

Ca River

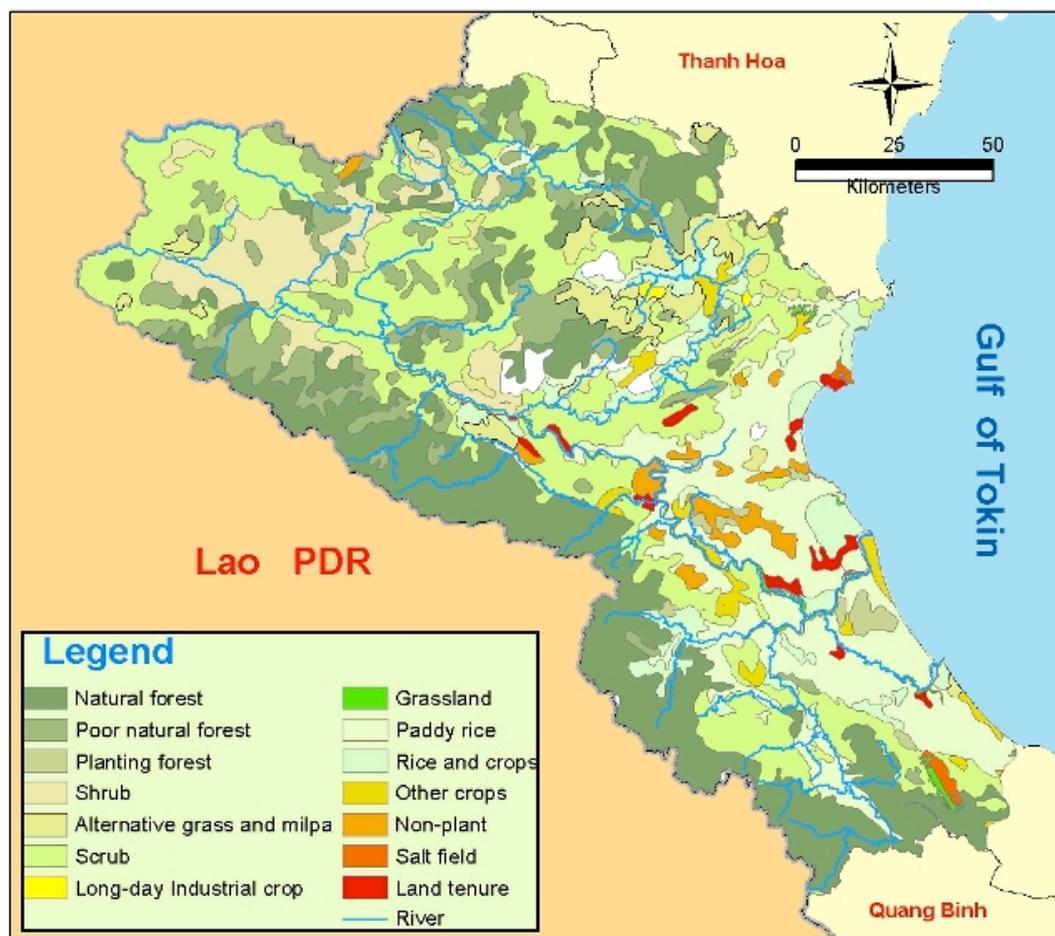
Map of River



Table of Basic Data

Name: Ca		
Location: Thanh Hoa, Nghe An and Ha Tinh provinces, Vietnam; Huaphanh province, Lao PDR	N 17°50'-20°50'	E 103°14'-106°10'
Area: 27,200 km ²	Length of main stream: 531 km	
Origin: Mt. Muong Mut, Lao PDR	Highest point: 2620 m (Nam Mo tributary)	
Outlet: East Sea	Lowest point: Cua Hoi (River Mouth) (0m)	
Main tributaries: Nam Mo (F=3,930 km ²), Huoi Nguyen (F=800 km ²), Khe Choang (F=431 km ²), Hieu River (F=5,340 km ²), Giang River (F=1,050 km ²), Ngan Sau (F=2,310 km ²), Ngan Pho (1,110 km ²).		
Main lakes: None		
Main reservoirs: Ban Ve, Ban Mong, Khe Bo, Thac Muoi, Ngan Truoi.		
Mean annual precipitation: 1400 mm (basin average)		
Mean annual runoff: 430 m ³ /s at Dua (20,800 km ²) (1959-2004)		
Population: 3,358,000 (in 2005)	Main cities: Vinh, Ha Tinh	
Land use: 44% forest, 16% paddy rice, 2% vegetable and crops, 38% others (in 2006)		

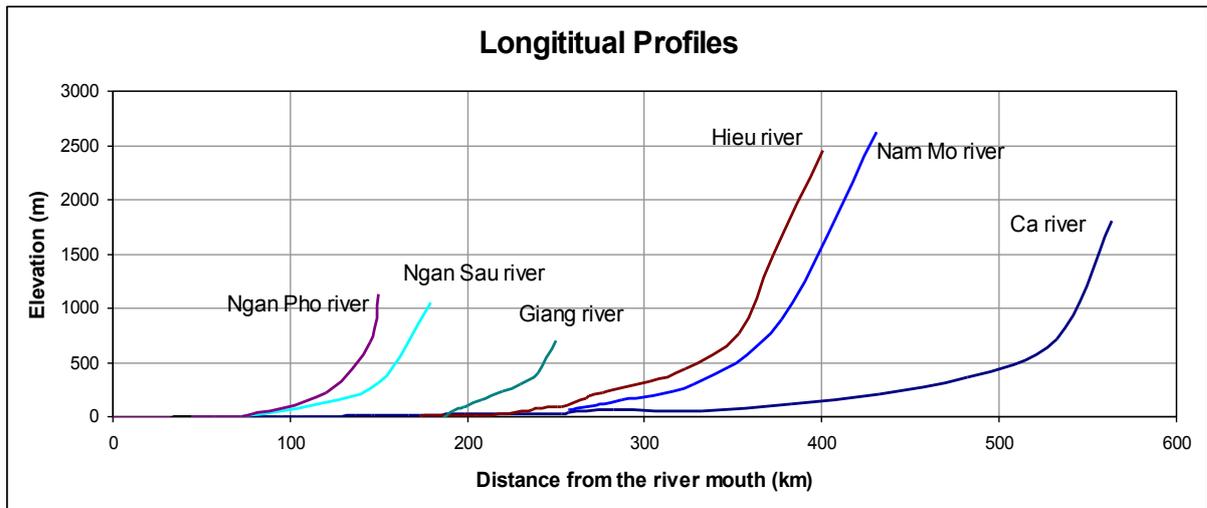
2.2 Land Use Map



2.3 Characteristics of river and main tributaries

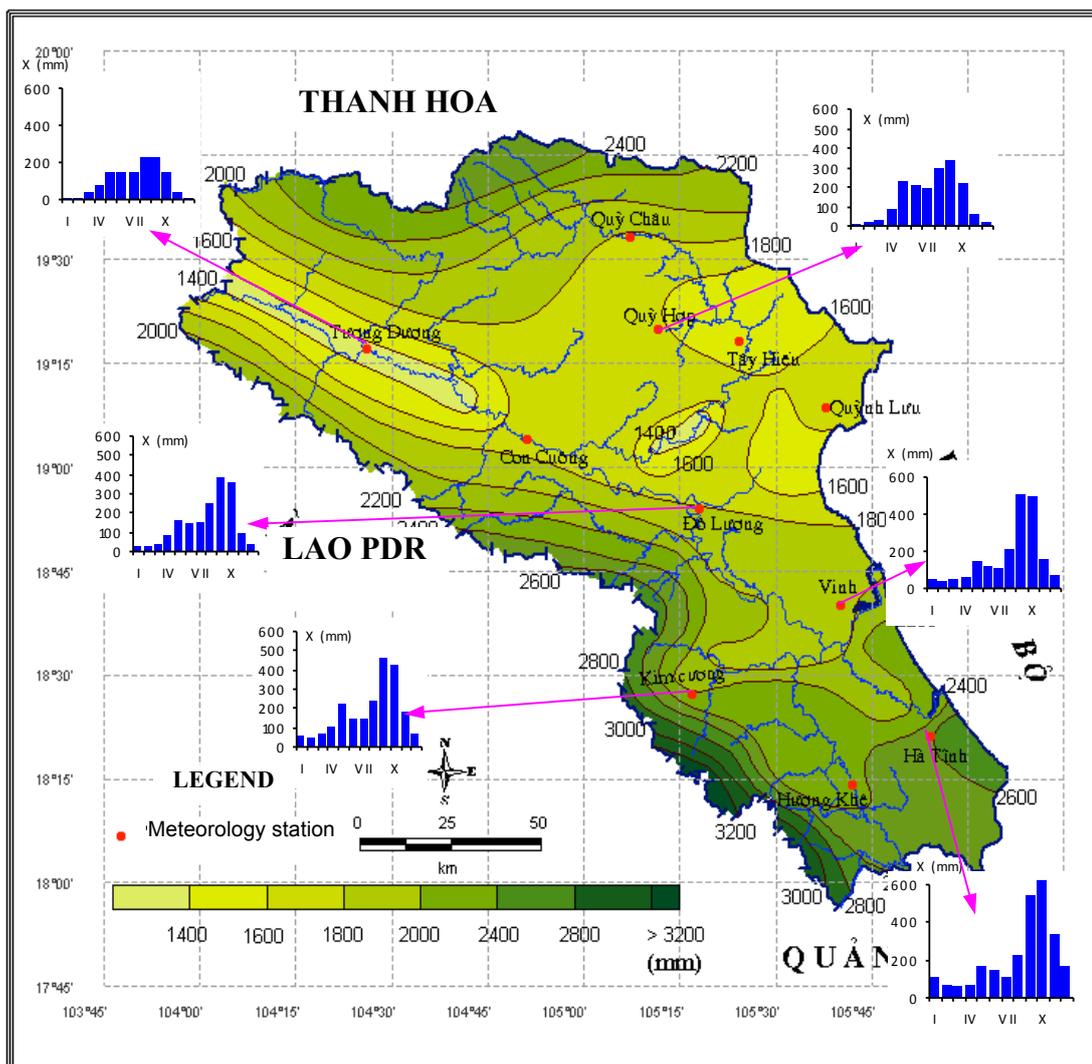
No.	Name of river	Length [km]	Highest peak [m]	Slope (%)
		Catchment area [km ²]	Lowest point [m]	
1	Ca (Main river)	531	1,800 ÷ 2,000	18.3
		27,200	0	
2	Nam Mo (Tributary)	173	2620	25.7
		3,970	59	
3	Giang (Tributary)	77	-	17.2
		1,050		
4	Hieu (Tributary)	228	2452	13.0
		5,340	6.3	
5	Ngan Sau (Tributary)	135	1047	28.2
		2,060	-7	
6	Ngan Pho (Tributary)	70	1136	32.5
		1070	-7	

2.4 Longitudinal Profiles



3. Climatological information

3.1 Annual isohyetal map and Observation stations



3.2 List of Meteorological observation stations

No	Station	Location		Monthly rainfall (mm)												
		Lat	Long	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	Annual
1	Vinh	105°40'	18°40'	53.8	41.6	48.3	62.9	147.6	115.5	114.3	214.8	514.7	497.0	163.9	69.4	2043.9
2	Do Luong	105°18'	18°54'	30.3	33.0	39.6	82.9	163.4	145.0	151.2	246.8	388.0	360.9	100.6	39.4	1781.0
3	Tay Hieu	105°25'	19°19'	18.9	23.1	31.4	67.2	153.3	168.2	158.2	250.8	344.5	267.7	61.3	22.7	1567.3
4	Tuong Duong	104°28'	19°16'	5.0	9.1	19.1	27.7	48.3	48.7	52.9	65.3	64.7	185.7	18.6	7.2	552.3
5	Quy nh Luu	105°38'	19°08'	17.6	23.5	28.6	54.5	107.6	133.9	120.4	230.7	420.2	323.0	76.5	32.4	1568.8
6	Ky Anh	106°16'	18°06'	111.3	73.2	59.6	56.8	154.9	129.1	101.7	240.6	560.7	765.4	414.3	202.1	2869.7
7	Quy Chau	105°06'	19°34'	13.5	14.4	28.4	84.2	230.4	214.0	194.1	294.8	335.0	215.0	53.0	17.3	1693.9
8	Quy Hop	105°11'	19°19'	18.7	24.7	31.4	77.7	196.8	198.9	169.0	278.1	311.6	254.3	61.5	22.1	1644.7
9	Huong Khe	105°42'	18°11'	42.7	45.3	62.1	93.8	211.5	163.3	145.3	272.8	452.6	531.9	192.1	71.0	2284.4
10	Ha Tinh	105°54'	18°21'	112.6	64.1	57.8	71.6	165.5	144.7	111.0	227.4	543.6	741.7	337.0	163.5	2740.5
11	Kim Cuong	105°24'	18°31'	54.1	51.7	64.7	104.8	224.0	145.5	147.0	243.8	469.3	427.3	186.7	71.4	2190.2

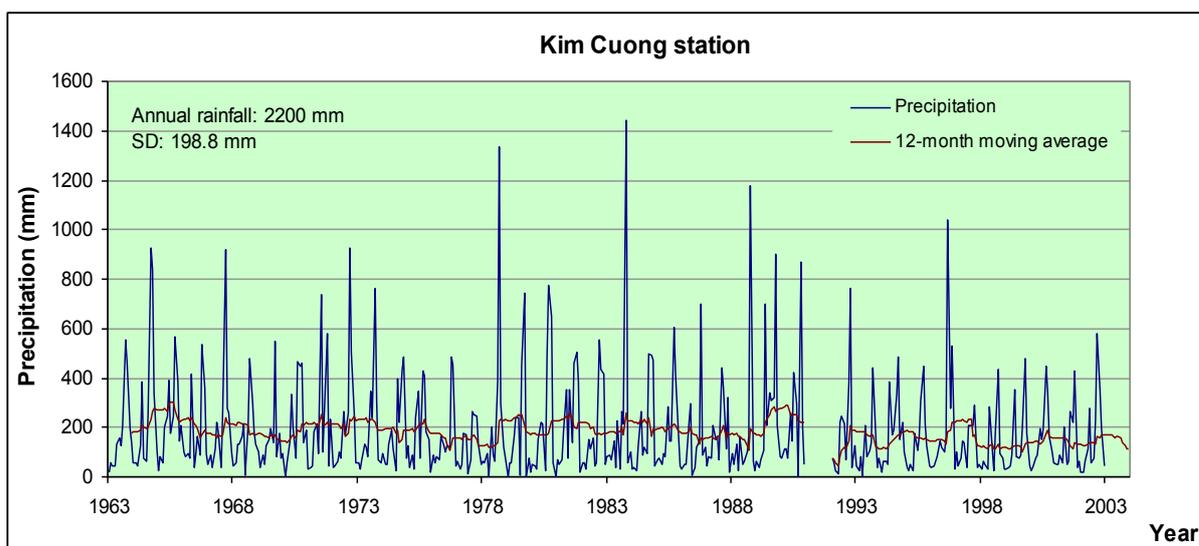
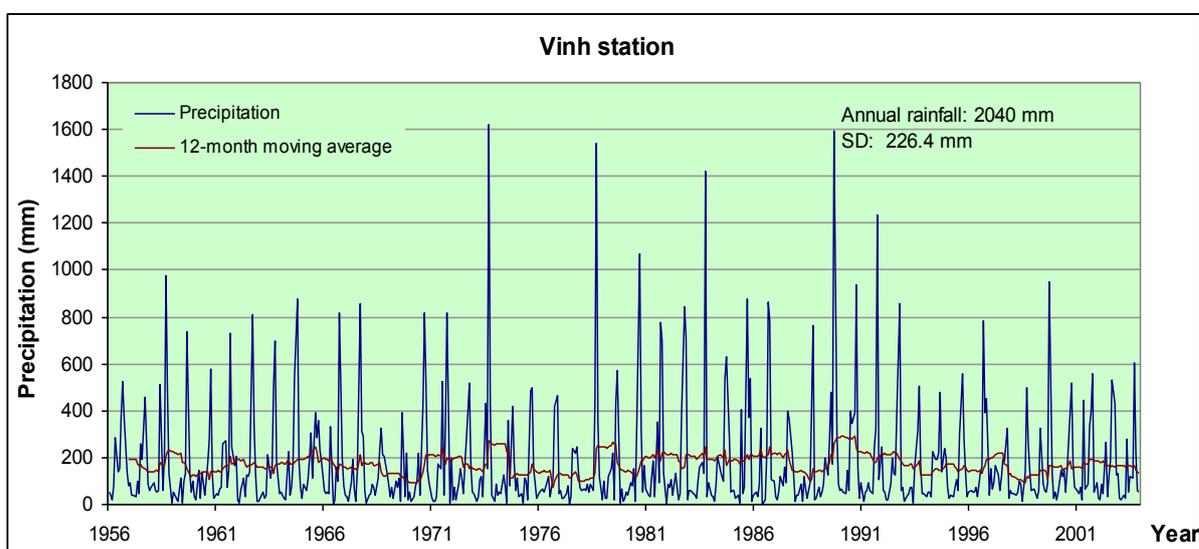
No	Station	Elevation [m]	Location		Observation period	Mean annual precipitation [mm]	Mean annual evaporation [mm]	Observation Items ¹⁾
1	Vinh	6	E105°40'	N18°40'	1956-present	2043.9	954.3	P, T, W, DS
2	Do Luong	-	E105°18'	N18°54'	1961-present	1781.0	789.0	P, T, W, DS
3	Tay Hieu	72	E105°25'	N19°19'	1960-present	1567.3	835.2	P, T, W, DS
4	Tuong Duong	97	E104°28'	N19°16'	1961-present	552.3	867.1	P, T, W, DS
5	Quy nh Luu	3	E105°38'	N19°08'	1961-present	1568.8	982.8	P, T, W, DS
6	Ky Anh	3	E106°16'	N18°06'	1961-present	2869.7	1161.3	P, T, W, DS
7	Quy Chau	87	E105°06'	N19°34'	1962-present	1693.9	703.9	P, T, W, DS
8	Quy Hop	88	E105°11'	N19°19'	1961-present	1644.7	945.4	P, T, W, DS
9	Huong Khe	10	E105°42'	N18°11'	1961-present	2284.4	1006.6	P, T, W, DS
10	Ha Tinh	3	E105°54'	N18°21'	1961-present	2740.5	799.8	P, T, W, DS
11	Kim Cuong	-	E105°24'	N18°31'	1962-present	2190.2	1036.5	P, T, W, DS

1) DS: Duration of sunshine, P: Precipitation, T: Air temperature, W: Wind velocity and wind direction.

3.3 Monthly climate data (Observation station: Vinh)

Observation item	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual	Period for the mean
Temperature [°C]	17.5	17.9	21.9	24.1	27.6	29.4	29.6	28.7	26.8	24.4	21.5	18.7	24.0	1957-2000
Precipitation [mm]	53.8	41.6	48.3	62.9	147.6	115.5	114.3	214.8	514.7	497.0	163.9	69.4	2043.9	1961-2005
Duration of sunshine [hr]	745.1	509.5	728.3	1364	2220	2068	2321	1970	1714	1400	1020	848.6	16909	1963-2000
Solar radiation [MJ/m ² /d]	6.97	6.75	9.11	15.10	20.19	17.77	19.97	17.38	16.81	12.48	9.35	7.69	13.30	1960-2003
Evaporation [mm]	39.4	28.9	35.5	54.1	110	155	180	121	65.6	59.9	54.7	50.5	954	

3.4 Long-term Variation of Monthly Precipitation



4. Hydrological Information

4.1 Map of Hydrometeorology stations network



4.2 List of Hydrological observation stations

No	Station	River	Location		Catchment area (A) [km ²]	Observation period	Observation items ¹⁾ (frequency)
1	Cua Rao	Ca	104°25'00"	19°17'00"	12800	1960-1976	Q, H, WQ
2	Dua	Ca	105°02'20"	18°59'20"	20800	1959-2004	Q, H, WQ
3	Yen Thuong	Ca	105°23'00"	18°41'10"	23000	1968-2004	Q, H, WQ
4	Muong Xen	Nam Mo	104°07'12"	19°24'30"	2620	1969-2004	Q, H
5	Coc Na	Khe Choang	104°45'00"	19°05'00"	417	1961-1976	Q, H, WQ
6	Quy Chau	Hieu	105°08'20"	19°23'30"	1960	1962-2005	Q, H, WQ
7	Nghia Khanh	Hieu	105°20'00"	19°26'00"	4024	1959-2004	Q, H, WQ
8	Khe La	Khe Thiem	105°19'00"	19°06'00"	27.8	1970-1985	Q, H, WQ
9	Hoa Duyet	Ngan Sau	105°35'00"	18°22'00"	1880	1959-1981, 1997-2004	Q, H, WQ
10	Trai Tru	Tiem	105°34'00"	18°10'00"	96.2	1964-1981	Q, H
11	Huong Dai	Ngan Truoi	105°29'00"	18°23'00"	408	1965-1976	Q, H
12	Son Diem	Ngan Pho	105°21'20"	18°30'30"	790	1961-1981, 1997-2004	Q, H, WQ
13	Ke Go	Rao Cai	105°55'07"	18°12'26"	229	1959-1975	Q, H, WQ

Station	\bar{Q} ²⁾ [m ³ /s]	Q max ³⁾ [m ³ /s]	Q min ⁴⁾ [m ³ /s]	\bar{Q} / A [m ³ /s/100km ²]	Q max / A [m ³ /s/100km ²]	Q min / A [m ³ /s/100km ²]	Period of statistics
Cua Rao	233	5690	30.3	1.820	0.445	2.37	1960-1976
Dua	417	10200	47.8	2.005	0.490	2.30	1959-2004
Yen Thuong	517	9140	61.4	2.248	0.397	2.67	1968-2004
Muong Xen	66.6	1170	8.60	2.542	0.447	3.28	1969-2004
Coc Na	15.2	920	2.79	3.645	2.21	6.69	1961-1976
Quy Chau	77.4	2870	6.70	5.160	1.91	4.47	1962-2004
Nghia Khanh	122.1	5750	10.4	3.034	1.43	2.58	1959-2004
Khe La	0.621	257	0.002	2.234	9.24	0.072	1970-1985
Hoa Duyet	113	3880	8.82	6.011	2.06	4.69	1959-1981, 1997-2004
Trai Tru	7.28	1120	0.850	7.568	11.6	8.84	1964-1981
Huong Dai	30.6	2080	4.35	7.500	5.10	10.7	1965-1976
Son Diem	47.2	4480	5.28	5.975	5.67	6.68	1961-1981, 1997-2004
Ke Go		1510	0.200		6.59	0.873	1959-1975

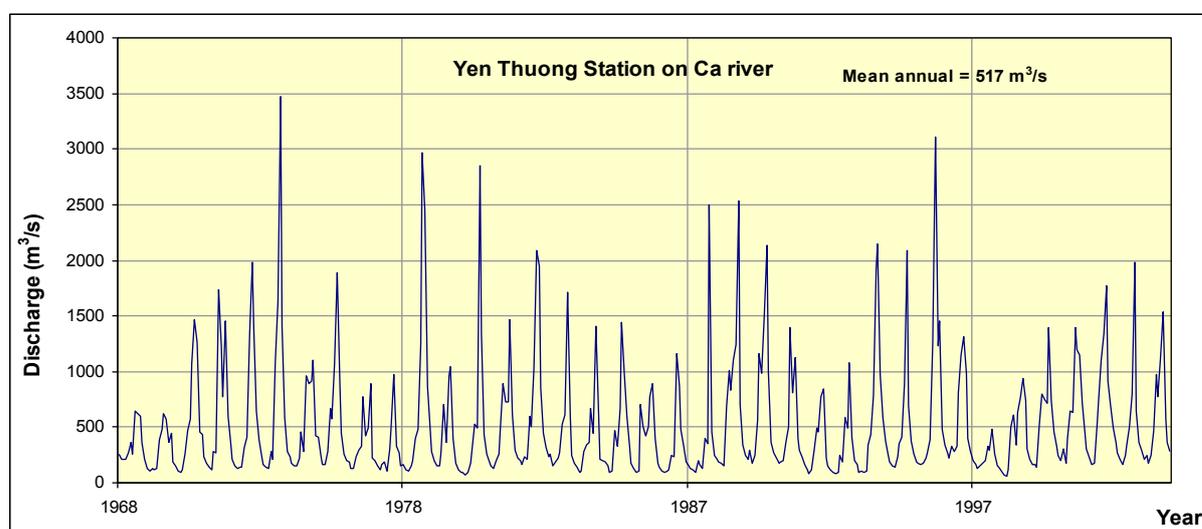
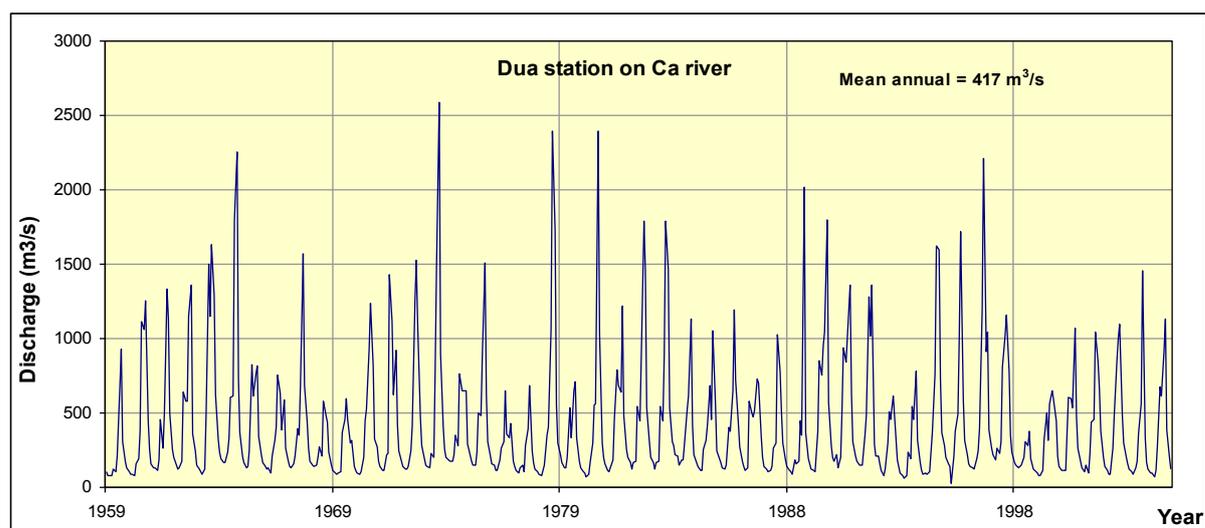
1) Q: Discharge, H: Water level, WQ: Water quality

2) \bar{Q} : Mean annual discharge.

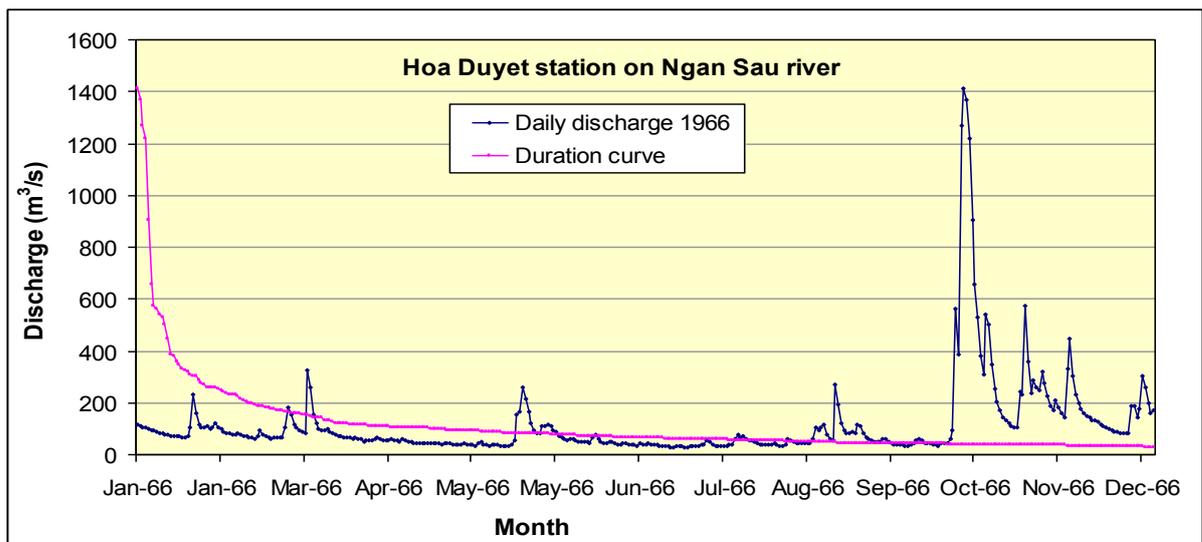
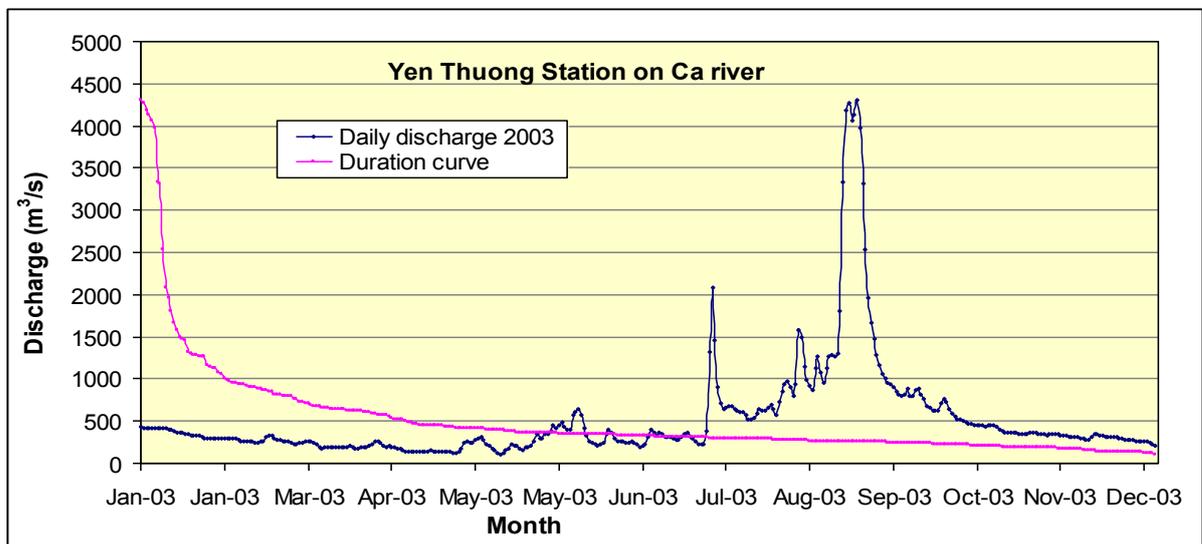
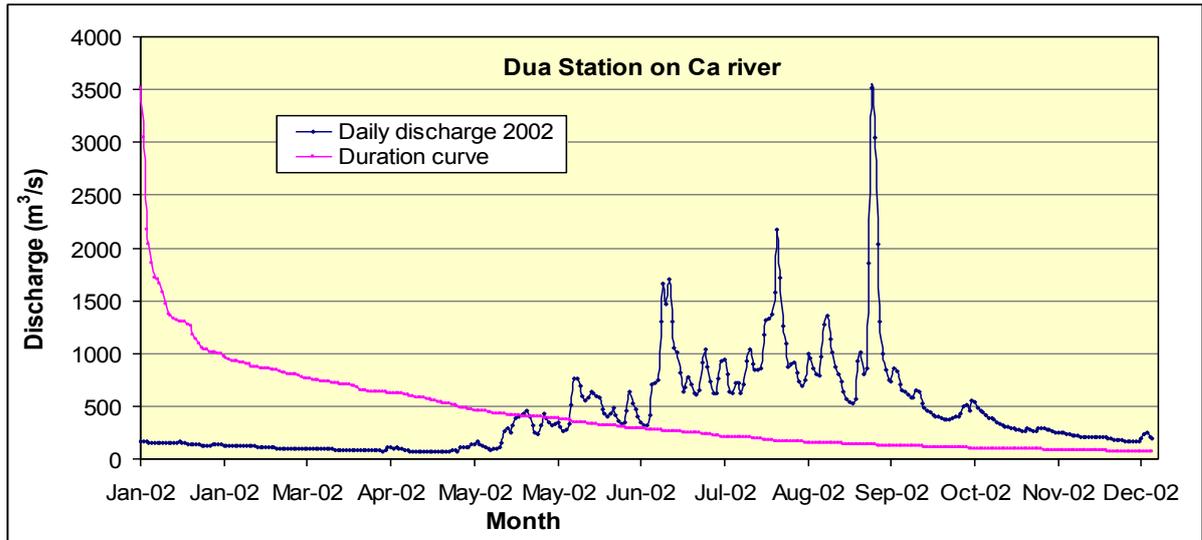
3) Q max: Maximum discharge.

4) Q min: Minimum discharge.

4.3 Long-term Variation of Monthly Discharge



Annual Pattern of Discharge



4.5 Annual Maximum and Minimum Discharges

Station: Dua

Year	Maximum ¹⁾		Minimum ²⁾		Year	Maximum ¹⁾		Minimum ²⁾	
	Date	[m ³ /s]	Date	[m ³ /s]		Date	[m ³ /s]	Date	[m ³ /s]
1959	24-Aug	1880	4-May	50.0	1983	12-Oct	3840	22-Jun	116
1960	15-Oct	2790	3-May	54.0	1984	15-Oct	2400	6-Apr	85.0
1961	21-Oct	3300	25-Apr	81.0	1985	13-Sep	3190	12-Jun	92.0
1962	1-Oct	6660	23-Mar	115	1986	25-Oct	3130	3-Apr	95.0
1963	26-Jul	8630	27-Apr	73.0	1987	24-Aug	4220	25-Apr	92.0
1964	10-Oct	4350	10-Apr	151	1988	18-Oct	8840	24-Apr	84.0
1965	3-Sep	2210	28-Apr	109	1989	26-Jul	4310	23-Apr	71.0
1966	16-Nov	2060	14-May	74.0	1990	6-Oct	4520	23-Apr	103
1967	9-Sep	2740	5-Apr	97.0	1991	20-Aug	5440	5-May	115
1968	15-Aug	3000	3-Apr	122	1992	22-Sep	2830	12-May	55.0
1969	19-Jun	1120	1-Apr	79.0	1993	14-Jul	2130	6-Apr	40.0
1970	21-Aug	2380	16-Mar	75.0	1994	1-Aug	4190	5-May	61.0
1971	20-Jul	4610	5-Apr	96.0	1995	31-Aug	4620	24-Apr	101
1972	7-Sep	4720	13-May	96.0	1996	24-Sep	5710	24-Mar	88.0
1973	28-Aug	7300	12-Apr	108	1997	30-Jul	2220	12-Mar	166
1974	30-Oct	1940	12-Apr	163	1998	4-Jul	862	3-May	112
1975	22-Sep	4060	30-Apr	133	1999	17-Oct	1860	23-Mar	64.5
1976	14-Aug	1180	19-Apr	82.0	2000	13-Sep	3520	5-Apr	76.0
1977	10-Sep	1860	20-Mar	83.0	2001	23-Oct	2850	24-Apr	79.2
1978	28-Sep	10200	2-Apr	69.0	2002	21-Sep	3690	12-Apr	63.4
1979	24-Sep	1610	12-Apr	110	2003	14-Sep	3985	9-May	51.0
1980	17-Sep	6620	11-Mar	64.0	2004	21-Sep	2540	31-Mar	69.0
1981	17-Oct	2620	25-Mar	79.0	2005	12-Aug	5100	6-May	72.8
1982	8-Sep	4370	20-Mar	108					

Station: Yen Thuong

Year	Maximum ¹⁾		Minimum ²⁾		Year	Maximum ¹⁾		Minimum ²⁾	
	Date	[m ³ /s]	Date	[m ³ /s]		Date	[m ³ /s]	Date	[m ³ /s]
1968	16-Aug	2740	31-Dec	84.2	1986	24-Oct	3280	14-Apr	72.5
1969	19-Jun	1060	22-May	78.3	1987	24-Aug	3790	24-May	68.6
1970	30-Sep	2930	10-Apr	103	1988	18-Oct	7150	27-Apr	73.7
1971	24-Oct	5050	25-Apr	91.5	1989	15-Oct	4480	22-Apr	129
1972	8-Sep	4920	14-May	77.0	1990	6-Oct	4590	23-Apr	152
1973	29-Aug	5850	12-Apr	124	1991	20-Aug	4420	27-Mar	158
1974	6-Nov	2660	8-May	108	1992	23-Sep	2790	14-May	70.1
1975	23-Sep	3610	29-Apr	75.0	1993	14-Jul	2400	5-Apr	65.0
1976	3-Nov	2820	20-Apr	76.4	1994	1-Aug	4010	6-May	73.4
1977	7-Sep	2350	20-Jun	73.3	1995	1-Sep	4140	23-Apr	127
1978	28-Sep	8680	14-Mar	96.0	1996	26-Sep	5960	24-Mar	133
1979	23-Sep	2950	29-Dec	61.4	1997	6-Oct	2190	11-Jun	164
1980	19-Sep	5640	13-Mar	110	1998	17-Sep	1010	26-Apr	102
1981	16-Oct	3320	25-Mar	144	1999	16-Oct	2420	20-Mar	47.8
1982	9-Sep	4520	23-Mar	118	2000	14-Sep	3430	4-Apr	102
1983	11-Oct	4100	21-Jun	79.2	2001	23-Oct	3690	22-Apr	139
1984	16-Oct	3040	23-Mar	47.5	2002	20-Sep	4270	9-Apr	111
1985	13-Sep	3000	12-Jun	84.2	2003	14-Sep	4310	9-May	108

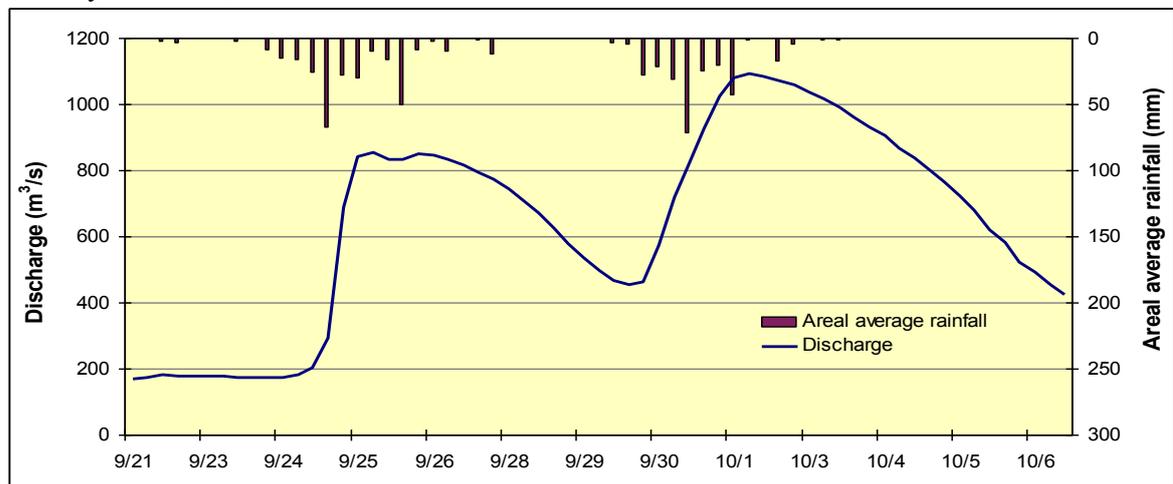
1), 2) Instantaneous observation by recording chart

Hyetograph and Hydrograph of Major Flood

Dua station, Oct 1988



Hoa Duyet station, Oct 2009



5. Water Resources

5.1 General Description

The Ca River system consists of Ca River and its tributaries such as Hieu River, Ngan Sau River, Ngan Pho River and so on. The total annual flow of the Ca River system is about 23.1 km³, in which the total annual flow originated from Lao PDR is 4.45 km³ and 18.6 km³ is generated in Vietnam (occupying 80.5%). Unit potential water availability per year on the Ca River basin system is about 849*10³ m³/km², and the assured water for a capital in year 2005 is approximately 5,320 m³ (only calculate for flow generated within Vietnam territory).

The flood season usually occurs in April, July to October and November on the main branch of the Ca River and its tributaries in the middle stream and upstream. On the other tributaries, the flood season occurs from August or September to December. The total flow volume in flood season occupies from 55-75% of the annual flow. The three subsequent months of highest flow discharge are usually occurred in July, August and September, or from August to October and from September to December. The three driest months are usually occurred from February to April or from March to May. The total flow volume in three months only occupies from 4.5-9.5% of the total annual flow. The flow regime of the rivers in coastal zone

area is influenced under of tide with diurnal tidal regime. The maximum flood peak can reach to more $10 \text{ m}^3/\text{s.km}^2$ on the main stream, $0.6\text{-}6.6 \text{ (m}^3/\text{s.km}^2)$ on the small branches and about $0.4\text{-}0.5 \text{ (m}^3/\text{s.km}^2)$ on medium streams. The maximum flood discharge of $10,200 \text{ m}^3/\text{s}$ at Dua station was recorded by the flood that occurred in Sep1978.

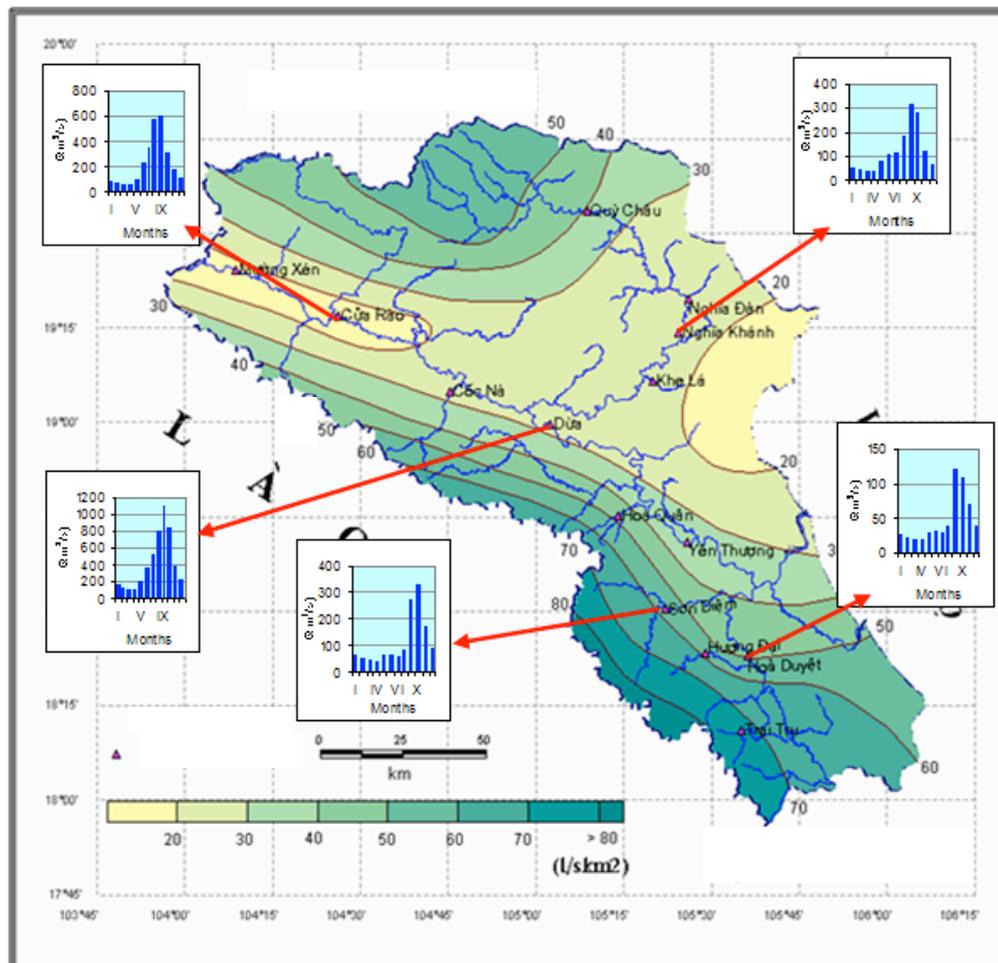
Annual flow at selected stations in Ca river basin

Station	River	Flv ¹⁾ (km ²)	W ₀ ²⁾ (10 ⁹ m ³)	Q ₀ ³⁾ (m ³ /s)	M ₀ ⁴⁾ (l/s.km ²)	Y ₀ ⁵⁾ (mm)
Cua Rao	Ca	12,800	6.72	213	16.6	525
Dua	Ca	20,800	13.4	424	20.4	643
Yen Thuong	Ca	23,000	16.0	508	22.1	695
Muong Xen	Nam Mo	2,620	2.05	65	24.8	782
Quy Chau	Hieu	1,500	2.49	79.1	52.7	1660
Nghia Khanh	Hieu	4,020	4.13	132	32.6	1027
Thac Muoi	Giang	785	1.15	36.4	46.4	1465
Son Diem	Ngan Pho	790	1.60	50.6	64.1	2025
Hoa Duyet	Ngan Sau	1,880	3.88	123	65.4	2063
Whole river basin	Ca	27,200	23.5	745	27.4	864

LEGEND
Hydrology station

1) Catchment area; 2) Mean annual flow volume; 3) Mean annual discharge; 4) Mean unit flow; 5) Mean flow depth

5.2 Annual isoline unit flow map



5.3 Map of Water Resource Systems



5.4 List of Major Water Resources Facilities

Major Reservoirs

Name of river	Name of dam (reservoir)	Catchment area [km ²]	Gross capacity [10 ⁶ m ³]	Effective capacity [10 ⁶ m ³]	Purpose ¹⁾	Year of completion
Ca	Ban Ve	8,700	1834.6	1383	A, I, M, P, F	2009
Hieu	Ban Mong	2,785	252.6	125.8	A, I, M, P	2012
Ca	Khe Bo	14,300	97.8	17.2	P	2010
Giang	Thac Muoi	785	558.1	437.8	P,F	-
Ngan Sau	Ngan Truoi	506	425.6	353.9	A, P, I, F, W	2014

1) A: Agricultural use
P: Hydro-power

F: Flood control
W: Municipal water supply

I: Industrial use
N: Maintenance of normal flows

5.5 Major Floods and Droughts

Major Floods

Date	Peak discharge [m ³ /s]	Rainfall [mm], Duration	Meteorological cause	Major damages (Districts affected)
26-28/IX/1978	10200 (Dua)	809.2 (Dua) 25÷28	Typhoon No.07, 08, 09	Nghe An and Ha Tinh
10-18/X/1988	8630 (Dua)	694 (Dua) 12÷14	Typhoon No.07	Nghe An and Ha Tinh
21-26/IX/1996	5710 (Dua)	100-250 (Dua)	Typhoon No.04	Nghe An
22/IX/2002	4480 (Son Diem)	794 (Huong Khe)	Tropical low pressure	Ha Tinh

5.6 River water quality

The Suspended Sediment of River Flow

The mean annual sediment concentration of the Ca river system varies from 100 - 450 g/m³, relatively high in upstream of the Ca river and on the Hieu river (above 200 g/m³), but quite low on other tributaries. The suspended sediment concentrations on rivers are seasonal variation, during flood season, the sediment concentration is usually high, but sediment concentration becomes low in the dry season. Aggressive factor of the mean annual suspended sediment is varying from 600 tonnes/km² per year in upstream of the Ca river to 100 - 300 tonnes/km² per year in middle stream of the Ca River and on other river branches, except some small streams on the right side downstream of the Hieu river (63 tonnes/km². year at the Khe La gauging station on the Khe Thiem River).

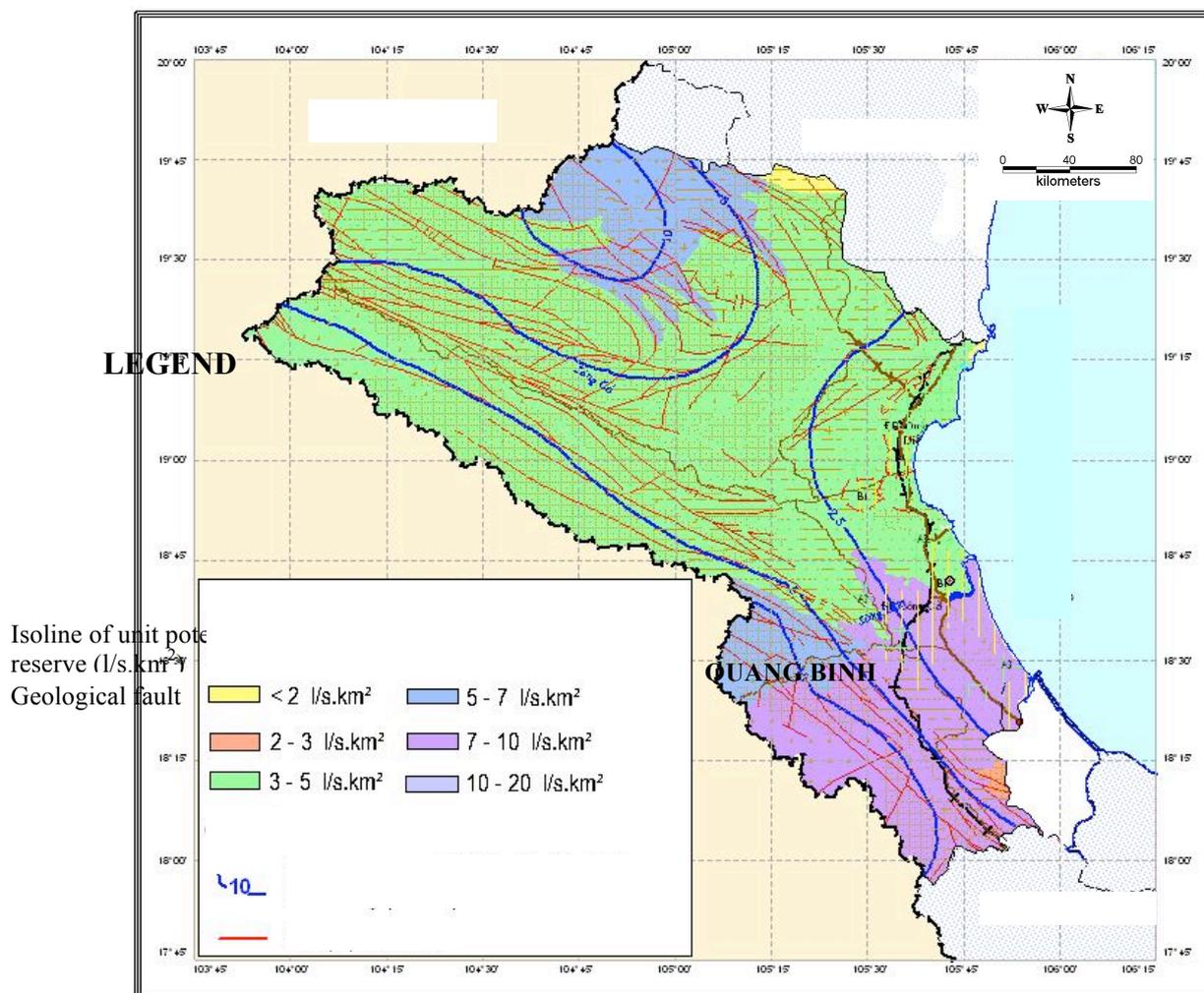
The Chemistry Components of River Flow

The mean total annual mineralized value varying from 100 - 150 mg/l. The pH value is about 7.0. The water of river flow belongs to hydrocarbon class; ion HCO₃⁻ is dominated in the total anion and ion Ca⁺⁺ is dominated in the total cation. Hardness value of river flow is about 1.1 to 1.5 mg-e/l. The river flows in the downstream of the basin and in estuaries are under influence of salinity. At the Cho Trang gauging station on the Ca River, the monthly average of salinity is less than 0.5‰, the maximum salinity may up to 1.65‰. At Trung Luong gauging station on the La river, the monthly average of salinity is less than 0.5‰, the maximum salinity may up to 1.75‰. The salinity regime is under tidal influence. In general, river flows are clean. But during dry season the river flows had being polluted on the river sections nearby urban areas, industrial areas, and nearby the open-cast mining exploitation areas.

5.7 Ground water

Natural dynamic reserves of Ca River in area of 22,555 km² (includes hydrological geology zones of Nghe An and Ha Tinh) is about 10,586,010 m³/day or 122.5 m³/s, related to unit flow of 5.43 l/s.km² and total volume is 3.86 km³/year. Potential exploit reserve is 8,067,408 m³/year, or 93.4 m³/s, related to unit flow of 4.14 l/s.km² and the total volume is 2.95 km³/year.

Map of Potential ground water of Ca river basin (inside Vietnam territory)



6. Socio-cultural Characteristics

Ca river basin in Vietnam territory runs through three provinces Nghe An, Ha Tinh and Thanh Hoa. The population in this part is 3,358,000 inhabitants with eight ethnic groups lived and in which is 90% of Kinh. The area is a supernatural land, where President Ho Chi Minh - a national liberation, a celebrity culture of the world was born and grew.

Nghe An and Ha Tinh have many touristic locations of historical and cultural interest such as Vu Mon Falls, Vu Quang Garden, Son Kim hot springs, Deo Ngang pass, Huong Tich Pagoda, and beautiful beaches at Thien Cam, Deo Con, Xuân Thanh, Chan Tien, Nga ba Dong Loc, Khe Dao. These provinces have not only rich in material cultural products but also have an abundant in immaterial cultural products. These immaterial culture have human culture, traditional struggle for defending the country and conquering the natural calamity; having the abundant folk culture and deeply stamped with national character such as: Vi dam singing, phong vai singing and ho, ve songs. The immaterial cultural products are much attracted travellers.

Nghe An, Ha Tinh also have trained so many talent generations, scientists for the country. Social organization, living standard and educational level of the people on the whole river

basin are improved on the quality both of life and living. Innovation in the basin over the past 10 years is remarkable results.

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