0	157.1	169.9	174.5	180.4	156.3	130.3	114.7	1,524.1	1963 ~

Station: Dinh Hoa

Observation item	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual	Period for the mean
Temperature [°C]	15.4	16.6	19.6	23.4	26.7	28.0	28.1	27.7	26.5	23.7	19.9	16.6	22.7	1961 ~
Precipitation [mm]	21.6	29.6	54.6	107.2	210.9	273.7	319.3	304.4	167.5	110.7	41.0	15.4	1,655.9	1961 ~
Evaporation [mm]	51.1	49.6	54.3	59.7	83.4	74.8	74.2	65.0	66.6	66.4	61.2	59.4	765.7	1961 ~
Duration of sunshine [hr]	46.8	43.4	36.0	71.2	131.4	137.5	139.3	166.3	166.3	156.6	123.0	100.8	1,318.6	1991 ~

Station: Thai Nguyen

Observation item	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual	Period for the mean
Temperature [°C]	15.9	17.0	19.9	23.6	27.0	28.4	28.5	28.1	27.0	24.5	21.0	17.6	23.2	1959 ~
Precipitation [mm]	22.7	35.3	62.3	113.6	240.0	349.6	424.7	381.2	238.5	124.7	47.2	22.8	2,062.6	1915 ~ *
Evaporation [mm]	72.5	63.5	61.9	65.6	96.3	92.9	90.1	79.3	85.8	91.9	86.5	83.5	969.8	1959 ~
Duration of sunshine [hr]	70.7	48.7	48.7	79.1	162.6	163.1	183.8	184.4	188.6	175.4	146.0	121.0	1,572.0	1959 ~

* indicates missing data in some years

Station: Tam Dao

Observation item	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual	Period for the mean
Temperature [°C]	11.2	12.1	15.3	18.7	21.6	22.9	23.1	22.7	21.5	19.0	15.8	12.7	18.1	1962 ~
Precipitation [mm]	37.1	46.6	82.8	142.1	233.8	374.7	432.6	455.5	328.4	226.2	95.5	36.0	2,491.4	1931 ~ *
Evaporation [mm]	33.2	24.6	30.5	31.8	50.9	47.5	45.3	42.2	54.4	64.2	64.3	54.8	543.7	1962 ~
Duration of sunshine [hr]	61.0	45.9	58.9	79.3	133.3	119.5	137.4	139.1	136.4	130.3	112.4	109.3	1,263.1	1962 ~

* indicates missing data in some years

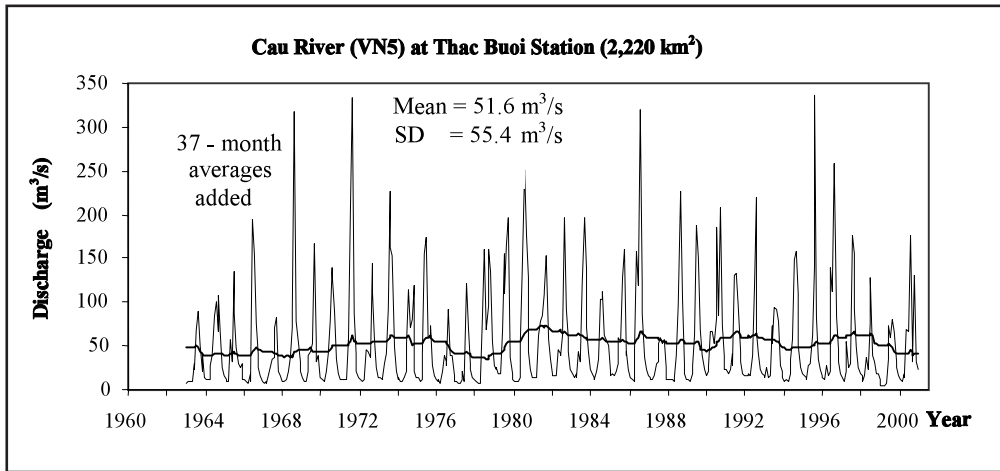
Station: Vinh Yen

Observation item	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual	Period for the mean
Temperature [°C]	16.6	17.5	20.4	24.1	27.6	29.0	29.2	28.6	27.6	25.0	21.5	18.2	23.8	1960 ~
Precipitation [mm]	21.5	23.2	38.1	98.1	168.6	250.0	256.5	294.0	186.0	133.5	55.1	18.6	1,543.3	1960 ~
Evaporation [mm]	66.7	60.1	65.2	72.6	104.7	98.3	97.3	79.2	80.6	81.6	76.2	76.0	958.4	1960 ~
Duration of sunshine [hr]	69.5	53.0	54.7	91.9	187.4	175.6	201.8	189.2	194.4	173.9	142.1	125.8	1,659.4	1960 ~

Station: Hiep Hoa

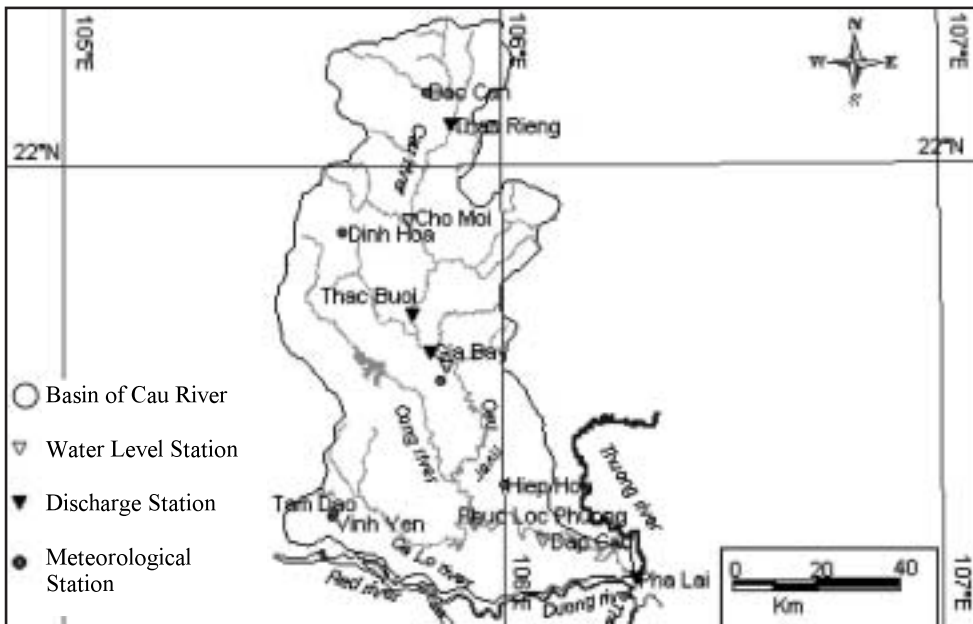
Observation item	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual	Period for the mean
Temperature [°C]	16.1	17.2	19.9	23.6	27.0	28.8	28.8	28.3	27.3	24.6	21.0	17.7	23.4	1971 ~
Precipitation [mm]	22.6	24.7	45.5	108.3	191.3	232.1	280.2	266.9	195.6	146.1	47.8	20.0	1,581.2	1961 ~
Evaporation [mm]	70.0	61.6	58.7	60.9	89.6	94.7	91.5	72.1	78.7	88.4	86.0	84.6	936.9	1971 ~
Duration of sunshine [hr]	65.8	47.3	47.9	85.0	175.9	175.3	193.4	180.8	193.4	176.6	151.4	132.1	1,625.0	1971 ~

3.4 Long-term Variation of Monthly Precipitation



4. Hydrological Information

4.1 Map of Stream flow Observation Stations



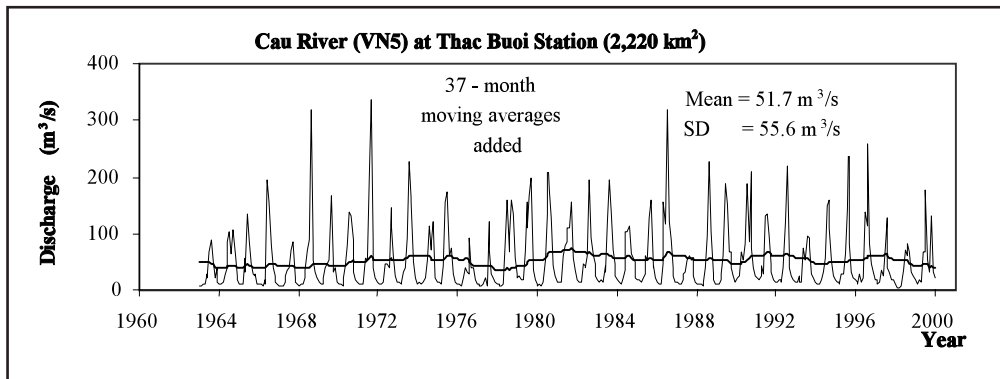
4.2 List of Hydrological Observation Stations

No.	Station	Location	Catchment area (A) [km ²]	Observation period	Observation items ¹⁾ (frequency)
91302	Thac Buoi	N: 21° 42' E: 105° 48'	2,220	1960 ~	H, Q, P, WQ

No.	\bar{Q} ²⁾ [m ³ /s]	Qmax ³⁾ [m ³ /s]	Qmax ⁴⁾ [m ³ /s]	Qmin ⁵⁾ [m ³ /s]	\bar{Q}/A [m ³ /s/100km ²]	Qmax/A [m ³ /s/100km ²]	Period of statistics
91302	51.7	3,490	1,240	7.83	2.33	157.21	1960 ~

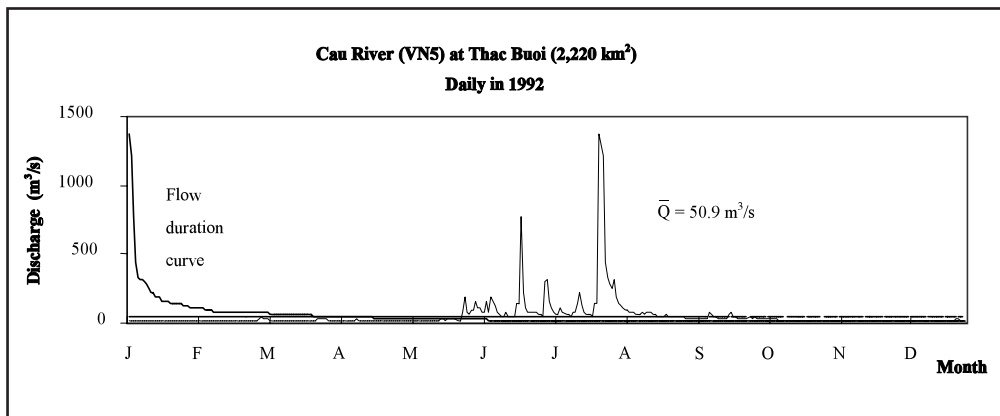
1) H: Water lever
 P: Precipitation (daily)
 Q: Discharge
 S: Sediment concentration
 WQ: Water quality
 2) Mean annual discharge
 3) Maximum discharge
 4) Mean maximum discharge
 5) Mean minimum discharge

4.3 Long-term Variation of Monthly Discharge



Note: The data above are monthly mean flows expressed in units of m³/s

4.4 Annual Pattern of Discharge



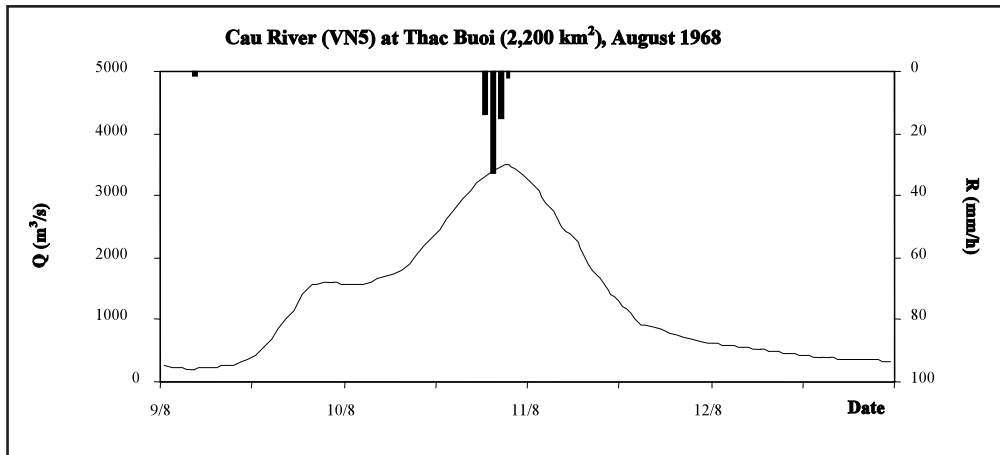
4.6 Annual Maximum and Minimum Discharge

At Thac Bui [6,030 km²]

Year	Maximum ¹⁾		Minimum ²⁾		Year	Maximum ¹⁾		Minimum ²⁾	
	Date	[m ³ /s]	Month	[m ³ /s]		Date	[m ³ /s]	Month	[m ³ /s]
1960	9.28	1,210	5	4.66	1981	9.7	838	3	8.70
1961	6.12	608	3	8.00	1982	8.20	1,110	3	11.0
1962	8.21	845	3	8.65	1983	7.31	2,680	4	7.53
1963	9.19	620	2	6.00	1984	6.27	636	5	8.70
1964	10.18	694	2	8.70	1985	9.8	1,140	5	10.1
1965	6.14	823	2	6.00	1986	7.24	2,330	3	8.40
1966	7.28	1,090	3	4.30	1987	5.13	556	2	10.8
1967	8.19	621	2	5.70	1988	8.27	1,730	6	4.62
1968	8.1	3,490	1	6.30	1989	6.13	1,480	2; 3	9.72
1969	8.16	1,280	4	7.25	1990	9.22	2,770	2	16.2
1970	7.27	962	3	5.99	1991	6.4	796	12	14.2
1971	7.24	2,140	3	8.20	1992	7.24	2,090	5	9.60
1972	8.29	605	5	5.50	1993	7.9	657	2	8.37
1973	7.29	1,410	4	7.95	1994	9.8	964	2; 3; 5	6.32
1974	10.4	1,420	4	6.68	1995	8.16	2,790	3	8.92
1975	6.6	749	3	7.50	1996	8.19	1,320	3	9.50
1976	8.14	419	3	5.80	1997	7.21	919	2	12.2
1977	7.22	853	6	5.35	1998	7.4	424	12	5.82
1978	10.4	1,590	2; 4	5.92	1999	6.13	578	3	3.40
1979	6.17	1,120	12	8.80	2000	7.22	1,110	5	7.63
1980	7.21	1,390	3	5.95					

1), 2) Discharge rated according to manual observation of water level

4.7 Hyetographs and Hydrographs of Major Floods



5. Water Resources

5.1 General Description

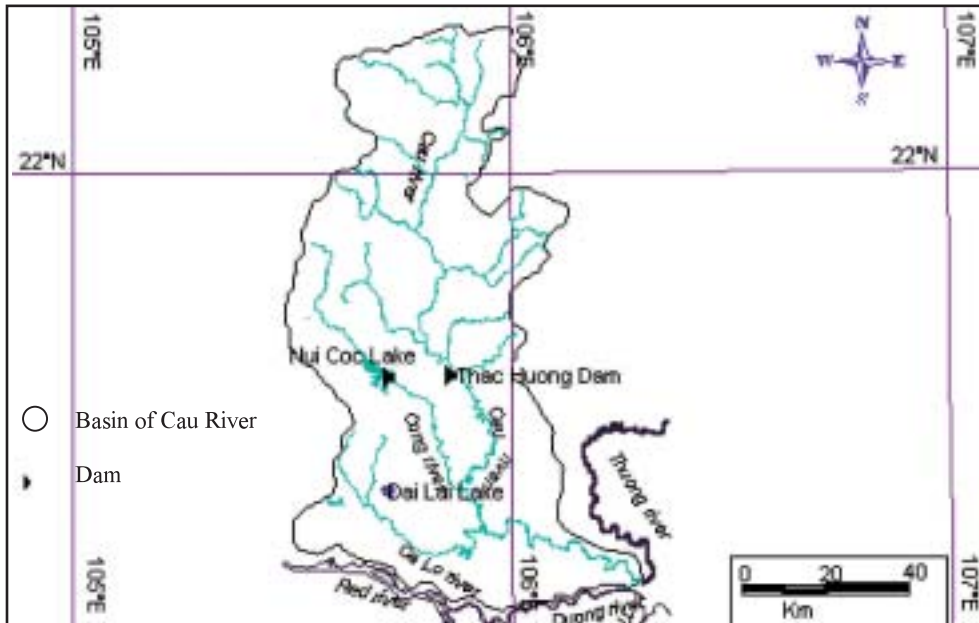
The long term annual specific discharge is unevenly distributed in the basin, and varies from $0.015 \text{ m}^3/\text{s}/\text{km}^2$ in the lower part of the Ca Lo River to more than $0.30 \text{ m}^3/\text{s}/\text{km}^2$ on the eastern slopes of the Tam Dao mountain range in the Cong River basin. The long-term annual runoff of the basin is about 4.50 km^3 , $0.235 \text{ m}^3/\text{s}/\text{km}^2$, or a runoff depth of 745 mm. The runoff is irregularly distributed through the year, and varies with season. The flood season lasts from May or June to October. Flood runoff makes up about 80 - 85% of the annual total with the highest monthly value in July. The low flow season occurs from November to April or May. Runoff in this season contributes only 15-20% of the annual total. The lowest monthly runoff occurs in February.

Data at the Thac Buoi station (catchment area $2,220 \text{ km}^2$) from 1960 - 2000 shows that the highest flood occurred in August 1968 with a peak discharge of $3,490 \text{ m}^3/\text{s}$ or a specific discharge of $1.57 \text{ m}^3/\text{s}/\text{km}^2$. The flood in August 1995 had a peak discharge of $2,790 \text{ m}^3/\text{s}$, while those in September 1990 and August 1983 had peak flows of $2,770 \text{ m}^3/\text{s}$ and $2,680 \text{ m}^3/\text{s}$ respectively. The smallest annual flood occurred in 1976 with a peak discharge of $419 \text{ m}^3/\text{s}$. The minimum recorded discharge is $3.40 \text{ m}^3/\text{s}$ or $0.153 \text{ m}^3/\text{s}/\text{km}^2$ in 1997.

Flash floods occur in the basin, and in the Quan Cay Creek (Area = 9 km^2) on the 22nd of October 1969 at Phuc Thuan village, Vo Nhai district, there was a flash flood with a peak specific discharge of $20 \text{ m}^3/\text{s}/\text{km}^2$.

The water resources of the Cau River are widely used for production and domestic consumption. Some medium sized reservoirs, including the Nui Coc reservoir on the Cong River, and many small ones, were built from 1972 to 1978. These reservoirs have a total storage capacity of $175.5 \times 10^6 \text{ m}^3$ and were developed to exploit the water resources of the basin. The Nui Coc reservoir provides irrigation water to the lower basin of the Cong River and additional water to the Cau River for supply to industrial and domestic users in Thai Nguyen city, and industrial centres like Song Cong and Go Dam. Some $20 \times 10^6 \text{ m}^3$ of water is diverted from the river at the Thac Huong Dam and is used to irrigate more than 20,000 ha in Bac Giang and Bac Ninh provinces.

5.2 Map of Water Resource Systems



5.3 List of Major Water Resources Facilities

Name of river	Name of dam (Reservoir)	Catchment area [km ²]	Gross capacity [10 ⁶ m ³]	Effective capacity [10 ⁶ m ³]	Purpose	Year of completion
Cong	Nui Coc	535	175.5	168	A, I, N, W	1978
Ca Lo	Dai Lai	60.1	30.5	26.4	A, N, W	1975
Cau	Lang Hit Dam	-	-	-	A, N	-
Cau	Thac Huong Dam	-	-	20	A, N	-

A: Agriculture I: Industrial use N: Maintenance of normal flows W: Municipal water supply

5.4 Major Flood and Droughts

Date	Peak discharge [m ³ /s]	Rainfall [mm] Duration	Meteorological cause	Dead and missing	Major damages (Districts affected)
1968 8.10	3,490	413.9 8.3 ~ 8.15	Typhoon		Thai Nguyen City
1971 7.24	2,140	301.7 8.23 ~ 8.24	Typhoon		Thai Nguyen City
1983 7.31 ~ 8.6	2,330	613.7 7.27 ~ 8.6	Typhoon		Thai Nguyen City
1986 7.24 ~ 8.30	2,330	640.0 8.13 ~ 8.30	Typhoon		Thai Nguyen City
1990 9.22 ~ 9.25	2,770	294.5 9.20 ~ 9.25	Typhoon		Thai Nguyen City
1992 7.24 ~ 7.29	2,090	301.2 7.21 ~ 7.29	Typhoon		Thai Nguyen City
1995 8.16	2,790	657.2 8.4 ~ 8.19	Typhoon		Thai Nguyen City

5.5 Water quality

Station: Thac Buoi

	T [°C]	pH	COD (mg/l)	ION [mg/l]						
				Ca ⁺⁺	Mg ⁺⁺	HCO ₃ ⁻	SO ₄ ⁻	Cl ⁻	SiO ₂	Fe ³⁺
Mean annual	24.2	7.5	2.60	26.4	5.85	89.1	4.81	4.11	10.5	0.17
Maximum	28.9	7.8	3.24	32.6	7.78	126	6.00	25.6	14.4	0.42
Minimum	17.0	6.4	1.48	24.3	4.62	62.1	2.10	0.85	5.82	0.07

The pH value of the Cau River varies from 6.4 to 7.8 at the Thac Buoi station, while the total iron concentration is 0.171mg/l. The river water belongs to the calcium group, hydrocarbonate class; the HCO₃⁻ ion concentration is of 112 mg/l and dominates among the anions; while the Ca⁺⁺ ion (25.4 mg/l) dominates among the cations. The hardness is 1.72 mg/l.

In general, the water quality is good, but in some reaches the water is polluted by wastes from factories, mining activities, population centres, and riparian villages that discharge directly into the river.

6. Socio-cultural Characteristics

The Cau River mainstream flows through Bac Can, Thai Nguyen, Bac Giang, and Bac Ninh provinces. The topography is mainly flat with splendid views of the Thien Thai and Tam Dao mountains; and the Dai Lai, and Nui Coc reservoirs.

The Cau River basin is famous for its historical culture. Bac Ninh is an ancient region and is one of the cradles of Vietnam civilisation. It is in this region that the famous Quan Ho songs and traditional village handicrafts, like Dong Ho pop painting, were developed.

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