CHAPTER 6 WATER DEMAND FORECAST FOR 14 RIVER BASINS

6.1 General

The water demand is projected in the Study for:

(i) Agriculture use including irrigation, livestock and aquaculture,

(ii) Domestic use,

(iii) Industrial use,

(iv) Power generation, and

(v) River maintenance flow.

In the water demand forecast, the present conditions of water demand are analyzed, and then, the water demand is basically considered to increase along with the economic growth of each sector: that is, the water demand of each sector is considered to basically increase along with the macro-economic targets towards the year 2020 in each of 14 river basins which are established in the socio-economic framework plan in Chapter 5.

Relationship between the socio-economic framework plan and the water demand of each sector is presented in detail in Chapter 8.

6.2 Agriculture Water Demand

6.2.1 Methodology on Irrigation Water Demand Projection

Estimate of water demand is undertaken in the manner as summarized hereinafter, which is discussed in detail in appendix-F.

(1) Collection of data and information.

(2) Estimate of the cultivated land area and planted area based on the presently available reference documents.

(3) Cropping pattern set-up based on the reference documents.

(4) Estimate of the irrigation area based on the reference documents.

(5) Study on the Potential Evapo-transpiration (ETo, mm/month) at the respective area based on the Vietnam Hydrometeorological ATLAS, 1994.

(6) Estimate of the Crop Coefficient (Kc) based on the reference documents.

Different Kc values were taken for the respective development stages:

- Initial stage
- Crop development stage

- Mid-season stage
- Late season stage
- Stage at harvest

(7) Estimate of the Crop Water Requirement (CWR)

CWR = ETc = ETo x Kc

where, CWR: Crop water requirement (mm/10-day)
ETc: Crop evapo-transpiration (mm/10-day)
ETo: Potential evapo-transpiration (mm/10-day)
Kc: Crop coefficient

(8) Consumptive Use of Water of Crops (CUW)

(a) Paddy rice

i) Estimate of the Percolation Loss (P, mm/day)

P = 2 mm/day
= 16 mm/8 days or 20 mm/10 days or 22 mm/11days

ii) Land preparation water requirement (LPW)

LPW = (LS + SW) + Ep + P

where, LPW: Land preparation water requirement (mm/10-day)
LS: Land soaking water (mm/10-day)
LS=10mm/20days wet time
LS=100mm/20days for dry time
The above LS mm/20days is to be converted into LS mm/10-day.
SW: Standing water requirement (mm/10-day)
SW=50mm/20days
The above SW mm/20days is to be converted into SW mm/10-day.
Evp: Evaporation from open water surface (mm/10-day)
Evp = ETo x 1.1
P: Percolation loss (mm/10-day)

iii) Consumptive use of water of paddy rice field (CUW)

The consumptive use of water (CUW mm/10-day) of the paddy rice field has been calculated as follows:

CUW = CWR + P for growing period
CUW = LPW for land preparation period

where, CUW: Consumptive use of water (mm/10-day)

CWR: Crop water requirement (mm/10-day)
P: Percolation loss (mm/10-day)
LPW: Land preparation water requirement (mm/10-day)

(b) Upland crops

The consumptive use of water is expressed as follows:

CUW = CWR

where, CUW: Consumptive use of water of crop (mm/10-day)
CWR: Crop water requirement (mm/10-day)

(9) Estimate of the Effective Rainfall (Peff) based on the reference documents.

In consideration of required accuracy and practical convenience, it has been determined to adopt the United States Department of Agriculture (USDA) Soil Conservation Service (SCS) Method, which is shown in the FAO Irrigation and Drainage Paper 46 mentioned above.

In the method, the effective rainfall is calculated on the monthly basis.

Peff = Ptot x (125 - 0.2Ptot) / 125 for Ptot =< 250 mm
Peff = 125 + 0.1Ptot for Ptot > 250 mm

where, Peff: Effective rainfall (mm/month)
Ptot: Monthly rainfall (mm/month)

Therefore, the above Peff (mm/month) has been divided into three (3) 10-day basis effective rainfalls Peff (mm/10-day) like the ETo (mm/10-day) case.

(10) Calculation of the Net Irrigation Water Requirement (NIR, mm/10-day)

NIR = CUW - Peff

where, NIR: Net irrigation requirement (mm/10-day)
CUW: Consumptive use of water of crop (mm/10-day)
Peff: Effective rainfall (mm/10-day)

(11) Estimate of the Irrigation Efficiency (Ep) based on the reference documents.

For estimation of irrigation efficiency, the following were referred to:

Ep = Ea x Eb x Ec

where, Ep: Project efficiency
Ea: Field application efficiency
Eb: Field canal efficiency
Ec: Conveyance efficiency

	Less-managed System (Year 2000)	Ordinary System (Year 2010)	Well-managed System (Year 2020)
Ea	0.78	0.80	0.82
Eb	0.88	0.90	0.92
Ec	0.87	0.90	0.93
Ep	0.60	0.65	0.70

Ref. Table 37 of FAO Paper 24

Ep of 0.60 has been applied for the present water demand, and 0.65 for 2010 and 0.70 for 2020 respectively for the future water demands in the Study.

(12) Estimate of the Gross Irrigation Requirement (GIR, mm/10-day)

GIR = NIR / Ep

where, GIR: Gross irrigation water requirement (mm/10-day)
NIR: Net irrigation water requirement (mm/10-day)
Ep: Irrigation efficiency (project efficiency)

(13) Estimate of the Irrigation Water Demand (IWD)

IWD = GIR x A / 1,000

where, IWD: Irrigation water demand (m^3/sec)
GIR: Gross irrigation water requirement (lit/sec/ha)
A: Irrigation area (ha)

6.2.2 Forecast of Irrigation Water Demand

(1) Gross Unit Irrigation Requirement (GIR)

Two kinds of gross unit water requirements (GIR) are applied herein, i.e.; GIR in a 1/4 drought year and GIR in the average rainfall year.

Peak GIR is used for the facilities design. The required storage volume of the reservoir and the capacity of irrigation facilities would be determined under condition of dependable rainfall with less than 1/4 of examined long period. In more detail, for example, a peak 10-day GIR in less than 1/4 of examined long period would be used for the design of irrigation canals and structures.

On the other hand, GIR in the average rainfall year is used to know the irrigation water demand (IWD) on an average. For example, total IWD in a ten-year period is known through the calculation of multiplying the IWD in the average rainfall year by 10. Monthly GIRs in the average rainfall year are used to estimate the IWD.

Summary of these two kinds of GIR for the 14 river basins is presented hereinafter.

(a) GIR in Less than 1/4 of Examine Long Period

Gross unit water requirements (GIR) of the 14 river basins in the respective 1/4 drought years have been estimated based on the present and future conditions of cropping patterns and irrigation areas as below.

It is noted that there are two (2) kinds of less than 1/4 of examine long period to be separately used case by case. One is selected from ranking of the peak 10-day GIR (annual maximum) and another is from ranking of the water shortage volume calculated in the water balance calculation.

The capacity of irrigation facilities such as intake structures, canals and related structures would be determined with use of the above peak 10-day GIR. This is not a matter of the water demand (volume of water) but of the peak unit water requirement to calculate the design discharges of the facilities. The peak 10-day GIR would be used for design of the facilities.

The year with less than 1/4 of examine long period of the respective river basins have been determined through the water balance analysis for the period from 1976 to 2000 (different number of years, for example 24 years, etc., have been used for some river basins depending upon the data availability).

The capacity of irrigation facilities such as intake structures, canals and related structures would be determined with use of the peak 10-day GIR. This is not a matter of the water demand (volume of water) but of the peak unit water requirement to calculate the design discharges of the facilities. The peak 10-day GIR would be used in something like feasibility studies for design of the facilities with major dimensions to be shown.

(b) GIR in Average Rainfall Year

Gross unit water requirements (GIR) of the 14 river basins estimated based on the present and future conditions of cropping patterns and irrigation areas in the average rainfall year are shown in the table below:

Gross Unit Irrigation Water Requirement (GIR)
Average Rainfall Year

River Basin	Present (2001)		Future (2010)		Future (2020)	
	Annual Average lt/sec/ha	Annual Total m^3/yr/ha	Annual Average lt/sec/ha	Annual Total m^3/yr/ha	Annual Average lt/sec/ha	Annual Total m^3/yr/ha
01. Bang Giang	0.33	10,600	0.22	6,800	0.19	6,100
02. Red	0.42	13,100	0.38	12,l00	0.35	11,100
03. Ma	0.38	11,800	0.30	9,400	0.28	8,800
04. Ca	0.38	11,900	0.28	8,900	0.24	7,500
05. Thach Han	0.46	14,500	0.36	11,200	0.32	10,000
06. Huong	0.38	12,100	0.37	11,700	0.41	13,000
07. Thu Bon	0.37	11,600	0.29	9,200	0.26	8,200
08. Tra Khuc	0.39	12,300	0.31	9,800	0.24	7,700
09. Kone	0.86	27,100	0.73	23,000	0.62	19,600
10. Ba	0.64	20,300	0.43	13,600	0.37	11,700
11. Sesan	0.26	8,100	0.27	8,600	0.25	7,900
12. Srepok	0.45	14,100	0.37	11,600	0.34	10,600
13. Dong Nai	0.68	21,500	0.40	12,600	0.30	9,600
14. Cuu Long Delta	0.62	19,600	0.54	17,100	0.48	15,100

The above GIRs is used to calculate the water demand in discharge (m^3/sec) or in volume (million m^3/year) to be supplied for the irrigation sector.

Present and projected monthly GIRs (lit/sec/ha) of the 14 river basins in the average rainfall year are shown in Tables 6.1 to 6.3, respectively.

(2) Irrigation Water Demand (IWD)

IWD in Average Rainfall Year

Irrigation water demands (IWDs) of the 14 river basins estimated based on the present and future conditions of cropping patterns and irrigation areas in the average rainfall year are as follows:

Irrigation Water Demand (IWD)
Average Rainfall Year

River Basin		Present(2001)	Future(2010)	Future(2020)
01. Bang Giang	Area (ha)	25,500	54,500	67,500
Water Demand	(m^3 / sec)	8.5	11.8	13.0
	(10^6 m^3 / year)	270	370	410
02. Red	Area (ha)	1,008,000	1,197,000	1,291,000
Water Demand	(m^3 / sec)	419.0	459.9	453.9
	(10^6 m^3 / year)	13,220	14,510	14,320
03. Ma	Area (ha)	112,000	176,000	199,500
Water Demand	(m^3 / sec)	42.0	52.6	55.4
	(10^6 m^3 / year)	1,330	1,660	1,750
04. Ca	Area (ha)	93,000	150,000	203,000
Water Demand	(m^3 / sec)	35.2	42.3	48.2
	(10^6 m^3 / year)	1,110	1,330	1,520
05. Thach Han	Area (ha)	5,000	12,300	15,400
Water Demand	(m^3 / sec)	2.3	4.4	4.9
	(10^6 m^3 / year)	70	138	154
06. Huong	Area (ha)	25,900	25,900	25,900
Water Demand	(m^3 / sec)	9.9	9.6	10.7
	(10^6 m^3 / year)	310	300	340
07. Thu Bon	Area (ha)	30,900	69,000	77,000
Water Demand	(m^3 / sec)	11.4	20.1	19.9
	(10^6 m^3 / year)	360	640	630
08. Tra Khuc	Area (ha)	33,000	42,000	54,000
Water Demand	(m^3 / sec)	12.8	13.1	13.1
	(10^6 m^3 / year)	410	410	410
09. Kone	Area (ha)	25,000	36,500	49,000
Water Demand	(m^3 / sec)	21.5	26.6	30.4
	(10^6 m^3 / year)	680	840	960
10. Ba	Area (ha)	41,000	129,000	186,000
Water Demand	(m^3 / sec)	26.4	55.4	68.9
	(10^6 m^3 / year)	830	1,750	2,170
11. Sesan	Area (ha)	22,500	35,400	50,000
Water Demand	(m^3 / sec)	5.8	9.6	12.6
	(10^6 m^3 / year)	180	300	400
12. Srepok	Area (ha)	29,000	35,000	91,000
Water Demand	(m^3 / sec)	13.0	12.9	30.5
	(10^6 m^3 / year)	410	410	960
13. Dong Nai	Area (ha)	115,000	255,000	393,000
Water Demand	(m^3 / sec)	78.5	101.7	119.2
	(10^6 m^3 / year)	2,480	3,210	3,760
14.Cuu Long Delta	Area (ha)	1,487,000	1,891,000	2,242,000
Water Demand	(m^3 / sec)	923.9	1,023.8	1,075.9
	(10^6 m^3 / year)	29,140	32,290	33,940

The above IWDs in the average rainfall year are used to indicate the water demand or irrigation water consumption of the respective 14 river basins in discharge (m^3/sec) or in volume (million m^3/year). Then, we would know how much ratio of the water is allocated to the irrigation sector in comparison with the other sectors on the same basis. That is the water demand on an average, which is recognized as the average of water demands in various years such as those in high water consumption years (dry years), ordinary consumption years and low consumption years (wet years).

Monthly IWDs (m^3/sec) of the 14 river basins are shown in Tables 6.1 through 6.3

together with the monthly GIRs (lit/sec/ha).

6.2.3 Methodology on Livestock Water Demand Projection

(1) Unit Water Requirement

The unit water requirement (lit/head/day) has been estimated as follows:

(Unit: lit/head/day)

Kind of livestock	Water requirement per head per day
Pig	15
Ox	35
Buffalo	35
Poultry	0.25
Goat	25

(2) Head numbers of various kinds of livestock

With reference to the Agriculture in Vietnam - 61 Provinces and Cities, MARD, NIAPP, 2001, head numbers of various kinds of livestock at present have been estimated.

Forecast for future water demand of 2010is based on the provincial plans, i.e. the Agriculture in Vietnam - 61 Provinces and Cities, MARD, NIAPP, 2001.

Estimation for the year 2020 has been made on an assumption that it might keep increase with the same rate as the average annual growth rate planned by each province, which is shown also in the same documents.

(3) Livestock Water Demand (LWD)

Livestock water demand (LWD) has been calculated as follows:

$$LWD = (UPi \times NPi + UO \times NO + UB \times NB + UPo \times NPo + UG \times NG)/1{,}000$$

where,
- LWD: Livestock water demand (m^3/day)
- UPi: Unit water requirement for pig (lit/head/day)
- NPi: Head number of pig (head)
- UO: Unit water requirement for ox (lit/head/day)
- NO: Head number of ox (head)
- UB: Unit water requirement for buffalo (lit/head/day)
- NB: Head number of buffalo (head)
- UPo: Unit water requirement for poultry (lit/head/day)
- NPo: Head number of poultry (head)
- UG: Unit water requirement for goat (lit/head/day)
- NG: Head number of goat (head)

6.2.4 Forecast of Water Demand for Livestock

With reference to the Agriculture in Vietnam - 61 Provinces and Cities, MARD, NIAAP, 2001, water demands for the present (2001) as well as for the future (2010 and 2020) are estimated as shown in Tables 6.4 to 6.6 respectively, and

summarized below:

Water Demand for Livestock

River Basin	Present Water Demand (2001)		Future Water Demand (2010)		Future Water Demand (2020)	
	Daily Consumption (m^3/day)	Required Intake Discharge (m^3/sec)	Daily Consumption (m^3/day)	Required Intake Discharge (m^3/sec)	Daily Consumption (m^3/day)	Required Intake Discharge (m^3/sec)
01. Bang Giang	15,100	0.18	27,000	0.31	38,700	0.45
02. Red	243,500	2.82	350,200	4.05	530,100	6.14
03. Ma	49,900	0.58	67,900	0.79	98,100	1.14
04. Ca	38,800	0.45	51,200	0.59	72,100	0.84
05. Thach Han	6,600	0.08	8,400	0.09	11,900	0.14
06. Huong	6,200	0.07	8,200	0.10	14,600	0.17
07. Thu Bon	17,700	0.21	21,000	0.24	25,900	0.30
08. Tra Khuc	12,500	0.15	15,900	0.18	22,800	0.26
09. Kone	8,800	0.10	13,700	0.16	22,300	0.26
10. Ba	17,100	0.20	21,580	0.25	36,300	0.42
11. Sesan	8,800	0.10	14,200	0.16	23,300	0.27
12. Srepok	8,100	0.09	14,900	0.17	29,800	0.35
13. Dong Nai	46,000	0.53	71,600	0.83	123,200	1.43
14. Cuu Long Delta	57,100	0.66	107,000	1.24	210,700	2.44

6.2.5 Methodology on Aquaculture Water Demand Projection

(1) Unit Fresh Water Requirement

With reference to the Standard on Fishery Industry in Vietnam, Ministry of Fishery, 2000, the unit fresh water requirement (mm/year) has been estimated as follows:

(a) Coastal brackish water shrimp culture

i) Required brackish water for one farming (BWF)

BWF = 2.30 m/farming/4months

ii) Required brackish water per year (BWY) (just for reference)

BWY =N x BWF = 6.90 m/year (in case N=3)

= 4.60 m/year (in case N=2)

iii) Required fresh water per year for shrimp culture (FWYS)

FWYS = 0.20 BWF = 0.46 m/ year (for salinity regulation in dry season)

(b) Inland fresh water fish culture

i) Required fresh water for farming per year (FWF)

FWF = 1.90 m/year

ii) Required fresh water for losses (FWL)

FWL = 1.50 m/year (incl. 1mm/day of percolation)

iii) Required fresh water per year for inland fish culture (FWYI)

FWYI = FWF + FWL = 3.40 m/ year

(2) Aquaculture Pond Area

(a) Present

Present aquaculture pond areas of both the coastal brackish water shrimp culture (AS) and the inland fresh water fish culture (AI) have been taken from the Statistical Data of Vietnam Agriculture, Forestry and Fishery 1975 - 2000, General Statistical Office - Department of Agriculture, Forestry and Fishery.

(b) Future

Some provinces have set up their plans for aquaculture development to 2010, and some of the said plans are available in the Agriculture in Vietnam - 61 Provinces and Cities, MARD, NIAPP, 2001. As for other provinces, which do not have specific plan for aquaculture development, it has been assumed that the increase rate in the next ten-year period is 10%, which is equivalent to the annual increase rate of 0.96%.

At present, provinces are rearranging the land use structure. They are transiting paddy fields to shrimp farms or to lands for the other purposes under the Governmental Resolution No. 09 of June 15, 2000. Therefore the assumed growth rate mentioned above and the rates planned by provinces might be changed as occasion demands.

Further, forecast of fresh water demand for aquaculture of 2020 has been estimated based on the respective average growth rates by river basins, which have been tentatively assumed to be one fourth (1/4) of those in the 2000 - 2010 period.

(3) Aquaculture Water Demand (AWD)

Aquaculture fresh water demand (AWD) for both the coastal brackish water shrimp culture and the inland fresh water fish culture have been calculated as follows:

$$AWD = FWYS \times 10{,}000AS + FWYI \times 10{,}000AI$$

where,

AWD:	Aquaculture water demand (m^3/year)
FWYS:	Required freshwater for shrimp culture (m/year)
AS:	Shrimp culture pond area (ha)
FWYI:	Required freshwater for fish culture (m/year)
AI:	Inland fish culture pond area (ha)

6.2.6 Forecast of Aquaculture Water Demand

(1) Present Water Demand for Aquaculture

With use of the unit water requirement, which is expressed in the water depth (m/year), and the estimated aquaculture pond area (ha), the present and future water demands have been estimated as shown in Tables 6.7 to 6.9 respectively and summarized as follows:

Water Demand for Aquaculture

River Basin	Present Water Demand (2001)		Future Water Demand (2010)		Future Water Demand (2020)	
	Fresh Water Demand (10^3 m^3)	Average Intake Discharge (m^3/sec)	Fresh Water Demand (10^3 m^3)	Average Intake Discharge (m^3/sec)	Fresh Water Demand (10^3 m^3)	Average Intake Discharge (m^3/sec)
01. Bang Giang	24,115	0.8	31,035	1.0	32,497	1.0
02. Red	2,786,134	88.3	4,148,005	131.5	4,504,114	142.8
03. Ma	403,706	12.8	492,684	15.6	513,615	16.3
04. Ca	289,480	9.2	411,505	13.0	437,581	13.9
05. Thach Han	18,554	0.6	26,116	0.8	28,485	0.9
06. Huong	35,926	1.1	107,790	3.4	146,307	4.6
07. Thu Bon	122,105	3.9	126,503	4.0	129,639	4.1
08. Tra Khuc	3,918	0.1	4,310	0.1	4,559	0.1
09. Kone	27,736	0.9	30,510	1.0	31,265	1.0
10. Ba	27,704	0.9	33,896	1.1	34,507	1.1
11. Se Sang	12,291	0.4	13,525	0.4	13,903	0.4
12. Srepok	62,475	2.0	68,731	2.2	70,907	2.2
13. Dong Nai	948,007	30.1	1,091,657	34.6	1,179,532	37.4
14. Cuu Long Delta	5,869,094	186.1	9,475,126	300.5	12,159,895	385.6

6.2.7 Water Demand for Agriculture

The water demand for the agriculture including irrigation, livestock and aquaculture are summarized as follows:

Agricultural Water Demand (AWD) for irrigation, livestock aquaculture

-Average Rainfall Year- (m^3/sec)

River Basin		Present (2001)	Future (2010)	Future (2020)
01. Bang Giang	Total	9.5	13.1	14.5
	Irrigation	8.5	11.8	13.0
	Livestock	0.2	0.3	0.5
	Aquaculture	0.8	1.0	1.0
02. Red	Total	510.1	595.5	602.8
	Irrigation	419.0	459.9	453.9
	Livestock	2.8	4.1	6.1
	Aquaculture	88.3	131.5	142.8
03. Ma	Total	55.4	69.0	72.8
	Irrigation	42.0	52.6	55.4
	Livestock	0.6	0.8	1.1
	Aquaculture	12.8	15.6	16.3
04. Ca	Total	44.9	55.9	62.9
	Irrigation	35.2	42.3	48.2
	Livestock	0.5	0.6	0.8
	Aquaculture	9.2	13.0	13.9
05. Thach Han	Total	3.0	5.3	5.9
	Irrigation	2.3	4.4	4.9
	Livestock	0.1	0.1	0.1
	Aquaculture	0.6	0.8	0.9
06. Huong	Total	11.1	13.1	15.5
	Irrigation	9.9	9.6	10.7
	Livestock	0.1	0.1	0.2
	Aquaculture	1.1	3.4	4.6
07. Thu Bon	Total	15.5	24.3	24.3
	Irrigation	11.4	20.1	19.9
	Livestock	0.2	0.2	0.3
	Aquaculture	3.9	4.0	4.1
08. Tra Khuc	Total	13.1	13.4	13.5
	Irrigation	12.8	13.1	13.1
	Livestock	0.2	0.2	0.3
	Aquaculture	0.1	0.1	0.1
09. Kone	Total	22.5	27.8	31.7
	Irrigation	21.5	26.6	30.4
	Livestock	0.1	0.2	0.3
	Aquaculture	0.9	1.0	1.0
10. Ba	Total	27.5	56.8	70.4
	Irrigation	26.4	55.4	68.9
	Livestock	0.2	0.3	0.4
	Aquaculture	0.9	1.1	1.1
11. Sesan	Total	6.3	10.2	13.4
	Irrigation	5.8	9.6	12.6
	Livestock	0.1	0.2	0.3
	Aquaculture	0.4	0.4	0.4
12. Srepok	Total	15.1	15.3	33.1
	Irrigation	13.0	12.9	30.5
	Livestock	0.1	0.2	0.4
	Aquaculture	2.0	2.2	2.2
13. Dong Nai	Total	109.1	137.1	158.0
	Irrigation	78.5	101.7	119.2
	Livestock	0.5	0.8	1.4
	Aquaculture	30.1	34.6	37.4
14. Cuu Long Delta	Total	1,110.7	1,325.5	1,463.9
	Irrigation	923.9	1,023.8	1,075.9
	Livestock	0.7	1.2	2.4
	Aquaculture	186.1	300.5	385.6

6.3 Water Demand for Domestic Use

6.3.1 Methodology

(1) Urban Water Supply

The current urban domestic water use depends on many factors, the most important ones are:

- Population living in urban areas
- Percentage of people served by piped water supply, (i.e. service coverage)
- Typical per capita demand of connected people
- Typical per capita demand of not connected people
- Costs of water
- Water used by institutions and commerce
- Leakage from the distribution pipelines
- Water used through illegal connections.

The last two factors are commonly known as Unaccounted For Water(UFW).

The population profile has been discussed in Chapter 5. The projected population figures taken for the drinking water demand calculation are presented in Table 6.10.

Most of the other factors depend highly on the condition of the water supply facilities in the urban areas. This is of course different for each urban area under consideration. It is therefore necessary to make an inventory of a representative part of the urban water supply schemes to assess the current status. Based on existing investment plans and government policy one can make a prediction on how the quality and quantity of water supply services is going to develop in the future, up to the year 2020.

The urban centres selected for the inventory include the five major cities Hanoi, Ho Chi Minh City, Hai Phong, Da Nang and Hue. Further, most secondary towns with a population of more than 100.000 people in 2001 were considered. It was found that such a selection would already cover 65% to 70% of the countries entire urban population.

To obtain this information, many different sources were consulted. These were;

- Recent reports of other projects and studies that contained relevant information
- Interviews with the local Water Supply Companies in various towns

A serious problem with using information from previous reports is the inconsistency of the data that one finds. Each report presents different figures. Even if updates and approximations are taken into account, the available data is quite often contradictory between various sources. There is an urgent need for a central, unambiguous database managed by preferably the Ministry of Construction, which should be regularly updated and verified with field investigations.

Most information on water supply systems and their performance indicators should be available with the Ministry of Construction. Without their co-operation the collection of the latest updated data had serious difficulty.

The best and most reliable source of information proves to be a visit to the Water Supply Company in a particular town. Within the timeframe of this study it was infeasible to visit all the major urban towns. For the moment, this approach was only carried out for the towns Thanh Hoa (Thanh Hoa Province), Hue (Thua Thien Province) and Qui Nhon (Binh Dinh Province), which already cover three of the fourteen river basins considered in this report. All other data came from reports and was cross-checked vice versa. The information thus obtained could be directly used to determine the current water use for a particular area, and also to create an overview on the general urban water supply situation in the country.

This overview is presented in Table 6.11.

(2) Rural Water Supply

The information obtained on rural water demands has entirely been taken from project reports, sector review document and policy papers. Physical investigation of the subject 'on site' was of course infeasible.

As we shall see later, the quantities of water used in the rural areas are 50% smaller compared to the urban areas. Further, this water demand is spread out over a very large area, where the uncountable wells, boreholes and gravity schemes, make the rural water demand insignificant for a water resources study of this scope.

However, rural water supply should not be omitted and an overview of the status of this sector is presented in Table 6.12 for the sake of completeness.

(3) Percentage of People Served

From Table 6.11 it can be seen that the service coverage in the 5 large cities is higher than in the various provincial towns. The big five have service coverage, as per 2001, of nearly 70%. The secondary provincial towns had coverage in 1995 of

55%. The few towns that updated information could be found for, suggest that since then, due to the growing population and delayed investments, the service coverage has been reduced. However, in most towns, construction programmes are under way or are about to be implemented. This will boost the coverage to well over 60% in the next few years.

(4) Typical Water Usage

Although the figures between individual cities and towns can vary considerably, on average the water use of the large cities and secondary towns are remarkably similar. At the moment the average per capita water use seems to be typically 100 litres per day. With the consistent economic growth the country has been experiencing over the last decade, and assuming that this will continue in the years to come, the Vietnamese populations economic strength will increase. In the current phase of Vietnams development it means that a wealthier population will gradually use more water.

The water use of urban people not connected to the water supply system is of course not known in detail. What is known is that these people have to take care of their own water supply and use private dug wells, protected or open, rain fed systems or other low consumption means to provide for their basic needs.

(5) Typical Institutional Use Figures

Typical water use figures for institutions as a percentage of domestic water usage differ between large cities and provincial towns. Larger cities need approximately 10% of their total water use for institutions, where smaller provincial towns sometimes supply 25% of their total water deliveries to their institutions. The apparent reasons is that the domestic coverage is much lower but all the town's administrations, which are basically the same as for the large towns, will be connected. When the secondary towns grow further and their domestic service coverage will increase, the percentage of water used by institution will also decrease.

For the water use projection purposes an overall 'safe' average of 15% for all cities and towns has been applied.

(6) Cost of Water

The water tariffs are set by the Provincial People's Committees and can vary per province. However, this variation is limited and a typical tariff structure could be as shown in Table 6.13.

With a typical water use of 100 lpcd, an average family size of 4 to 5 persons and

average water price of VND 1,500 per m^3, it follows that the typical Vietnamese family spends VND 20,250 per month on water. In a year this will be VND 250,000 or approximately US$16. With an average family income of US$1,500 to 2,000 per year, Vietnamese families spend approximately 1% of their income on water supply.

The World Bank has defined 3 to 5% as a reasonable percentage people could spend on water supply. The situation in Vietnam is still well below that level. Although a comprehensive household survey should provide further insight in what people spend and how they perceive the costs for water, it can now be assumed that the costs of water supply services is not likely to limit the water consumption in the foreseeable future.

(7) UFW (Unaccounted For Water)

Also this performance indicator varies much per town. Hanoi was reported to have an extremely high UFW-factor of 70%. On the other hand, Ho Chi Minh City has only a UFW factor of 20%, which is rather low for a city of that size and development level. No doubt, there are errors in the reports working in favour or against the value of the UFW figure. Taking averages over a larger number of water supply systems should more or less cancel out such errors and present a representative value for the typical UFW value in Vietnamese towns. The current report does not need any further discussion on the differences between leakage and illegal connections. Both phenomena are considered together as UFW.

Based on the information compiled in Table 6.11, the national average UFW value is approximately 40 to 45%.

6.3.2 Forecast of Water Demand for Domestic Use

Based on the current status of urban and rural water supply in Vietnam, a projection on future water use should be presented. This should ideally be based on long term development plans of the Government of Vietnam. In short, these are not available. What is known is that currently several investment plans in the water supply sector are being implemented. These investment plans will boost the availability of water and increase coverage by 10 to 20% in the next 5 to 10 years. What is going to happen after that is totally unclear. To improve the situation further and expand water availability and coverage in the same order towards the year 2020, continued capital investment will be necessary also after the present plans have been implemented.

For the future water use figures, it has been assumed that the Government of

Vietnam will continue to give priority to urban and rural water supply expansion, resulting in gradually expanding water availability and improving service coverage. Based on the expectation that the Vietnamese government will continue to give priority to the water supply sector the following assumptions were made:

- Actual water use will steadily grow over the next 20 years to 140 lpcd for urban people connected to a water supply system, and 40 lpcd for people in rural areas obtaining water from a safe supply.
- Service coverage will grow on an average rate of 1% per year in urban and rural areas.
- There is no reason to assume that the UFW factor will reduce in the future and is therefore maintained at an overall value of 40% of the water supplied.
- As stated in the previous paragraph, institutional water use will stay stable at 15% of the total domestic water use.

Table 6.14 presents an overview of all domestic water demands in the fourteen river basins. The table is split in two parts. Part (1) represents the water demand that should be provided by the combined water production capacity of the Water Supply Companies. Part (2) also includes the water demand of the people that are still not connected to a safe water system. The values in part (2) of the table can thus be considered as the total water demand on the river basins.

The figures presented in a forecast like this should always be treated with caution. Considering the uncertainty of some of the data collected and intrinsic uncertainty in predicting future trends, it should be clearly understood that the accuracy of the figures here presented could easily divert 30 to 40% either way.

6.4 Water Demand for Industrial Use

6.4.1 Methodology

The methodology for estimating water usage for industrial needs starts with the same principle as for domestic water supply.

Chapter 5 has presented the socio-economic framework, which also describes the expected economic growth for each river basin. For the smaller river basins this is certainly an adequate basis to project industrial growth and water uses. It is assumed that there is a linear relation between the growth in industrial production and industrial water demand. In reality, the relation is not quite linear. With the introduction of newer technology and modernisation, the production processes will gradually become more efficient, also in their water use. By assuming a linear

relation the estimated figures will therefore be on the higher side or 'safe' side.

The Government of Vietnam has designated seven future Export Processing Zones (EPZ) and Industrial Estates (IE). These are again mainly located in the Red River and Dong Nai river basin. One other industrial development location is found around Da Nang or the Vu Gia – Thu Bon river basin. It is fairly well known how large these areas will be and what kind of industries will be expected there. As reported by D. Boggs, 1995, the plans are ambitious and will certainly take the next 10 to 20 years to implement. Since these designated industrial zones are the most likely places for further expansion, it is assumed that the bulk of the industrial development in these three river basins will take place there. It is further assumed that the development of industries will be evenly spread through time covering the studies planning horizon until the year 2020 to complete.

Table 6.15 provides an overview of the seven Export Processing Zones and Industrial Estates, divided into sub-zones including the expected water demand projections .

Based on typical industrial water demand figures related to surface area, a forecast can be made on the water demands to be expected between the years 2001 to 2020.

6.4.2 Forecast of Water Demand for Industrial Use

Table 6.16 presents the industrial water demand forecast from 2001 to 2020 in five-year intervals. The current industrial water demand has been calculated as 715 million m^3 per year. This quantity is going to grow up to 2,107 million m^3 per year in 2020.

If comparing domestic and industrial water demands, it is noted that industrial needs will be only 75% of the domestic water demands. Some reports mention national industrial water demand to reach 16,000 million m^3 already in the year 2000, (Red River Basin Water Resources Management Project). This is quite exceptional and it must be based on erroneous data or assumptions.

But also the otherwise comprehensive ADB Report on Municipal and Industrial Water Supply and Disposal arrives at significantly higher water demands for industries and urban water supply. Unfortunately, none of these reports provide insight on how their figures were calculated.

As far as industrial demands are concerned, typical water use by industries in Western Europe range from 75 lpcd to 120 lpcd, (A.C. Twort et.al., 1994). These figures are related to the urban population. It is here recalled that typical domestic

use in Western Europe varies from 120 to 150 lpcd. On average the industrial demand amounts to approximately 75% of the urban domestic demand, which is similar to what has been calculated for Vietnam in this report.

6.5 Water Demand for Power Generation

6.5.1 Power Demand Forecast

(1) Tendency of the Past Power Demand

The power demand in terms of power energy sales in Vietnam has been steadily increased during recent 10 years as follows:

Year	Power Energy Sales
1989	5,661 GWh
1994	9,198 GWh
1998	17,739 GWh

Annual average growth rate during 5 years since 1993 is 17.2% as a whole. The domestic use indicates the highest growth rate of 22.2%, followed by 14.9% in the commercial use, 13.3% in the industrial use and 10.7% in the agricultural sector. Figure 6.1 shows the growth of the past demand.
The growth rate of domestic use is remarkable as seen. Its reason is considered to be the development of rural electrification and increase of consumption per capita.

Increase of peak load and load factor during 5 year from 1993 to 1998 is as shown below:

Year	Peak Load (MW)	Load Factor (%)
1993	2,083	58.2
1994	2,397	54.9
1995	2,895	62.2
1996	3,100	65.2
1997	3,481	63.6
1998	3,911	64.0

As shown, peak load increased at annual average growth rate of 13.4% during 5 years from 1993 to 1998. The peak load appears in about 4 hours of pm 6:00 to 10:00 o'clock.

Load factor is also rising as seen above. Load factor is prospected to further rise in accordance with increase of daytime power demand by the development of industrialization.

(2) Power Demand Forecast by EVN

EVN(Electricity of Vietnam) formulated a Master Plan of Vietnam power

development in which EVN conducted the national power demand forecast up to 2020. In this power demand forecast, the peak load is forecast to increase from 5,800 MW in 2001 to 32,500 MW in 2020. Annual average growth rates are estimated as follows:

Year	Annual Average Growth Rate (%)
2001 - 2005	11.6
2006 - 2010	12.2
2011 - 2015	8.0
2016 - 2020	6.7

Power energy demand in terms of power energy generation requirement is forecast to increase from 30,000 GWh/yr. in 2001 to 202,000 GWh/yr. in 2020. Load factor is also estimated to gradually increase to 0.675 in 2020.

The said EVN's power demand forecast is shown in Table 6.17 and Figure 6.2

The EVN's Master plan proposed the power development plan based on the above power forecast and was officially approved by the Government.

6.5.2 Power Development Plan

(1) Existing Power Station

The actual power energy generation is increasing as shown below:

Year	Actual Power Energy Generation (GWh/yr.)
1989	7,729
1994	12,283
1998	20,850

The tendency of composition of power supply sources is as follows: That is, the hydropower occupied about 70% of the whole power supply sources from 1992 to 1995.

Its proportion, however, is decreasing yearly to 70.6% in 1996, 61.0% in 1997 and 53.2% in 1998, while the proportion of the thermal power plants is increasing gradually from 19.4% in 1996 to 22.6% in 1997 and 23.1% in 1998. The gas turbine power plants largely extended its share from 8.5% in 1996 to 15.2% in 1997 and 22.0% in 1998, of which major reason is no new installation of hydropower plants during 1996 to 1998.

The existing power stations as of 2000 are shown in Table 6.1.8. Total installed capacity is counted at 5,475MW. The composition of the power sources is as follows:

Power Sources	Installed Capacity (MW)	Proportion (%)
Hydropower	3,272.5	59.7
Thermal (Coal – fired)	645.0	11.8
Thermal (Oil – fired)	198.0	3.6
Gas Turbine	962.5	17.6
Diesel	397.0	7.3
Total	5,475.0	

(2) National Power Development Plan

The Master Plan of power development formulated by EVN and approved by the Government prepared a power generation development program for the period from 2001 to 2020.

The power development up to 2020 based on the EVN's power development program is shown in Table 6.19. A probable power development (increase of the installed capacity) is shown in comparison with the power demand increase in Figure 6.2.

The power development program considers the following:

- to develop the hydropower projects at maximum to utilize water resources in Vietnam.
- to consider the import from Laos and Cambodia for shortage of power supply capacity.
- to consider pumped storage projects for peak power supply.
- to introduce nuclear power plants around in 2020.

The additional installed capacity from 2001 to 2020 is planned to be 35,832 MW as seen in Table 6.19. Adding the existing capacity of 5,475MW as of 2000, the total installed capacity in 2020 will be 41,307 MW against the estimated peak load demand of 32,500 MW with the reserve margin of about 27%.

6.5.3 Role of Each Power Station

(1) Power Load Duration Curve

An approximate power load duration curve in 2020 will be as shown in Figure 6.3 which is prepared based on:

a) Daily peak load of 32,500 MW in 2020,

b) Daily power energy demand (power energy generation requirement) of 553.4 GWh/day (or 202,000 GWh/yr.), and

c) Estimated load factor of 0.675 in 2020.

(2) Power Supply by Each Power Station

Power Supply by each power station to meet the power load duration curve was assumed as shown in Figure 6.3 in due consideration of characteristic of each power station as follows:

a) The power plants such as nuclear and coal-fired or oil-fired thermal should undertake the base load power supply.
b) Gas turbine power plants and pumped storage projects have characteristics suitable to supply for peak load of short duration.
c) Combined cycle and hydropower plants have characteristics suitable to supply for power load of short to medium duration.

Each of the existing and planned power stations was allocated in the load duration curve, based on the above consideration. As mentioned above, the hydropower plants have characteristics suitable to supply for power load of short to medium duration. However, in the case of Vietnam, the hydropower plants are forced to cover power supply for medium to base duration as seen in Figure 6.3.

6.5.4 Water Requirement for Power Generation of Multipurpose Reservoir Projects in 14 River Basins

Various power plants are planned to be developed to meet the power demand in 2020. However, with these development of additional power plants, power supply capacity will be still insufficient, and the shortage will have to be covered by power supply to be imported. As such, all hydropower plants including those of multipurpose reservoir projects are expected to contribute to power supply under the national power supply grid as much as possible in order to minimize consumption of fossil fuel energy and power supply to be imported. Besides that, power generation of major multi-purpose reservoir projects is already taken into consideration in the national power supply plan.

Such being the case, multi-purpose reservoir projects incorporated in the national power development plan should be operated so that the planned power generation of each multi-purpose reservoir project be secured.

Hydropower projects and multipurpose projects which were incorporated in the national power development plan are expected to ensure the planned firm power output of each project. Therefore, the water discharge necessary for the planned firm power output is considered the minimum requirement for the power generation of hydropower or multipurpose projects.

The main role of multipurpose projects which were not considered in the national

power development plan is the water supply for the water demands such as irrigation, domestic & industrial water and river maintenance flow, etc. and therefore, power generation of these projects are assumed to be basically conducted by utilizing the discharge for the said water supply.

Table 6.20 calculates the minimum water requirement for power generation of the hydropower and multi-purpose reservoir projects which were incorporated in the national power development plan.

6.6 Water Demand for River Maintenance Flow

6.6.1 General

River maintenance flow is essential:

(i) to prevent saline water intrusion to secure necessary salinity for irrigation water,

(ii) to prevent water pollution due to waste water for ecological conservation and necessary water quality for domestic and industrial water, and

(iii) to maintain present activities in the river such as fluvial navigation.

Necessary river maintenance flow is preliminarily examined from the above aspects hereunder, referring to the study for the Huong River basin.

6.6.2 Prevention of Saline Water Intrusion

The maximum salinity content for irrigation water supply should meet the condition less than 1‰. Based on the study for the Huong River basin, river maintenance flow to meet the above necessary condition of salinity is found to be $61m^3/s$ at the intake site located at 14.2 km from the East Sea.

Effectiveness of prevention of saline water intrusion is dependent on the balance between inflow of salt water wedge from the sea and counter flow from the upstream at the river mouth. It is considered that counter flow against saline water intrusion is mainly ruled by river-bed gradient and width of surface water as factors of physical river conditions. Thus, the following formula, showing the relation between the river conditions of respective river and necessary flow for prevention of saline water intrusion, was generated from the experience of the Huong River basin.

$$I^{1/2}*Q/B = I_H^{1/2}*Q_H/B_H$$

where, I : River-bed gradient near the river mouth of respective river except Huong river

Q : River maintenance flow against saline water intrusion of

respective river except Huong river (m^3/s)

B : Width of surface water at the river mouth of respective river except Huong river (m)

I_H : River-bed gradient near Huong River mouth (1/10,000)

Q_H : River maintenance flow against saline water intrusion of Huong River (61 m^3/s)

B_H : Width of surface water at Huong River mouth (400 m)

Among 14 rivers, topographical information of "I" and "B" is available for 7 rivers; i.e. Ma, Ca, Huong, Vu Gia-Thu Bon, Tra Khuc, Kone, and Ba. The calculated results of maintenance flow for prevention of saline water intrusion are shown in Table 6.21.

The said formula is not applied for Sesan, Srepok, and Bang Giang & Ky Cung rivers since these rivers have no river mouth in Vietnam.

6.6.3 Prevention of Water Pollution

In the existing study in the Huong River basin, ecologically necessary minimum discharge is determined to be equal to minimum monthly discharge at river mouth with P= 90%, and 31.0 m^3/s is obtained.

This method is considered reasonable in view that the favourable ecological conditions have been maintained in the past. Therefore, the maintenance flow of other 13 rivers for ecology was calculated according to the same manner as Huong River as shown below:

i) the minimum monthly discharge with P= 90 % at a diversion point forward to many estuaries or at a point on the national boundary of respective river was examined based on the results of hydrological analysis, and

ii) the maintenance flow for ecology at river mouth was obtained through conversion of the result of i) according to the basin area, when the river has estuaries in Vietnam.

The ecological maintenance flow calculated for 14 rivers are shown in Table 6.21.

For determination of the maintenance flow for water quality control, the water pollution analysis on BOD is generally employed as quantitative examination. However, the data and information prerequisite for analysis, such as original unit of pollutant load, pollution runoff ratio, and attenuation rate of the river, are not available in 14 river basins.

Existing data on water quality indicates, as mentioned in Section 2.3, that the

organic pollution of water in most of 14 rivers is insignificant even in the dry season although no data is available in Ma and Ba rivers. It seems important that, in order to ensure the existing good condition of water quality in respective river, the decrement of existing low discharge be avoided through maintaining the hydrological regime of low water. In general, the maintenance flow for ecology will be sufficient to maintain the low water regime and to meet the necessary discharge for water quality control.

6.6.4 Prevention of Adverse Effects on the Present Activities in the River such as Fluvial Navigation

It seems that no particular adverse effects on the activities in the river have arisen in the past when the river discharge decreased to as small as the minimum monthly discharge corresponding to P= 90% which is calculated at 31.0 m^3/s at the river mouth of the Huong River.

The standard for technical classification of inland waterways of Ministry of Transportation and Communication (TCVN 5664-1992) stipulates channel dimensions such as water depth and width for fluvial navigation in the rivers. This standard classified channel dimensions into 6 classes, and is applied to major rivers in Vietnam including 14 rivers. In relation to the maintenance flow for fluvial navigation, the classes applied to respective river are determined based on the frequency of plying service corresponding to P= 95 % of natural hydrological regime in the dry season. It is considered that necessary maintenance flow for fluvial navigation can be covered by the one for ecological conservation (P= 90 %).

6.6.5 Determination of River Maintenance Flow

The maintenance flow examined through the above is summarised in Table 6.21. Among these, the maintenance flow for prevention of saline water intrusion of 4 rivers is unclear due to the lack of information. However, the maintenance flow for ecology exceeds the one for prevention of saline water intrusion in case of other river basins except Huong River. In the case of the Huong River, the river flow for prevention of saline water intrusion (61 m3/s) is more than the river flow for ecology (31 m3/s). However, since the river flow for prevention of saline water intrusion will become unnecessary by completion of the Thao Long Barrage, the necessary river maintenance flow is determined with the river flow for ecology. Thus, it is considered that ecological maintenance flow is almost enough as counter flow against saline water intrusion.

In conclusion, the maintenance flow of respective river was determined as shown below:

Maintenance Flow of 14 River Basins

Unit: m^3/s

Ban Giang & Ky Cung Rivers	29.3	Tra Khuc River	52.0
Red & Thai Binh Rivers	867.0	Kone River	13.5
Ma River	114.7	Ba River	28.7
Ca River	173.0	Dong Nai River	97.5
Thach Han River	10.9	Sesan River	96.1
Huong River	31.0	Srepok River	40.5
Vu Gia-Thu Bon River	147.1	Cuu Long River	2,074.6

Regarding the above maintenance flow, however, the following is noted:

The assessed river flows for prevention of saline water intrusion are just preliminary ones converted to other rivers based on the available data in the Huong River. The applied formula for converting to other rivers would generally be suitable for the ordinary river systems having the river mouth to the sea. However, other concepts are needed to be studied especially for the rivers with plural river mouths.

CHAPTER 7 WATER BALANCE ANALYSIS

7.1 General

The analysis is made to respectively evaluate water balance in the objective 14 river basin between available water resources (supply side) and respective water requirement (demand side) in present and future conditions. The evaluation incorporates the following components:

Water resources

1) River runoff (surface water) in natural flow condition
2) Reservoir storage water (as supplemental water resources during drought season and high irrigation demand period as well as resource for regular release for hydropower generation)

Water demand

1) Agriculture including irrigation, fishery and livestock
2) Domestic use
3) Industry
4) Hydropower generation as minimum water release requirement

River maintenance flow

The analyses have been undertaken for the 14 river basins.

7.2 Methodology

7.2.1 Basic Condition

(1) Water Balance System

Water balance point is predetermined at the water demanding point of each sub-basin and river mouth. Runoff at the water demanding point is evaluated if it is in surplus or in deficit incorporating agricultural uses, domestic use and industry water use. Balance point at the river mouth is to evaluate sufficiency of river maintenance flow in a whole basin basis.

Water balance analysis is made in monthly basis. Water resources and water demand data are given as monthly basis for the duration of 13-25 years, respectively.

(2) Natural Flow

Natural flow is defined in the Study as the river runoff in each river system assuming no intake water and no supply by the existing reservoir storage.

The river runoff without reservoir regulation effect was worked out in the hydrological study, and the natural flow has been estimated by removing present intake water as of year 2000 including irrigation use, domestic use and industrial use and others.

(3) Reservoir Operation

Simple assumption is applied for a reservoir operation in the analysis model that operation rule is controlled by a maximum storage capacity and monthly minimum outflow discharge in each dam, as stated below:

a) A minimum discharge is predetermined at each dam based on the power generation plan of EVN in order that a certain amount of discharge is firmly released for the hydropower generation purpose.

b) In case that reservoir storage exceeds its capacity, outflow discharge should be equal to the inflow or more to keep hydropower release.

c) As long as water storage is available in the reservoir, a minimum outflow (for hydropower release) should be released.

d) When a reservoir has vacant space and sufficient inflow is available, a part of inflow would be stored until its storage capacity.

e) If a reservoir is empty, inflow less than predetermined minimum outflow would be directly discharged as outflow.

f) In case that flood control space is required during every flood period, the required space is assumed to be kept for the period.

(4) Return Flow of Irrigation Water

a) Return flow from irrigation area is assumed to be 10 % of demand, respectively.

b) Return flow of the irrigation water would not come back to the river in case that the flow go directly to the sea.

(5) Return Flow of Domestic and Industrial Waters

Return flow from the domestic and industrial water uses is not incorporated in runoff at the balance point.

7.2.2 River Maintenance Flow

A river maintenance flow is considered at the balance point of river mouth, incorporating a concept to prevent excessive saline water intrusion issues as well as maintaining river ecology as mentioned in Chapter 6.

7.2.3 Evaluation Criteria on Probable Drought Year

Water supply condition against the water demand is evaluated of its tightness in accordance with the criteria set out as follows:

Water Demand	Criteria
(a)Agriculture, River maintenance flow	:Water demand shall be satisfied more than 3/4 period in years out of evaluated long period
(b)Domestic use, Industrial use	:Water demand shall be satisfied more than 9/10 period in years out of evaluated long period

7.3 Water Balance System of 14 River Basins

As mentioned in 7.1, water resources, water demands and river maintenance flow are considered in the water balance system of the objective 14 river basins. The respective components are described in this Section and presented in the schematic model of each river basin in Figures 7.1 to 7.12, respectively.

7.3.1 River Basin and Reservoirs Considered

The natural flow of each river basin worked out in Chapter 3 are applied for the analysis as monthly runoff series with a certain duration. In addition to the natural flow as basin runoff, reservoir storage are also considered as water resources during drought period. General feature of river basin and reservoirs are as follows:

River Basin		Reservoir Considered		
Name	Catchment Area (km^2)	Reservoir	Status	Effective Storage (MCM)
(1) Bang Giang and Ky Cung	11,250	Ban Lai	Planned	310.5
(2) Red River and Thai Binh	169,040	Hoa Binh	Existing	5,650
		Thac Ba	Existing	1,200
		Dai Tri	Planned	1,091
		Bac Me	Planned	1,055
		Son La	Planned	14,900
(3) Ma	31,060	Cua Dat	Planned	1,210
(4) Ca	29,850	Ban La	Planned	1,244
		Ban Mai	Planned	-
(5) Thack Han	2,550	Rao Quan	Planned	291
(6) Huong	3,300	Ta Trach	Planned	460
		Huu Trach	Planned	-
		Co Bi	Planned	-
(7) Vu Gia-Thu Bon	11,510	Ho song Tranh II	Planned	945
		Son Cai	Planned	-
(8) Tra Khuc	5,200	Nuoc Trong	Planned	186
(9) Kone	3,640	Vin Son	Existing	102
		Thuan Ninh	Existing	32
		Nui Mot	Existing	90
		Dinh Binh	Planned	209
(10) Ba	14,030	LaYun	Existing	201
		Hinh	Existing	323
		Song Ba Ha	Planned	484
		An Khe	Planned	357
(11) Sesan	11,530	Dak Bla	Planned	873
(12) Srepok	12,030	Buon Kuop	Planned	315
		Krong Boung	Planned	21.6
		Upper Krong Pach	Planned	72.0
		Upper Krong Buk	Planned	83.4
		Lower Krong Buk	Existing	45.0
(13) Dong Nai	39,580	Dan Tieng	Existing	
		Thac Mo	Existing	
		Tri An	Existing	
		Ham Thuan /Da Mi	Existing	
(14) Cuu Long Delta	37,870 (Vietnam)	-	-	-

In the analysis, the storage capacity mentioned above is considered to be available for water supply, while available storage volume was reduced as a flood control volume to accept flood inflow in some reservoirs during early and/or major flood seasons.

7.3.2 Water Demands

Water demands incorporated in the analysis are for the agriculture including irrigation, fishery and livestock as well as domestic water and industry. Water release for hydropower generation is incorporated as minimum water release from the reservoir. In case of several reservoirs, the flood control volume is assumed during a certain months as a restriction of water availability in the analysis.

River maintenance flow requirement is not a water demand but incorporated in the evaluation of the water balance analysis.

Those demands, required flood control volume and assumed maintenance flow are summarized in the table in succeeding Section 7.4.

7.4 Results of Water Balance Analysis

The following table shows the result of the water balance analysis as well as the proposed new reservoir schemes in the 14 basins, respectively.

Water Balance Analysis for 14 River Basins

River Basin	Year	Water Demand: Agriculture Irrigation (1,000 ha)	Water Demand: Agriculture Fishery/ Livestocks (MCM/month)	Water Demand: Urban Domestic Water (MCM/month)	Water Demand: Urban Industrial Water (MCM/month)	Maintenance Flow Requirement: Saline Water Intrusion (m^3/sec)	Maintenance Flow Requirement: River Ecology (m^3/sec)	Water Resources Development: Dam	Status	River	Available Volume for Water Supply (MCM)	Hydropower Minimum Release (MCM/month)	Required Flood Control Space (MCM)	Water Balance Analysis and Evaluation: Duration of Runoff Series (Year)	Case	Drought Years: Water deficit in the year (Nos. of year(s) (No M.flow case))	Design Drought Year: Rank from the most severe drought	Design Drought Year: Lowest Reservoir Storage in the Year (MCM)
1 **Bang Giang & Ky Cung**	Present	25.5	1.38	0.88	0.04			**Ban Lai**	**Plan**	Ky Cung	310.5	–	96.2	15	Present	12 (0)	–	–
	2010	54.5	2.01	1.42	0.04	0.04	29.3								2010	12 (2)	–	–
	2020	67.5	2.42	2.21	0.10										2020 with Dam	0 (0)	12/15	100.5
															2020 - No Dam	14 (5)	–	–
2 **Red River & Thai Binh**	Present	1008.0	117.0	22.0	25.8			Son La	Plan	Da	14,900	1,306		20	Present	0 (0)	–	–
	2010	1197.0	173.9	45.0	25.8	(-)	**867.0**	Hoa Binh	Exist	Da	5,650	–			2010	3 (0)	–	–
	2020	1291.0	193.3	79.4	46.8			Bac Me	Plan	Gam	1,055	233.4			2020 with Dam	0 (0)	–	
								Dai Thi	Plan	Gam	1,091	261			2020 - No Dam	3 (0)	–	–
								Thac Ba	Exist	Thao	1,055	–						
3 **Ma**	Present	112.0	18.1	1.93	0.34			**Cua Dat**	**Plan**	Chu	1,210	80.9	105.6	20	Present	19 (1)	–	–
	2010	177.6	22.1	5.40	0.34	61.0	**114.7**								2010	19 (5)	–	–
	2020	199.5	23.9	8.42	1.63										2020 with Dam	3 (1)	16/20	122.0
															2020 - No Dam	20 (6)	–	–
4 **Ca**	Present	9.30	12.7	2.10	0.04			**Ban La**	**Plan**	Nam Non	1,244	140.1	216.0	25	Present	24 (7)	–	–
	2010	150.0	17.9	4.60	0.04	72.3	**173.0**	Ban Mai	Plan	Ca	3,140	–			2010	23 (4)	–	–
	2020	203.0	19.6	7.78	0.13										2020 with Dam	1 (0)	19/25	595.0
															2020 - No Dam	22 (1)	–	–
5 **Thach Han**	Present	5.00	0.96	0.57	0.01			**Rao Quan**	**Plan**	Rao Quan	291.0	6.6	104.7	24	Present	13 (1)	–	–
	2010	12.3	1.30	0.89	0.01	(-)	**10.9**								2010	17 (6)	–	–
	2020	15.4	1.52	1.40	0.02										2020 with Dam	5 (5)	19/24	0.0
															2020 - No Dam	17 (8)	–	–
6 **Huong**	Present	21.2	1.55	1.19	0.53			**Ta Trach**	**Plan**	Ta Trach	460.0	–	390.0	24	Present	24 (9)	–	–
	2010	21.2	4.28	2.03	0.53	**61.0**	**31.0**	Huu Trach	Plan	Huu Trach		–	(105.0)		2010	23 (9)	–	–
	2020	21.2	5.90	3.62	1.96			Co Bi	Plan	Bo		–	(44.0)		2020 with Dam	5 (2)	19/24	0.0
															2020 - No Dam	23 (13)	–	–
7 **Vu Gia -Thu Bon**	Present	30.9	6.49	2.83	8.58			**Ho Song Tran**	**Plan**	Thu Bon	945.0	200	800.0	17	Present	12 (10)	–	–
	2010	69.0	5.87	4.76	8.58	28.9	**147.1**	**Song Cai**	**Plan**	Vu Gia		–	(550.0)		2010	13 (12)	–	–
	2020	77.0	6.04	7.34	17.0										2020 with Dam	3 (3)	13/17	0.0
															2020 - No Dam	13 (13)	–	–

River Basin	Year	Water Demand: Agriculture: Irrigation (1,000 ha)	Water Demand: Agriculture: Fishery/ Livestocks (MCM/month)	Water Demand: Urban: Domestic Water (MCM/month)	Water Demand: Urban: Industrial Water (MCM/month)	Maintenance Flow Requirement: Saline Water Intrusion (m^3/sec)	Maintenance Flow Requirement: River Ecology (m^3/sec)	Water Resources Development: Dam	Status	River	Available Volume for Water Supply (MCM)	Hydropower: Minimum Release (MCM/month)	Required Flood Control Space (MCM)	Water Balance Analysis and Evaluation: Duration of Runoff Series (Year)	Case	Drought Years: Water deficit in the year, Nos. of year(s)	(No M.flow case)	Design Drought Year: Rank from the most severe drought	Design Drought Year: Lowest Reservoir Storage in the Year (MCM)
8 **Tra Khuc**	Present	33.0	0.60	0.70	0.18			**Nuoc Trong**	**Plan**	Thach Nham	185.8	–	184.2	20	Present	15	(1)	–	–
	2010	42.0	0.73	1.13	0.18	24.1	**52.0**								2010	15	(1)	–	–
	2020	54.0	0.95	1.85	0.46										2020 with Dam	3	(0)	16/20	31.0
															2020 - No Dam	15	(2)	–	–
9 **Kone**	Present	25.0	1.52	1.42	0.17			**Dinh Binh**	**Plan**	Kone	209.0	–	97.2	25	Present	11	(10)	–	–
	2010	36.5	1.80	2.35	0.17	**15.3**	13.5	Vinh Son	Exist		102.0				2010	17	(15)	–	–
	2020	49.0	2.09	3.95	3.94			Thuan Ninh	Exist		32.3				2020 with Dam	4	(4)	20/25	0.0
								Nui Mot	Exist		90.0				2020 - No Dam	17	(15)	–	–
10 **Ba**	Present	41.0	1.75	1.67	0.04			**Song Ba Ha** *1	**Plan**	Ba	484.4	148.2	38.1	13	Present	0	(0)	–	–
	2010	129.0	2.20	3.32	0.04	17.1	**28.7**	La Yun	Exist	Dak la Yun	201.0	–			2010	2	(1)	–	–
	2020	186.0	2.72	5.19	0.11			Hinh	Exist	Hinh	323.0	–			2020 with Dam	2	(2)	10/13	0.0
								An Khe - Kanak *2	Plan	Ba		–			2020 - No Dam	5	(5)	–	–
11 **Sesan**	Present	22.5	0.72	0.75	0.05			**Dak Bla**	**Plan**	Dak Bla	873.0	–	78.0	22	Present	7	(0)	–	–
	2010	35.4	0.95	1.19	0.05	(-)	**96.1**	Plei Krong	Plan	Krong Poko	1,131				2010	6	(0)	–	–
	2020	50.0	1.24	1.92	0.13										2020 with Dam	0	(0)	18/22	790.0
															2020 - No Dam	7	(0)	–	–
12 **Srepok**	Present	29.0	2.66	1.66	0.05			**Buon Kuop**	**Plan**	Srepok	315.0	116.1	–	24	Present	22	(17)	–	–
	2010	35.0	3.10	3.37	0.05	(-)	**40.5**	**Krong Boung**	**Plan**	Krong Boung	21.6	–	21.4		2010	22	(19)	–	–
	2020	91.0	3.64	6.86	0.14			**Upper Krong Pach**	**Plan**	Krong Pach	72.0	–	26.2		2020 with Dam	22	(5)	19/24	0.0
								Upper Krong Buk	**Plan**	Krong Buk	83.4	–	–		2020 - No Dam	23	(20)	–	–
								Lower Krong Buk	Exist	Krong Buk	45.0	–	33.3						
13 **Dong Nai**	Present	115.0	39.8	18.9	77.0			Dau Tieng	Exist	Sai Gon					Present			–	–
	2010	224.0	45.9	36.8	77.0	(-)	**97.5**	Thac Mo	Exist	Be					2010			–	–
	2020	362.0	51.0	59.9	102.9			Tri An	Exist	Dong Nai					2020 with Dam				
								Ham Thuan /Da Mi	Exist	Dong Nai					2020 - No Dam			–	–
14 **Cuu Long**	Present	1,487.0	307.2	12.8	0.64										Present			–	–
	2010	1,891.0	475.4	26.8	0.64	(-)	**2,075.0**								2010			–	–
	2020	2,242.0	612.3	42.2	1.97										2020 with Dam				
															2020 - No Dam			–	–

Evaluation based on the analysis are made by basin as follows:

(1) Ban Giang and Ky Cung Rivers

It seems that the present water demand cause water deficit almost every year as well as in case of 2020 demand. Implementation of Ban Lai Dam would eliminate projected 2020 demand completely.

(2) Red River and Thai Binh:

Present demand is satisfied by the existing dams, but some deficit will be caused against 2010 demand if no dam is additionally constructed. However, projected 2020 demand would be completely satisfied by additional three dams under planning.

(3) Ma River

Serious water deficit is observed in the present condition which has no water regulating dam. Construction of one dam which is assumed to be Cua Dat Dam is quite necessary to cope with the projected 2020 demand.

(4) Ca River

Present and future condition is similar to the Ma River case. To meet with the water supply demand in 2020, the Ban La Dam will be necessary and it would have rather sufficient capacity for water supply exceeding estimated 2020 requirement.

(5) Thach Han River

Present water deficit will become severe in 2010 and 2020 without a dam. The proposed Rao Quan Dam would satisfy the projected 2020 demand only and no spare capacity is anticipated to cope with demand after 2020.

(6) Huong River

Present condition of water deficit will be similar in 2010 even though the Thao Long Barrage would be available as well as in 2020 without a dam. The proposed Ta Trach Dam would satisfy the projected 2020 demand only and no spare capacity is anticipated to cope with demand after 2020.

(7) Vu Gia and Thu Bon Rivers

Present condition of water deficit will be similar in 2010 as well as in 2020 without a dam. The proposed Ho Song Tran II Dam would satisfy the projected 2020 demand only and no spare capacity is anticipated to cope with demand exceeding 2020. The proposed Song Cai Dam may not be required for water

supply purposes until 2020.

(8) Tra Khuc River

Similar situations to present water availability for water supply will be applicable for the future one. The proposed Nuoc Trong would much improve such condition even though water deficit would be anticipated for a few years.

(9) Kone River

Present condition of water deficit with three existing dams will be more serious to meet increasing water requirement to attain the future development plan in the Kone River basin. The proposed Dinh Binh Dam will meet such demand in 2020. However another water resource development might be necessary in case water demand after 2020 will be still increasing.

(10) Ba River

As long as the present water requirement is concerned, no water deficit is observed through the analysis owing to the storage capacity of the existing two dams. However, due to sharply increasing demand projected in the analysis, water deficit will be increasingly expected. To meet water demand to be increased by 2020, the proposed Song Ba Ha Dam would be necessary in addition to the existing dams.

(11) Sesan River

In Sesan River basin case, water supply will be covered yet even in 2020 by the river runoff itself. However responsible minimum flow to be secured for Cambodia requires additional discharge. To attain water requirement and minimum flow requirement, the Dak Bla Dam is proposed, which storage capacity would have much surplus against the projected 2020 demand.

(12) Srepok River

Due to irrigation water requirement in the sub-basin where benefit of water regulation by the proposed Buon Kuop Dam will not cover, very severe water deficit is anticipated including present and future conditions, as long as river surface water is available for irrigation. To ease such deficit, some small-medium scale dams are considered in the analysis, a conceivable measure is not found except assuming much less water demand.

CHAPTER 8 BASIC STRATEGY OF WATER RESOURCES DEVELOPMENT AND MANAGEMENT MASTER PLAN

8.1 Goal of Water Resources Development and Management Master Plan

8.1.1 Socio-economic Goal Towards 2020

The socio-economic framework plan described in Chapter 5 presents the government's regional development policy as well as the macro-economic targets by river basin, as summarized as follows:

(1) Regional Development Policy

(a) Red River Delta and Northern Key Economic Region

The downstream area of the Red and Thai Binh River basins are included in this region, as well as the capital, Hanoi.

Major regional orientations:

- To transform the economic and labor structures, and to transform more large number of agricultural work force to industries and services,
- To develop diverse cash crop agriculture and to enhance winter crop production by forming areas specialized in vegetables, fruit trees, meat, flowers, and to extend aquaculture together with staple food,
- In the key economic region, to develop industrial parks, high-tech zones, export-oriented, electronic, and information industries, establishments for shipbuilding, metallurgy, fertilizers, etc.

(b) Southeast and Southern Key Economic Regions

The Dong Nai River basin is included in these regions, as well as the commercial center of the nation, Ho Chi Minh City.

Major regional orientations:

- To establish centers of commerce, export, telecommunication, tourism, finance, banking, science, technology, culture, training in the South,
- To promote industries of oil and gas exploitation,
- To enhance production of electricity, fertilizer, chemicals,
- To accomplish and upgrade industrial parks, export processing zones, and high-tech zones,
- To develop industries in provinces avoiding over-concentration in large cities.
- To develop industrial crops (rubber, coffee, cashew nuts, sugar-cane, cotton, etc.), fruit trees, industrialized animal husbandry, etc, and

- To form specialized farming areas linked to processing industries to attract more labor from the Cuu Long River Delta.

(c) North Central, Central Coastal Area, and Central Key Economic Regions

The region includes the Ma, Ca, Thach Han, Huong, Vu Gia-Thu Bon, Tra Khuc, Kone, and Ba River basins.

Major regional orientations:

- To take measures to mitigate losses caused by natural calamities such as heavy floods and droughts,
- To exploit the western lands by building water reservoir against flash floods and for hydropower production,
- To develop industrial crops, fruit trees, and cattle breeding combined with processing industries, and to push forward with forestation,
- To establish coastal industrial zones, integrated industrial-commercial zones, and economic development zones,
- To develop oil refining, petro-chemical, building materials, processing and manufacturing industries, and diverse services, and
- To promote sea and coastal tourism associated with historical sites, particularly along the Hue - Da Nang - Hoi An - Nha Trang line.

(d) Northwest and Northeast Regions

The regions include the Bang Giang & Ky Cung, upstream area of the Red and Thai Binh, upstream area of the Ma River basins.

Major regional orientations:

- To develop industrial crops, fruits trees, medical plants, cattle husbandry in association with processing industries,
- To speed up the study and construction of the Son La hydropower plant,
- To develop small-scale water conservancy projects in association with small-scale hydropower project to supply clean water and electricity for the rural population,
- To develop exploitative and processing industries for minerals, agro and forest products for export, and
- To establish major industrial bases along Highway No.18.

(e) Central Highlands Region

The region includes the Se San, Srepok, and upstream reaches of the Ba River basins. The country put much importance on this region, since the region is an important strategic location in both socio-economic and defense-security

terms.

Major regional orientations:

- To develop large-scale agricultural and forest goods production in combination with processing industries,
- To develop intensive farming, industrial crops for export (coffee, rubber, tea, cotton, etc.), cattle breeding, forest planting, medical plant, and their processing industry,
- To promote such industries as exploitation and processing bauxite, paper, energy and mining industry, and
- To develop large and medium-scale hydropower plants as well as reservoirs for efficient use of water resources.

(f) Cuu Long River Delta region

The region has played a vital role as the country's largest rice and agricultural products exporter.

Major regional orientations:

- To continue promoting its role as the largest rice and agro-product exporter,
- To increase the production and raise the quality of cash crops, vegetables, fruits, livestock, and aquaculture,
- To develop farm products processing industries,
- To shift economic structure and to raise the proportion of labor employed in industry and services, and
- To plan and construct residential quarter and infrastructures adaptable to annual flood and saline water control.

(2) Macro-economic Targets by River Basin

The macro-economic targets set for each of 14 river basins in the socio-economic framework plan are summarized hereinafter. It is noted that the targets expressed in the following table were estimated by the Study Team based on the socio-economic development plan of the provinces located in the pertinent river basin.

Bang Giang and Ky Cung River Basin

Objective Provinces: Cao Bang and Lang Son

Year	2001	2005	2010	2015	2020
Population (1,000)	1,234	1,291	1,366	1,445	1,530
of which urban	204	211	222	233	245
of which rural	1,030	1,080	1,144	1,212	1,285
Annual population growth rate (%)	1.1	1.1	1.1	1.1	1.1
GRDP (Billion VND in 2000 price)	3,821	5,173	7,660	11,500	17,488
Annual GRDP growth rate (%)	(2000-01)	(2001-05)	(2005-10)	(2010-15)	(2015-20)
Whole	7.8	7.8	8.2	8.6	8.6
of which, agri., for., & fishery	5.7	5.7	6.0	6.3	6.3
of which, industry & constr.	10.6	10.6	10.7	10.7	10.7
of which, service	9.4	9.4	9.5	9.6	9.6
Share (%): - Agri., for., & fishery	48	45	40	36	33
- Industry & constr.	14	16	18	20	22
- Service	38	39	42	44	45
Per capita GRDP (VND1,000 in 2000 price)	3,096	4,007	5,608	7,958	11,430

Red and Thai Binh River Basin (Red River Delta)

Objective Provinces: Ha Noi, Hai Phong, Vinh Phuc, Ha Tay, Bac Ninh, Hai Duong, Hung Yen, Ha Nam, Nam Dinh, Thai Binh, and Ninh Binh

Year	2001	2005	2010	2015	2020
Population (1,000)	17,360	18,311	19,394	20,425	21,649
of which urban	3,585	4,567	5,842	6,668	7,646
of which rural	13,775	13,744	13,552	13,757	14,003
Annual population growth rate (%)	1.4	1.3	1.2	1.1	1.1
GRDP (Billion VND in 2000 price)	82,229	114,589	175,457	243,620	369,605
Annual GRDP growth rate (%)	(2000-01)	(2001-05)	(2005-10)	(2010-15)	(2015-20)
Whole	8.0	8.0	8.9	7.7	7.7
of which, agri., for., & fishery	8.4	8.4	3.9	2.9	2.9
of which, industry & constr.	9.4	9.4	12.2	11.2	11.2
of which, service	6.7	6.7	8.5	5.3	5.3
Share (%): - Agri., for., & fishery	23	24	19	16	12
- Industry & constr.	33	35	41	47	56
- Service	44	41	40	37	32
Per capita GRDP (VND1,000 in 2000 price)	4,737	6,258	9,047	11,928	17,073

Red and Thai Binh River Basin (Other Areas of the River Basin)

Objective Provinces: Ha Giang, Lao Cai, Bac Kan, Tuyen Quang, Yen Bai, Thai Nguyen, Phu Tho, Bac Giang, Quang Ninh, Lai Chau, Son La, and Hoa Binh

Year	2001	2005	2010	2015	2020
Population (1,000)	10,228	11,098	12,101	13,038	14,077
of which urban	1,721	2,083	2,603	2,954	3,363
of which rural	8,507	9,015	9,498	10,084	10,714
Annual population growth rate (%)	1.8	2.0	1.7	1.5	1.5
GRDP (Billion VND in 2000 price)	29,139	47,337	68,828	93,386	128,673
Annual GRDP growth rate (%)	(2000-01)	(2001-05)	(2005-10)	(2010-15)	(2015-20)
Whole	11.8	11.8	7.8	6.5	6.5
of which, agri., for., & fishery	8.0	8.0	6.0	6.0	6.0
of which, industry & constr.	15.4	15.4	9.3	6.9	6.9
of which, service	12.7	12.7	7.8	6.3	6.3
Share (%): - Agri., for., & fishery	36	32	29	29	28
- Industry & constr.	28	32	34	35	36
- Service	36	36	37	36	36
Per capita GRDP (VND1,000 in 2000 price)	2,849	4,265	5,688	7,163	9,141

Ma River Basin

Objective Province: Thanh Hoa

Year	2001	2005	2010	2015	2020
Population (1,000)	3,605	3,790	3,980	4,183	4,396
of which urban	378	568	995	1,046	1,099
of which rural	3,227	3,222	2,985	3,137	3,297
Annual population growth rate (%)	1.2	1.3	1.0	1.0	1.0
GRDP (Billion VND in 2000 price)	8,498	12,535	20,965	37,040	68,664
Annual GRDP growth rate (%)	(2000-01)	(2001-05)	(2005-10)	(2010-15)	(2015-20)
Whole	10.3	10.3	10.8	12.6	12.6
of which, agri., for., & fishery	6.2	6.2	3.8	3.8	3.8
of which, industry & constr.	16.3	16.3	16.5	16.5	16.5
of which, service	8.6	8.6	9.4	9.4	9.4
Share (%): - Agri., for., & fishery	37	31	23	15	10
- Industry & constr.	31	38	49	59	68
- Service	32	31	28	26	22
Per capita GRDP (VND1,000 in 2000 price)	2,357	3,307	5,268	8,855	15,620

Ca River Basin

Objective Provinces: Nghe An and Ha Tinh

Year	2001	2005	2010	2015	2020
Population (1,000)	4,394	4,687	4,989	5,271	5,575
of which urban	373	543	716	777	843
of which rural	4,021	4,144	4,273	4,494	4,732
Annual population growth rate (%)	1.3	1.6	1.3	1.1	1.1
GRDP (Billion VND in 2000 price)	12,405	17,765	24,100	34,068	48,500
Annual GRDP growth rate (%)	(2000-01)	(2001-05)	(2005-10)	(2010-15)	(2015-20)
Whole	9.4	9.4	6.3	7.2	7.2
of which, agri., for., & fishery	4.5	4.5	2.5	4.7	4.7
of which, industry & constr.	17.7	17.7	14.4	8.6	8.6
of which, service	10.6	10.6	3.4	7.8	7.8
Share (%): - Agri., for., & fishery	44	37	31	27	24
- Industry & constr.	19	25	36	38	40
- Service	37	38	33	35	36
Per capita GRDP (VND1,000 in 2000 price)	2,823	3,790	4,831	6,463	8,700

Thach Han River Basin

Objective Province: Quang Tri

Year	2001	2005	2010	2015	2020
Population (1,000)	598	633	669	706	746
of which urban	148	154	163	172	182
of which rural	450	479	506	534	564
Annual population growth rate (%)	1.9	1.5	1.1	1.1	1.1
GRDP (Billion VND in 2000 price)	1,813	2,529	3,500	4,978	7,100
Annual GRDP growth rate (%)	(2000-01)	(2001-05)	(2005-10)	(2010-15)	(2015-20)
Whole	8.5	8.5	6.7	7.3	7.3
of which, agri., for., & fishery	5.3	5.3	4.6	5.7	5.7
of which, industry & constr.	20.5	20.5	8.8	8.4	8.4
of which, service	6.2	6.2	7.3	7.9	7.9
Share (%): - Agri., for., & fishery	44	39	35	32	30
- Industry & constr.	17	25	28	30	31
- Service	39	36	37	38	39
Per capita GRDP (VND1,000 in 2000 price)	3,032	3,996	5,232	7,051	9,517

Huong River Basin

Objective Province: Thua Thien-Hue

Year	2001	2005	2010	2015	2020
Population (1,000)	1,083	1,142	1,220	1,307	1,403
of which urban	319	348	400	460	528
of which rural	764	794	820	847	875
Annual population growth rate (%)	1.6	1.4	1.3	1.4	1.4
GRDP (Billion VND in 2000 price)	3,875	6,510	10,650	15,541	22,896
Annual GRDP growth rate (%)	(2000-01)	(2001-05)	(2005-10)	(2010-15)	(2015-20)
Whole	13.5	13.5	10.3	8.0	8.0
of which, agri., for., & fishery	9.5	9.5	5.4	4.0	4.0
of which, industry & constr.	16.5	16.5	14.0	10.0	10.0
of which, service	13.3	13.3	9.2	7.0	7.0
Share (%): - Agri., for., & fishery	23	20	16	13	11
- Industry & constr.	32	35	42	46	50
- Service	45	45	42	41	39
Per capita GRDP (VND1,000 in 2000 price)	3,578	5,701	8,730	11,891	16,319

Vu Gia-Thu Bon River Basin

Objective Provinces: Da Nang and Quang Nam

Year	2001	2005	2010	2015	2020
Population (1,000)	2,133	2,246	2,415	2,518	2,619
of which urban	790	859	975	1,035	1,096
of which rural	1,343	1,387	1,440	1,483	1,523
Annual population growth rate (%)	1.0	1.2	1.5	0.8	0.8
GRDP (Billion VND in 2000 price)	7,660	12,143	19,169	29,289	45,341
Annual GRDP growth rate (%)	(2000-01)	(2001-05)	(2005-10)	(2010-15)	(2015-20)
Whole	11.9	11.9	9.6	9.0	9.0
of which, agri., for., & fishery	1.6	1.6	4.7	4.2	4.2
of which, industry & constr.	14.7	14.7	12.2	8.7	8.7
of which, service	15.8	15.8	8.8	10.6	10.6
Share (%): - Agri., for., & fishery	27	18	15	12	9
- Industry & constr.	37	40	46	45	44
- Service	36	42	39	43	47
Per capita GRDP (VND1,000 in 2000 price)	3,591	5,407	7,937	11,632	17,312

Tra Khuc River Basin

Objective Province: Quang Ngai

Year	2001	2005	2010	2015	2020
Population (1,000)	1,214	1,273	1,345	1,421	1,501
of which urban	145	152	161	170	180
of which rural	1,069	1,121	1,184	1,251	1,321
Annual population growth rate (%)	1.2	1.2	1.1	1.1	1.1
GRDP (Billion VND in 2000 price)	3,618	4,822	6,818	9,908	14,597
Annual GRDP growth rate (%)	(2000-01)	(2001-05)	(2005-10)	(2010-15)	(2015-20)
Whole	7.4	7.4	7.2	7.9	7.9
of which, agri., for., & fishery	4.3	4.3	3.7	4.0	4.0
of which, industry & constr.	10.8	10.8	9.2	10.0	10.0
of which, service	6.2	6.2	7.8	7.0	7.0
Share (%): - Agri., for., & fishery	38	34	28	24	20
- Industry & constr.	40	45	50	55	60
- Service	22	21	22	21	20
Per capita GRDP (VND1,000 in 2000 price)	2,980	3,788	5,069	6,973	9,725

Kone River Basin

Objective Province: Binh Dinh

Year	2001	2005	2010	2015	2020
Population (1,000)	1,503	1,573	1,684	1,793	1,910
of which urban	363	387	437	483	533
of which rural	1,140	1,186	1,247	1,310	1,377
Annual population growth rate (%)	1.1	1.1	1.4	1.3	1.3
GRDP (Billion VND in 2000 price)	5,010	6,674	9,797	14,609	21,939
Annual GRDP growth rate (%)	(2000-01)	(2001-05)	(2005-10)	(2010-15)	(2015-20)
Whole	7.8	7.8	8.0	8.4	8.4
of which, agri., for., & fishery	3.8	3.8	2.5	5.2	5.2
of which, industry & constr.	12.5	12.5	11.6	9.0	9.0
of which, service	8.9	8.9	9.7	9.7	9.7
Share (%): - Agri., for., & fishery	40	35	27	23	20
- Industry & constr.	24	28	33	34	35
- Service	36	37	40	43	45
Per capita GRDP (VND1,000 in 2000 price)	3,333	4,243	5,818	8,148	11,486

Ba River Basin

Objective Province: Phu Yen and Gia Lai

Year	2001	2005	2010	2015	2020
Population (1,000)	1,834	2,003	2,255	2,378	2,507
of which urban	423	486	629	664	700
of which rural	1,411	1,517	1,626	1,714	1,807
Annual population growth rate (%)	2.3	2.2	2.4	1.1	1.1
GRDP (Billion VND in 2000 price)	6,272	8,329	12,706	19,062	29,396
Annual GRDP growth rate (%)	(2000-01)	(2001-05)	(2005-10)	(2010-15)	(2015-20)
Whole	7.3	7.3	8.8	8.7	8.7
of which, agri., for., & fishery	4.8	4.8	4.0	4.0	4.0
of which, industry & constr.	11.6	11.6	11.6	10.7	10.7
of which, service	6.6	6.6	16.0	11.9	11.9
Share (%): - Agri., for., & fishery	56	50	40	32	25
- Industry & constr.	30	36	41	45	49
- Service	14	14	19	23	26
Per capita GRDP (VND1,000 in 2000 price)	3,420	4,158	5,635	8,016	11,726

Dong Nai River Basin

Objective Provinces: Ho Chi Minh City, Lam Dong, Binh Phuoc, Tay Ninh, Binh Duong, Dong Nai, and Binh Thuan

Year	2001	2005	2010	2015	2020
Population (1,000)	11,966	13,616	15,231	16,266	17,381
of which urban	5,465	6,664	7,866	8,600	9,404
of which rural	6,501	6,952	7,365	7,666	7,977
Annual population growth rate (%)	2.1	3.0	2.3	1.3	1.3
GRDP (Billion VND in 2000 price)	88,571	113,078	154,939	185,167	224,911
Annual GRDP growth rate (%)	(2000-01)	(2001-05)	(2005-10)	(2010-15)	(2015-20)
Whole	7.0	7.0	6.5	3.8	3.8
of which, agri., for., & fishery	5.8	5.8	4.4	3.2	3.2
of which, industry & constr.	9.0	9.0	8.2	4.4	4.4
of which, service	5.3	5.3	5.1	3.1	3.1
Share (%): - Agri., for., & fishery	12	12	11	10	10
- Industry & constr.	44	47	51	52	54
- Service	44	41	38	38	36
Per capita GRDP (VND1,000 in 2000 price)	7,402	8,305	10,173	11,384	12,940

Se San River Basin

Objective Province: Kon Tum

Year	2001	2005	2010	2015	2020
Population (1,000)	338	380	420	480	550
of which urban	226	247	260	281	303
of which rural	112	133	160	199	247
Annual population growth rate (%)	3.1	3.0	2.0	2.7	2.7
GRDP (Billion VND in 2000 price)	876	1,277	1,812	2,512	3,529
Annual GRDP growth rate (%)	(2000-01)	(2001-05)	(2005-10)	(2010-15)	(2015-20)
Whole	8.6	8.6	7.2	6.9	6.9
of which, agri., for., & fishery	7.6	7.6	5.3	4.0	4.0
of which, industry & constr.	13.8	13.8	14.2	10.0	10.0
of which, service	7.5	7.5	5.1	7.0	7.0
Share (%): - Agri., for., & fishery	44	43	39	34	30
- Industry & constr.	16	20	27	32	37
- Service	40	37	34	34	33
Per capita GRDP (VND1,000 in 2000 price)	2,592	3,361	4,314	5,233	6,416

Srepok River Basin

Objective Province: Dak Lak

Year	2001	2005	2010	2015	2020
Population (1,000)	1,940	2,190	2,549	2,935	3,325
of which urban	412	484	614	764	925
of which rural	1,528	1,706	1,935	2,171	2,400
Annual population growth rate (%)	3.1	3.1	3.1	2.7	2.7
GRDP (Billion VND in 2000 price)	5,460	7,035	10,624	15,344	22,552
Annual GRDP growth rate (%)	(2000-01)	(2001-05)	(2005-10)	(2010-15)	(2015-20)
Whole	6.5	6.5	8.6	7.8	7.8
of which, agri., for., & fishery	4.3	4.3	4.7	4.5	4.5
of which, industry & constr.	12.9	12.9	15.5	11.0	11.0
of which, service	8.2	8.2	11.3	9.5	9.5
Share (%): - Agri., for., & fishery	62	57	47	41	35
- Industry & constr.	13	16	22	26	30
- Service	25	27	31	33	35
Per capita GRDP (VND1,000 in 2000 price)	2,814	3,212	4,168	5,228	6,783

Cuu Long River Delta

Objective Province: Long An, Dong Thap, An Giang, Tien Giang, Vinh Long, Ben Tre, Kien Giang, Can Tho, Tra Vinh, Soc Trang, Bac Lieu, Ca Mau

Year	2001	2005	2010	2015	2020
Population (1,000)	16,832	18,049	19,466	20,471	21,509
of which urban	3,036	3,884	4,952	5,256	5,569
of which rural	13,796	14,165	14,514	15,215	15,940
Annual population growth rate (%)	1.5	1.7	1.5	1.0	1.0
GRDP (Billion VND in 2000 price)	73,071	115,114	190,891	276,851	418,777
Annual GRDP growth rate (%)	(2000-01)	(2001-05)	(2005-10)	(2010-15)	(2015-20)
Whole	10.8	10.8	10.6	8.2	8.2
of which, agri., for., & fishery	7.6	7.6	7.2	4.5	4.5
of which, industry & constr.	16.0	16.0	14.4	11.9	11.9
of which, service	13.1	13.1	12.6	8.6	8.6
Share (%): - Agri., for., & fishery	53	47	40	34	28
- Industry & constr.	18	22	26	31	36
- Service	29	31	34	35	36
Per capita GRDP (VND1,000 in 2000 price)	4,341	6,378	9,806	13,524	19,470

8.1.2 Goal of Water Resources Development and Management Master Plan

The Government's regional development policy and macro-economic targets by river basin in line with the Government's regional development policy towards the year 2020 are established as seen in the preceding Section 8.1.

The goal of the Water Resources Development and Management Master Plan is defined as formulation of water resources development and management plan which will meet achievement of the macro-economic targets by river basin towards the year 2020, which are considered to reflect the government's policies.

8.2 Basic Strategy for Formulating the Water Resources Development and Management Master Plan

8.2.1 Basic Strategy for Water Utilization Plan

The goal of the water Resources Development and Management Master Plan is to meet achievement of the macro-economic targets by river basin towards the year 2020.

Formulation of the water resources development and management to meet the water demand increase in accordance with the targeted economic growth is set as the basic strategy of water utilization plan. The water demand increase in accordance

with the targeted economic growth is discussed hereunder.

(1) Domestic Water Demand Increase

The domestic water demand is considered to cover the water needs for households, institutions (offices, hospitals and schools, etc.) and commercial enterprises (business, hotels, restaurants, and shops, etc).

The domestic analysis of domestic water demand increase towards the year 2020 is based on:

- The estimated present domestic water use in 2001,
- The population growth rates set for each river basin in the macro-economic targets, and
- The estimated increase of water demand per capita.

The analyzed domestic water demand by river basin towards the year 2020 is summarized in Table 8.1.

(2) Industrial Water Demand Increase

The industrial water demand increase is analyzed based on:

- The estimated present industrial demand in 2001,
- The GRDP growth rates of industrial and construction sector set for each river basin in the macro-economic targets (the industrial water demand is assumed to increase in proportion to the economic growth of industrial and construction sector), and
- Development of the future Export Processing Zones (EPZ) and Industrial Estates (IE).

Details of the analyzed industrial water demand increase is given in Table 6.16. The analyzed industrial water demand by river basin towards the year 2020 is summarized in Table 8.1.

(3) Water Demand for Power Generation

As explained in the foregoing Sub-section 6.5.4, hydropower projects and multipurpose projects which were incorporated in the national power development plan are expected to ensure the planned firm power output of each project. Therefore, the water discharge necessary for the planned firm power output is considered the minimum requirement for the power generation of hydropower or multipurpose projects. If the water for water supply purposes is less than the said minimum requirement for power generation, reservoirs should be operated to increase the discharge to meet the minimum requirement for power generation.

On the other hand, the main role of multipurpose projects which were not considered in the national power development plan is the water supply for the water demands such as irrigation, domestic & industrial water and river maintenance flow,

etc. and therefore, power generation of these projects are assumed to be basically conducted by utilizing the discharge for the said water supply without particular water demand for power generation.

The minimum water requirement for power generation of the projects considered in the national power development plan is calculated as seen in Table 6.20.

Agricultural Water Demand Increase

The agricultural water demand is analyzed, duly referring to the government's agricultural development policy in which the macro-economic targets by river basin towards 2020 are reflected.

The present and future cultivated land area and crop planted area as well as cropping pattern and water to be required ware estimated by following the government's agricultural development policy.

Table 8.2.1 presents the summary of the agricultural water demand increase.

8.2.2 Basic Strategy for Flood Control

(1) Objective Area

Flood control aims at mitigation of socio-economic damages due to flooding in the objective area. In preparation of flood control plan, the objective area of each objective river basin should be defined. The objective area of each objective river basin is defined in consideration of the past flood prone area and the susceptible area of flooding in each river basin. Further, the following aspects are also taken into consideration:

- Industrial activities,
- Agricultural activities,
- Political aspects,
- Populations,
- Social assets,
- National development strategy and others.

(2) Protection Level

Flood protection level should be also defined in consideration of the aspects mentioned above. In the present study, the flood protection level is defined based on the requirement from each river basin. The flood protection level of each river basin is shown in Table 8.2.

(3) Flood Control Measures

Basically flood control measures consist of structural measures and non-structural measures, as follows:

Structural measures

- Construction of dyke including surrounding dyke and parapet wall
- Excavation of river-bed
- Construction of reservoir in the upstream basin
- Construction of retarding basin in the middle stream basin
- Construction of flood diversion channel
- Construction of underground reservoir

Non-structural measures

- Forestation in the upstream basin
- Establishment of flood forecasting and warning system
- Establishment of evacuation system, including construction of evacuation shelter, evacuation road, and others
- Establishment of flood fighting system
- Regulation of land use
- Regulation of activities in the river area
- Public education
- Obligation of construction of flood retention pond for land use development such as industrial zone development and residential area development
- Construction of flood proofing buildings or high-floor building
- Regulation of land fill of swamp and ponds or low-lying areas

These structural and non-structural measures should be introduced in the flood control planning in consideration of "technically viable, economically feasible, socially acceptable, and environmentally sustainable". Further, other various aspects should be also taken into consideration, including, Comprehensiveness and integration, Consistency, Social equity, Management system, Operation and maintenance costs, Land use, Capacity of responsible agencies, Community characteristics, Laws and regulations, History, and Socio-economic activities.

CHAPTER 9 FORMULATION OF WATER RESOURCES DEVELOPMENT AND MANAGEMENT PLAN FOR 14 OBJECTIVE RIVER BASINS

9.1 Formulation of Water Resources Development Plan

9.1.1 Flood Control Plan

(1) Flood Control Criteria

(a) Design discharge

Flood control criteria of each river basin adopted in the Study is based on the requirement of each river basin. The adopted flood control criteria are shown in Table 9.1.

In the said criteria, the design discharge at basic point of each basin for the objective area for flood control is estimated from the said reference discharge in the following manner:

- When the discharge is given at certain location in the basin, the discharge is adopted as the basic reference discharge in the basin.
- When the discharge is not given in the table, but the occurrence probability is given, the reference discharge is estimated based on the occurrence probability.

When both the discharge and the occurrence probability are not given in the table, the design discharge is estimated based on the objective occurred flood record.

(b) Design discharge hydrograph

As mentioned in the section on hydrological analysis, the hourly design discharge hydrograph is prepared only in the Huong River Basin, since the record on hourly flood discharge hydrograph is available only in the Huong River Basin. Accordingly the necessary calibration of run-off model constants is conducted only in the Huong River Basin.

The hourly hydrographs of the design discharge necessary for preparation of flood control plan of other river basins are prepared based on the daily discharge record during the major flood of each river basin and the instant peak discharge record during the flood at an observation station. The objective flood is selected based on the occurred flood defined as the objective flood listed in Table 9.1.

The hourly discharge hydrograph at the observation site is prepared so that the daily discharge of the prepared hourly discharge hydrograph at the site is the same with the daily discharge record. The peak discharge of the hourly discharge hydrograph is the same with the instant peak discharge record. Then the hourly design discharge hydrograph at the basic point for the objective flood control protection area is prepared proportionally so that the peak discharge is the same with that of the design discharge criteria in the said flood control criteria.

(2) Flood Control Plan for 14 River Basins

(i) Bang Giang and Ky Cung River Basin

The objective area is 10,000 ha agricultural land and Lang Son Town. The design discharge for the objective flood protection area is 2,800 m^3/s based on the above-mentioned criteria table.

The hourly design discharge hydrograph at the basic point of the river basin is prepared based on the flood record at Lang Son in July 1986 as discussed in the above.

In consideration that the downstream of the rivers is in China, the flood control of the basin should be attained by construction of reservoir in the upstream basin. The flood control by construction of dike system may worsen the flooding situation in the downstream basin in China.

The reservoir proposed is the Ban Lai reservoir and necessary flood control volume is estimated at 96.2 million m^3.

(ii) Red River Delta

The objective area of flood control is the Red River delta including the capital city, Hanoi of Vietnam. Although the present dike system is provided for the probable flood of occurrence probability of 0.8% (125-year return period) of major flood, the Government of Vietnam has recently decided to raise up the flood protection level to 0.4% in the medium term and to 0.2% or more in the long term as presented in detail in Chapter 2 of this Volume in consideration of the recent tendency of increase of flood peak under the background of upstream development and the world wide climate change due to El Niño, green house effect, and others. For this purpose, Dhai Thi reservoir is planned for the flood of the occurrence probability of 0.4% and Son La reservoir is planned for the flood of the occurrence probability of 0.2% for the long-term flood control in the Red River basin.

Accordingly no additional plan to this flood control plan is proposed in the present study.

(iii) Ma River Basin

The objective area includes the Thanh Hoa City, the capital of the Than Hoa province. The basic design discharge of the Ma River for the objective area is estimated based on the occurrence probability of 1% shown in the flood control criteria in Table 9.1. The estimated basic design discharge at the basic point for the objective flood control area is 7,000 m^3/s.

The hourly design discharge hydrograph at the basic point of this river basin is prepared based on the flood record at Cam Thuy in September 1996 as afore-mentioned, since the other year's flood record is not available.

As shown in the flood control criteria in the said table, the design high water level at Tao Bridge of the Ma River is defined to be 5.6 m. The discharge of 5,000 m^3/s in the present river conditions corresponds to the design high water level of 5.6 m at Tao Bridge. This high water level seems to have enough freeboard in the present river conditions.

In consideration that the present Ma River in the downstream reaches has the dyke system and the height of the dyke is already high enough, additional heightening of the dyke is not proposed for the new basic design discharge of 7,000 m^3/s. Accordingly the design discharge distribution of the Ma River in the downstream reaches is proposed to be 5,000 m^3/s and it is proposed that the remaining 2,000 m^3/s should be retained in the upstream reservoir.

Cua Dat reservoir to be located in the upstream basin of the Chu River, one of the main tributaries of the Ma River, is proposed to have the function of flood control. The required flood control volume is estimated at 105.6 million m^3. The design high water level of the design discharge of the Ma River is shown in Figure 9.1. Accordingly no river improvement works are proposed in the present study on the flood control plan of the Ma River.

(iv) Ca River Basin

The objective area includes the Vinh City, the capital of the Ngye An province. The basic design discharge of the Ca River for the objective area is estimated based on the occurrence probability of 1% shown in the flood control criteria. The estimated basic design discharge at the basic point for the objective flood control area is 11,900 m^3/s.

The hourly design discharge hydrograph at the basic point of this river basin

is prepared based on the flood record at Dua in September 1978 as afore-mentioned.

The design high water level at Ben Thuy Bridge of the Ca River is defined to be 6.28 m. The discharge of 10,000 m^3/s in the present river conditions corresponds to the design high water level of 6.28 m at Ben Thuy Bridge. This high water level does not seem to have enough freeboard in the present river conditions.

In consideration that the present Ca River in the downstream reaches has the dyke system and the height of the dyke is already high enough, additional heightening of the dyke is not proposed for the new basic design discharge of 11,900 m^3/s. Accordingly the design discharge distribution of the Ca River in the downstream reaches is proposed to be 10,000 m^3/s and it is proposed that the remaining 1,900 m^3/s should be retained in the upstream reservoir of the Ca River.

Ban La reservoir to be located in the upstream basin of the Ca River is proposed to have the function of flood control. The required flood control volume is estimated at 216.0 million m^3. The design high water level of the design discharge of the Ca River is shown in Figure 9.2. Since the present dyke system in the downstream reaches of the Ca River does not have enough freeboard in its elevation, the heightening of the present dike within the limit of necessary freeboard in the downstream reaches is proposed.

(v) Thach Han River Basin

The objective area includes the Quang Tri City, the capital of the Quang Binh province, and Dong Ha City. The basic design discharge of the Ca River for the objective area is estimated from 1999 flood shown in the flood control criteria. The estimated basic design discharge at the basic point (in the reaches downstream of the confluence of the Cam Lo River) for the objective flood control area is 16,520 m^3/s.

As the flood control criteria in the said flood control criteria table, the design high water level at Quang Tri Citadel of the Thac Han River is defined to be 6.5 m. The basic flood design discharge at the Quang Tri Citadel site is estimated at 13,670 m^3/s. To keep the design high water level at the site at 6.5 m to this basic design discharge of 13,670m, the present river channel needs to be greatly widened. Accordingly the design discharge distribution at this site should be decreased as much as possible by constructing the upstream reservoir.

Accordingly the Rao Quan reservoir in the upstream basin is proposed to have the function of flood control. The possible flood control volume is estimated at 104.7 million m^3. In consideration of this flood control function of Rao Quan reservoir, the design flood discharge distribution of the Thac Han River is estimated at 9,210 m^3/s in the reaches downstream of Quang Tri Citadel site to the confluence and 12,050 m^3/s in the reaches downstream of the confluence of the Cam Lo River to the river-mouth.

To fulfill the flood control criteria that the design high water level at Quang Tri Citadel should be 6.5 m, the necessary river improvement works are proposed since the present river channel does not have enough discharge carrying capacity for the said 9,210 m^3/s below the water level of 6.5m. The necessary river improvement works are river widening and construction of river dyke.

The longitudinal profile of the design high water level of the Thac Han River is shown in Figure 9.3.

(vi) Huong River Basin

The objective area includes the Hue City, the capital of the Thua Thien-Hue province. The basic design discharge of the Huong River for the objective area is defined as 13,670 m^3/s based on the flood control criteria.

As afore-mentioned, the hourly design discharge hydrograph in this river basin is prepared with the flood run off calculation. The hourly design discharge hydrograph is prepared with the flood run-off calculation by use of probable 2-day rainfall in the river basin in consideration that 2-day rainfall is the dominant rainfall in the past major flood records.

As shown in the flood control criteria, the design high water level at Kim Long of the Huong River is defined to be 3.71 m. In consideration of the design high water level of 3.71 m at Kim Long, the design discharge distribution of the site is estimated at 2,000 m^3/s. The remaining 11,670 m^3/s should be retained in the upstream reservoirs. Since the Hue City is one of the important tourism industry centers in Vietnam, no dyke can be constructed along the Huong River in its downstream reaches.

The alternative study among several combinations of Ta Trach reservoir, Huu Trach reservoir, retarding basin, flood diversion channel to the Bo River, the flood diversion tunnel to the Song River, and the parapet wall around the Hue

City, shows that the combination of the Ta Trach reservoir and the Huu Trach reservoir is the conceivable option as the flood control measures of the Huong River basin for the present flood control criteria.

The necessary flood control volumes of the reservoirs are estimated at 390 million m^3 for Ta Trach and 105 million m^3 for Huu Trach respectively.

(vii) Vu Gia – Thu Bon River Basin

The hourly design discharge hydrograph at the basic point of this river basin is prepared based on the flood record at Nong Son in November 1998 as afore-mentioned.

Vu Gia River

The objective area includes the Hoian City, one of the important tourism industry centers in Vietnam, and Tam Ky City. The Vu Gia River flows near the Danang City. But even during the 1999 flood, Da Nang City was out of inundation area situated at rather highly elevated area. Accordingly Da Nang City is set out of the flood control objective area.

The basic design discharge of the Vu Gia River is defined to be 9,100 m^3/s at Nong Son in the flood control criteria. Based on this criterion, the basic design discharge of the Thu Bon River at Ai Nghia, the basic point of the Vu Gia River for the objective flood control area is estimated at 10,870 m^3/s.

As shown in the flood control criteria, the design high water level at Ai Nghia of the Vu Gia River is defined to be 9.5 m. In consideration of the design high water level of 9.5 m at Ai Nghia, the design discharge distribution of the site is proposed to be 6,510 m^3/s including the river improvement and construction of reservoir in the upstream basin.

The difference of discharge between the basic design discharge of 10,870 m^3/s and the design discharge distribution in the downstream reaches of 6,510 m^3/s is proposed to be retained in the Song Cai reservoir to be located in the upstream reaches of the Vu Gia River. The necessary flood control volume of the Song Cai reservoir is estimated at 550 million m^3. The longitudinal profile of the Vu Gia River for the design discharge distribution is shown in Figure 9.4.

Thu Bon River

The basic design discharge of the Thu Bon River is defined to be 9,100 m^3/s at Nong Son of the Thu Bon River in the flood control criteria. Based on this

criterion, the basic design discharge of the Thu Bon River at Giao Thuy the basic point of the Thu Bon River for the objective flood control area is estimated at 10,870 m^3/s.

As shown in the flood control criteria, the design high water level at Giao Thuy of the Thu Bon River is defined to be 8.4 m. In consideration of the design high water level of 8.4 m at Giao Thuy the design discharge distribution of the site is estimated at 4,600 m^3/s. In consideration of the special aspects of the Hoian City that is registered as the world cultural heritage, and the characteristics of the river channel in the objective area that flows very widely in the downstream basin, the flood control of the Thu Bon River is to be attained by construction of reservoir in the upstream basin.

Accordingly no river improvement works are proposed in the present study and the difference of the discharge is proposed to be retained in the upstream reservoir, i.e.; Ho Song Tranch II reservoir. The necessary flood control volume is estimated at 800 million m^3. The longitudinal profile of the Thu Bon River for the design discharge distribution is shown in Figure 9.5.

(viii) Tra Khuc River Basin

The objective area of flood control includes the Quang Ngai City, the capital of the Quang Ngai Province. But the city is surrounded by ring levee for flood control. Accordingly the city will have to solve the drainage congestion problem even the city may be free from flooding from the Tra Khuc River.

The basic design discharge of the Tra Khuc River is defined to be 10,200 m^3/s at Son Giang of the Tra Khuc River in the flood control criteria. Based on this criterion, the basic design discharge of the Tra Khuc River at the basic point of the objective area of flood control is estimated at 10,690 m^3/s.

The hourly design discharge hydrograph at the basic point of this river basin is prepared based on the flood record at Son Giang in November 1998 as afore-mentioned.

As shown in the present flood control criteria, the design high water level at Tra Khuc of the Tra Khuc River is defined to be 6.2 m. In consideration of the design high water level of 6.2 m at Tra Khuc, the design discharge distribution of the site is proposed to be 6,040 m^3/s. For this design discharge distribution in the downstream reaches of the Tra Khuc River, the existing dyke does not have enough freeboard. Accordingly the heightening of the

present dyke within the limit of necessary freeboard is proposed for the Tra Khuc River. The remaining discharge is proposed to be retained in the upstream reservoir, i.e.; the Nuoc Trong reservoir. The necessary flood control volume is estimated at 184.2 million m^3. The longitudinal profile of the Tra Khuc River for the design discharge distribution is shown in Figure 9.6.

(ix) Kone River Basin

The objective area of flood control does not include the Quy Nhon City, the capital of the Binh Ding Province since Quy Nhon City is located rather far from the river mouth of the Kone River and free from flooding from the Kone River.

The basic design discharge of the Kone River is defined to be 4,920 m^3/s at Cay Muong of the Kone River in the flood control criteria. Based on this criterion, the basic design discharge of the Kone River at the basic point of the objective area of flood control is estimated at 5,580 m^3/s.

The hourly design discharge hydrograph at the basic point of this river basin is prepared based on the flood record at Cay Muong in November 1987 as afore-mentioned.

As shown in the flood control criteria, the design high water level at Tan An of the Kone River is defined to be 7.6 m. In consideration of the design high water level of 7.6 m at Tan An, the design discharge distribution of the site is proposed to be 3,000 m^3/s. For this design discharge distribution in the downstream reaches of the Kone River, the river improvement and the upstream reservoir are needed. Dinh Binh reservoir to be located in the upstream basin of the Kone River is proposed to have the function of flood control. The necessary flood control volume of the Dinh Binh reservoir is estimated at 97.2 million m^3. The river improvement of the Kone River is rather in a large scale. The longitudinal profile of the Kone River for the design discharge is shown in Figure 9.7.

(x) Ba River Basin

The objective area of flood control includes the Tuy Hoa City, the capital of the Phu Yen Province.

The basic design discharge of the Ba River is defined to be 13,675 m^3/s at Cung Son of the Ba River in the flood control criteria. Based on this criterion, the basic design discharge of the Ba River at the basic point of the objective

area of flood control is estimated at 13,560 m^3/s.

The hourly design discharge hydrograph at the basic point of this river basin is prepared based on the flood record at Cum Son in October 1993 as afore-mentioned.

As shown in the flood control criteria, the design high water level at Phu Lam of the Ba River is defined to be 4.39 m. In consideration of the design high water level of 4.39 m at Phu Lam, the design discharge distribution of the site is proposed to be 11,000 m^3/s. For this design discharge distribution in the downstream reaches of the Ba River, the existing dyke does not have enough freeboard. Accordingly the heightening of the existing dyke is proposed within the limit of necessary freeboard. The remaining discharge should be retained in the upstream reservoir of Song Ba Ha reservoir. The necessary flood control volume of the Song Ba Ha is estimated at 38.1 million m^3. The longitudinal profile of the Ba River for the design discharge distribution is shown in Figure 9.8.

(xi) Sesan River Basin

The basic design discharge of the Sesan River is defined to be 3,600 m^3/s at Kontum of the Sesan River in the flood control criteria.

As shown in the flood control criteria, the design high water level at Dakbla bridge of the Sesan River is defined to be 517.0 m. The corresponding discharge at Dakble bridge to the water level of 517.0 m is estimated at 642 m^3/s.

The hourly design discharge hydrograph at the basic point of this river basin is prepared based on the flood record at Kon Tum in September 1996 as afore-mentioned.

In consideration that the downstream of the Sesan River is Cambodia, the river improvement of the said reaches of the river is not proposed in the present study. The discharge more than 642 m^3/s to the basic design discharge of 3,600 m^3/s is proposed to be retained in the upstream reservoir. The Dak Bla reservoir to be located along the Krone River, one of the tributaries of the Sesan River, is proposed for this purpose. The necessary flood control volume of the Dak Bla reservoir is estimated at 78.0 million m^3.

(xii) Srepok River Basin

Since the Duc Xuyen site is to be submerged as the impounding area of Buon Kuop reservoir, the Duc Xuyen site is not taken up in the Study.

The basic design discharge at Giang Son site is defined to be the discharge of occurrence probability of 10% as shown in the flood control criteria. The estimated discharge corresponding to this criterion is 2,550 m^3/s.

The hourly design discharge hydrograph at the basic point of this river basin is prepared based on the flood record at Duc Xyen in Octover 1992 as afore-mentioned.

As shown in the flood control criteria, the design high water level at Giang Son located along the Ea Krong Ana River, one of the tributaries of the Srepok River is defined to be 425.0 m.

The corresponding discharge at Giang Son to the water level of 425.0 m is estimated at 527 m^3/s. In consideration that the downstream of the Srepok River is Cambodia, the river improvement of the said reaches of the river is not proposed in the present study. The discharge more than 527 m^3/s to the basic design discharge of 2,550 m^3/s is proposed to be retained in the upstream reservoir.

The existing Lower Krong Buk reservoir, proposed Upper Krong Buk reservoir, and proposed Krong Buong reservoir are proposed for retaining the excess discharge from 527 m^3/s to 2,550 m^3/s. The necessary flood control volume of these reservoirs is estimated at 33.3 million m^3, 26.2 million m^3, 21.4 million m^3 respectively.

(xiii) Dong Nai River Basin

The master plan of the Dong Nai River basin has been prepared based on the JICA Study under the name of Master Plan Study on Dong Nai River and Surrounding Basins Water Resources Development, in August 1996.

It is reported that the basic flood control in the Dong Nai River basin can be coped with the existing reservoirs. Accordingly no additional flood control plan on the Dong Nai River basin will be proposed in the present study.

(xiv) Cuu Long River Basin

The flood control plan of this river basin was prepared in October 1993 by NEDECO under the title of "THEMATIC STUDY ON MANAGEMENT OF WATER RESOURCES of "MEKONG DELTA MASTER PLAN. Accordingly no additional flood control plan is proposed in the present study.

9.1.2 Formulation of Water Utilization Plan

(1) Formulation of Master Plan on Irrigation Development

(a) Establishment of standard for future facilities level

Irrigation facilities level of the year 2020 should be one that the irrigation efficiency of 0.70 can be realized with the well water management to be made by skillful operators who use the facilities.

(b) Necessary projects so as to realize the facilities level of the year 2020

i) Rehabilitation of the irrigation system

- Repairing existing canals (partly lined at present) and related structures (mainly without discharge measurement device)

ii) Improvement of the system

- Canal lining should be made for all irrigation canals such as main to tertiary and quaternary ones.
- Discharge measurement device should be installed at every diversion structures such as turnouts, off-takes, etc.

iii) New development of the system.

- New construction of intake facilities (weirs, pumps, etc.), irrigation and drainage canals and related structures (with improved facilities level) for extension of irrigation systems over rain-fed areas

(c) Necessary projects so as to realize the operation level of the year 2020

i) Formulation of agricultural water use policy within the framework of water resources policy including all the other water-related sectors such as domestic water, industrial water, hydropower generation water, river maintenance flow

As FAO Irrigation and Drainage Paper No.52 “Performing Water Resources Policy - A guide to methods, processes and practices” presents the practical approach to the goal, it would be referred to as a guide in the course of the on-going water resources policy formulation in Vietnam.

ii) Capacity building and training, which are on-going in Vietnam, for (i) central, provincial and district governments’ water-related officials, (ii) irrigation management companies’ (IMCs’) staff, (iii) cooperatives’ water management staff and (iv) water users (farmers)

FAO Irrigation and Drainage Paper No.40 "Organization, Operation and Maintenance of Irrigation Schemes" would be used as a training material. No.40 presents also an important suggestion about the personnel training.

iii) Transfer of irrigation management services, which is on-going in Vietnam, from IMCs to cooperatives for efficient and effective operation and maintenance of irrigation schemes

FAO Irrigation and Drainage Paper No.58 "Transfer of irrigation management services - Guidelines" presents useful suggestions on all the steps from the mobilization to the implementation of the irrigation management transfer (IMT).

As projects related to the above are already on-going by the Government of Vietnam, WB, ADB, AusAID, DANIDA, etc. or going to start newly by them and others, the necessary measures to be taken from now on would be ones to improve the present methods so as to achieve their goals more efficiently and effectively in consideration of the Vietnam's characteristics on the basis of the international standards mentioned above. To estimate the required period, staffing, and budget for the capacity building and training projects, the data of the on-going projects would be referred to. For example, according to the interview to the team leader of the AusAID Project made at the beginning of the Phase 1, the following were confirmed:

- Period : 32 months from October 2001
- Staffing : 3 foreign consultants with 124 M/M of local consultants

(d) Formulation of irrigation projects

Projects have been formulated with reference to:

- Answers from provinces upon the questionnaire from the Study Team
- Agriculture in Vietnam - 61 Provinces and Cities, MARD, NIAPP, 2001
- Profiles for river basins, World Bank - Vietnam Water Resources Assistance Program, October 2000
- Main Report, Vietnam Water Resources Sector Review, World Bank, ADB, FAO, UNDP, NGOs, IWRP, May 1996
- Vietnam Water Resources

(2) Summary of Master Plan on Irrigation Development

Irrigation projects to realize the required irrigated area estimated based on the

agriculture development strategy are shown in the succeeding table. There are many existing irrigation systems with large nonfunctional area due to deterioration of the facilities. Those areas would become functional up to the present level with the rehabilitation works and would further be improved with the improvement works by the irrigation projects to be executed as planned below:

Irrigation Projects to be Required for Target Agriculture Development

River Basin		Present (2000)	Future (2010)	Future (2020)
01. Bang Giang	Irri. Area (ha)	25,500	54,500	67,500
Rehabilitation works	Area (ha)	11,500	0	
Improvement works	Area (ha)	37.000	0	
New Development works	Area (ha)	17,500	13,000	
02. Red	Irri. Area (ha)	1,008,000	1,197,000	1,291,000
Rehabilitation works	Area (ha)	189,000	94,000	
Improvement works	Area (ha)	1,197,000	94,000	
03. Ma	Irri. Area (ha)	112,000	176,000	199,500
Rehabilitation works	Area (ha)	64,000	22,400	
Improvement works	Area (ha)	176,000	22,400	
New Development works	Area (ha)	0	1,100	
04. Ca	Irri. Area (ha)	93,000	150,000	203,000
Rehabilitation works	Area (ha)	57,000	53,000	
Improvement works	Area (ha)	150,000	53,000	
05. Thach Han	Irri. Area (ha)	5,000	12,300	15,400
Rehabilitation works	Area (ha)	7,300	3,100	
Improvement works	Area (ha)	12,300	3,100	
06. Huong	Irri. Area (ha)	25,900	25,900	25,900
Rehabilitation works	Area (ha)	0	0	
Improvement works	Area (ha)	3,900	22,000	
07. Thu Bon	Irri. Area (ha)	30,900	69,000	77,000
Rehabilitation works	Area (ha)	38,100	5,900	
Improvement works	Area (ha)	69,000	5,900	
New Development works	Area (ha)	0	2,100	
08. Tra Khuc	Irri. Area (ha)	33,000	42,000	54,000
Rehabilitation works	Area (ha)	9,000	12,000	
Improvement works	Area (ha)	42,000	12,000	
09. Kone	Irri. Area (ha)	25,000	36,500	49,000
Rehabilitation works	Area (ha)	10,400	3,400	
Improvement works	Area (ha)	35,400	3,400	
New Development works	Area (ha)	1,100	9,100	
Van Phone Weir	River Width (m)	700	-	
Two Pumping Stations	Comm. Area (ha)	0	5,200	
10. Ba	Irri. Area (ha)	41,000	129,000	186,000
Rehabilitation works	Area (ha)	88,000	50,400	
Improvement works	Area (ha)	129,000	50,400	
New Development works	Area (ha)	0	6,600	
11. Sesan	Irri. Area (ha)	22,500	35,400	50,000
Rehabilitation works	Area (ha)	12,900	14,600	
Improvement works	Area (ha)	35,400	14,600	
12. Srepok	Irri. Area (ha)	29,000	35,000	91,000
Rehabilitation works	Area (ha)	600	30,700	
Improvement works	Area (ha)	29,600	30,700	
New Development works	Area (ha)	5,400	25,300	
Upper Krong Buk Weir	River Width (m)	200	-	
13. Dong Nai	Irri. Area (ha)	115,000	224,000	362,000
Rehabilitation works	Area (ha)	100,000	38,000	
Improvement works	Area (ha)	215,000	38,000	
New Development works	Area (ha)	9,000	100,000	
New Weir	River Width (m)	-	200	
New Weir	River Width (m)	-	200	
New Weir	River Width (m)	-	200	
Pumping Stations	Comm. Area (ha)	9,000	70,000	
14. Cuu Long Delta	Irri. Area (ha)	1,487,000	1,891,000	2,242,000
Rehabilitation works	Area (ha)	304,000	101,000	
Improvement works	Area (ha)	1,791,000	101,000	
New Development works	Area (ha)	100,000	250,000	
Pumping Stations	Comm. Area (ha)	100,000	250,000	

(3) Master Plan on Irrigation Development by River Basin

(a) Bang Giang and Ky Cung River Basin

Present condition

Existing irrigation schemes are mainly of 10 - 100 ha. Those were constructed 30 - 40 years ago and the total area was 37,000 ha, of which locations are shown in Figure 9.9. However, it has been estimated that only about 70 % of those, 25,500 ha, are effective at present.

General feature of development

The master plan of the irrigation development at an initial stage would be the rehabilitation and improvement of the existing irrigation schemes, which would cover the above-mentioned 37,000 ha.

On the other hand, the required irrigation area to realize the target agricultural production in the Bang Giang and Ky Cung River Basin has been estimated much larger than the area of 37,000 ha as shown in the above summary table.

This would developed with the new water resources development.

(b) Red and Thai Binh River Basin

Present condition

Irrigated agriculture has been intensified already and there is no additional irrigable land in the delta. Nearly all paddy-cultivated areas in the delta are supplied with irrigation. The system relies heavily on pumping. Currently, irrigation pumping covers nearly 500,000 ha, half of the system.

However, much of the system, which was built in the 1960s and 1970s, has deteriorated and requires systemic renovation and modernization. Major irrigation systems are shown in Figure 9.10.

General feature of development

In consideration of the present condition, the master plan of the irrigation development in the Red River Basin including hilly areas surrounding the delta would be the rehabilitation and improvement of the existing irrigation schemes. Rate of increase of the required irrigation area based on the agriculture development strategy is calculated at 1.28 from 1,008,000 ha in 2001 to 1,291,000 ha in 2020.

(c) Ma River Basin

Present condition

The constructed area of the irrigation schemes in the past was 224,000 ha. As of year 2000, there were 560 gravity schemes (small reservoirs, weirs) in the upper Ma to irrigate 75,500 ha (actually irrigated area) and some 800 pumps (250 pumping stations) in the lower Ma to irrigate 61,000 ha, of which the total area was 136,000 ha.

However, the system is 30 - 80 years old and had deteriorated badly. Then, the effective irrigation area has been estimated at 112,000 ha as shown in the above summary table taking into account ongoing rehabilitation projects of the World Bank in these years.

Major irrigation systems are shown in Figure 9.11.

General feature of development

In consideration of the above, the master plan of the irrigation development in the Ma River Basin would be the rehabilitation and improvement of the existing irrigation schemes. The required irrigation area was estimated based on the agriculture development strategy. Some 86,000 ha would be rehabilitated by the year 2020.

In addition, a part of Song Muc Irrigation Project would be executed for new development of some 1,100 ha.

(d) Ca River Basin

Present condition

Vietnam Water Resources Sector Review, Main Report, May 1996, IWRP, WB, ADB, FAO, UNDP, NGOs mentions that the irrigation system in the basin is relatively well-developed by several major systems such as Nam Hung Nghi, Nghe An and Linh Cam, however, the effective irrigated area is only 85,000 ha (60 % of the developed 143,000 ha) due to severe deterioration of the system. Including many small scale existing schemes constructed in the past, the total area of the systems constructed is estimated to be some 200,000 ha or more. It was examined through the field investigation made in this Study.

Through the present crop production analysis, the effective irrigation area has been estimated at 93,000 ha as shown in the above summary table.

Major irrigation systems are shown in Figure 9.12.

General feature of development

The required irrigation area was estimated based on the agriculture development strategy. Total irrigation area should reach 203,000 ha by the year 2020. The remaining 110,000 ha should be rehabilitated.

(e) Thach Han River Basin

Present condition

Through the present crop production analysis, the effective irrigation area has been estimated at 5,000 ha, which is equivalent to 25% of the cultivated land area of 21,000 ha in the river basin, as shown in the above summary table.

Major irrigation systems are shown in Figure 9.13.

General feature of development

The required irrigation area was estimated based on the agriculture development strategy. Total irrigation area should reach 15,400 ha by the year 2020.

(f) Huong River Basin

Present condition

With reference to the Feasibility Report TA TRACH PROJECT, May 2000, HEC 1, almost all the cultivated area of 25,900 ha in the river basin has irrigation facilities such as sluices, pumps, canals and related structures and is actually irrigated.

However, those have been constructed since 1970s. Therefore, annual maintenance and repair are to be needed. As to pumps, the difference between the actual capacity and the designed is believed to be larger. Out of about 80 major existing pumping stations, 60% might need or become to need such maintenance and repair.

Area of the irrigation system is shown in Figure 9.14.

General feature of development

The present irrigation facilities for the 25,900 ha would be improved to increase the irrigation efficiency. To save the irrigation water, irrigation canals should be lined and discharge measurement devices should be installed at diversion points.

(g) Vu Gia - Thu Bon River Basin

Present condition

Irrigation system had covered nearly all paddy fields. Much of the facilities were built either before 1954 or after 1975.

Through the present crop production analysis, the effective irrigation area has been estimated at 30,900 ha. It is equivalent to 35% of the cultivated land area of 88,000 ha in the river basin, as shown in the above summary table.

Major irrigation systems are shown in Figure 9.15.

General feature of development

The required irrigation area was estimated based on the agriculture development strategy. Total irrigation area should reach 77,000 ha by the year 2020. To cover the target irrigation area, new development projects would be executed in addition to the rehabilitation and improvement works for the existing facilities.

Viet An Irrigation Project would be executed for new development of some 2,100 ha.

(h) Tra Khuc River Basin

Present condition

The Trach Nam Weir was constructed in the mainstream of the Tra Khuc River with the design irrigation areas of 50,000 ha. However, due to limited water resources and incomplete water infrastructure, irrigated areas cover 26,000 ha, i.e. 50% of the designed (or initially constructed). Including other irrigation systems, the total area of the systems constructed in the past and the presently effective irrigated area is to be some more then those mentioned above.

Through the present crop production analysis, the effective irrigation area has been estimated at 33,000 ha as shown in the above summary table.

Major irrigation systems are shown in Figure 9.16.

General feature of development

The required irrigation area was estimated based on the agriculture development strategy. Total irrigation area should reach 54,000 ha by the year 2020. The remaining 21,000 ha should be rehabilitated.

(i) Kone River Basin

Present condition

There exist major irrigation schemes such as Thanh Hoa 1 and 2 Irrigation Scheme with 4,100 ha (2,600 ha + 1,500 ha) of the designed irrigation area (initially constructed area), Nui Mot Irrigation Schemes with 3,000 ha of the designed and Thuan Ninh Irrigation scheme of 2,700 ha. With reference to the answer to questionnaire from Binh Dinh Province, the effective (actual) irrigation area has been estimated to be 25,000 ha, which has been summed up after excluding areas in the La Tinh River Basin and the Lai Giang River Basin.

Through the present crop production analysis, the effective irrigation area of 25,000 ha has been divided into 24,000 ha of paddy field and 1,000 ha of upland crop field. It is equivalent to 35% of the cultivated land area of 71,000 ha in the river basin.

Major irrigation systems are shown in Figure 9.17.

General feature of development

The required irrigation area was estimated based on the agriculture development strategy. Total irrigation area should reach 49,000 ha by the year 2020. To cover the target irrigation area, new development projects for would be executed in addition to the rehabilitation and improvement works for the existing facilities.

Van Phong Irrigation Project including new construction of the Van Phong Weir would be executed for new development of some 7,000 ha to realize the commanding area of 17,000 ha including existing irrigation area for rehabilitation.

South Kone Irrigation Project including new construction of two major pumping stations would be executed for new development of some 3,000 ha.

(j) Ba River Basin

Present condition

Dong Cam Irrigation Scheme, which is a well-established irrigation system near the coastal region, covers 21,500 ha of the actual irrigation area. In addition, several schemes such as the upstream Ia Yun and Hin have been constructed recently and another 20,000 ha have become into use.

Through the present crop production analysis, the effective irrigation area has

been estimated at 41,000 ha. It is equivalent to 15% of the cultivated land area of 283,000 ha in the river basin.

Major irrigation systems are shown in Figure 9.18.

General feature of development

The required irrigation area was estimated based on the agriculture development strategy. Total irrigation area should reach 186,000 ha by the year 2020. To cover the target irrigation area, new development projects would be executed in addition to the rehabilitation and improvement works for the existing facilities.

Song Hinh Irrigation Project would be executed for new development of some 6,600 ha.

(k) Sesan River Basin

Present condition

Through the present crop production analysis, the effective irrigation area has been estimated at 22,500 ha as shown in the above summary table.

Major irrigation systems are shown in Figure 9.19.

General feature of development

The required irrigation area was estimated based on the agriculture development strategy. Total irrigation area should reach 50,000 ha by the year 2020. The remaining 27,500 ha should be rehabilitated.

(l) Srepok River Basin

Present condition

Through the present crop production analysis, the effective irrigation area has been estimated at 29,000 ha as shown in the above summary table.

Major irrigation systems are shown in Figure 9.20.

General feature of development

The required irrigation area was estimated based on the agriculture development strategy. Total irrigation area should reach 91,000 ha by the year 2020. To cover the target irrigation area, new development projects would be executed in addition to the rehabilitation and improvement works for the existing facilities. The following projects covering 30,700 ha would be the expected projects:

- Upper Krong Buk Irrigation Project: 5,400 ha
- Chu Bong Krong Irrigation Project: 2,100 ha
- Buon Kuop Irrigation Project: 16,800 ha
- Dray Hlinh Irrigation Project: 6,400 ha.

(m) Dong Nai River Basin

Present condition

Irrigation systems, of which each area is larger than 100 ha, constructed in the past are some 300 schemes and it is estimated that the commanding area was some 170,000 ha. Major existing irrigation schemes in the river basin are Tuyen Lam / Quan Hiep Scheme, Dai Don Scheme, Vo Xu Scheme and Phuoc Chi Scheme. Including other small systems, the total area of the systems constructed in the past is estimated to be some 250,000 ha or more.

Through the present crop production analysis, the effective irrigation area has been estimated at 115,000 ha as shown in the above summary table.

Major irrigation systems are shown in Figure 9.21.

General feature of development

The required irrigation area was estimated based on the agriculture development strategy. Total irrigation area should reach 362,000 ha by the year 2020. To cover the target irrigation area, new development projects would be executed in addition to the rehabilitation and improvement works for the existing facilities. The following projects would be major ones of the expected new construction projects.

- Phuoc Hoa Irrigation Project: 46,000 ha
- A part of Tao Pao Irrigation Project: 13,000 ha
- Vo Dat Irrigation Project: 15,000 ha

(n) Cuu Long River Delta Basin

Present condition

Currently, there are some 2,400,000 ha of lands used for cultivated land.

Major irrigation systems constructed in the past are some 50 schemes and it is estimated that the commanding area was around 1,800,000 ha.

Through the present crop production analysis, the effective irrigation area has been estimated at 1,487,000 ha as shown in the above summary table.

Major irrigation systems are shown in Figure 9.22.

General feature of development

The required irrigation area was estimated based on the agriculture development strategy. Total irrigation area should reach 2,242,000 ha by the year 2020. To cover the target irrigation area, new development projects would be executed in addition to the rehabilitation and improvement works for the existing facilities. The following projects would be major ones of the expected new construction projects.

- Lang The Irrigation Project: 27,000 ha
- My Van Irrigation Project: 7,000 ha

9.1.3 Projects to Compose the Master Plan

(1) Dam/Reservoir Projects

The Study takes up major dam/reservoir projects which have been planned in the respective river basins. The major dam/reservoir projects which have been planned in each river basin were found from the following documents and information:

(i) dam/reservoir projects listed as priority projects in "Water Resources Development Strategy to the year 2010, MARD, August 1999",

(ii) dam/reservoir projects listed as proposed development projects in "Water Resources Sector Review, 1996, WB, ADB, FAO, UNDP, NGO's Water Resources Group in cooperation with IWRP" and

(iii) information on dam/reservoir projects with high priority in each province, which was obtained through the field reconnaissance, etc.

The major dam/reservoir projects planned in each river basin are as shown in Table 9.2.

(2) Groundwater Development Plan

Data and information for proper evaluation and development plan of groundwater were not available, making it impossible to incorporate the groundwater development plans in the basin plan. Thus, the basin plan is formulated with development of the surface water.

In connection with the groundwater, a further and separate study for the present situation including inventory survey is considered necessary.

(3) Drainage Plan

The plan formulation included the farm drainage within the irrigation plan. Although other drainage plans, especially urban drainage plan, were considered to

be out of scope of the Phase 1 study, availability of data for planning was investigated.

The investigation found that collection of data and information for planning would face an extreme difficulty. As such, a separate study for individual river basins seems to be necessary for formulation of drainage plan in each river basin.

(4) Summary of Master Plan Formulated for 14 River Basins

As is discussed in the preceding Sections 9.1.1 and 9.1.2 for the flood control plan and the water utilization plan respectively, the project components are identified in the respective river basins as well as dam reservoir projects as listed in aforementioned (1).

Those major projects are summarized in Table 9.3 and presented locations in Figures 9.9 through 9.22 as well as available details of the proposed dam/reservoirs in Figures 9.23 through 9.32.

9.1.4 Preliminary Cost Estimate for Projects

The overall financial requirement for the implementation of the Water Resources Development and Management Master Plan for 14 River Basins is shown in Table 9.4.

As shown in Table 9.4, 80,079,217 million VND equivalent to 5,315 million US$ would be required in total for the implementation of the recommended projects and measures for the 11 river basins from 2002 to 2020, excluding 3 river basins of the Red & Thai Binh, Dong nai and Cuu Long with the authorized Master Plan.

The reason why 3 river basins having the authorized Master Plan are excluded here is explained in the succeeding chapter. The financial requirement for each river basin is summarized below:

River Basin	Project Cost	
	Million VND	Equivalent to Million US$
Bang Giang & Ky Cung	3,580,717	238
Red & Thai Binh	-	-
Ma	11,111,689	737
Ca	12,838,780	852
Thach Han	3,419,005	227
Huong	3,717,229	247
Vu Gia-Thu Bon	14,881,578	988
Tra Khuc	2,068,870	137
Kone	3,825,525	254
Ba	10,630,547	706
Sesan	5,218,115	346
Srepok	8,787,162	583
Dong Nai	-	-
Cuu Long Delta	-	-
Total	**80,079,217**	**5,315**

9.1.5 Economic Viability of the Projects

Economic analyses of the projects have been examined for the following 11 river basins:

1) Bang Giang & Ky Cung Rivers
2) Ma River
3) Ca River
4) Thach Han River
5) Huong River
6) Vu Gia-Thu Bon Rivers
7) Tra Khuc River
8) Kone River
9) Ba River
10) Se San River
11) Srepok River

The Red, Dong Nai, and Cuu Long River basins already have basins' master plans and they have already been approved by the Government. The study team reviewed the master plans and found that the measures proposed in the master plans are appropriate. Therefore, economic analysis for the master plans will not be made.

Economic analysis has been conducted preliminary basis, since the information on

some basins is very limited. Especially the information on flood damage in Bang Giang & Ky Cung, Se San, and Srepok River basins are very few.

(1) Results of Economic Analysis

The results of the economic analyses showed the projects of Bang Giang & Ky Cung, Ca, Huong, Tra Khuc, Kone, Ba, and Srepok river basins have sufficient economic efficiency with EIRRs of more than 12%, which reflects the opportunity cost of capital in Vietnam. Especially the projects in the Central Coast Region such as Huong, Tra Khuc, Kone, and Ba show high economic efficiency with EIRRs of more than 15%.

Economic indicators are calculated and summarized below:

Economic Indicators

River basin projects	EIRR (%)	B/C Ratio	NPV (Million US$)
Bang Giang & Ky Cung	14.1	1.27	24.8
Ma	11.7	0.97	-7.5
Ca	12.5	1.06	16.2
Thach Han	11.2	0.91	-8.6
Huong	17.4	1.70	59.5
Vu Gia-Thu Bon	9.6	0.78	-81.8
Tra Khuc	19.8	2.12	60.5
Kone	15.4	1.40	35.3
Ba	15.6	1.44	103.9
Se San	9.9	0.79	-24.7
Srepok	13.5	1.16	33.9

Note: B/C and NPV are calculated with a discount rate of 12%.

(2) Assumptions Applied for the Economic Analysis

a) Price level and exchange rate

The analyses are made at the price level of December 2001 and applied foreign exchange rate is one U.S. dollar equivalent to VND15,068 and 100 Japanese Yen equivalent to VND12,212.

b) Project life

The project life of 50 years after construction is assumed for the economic analysis. Average lifetime of the electrical and mechanical facilities related to the projects is assumed 25 years after installation. Replacement costs cover the cost for replacement of such facilities after the lifetime within project life.

c) Discount rate

A discount rate of 12% is applied to reflect the opportunity cost of capital in Vietnam.

d) Standard conversion factor (SCF)

The standard conversion factor (SCF) of 0.9 with reference to recent similar studies is applied to adjust the effects of trade distortion, foreign exchange premiums, the local costs for non-traded goods and services.

e) Transfer payment

From the viewpoint of national economy, the transfer payment such as taxes, duty, subsidy and interest is merely a domestic monetary movement without direct productivity. Therefore, it is excluded from the costs of goods and services.

f) Economic prices of agricultural outputs

The prices of agricultural outputs are adjusted by SCF on assumption that most of the incremental outputs are for domestic consumption.

g) Economic price of electricity

The economic price of electricity is assumed at 5 US Cents/KWh, which is generally used as a price of electricity in economic analyses.

h) Economic price of domestic and industrial water supply

The economic price of domestic and industrial water is assumed at VND1,800/m^3, the long-term marginal cost of production adjusted by SCF.

i) Economic project cost

The economic project cost has been estimated from the financial project cost adjusting by SCF after deducting the direct transfer payment.

j) Operation and maintenance cost

The following annual operation and maintenance costs are assumed:

- Civil construction including dam and irrigation facilities: 0.5% of construction cost
- Mechanical and electrical facilities including hydropower facility: 1.5% of facility cost
- Domestic and industrial water supply: 5% of the construction cost

k) Replacement Cost

The following replacement costs are assumed for replacement of facilities 25 years after installation:

- Mechanical and electrical facility for dam and hydropower generation

- Pumps and gates for irrigation and water supply facilities

(3) Project Benefits

(a) Flood control benefit

1) Definition of flood control effect

Flood control effects are measured from difference of flood damages between those with and without project conditions. In other words, they are flood damage mitigation benefit.

2) Procedure of flood damage estimation for the central regions

The Central Vietnam was suffered from extremely serious damages by the flood in November 1999. Especially Thua Thien Hue Province was suffered from very serious damages. The damages were assessed by several institutions after the flood. General Statistical Office of Thua Thien Hue Province conducted a damage assessment. The results are shown in Table 9.5 and summarized below:

Flood Damage in November 1999

Item	Damage (VND million)
A. Flood, storm prevention structure and infrastructure	481,122.9
1. Flood and storm prevention structure	76,500.6
2. Water resources	58,292.8
3. Transportation and fishery	293,081.5
4. Electricity and post office	53,248.0
B. Damages to business	523,548.7
C. Damages to welfare, cultural structure	86,227.3
D. Damages to houses	235,921.8
E. Other damaged assets	419,585.0
Total	1,746,405.7

The result of the assessment is quite detail and broad though the damages to houses seemed under evaluated comparing with the actual value of houses. The damages to household durable assets, such as TV, radio, other electric devices, cooking stoves, tableware, cloths, and furniture, were not included.

According to the rainfall analysis, two-day rainfall at the time of the flood in November 1999 was almost the same as the rainfall of the occurrence probability of 50 years. The rainfall in November 1999 lasted for more than five days and the continual rain might make the flood damage worse. However, after reviewing the flood damage record discussed above, the damages due to long lasting inundation are not

very significant. Therefore, it is assumed that if a 50-year flood occurred, the same scale of damages may happen.

From the above consideration, the study team uses this flood damage record for the basis for estimation of the probable flood damages by adjusting the damages to houses and household durable assets by region.

3) Flood conditions

Based on the point elevations shown in the topographical maps of 1/50,000, the elevation-volume curve (HV curve) and the elevation-area curve (HA curve) have been prepared by the study team.

Inundation volumes under various magnitudes of floods have been calculated by flood simulation analyses. Based on the HV/HA curves and the inundations volumes under various magnitude of floods, the flood conditions such as inundation depth and area are estimated.

4) Estimation of flood damage

Crops

According to the information obtained during the site reconnaissance, farmers in the flood prone area do not cultivate crops during the major flood season in order to avoid flood damages. However, in the early flood season, paddy cultivation is widely practiced and it suffers from flood damage sometimes.

The paddy cultivation area is estimated at about 72% of inundation area from the present land use map. The expected value of unit gross output under present condition is VND6.3 million/ha.

Flood damage to paddy cultivation is decrease in yield due to submergence. In order to estimate the flood damage to paddy cultivation, the flood damage rates developed by Ministry of Construction, Japan are applied since no such uniformed standard is available in Vietnam.

Flood Damage Rates to Paddy

	Depth of Submergence		
	- 49cm	50-99cm	100cm-
Paddy	0.30	0.44	0.54

Source: Manual for flood control benefit survey, Ministry of Construction, Japan

It is assumed that the cultivation area and unit production volume will not change during the project life.

Houses/building

Number and value of houses are estimated by the following procedures:

- Average value of a house is estimated based on "Average current sales value of house by type of house and region" in Viet Nam Living Standards Survey (VLSS) 1997-1998, GSO. The prices have been adjusted by CPI to the prices in 2001.
- In order to separate the value of land use right from the sales value of house, half the value is considered as the value of house.
- Numbers of houses in flood prone areas are estimated from population density of the districts in flood prone areas dividing by average family size.

Household durable assets

Value of the household durable assets has been estimated based on "Average value of durable assets per household at current price by 10 regions" in the same VLSS. The price has been adjusted by CPI to 2001 price.

With respect to house/building and household durable assets, basically the standard flood damage rates developed by Ministry of Construction, Japan are applied since no such uniformed standard is available in Vietnam. Floor level of houses is assumed 30cm above ground level based on actual situation observed through site reconnaissance (no flood damage considered for 30 cm depth inundation above ground level).

Flood Damage Rates

	Inundation depth above floor level				
	- 49cm	50-99cm	100-199cm	200-299cm	300cm-
House	0.092	0.119	0.266	0.580	0.834
Household effects	0.145	0.326	0.508	0.928	0.991

Source: Manual for flood control benefit survey, Ministry of Construction, Japan

Flood damages to houses and household durable assets are estimated from number of houses in inundation areas, unit value of houses and assets multiplied by the damage rate corresponding to inundation conditions. Difference of the flood damage between those with and

without project is the flood reduction benefit.

From now to the target year, 2020, the number of houses in the flood prone area is supposed to increase and the urban area will expand according to population increase and economic development. In other words, flood damage potential will increase gradually to 2020. The future number of houses has been estimated by applying the target population growth rates discussed in the socio-economic framework. The flood damages have been estimated for with and without project conditions under the situations in the year 2001 and the year 2020 based on the estimated future number of houses.

It should be noted that even after implementation of the projects, flood inundation may occur in the low-lying areas and flood damages may remain.

5) Probable Damages

Based on the newly estimated flood damages to houses and household durable assets, the flood damage of Thua Thien Hue Province in November 1999 has been recalculated as shown below:

Recalculation of Flood Damage of Thua Thien Hue Province, November 1999

Item	Damage (VND billion)	Ratio to Item 1
1. Newly estimated damages to houses and household durable assets (50-year flood)	1,417.2	
2. Flood, storm prevention structure and infrastructure	481.1	33%
3. Damage to business	523.5	36%
4. Damage to welfare, cultural structure	86.2	6%
5. Other damaged assets	419.6	29%
Total	2,927.6	

The above calculation is regarded as the flood damages of 50-year probable flood and the same ratios against the newly estimated housing damages are applied for all other river basins in the Central Region. The results of calculation are shown in Table 9.6(1).

6) Annual Mean Flood Damage and Flood Mitigation Benefit

Annual mean flood damage is estimated as accumulation of flood damage segments derived from various magnitude of probable flood damage multiplied by the corresponding probability of occurrence, from non-damageable flood up to design protection level of flood. Table 9.6(2) shows the annual mean flood damage under the conditions with and without project.

Difference of the annual mean flood damage between those with and without project is considered as annual flood reduction benefit.

According to the analysis, the Ca River has enough discharge capacity and flood overflow will not occur even without project condition.

As to Bang Giang & Ky Cung, Se San, and Srepok River basins, since the information is very limited, flood control effects have been roughly estimated as follows:

a) Bang Giang & Ky Cung

According to the Water Resources Sector Review, 10,000ha of farmland in the river basin suffered from flood damage almost every year. This damage has been estimated at VND27.72 billion/year by the study team. It is assumed that after implementation of the project, this damage will be mitigated.

b) Se San

According to a flood damage record collected by the study team, 1,200ha of farmland in the river basin was suffered from flood damage in 1996 and the damage has been estimated at VND9.48 billion. Since no other flood report is available within 10 years, the study team regarded that the same scale of flood occurs once 10 years. It is assumed that after implementation of the project, this damage will be mitigated: VND948 million/year

c) Srepok

According to a flood damage record collected by the study team, the river basin was suffered from flood damage in 1999 and the damage was estimated at VND3.5 billion. Since no other flood report is available within 10 years, the study team regarded that the same scale of flood occurs once 10 years. It is assumed that after implementation of the project, this damage will be mitigated: VND350 million/year

(b) Incremental Agricultural Benefit

Agricultural benefits of the projects have been estimated for production of crop, livestock, and aquaculture.

According to the agronomic study using model crops and cropping patterns based on the characteristics of the project area, after implementation of the projects, improvement in crop yields and production of higher value crops are

expected. The benefits of incremental crop production are estimated as presented in Table 9.7.

Unit values of livestock and aquaculture have been estimated by the study referring to "Statistical Data of Vietnam, Agriculture, Forestry, and Fishery 1995 - 2000, GSO".

The results of the estimation are summarized in Table 9.8.

(c) Hydropower Generation Benefit

Electricity production in Vietnam by mid-2000 was 350kWh per capita, about the half the level of Indonesia and one-fifth of that of Thailand. Although electricity output rose by 111% between 1993 and 1999, it has had difficulty in keeping up with demand.

The government has a master plan to increase power generation double by 2010 and five times from present level by 2020. Especially the government gives priority to develop hydropower plants, which bring about combined benefits such as flood control, water supply, irrigation, and electricity generation. The plan also mentions that exchange of electricity with neighboring countries will necessary in order to meet power demand in each region and whole country.

The economic price of electricity is assumed at 5 US Cents/kWh, which is generally used as a price of electricity in economic analyses. Annual mean energy produced by the projects is summarized in Table 9.8.

(d) Water Supply Benefit

Future demand increase of domestic and industrial water supply in each river basin is discussed in Chapter 7. The economic price of domestic and industrial water is assumed at VND1,800/m^3. The water supply benefits of the projects are summarized in Table 9.8.

(e) Other Intangible Benefits

Other than benefits discussed above, various effects are expected by the implementation of the projects as listed below:

- Contribution to national food security,
- Reduction of food import and saving foreign exchange holdings,
- Creation of new job opportunity,
- Improvement of self-sufficiency and nutritional level of rural farmers,
- To narrow the earnings differentials among regions,

- Convenience of rural population by improvement of access roads to the dam sites and the roads may reduce the cost of moving produce from the farm to the consumer,
- Improvement of public health and quality-of-life by supplying better quality water including decrease of water-related disease,
- To ease the water carrying works,
- Groundwater recharge and improvement of vegetation, and
- Stabilization of rural farmers' livelihood and prevention of influx of rural population into urban areas.

The benefits listed above are very valuable, they are nevertheless virtually impossible to value satisfactory in monetary terms.

(f) Indirect Benefit

During construction period, the construction works may fuel various demand for other industries. Meanwhile, after construction works, incremental agricultural production will also arouse various demands for many different industries such as chemical industries, transportation services, trade services, etc. Flood control effect may prevent inundation of highway or railway and paralysis of economic activity may be prevented or mitigated. Such ripple effects must be enormous. However, such benefits are also very hard to value in money terms without more detailed study.

(4) Economic Project Cost

The economic project cost has been estimated from the financial project cost adjusting by SCF (0.9) after deducting the direct transfer payment. The financial and economic costs of the projects are shown in Table 9.9. Annual economic project costs are presented in Table 9.10.

(5) Cost-Benefit Analysis

Based on the benefits and costs discussed above, economic viabilities of the projects are examined by cost-benefit analysis. The analysis is conducted by the discounted cash flow analysis. The cash flow of the projects is presented in Appendix-I. The results of the economic analysis are summarized in the beginning of this Subsection 9.1.5.

9.2 Formulation of Water Resources Management Plan

9.2.1 General

A water resources management plan for the 14 river basins is proposed to be formulated properly consisting of the following four sub-components:

Engineering component

(1) Flood control related sub-component

(2) Water use related sub-component

(3) River environment related sub-component

Administrative/ Institutional Component

(4) Administration and institution related sub-component

9.2.2 Flood Control Management Plan

Flood control management plan should consist of structural and non-structural measures and institutional plans. Various structural measures for flood control plan have been formulated in the Study, including construction of multi-purpose dams, river improvement and construction of river dyking system.

While, non-structural measures and institutional plan are to be focused as the other aspects of flood control management plan. Non-structural measures, as being one inevitable component of a flood control plan, can also function as urgent flood control measures until the proposed structural flood control measures are completed, since non-structural measures are usually much less costly than structural measures that usually needs a huge amount of investment cost for the implementation. The following are not all the non-structural measures but some urgent measures.

(1) Flood Warning and Communication System

In 1999 flood, the Huong River basin suffered from serious flood damages. The damages included not only inundation damage of basin properties including agricultural products, but also many human lives. It is reported that in Phong Dien district along the Bo River, the flood water level reached to 2m above the river bank ground elevation. People in the district evacuated to a temple about 500 m far from the district. It is reported that many people who tried to evacuate on foot were washed away by the flood. In the Thu Bon River basin, it is reported that people on the way of evacuation on the national road No.1 on foot were also lost by straying away the road because the road was not visible since the inundation depth was already about 1.0 m.

In such a manner, many people's lives were lost during floods mainly due to the delay of evacuation. In this sense, the establishment of flood warning and communication system is a vital part of flood control management plan so that people would know and find a time for early and safe evacuation.

At the national level, the Law on Water Resources, ratified in January 1999 specifically designates the responsibility for the timely issuing of information relating to rain and floods to the Hydro-meteorological Service of Vietnam (HMS), re Article 37:

> *Article 37.- Setting norms and plans to prevent and combat floods:*
> *Point 4: The State managing agency in meteorology has the responsibility to organize the observation and forecast and issue timely information on rain, flood and the rising of sea water on the national scale.*

The lessons learnt from the 1999 flood indicated communication between the national HMS and regional and provincial centers was weak. The transmission of national-level satellite imagery to the provincial-level was too slow and unreliable to enable timely warnings given by the FSC to be effective. Most of the relevant data was received at the provincial level only after the disaster event had occurred.

At the individual river basin level, several automatic rainfall stations at the representing location of the upstream sub-basins as well as water-level stations in the middle reaches and downstream reaches shall be established. Information of storm in the upstream basin and water-level should be informed to the provincial flood warning committee. The relationship between the upstream rainfall and the water level in the downstream reaches and/or the relationship between the river water-level in the middle reaches and the water-level in the downstream reaches should be analyzed beforehand. Based on the upstream rainfall and water-levels in the middle and downstream reaches, and by using the pre-analyzed relationships, the flood warning committee should issue the evacuation order to related districts with enough evacuation time ahead

Then the district should broadcast the information to the resident people and decide the required actions to be taken as well as evacuation activities in order to mitigate loss of lives and properties.

As of the Huong River basin, a flood warning and communication system is already established. An evacuation order is issued by the people's committee based on the ranking table of flood risk. Based on the evacuation order, the district office should indicate the evacuation place to the resident people. The communication is done by radio broadcasting. However, the existing system still needs to be upgraded for

more accuracy and early evacuation.

(2) Flood Hazard Map

Preparation of a flood hazard map is also an inevitable part of flood control management plan. A flood hazard map shows possible flood water levels or the past flood water levels recorded in the basin. To disclose the flood hazard information in terms of expected inundation area and depth is quite effective way to the local commune to aware of the flood risks in any rainy season.

Some series of maps shall be produced, for instance, corresponding to flood probabilities of 1 in 10 years (P=10%), 1 in 20 years (P=5%) and the maximum record in the past. For each of these probabilities, flood inundation maps shall be prepared. Indicated on the maps are those areas inundated by flood waters in a certain depth ranges such as 0-1m, 1-2m, 2-3m and those areas where the depth of flood inundation is greater than 3m. The direction of flood flow and location of surveyed flood marks shall be also indicated.

The preparation of such kind flood hazard map needs a rather complicated analysis and a rather long time. Accordingly as one of an urgent non-structural measures and one of flood risk dissemination measures of flood control management of the basin,, the establishment of flood mark monuments should be implemented first.

This practice is already conducted in the Huong River basin and the Thu Bon River basin as the flood risk dissemination and as the help of flood warning as visual tool so that the resident people ca easily understand the coming flooding situation

(3) River Basin Conservation

The river basin conservation is also an inevitable part of flood control management plan and of water use management plan of a basin. Key issues of river basin conservation are as follows:

(i) Deforestation, and

(ii) Non-control development

Current condition in Vietnam of forest covering rate reduced 28% than before 43% (equal to 14.3 million ha) in 1945. If it continues on this trend, within 100years forest disappear from Vietnam. Generally, decrease of forest is caused by the war, cutting for firewood by the villager, fire in mountain, land reclamation for agriculture and environmental effect etc.. Therefore a counter measure is examined by grasping the river basin condition.

Deforestation without intentional forestation activity will cause a problem of

erosion and much sediment discharge to the river course and it's downstream. Non-controlled land development for housing and cultivation will create bare land and will cause problems similar to the deforestation.

Much sediment inflow cause sedimentation in reservoirs as well as riverbed aggradations, which lead to reduction of flood control capacity and discharge capacity of river channel.

Deforestation will cause faster flood runoff and higher flood peak discharge due to less effect of evapo-transpiration by forest. It is expected that more serious flood damage would be encountered and much more investment might be necessary to prevent such disasters.

In order to cope with the aforementioned issues, a river basin conservation plan will be such that include the following measure and activities:

(a) Land use management (control)

(b) Forestation

9.2.3 Water Use Management Plan

(1) Water Demand Management

To cope with increasing water demand, it is deemed necessary to promote water resource development which needs huge amount of investment and long period for realization as well as social and natural environmental impacts.

Considering such restriction, non-structural countermeasure for demand increase, as an alternative measure, conceivable and appropriate actions shall be taken for the proper water demand management in order to decrease excessive water consumption, including excess water intake control, reduction of water conveyance loss, water re-cycling, so forth. Among such water saving measures, the water intake control will be the most effective way, for which the following water use management in each river basin will be necessary:

1) Proper intake control by appropriate intake water measurement

Current intake water amount needs to be measured by an appropriate structure not so as to intake excessive water. Further improvement will be that an authority concerned will monitor the actual intake amount by the respective water users.

2) Integration and coordination of water demand by an authority

Prior to high water demand season, an authority shall coordinate expected

water demand by each user. This water demand schedule is to be coordinated in order that each water user could get adequate water allotment within available resources.

When drought situation is foreseen, an authority will coordinate all water users to cope with expected water deficit by adjusting water demands. While, an authority needs monitor the current available water resources of river runoff and reservoir storage as well as actual water requirement. It is expected by such activities that increase of production be expected by additional water allotment when excess water is available.

A river basin organization which shall be independent from the water-use stakeholders will be the one to execute the use management activities.

(2) Control of Saline Water Intrusion

To prevent saline water intrusion is focused as a subject of the water use management plan. Key issues of this subject are assumed as follows:

(i) Insufficient river-flow allowing salinity water intrusion, due to over abstraction of river water during a drought period.

(ii) Allocation of minimum discharge which is to be required to prevent saline water intrusion and to maintain river-flow in good quality condition.

River water containing saline water are not appropriate for domestic and industrial water, while in irrigation use, it produce adverse result of the low agricultural production due to crop damage and/or interruption of water abstraction from river.

In order to improve such situation, a water use management plan is to be composed of the following measure and activities:

(1) To secure appropriate maintenance flow

(2) In order to ensure the objective(1), the management and/or control system of river water abstraction is to be established

(3) Regular monitoring of water quality is also necessary for (1) above in order to determine adequate maintenance flow.

The strengthening of management of water abstraction expect a proper and adequate water intake to meet each requirement so that water saving effect would be attained as well as minimizing further water resources development.

9.2.4 River Environment Management Plan

River environment management plan for the 14 river basins focus on the river

water quality which includes salinity water intrusion as well as the deterioration of water quality due to waste water discharge from domestic and industrial uses.

The reasons would be the insufficient control of wastewater if such problem is evident in some rivers within 14 river basins.

In order to improve such situation if any, a river environment management plan will include the following measure and activities:

(1) To establish / strengthen / maintain waste water management system

(2) Monitoring system of river water quality

(3) Management (control) system of required minimum river flow.

9.2.5 Administrative Management Plan

As described in the preceding section, the management/control sub-plan concerning the following issues will compose a part of the administrative management plan:

(1) Flood Warning Dissemination

(2) Deforestation without regular forestation

(3) Land use and development

(4) Excessive water abstraction

(5) Discharge of waste water

(6) Proper maintenance flow

Other than those sub-plans, the river basin management system will be necessary by involvement of organizations and arrangement as follows:

(a) River Basin Organization to manage solely each river basin

(b) Committee involving all water-use stakeholders to effectively share limited water resources

(c) Appropriate water allotment during drought year/period by prioritizing water use.

Recently, the Government has established NWRC (National Water Resources Council) and RBO (River Basin Organization), etc. and the detailed enforcement regulations towards enforcement of the new law on water resources. As regard to RBO, the three(3) RBO for the Red River, the Dong Nai River and the Cuu Long River were established. Further, the Board of Management of the Huong River Projects has been established as a RBO.

The river basin organization shall be established early in the respective river basins and the following actions will be required:

1) To determine the primary tasks of the organization in accordance with the present situation of the respective river basins including issues and requirement,
2) To formulate a specific action plan to execute the tasks, and
3) To undertake capacity building of the organization and training of the personnel.

CHAPTER 10 EVALUATION OF PROJECTS AND RIVER BASINS

10.1 General

Evaluation of projects and 14 river basins is made, mainly aiming at selection of the priority river basin for which a comprehensive water resources development and management plan will be formulated in Phase 2-2.

The Study aims at selecting the priority river basin for which a Master Plan will be formulated. It is noted that this evaluation study conducts a relative comparison of river basins from the aspect of development needs in line with the Government's regional development policy.

10.2 Projects and Rivers Basins to be Evaluated

10.2.1 Eleven River Basins without Master Plan

The socio-economic framework plan (the macro-economic targets of each river basin) was established in Chapter 5 in line with the government's development policy. Then, the basic strategy for formulating the Water Resources Development and Management Master Plan which would meet achievement of the above goal have been set out in the Study as mentioned in Chapter 8.

Projects in each of eleven (11) river basins which have no basin master plan yet are examined and taken up out of the planned projects along the said basic strategy, and evaluation is made on these projects which compose the basin master plan. Evaluation for river basin is made on the basis of evaluation on the projects in each of the eleven (11) river basins.

10.2.2 Three River Basins with Master Plan

Three (3) river basins of the Red&Thai Binh, Dong Nai and Cuu Long already have the respective Master Plan for water resources development and management of the basin. The Master Plan and projects taken up in the Master Plan have been authorized and officially recognized as the most important projects and/or basins.

Therefore, the Study treats projects in these three (3) basins as "authorized" and these three (3) river basins are excluded in the examination to select the priority river basin.

10.3 Evaluation Items

The evaluation of projects and river basins is conducted through evaluation on the following items that are considered important factors in the water resources development and management of Vietnam.

(i) Domestic water supply
(ii) Industrial water supply
(iii) Agricultural water supply
(iv) Power generation
(v) Flood control effect
(vi) River maintenance flow
(vii) Degree of poverty in river basin
(viii) Investment cost (Degree of financing difficulty)
(ix) Resettlement (Adverse impact on social environment)

The government's policy is also an important factor in evaluation that is incorporated in weight to be given to each evaluation item.

10.4 Methodology of Evaluation

10.4.1 Evaluation/Scoring of Projects in Each Evaluation Item

Evaluation/ scoring of projects that compose the Master Plan is made for each of evaluation items indicated in the foregoing Section 10.3.

In each evaluation item, the projects are classified into five (5) groups, i.e., Grade I to Grade V. Then, the following scores are given to each project classified into each Grade.

Grade	Score to be given	
	Items (i) to (vii)	Items (viii) and (ix)
I	100	-100
II	80	-80
III	60	-60
IV	40	-40
V	20	-20

Negative factors of projects including two (2) evaluation items of (viii) Investment Cost (Degree of financing difficulty) and (ix) Resettlement (Adverse impact on social environment) out of nine (9) evaluation items should duly be evaluated for a fair evaluation of projects, and negative scores is given.

Value of project in each evaluation item is set out in the Study as follows:

Evaluation Items		Value of Project
(i)	Domestic water supply	Project's contribution degree in % to be calculated by "Project's domestic water supply capacity/ Basin's domestic water supply requirement in 2020".
(ii)	Industrial water supply	Project's contribution degree in % to be calculated by "Project's industrial water supply capacity/ Basin's industrial water supply requirement in 2020".
(iii)	Agricultural water supply	Project's contribution degree in % to be calculated by "Project's agricultural water supply capacity/ Basin's irrigation water supply requirement in 2020".
(iv)	Power generation	Project's annual power energy generation in GWh.
(v)	Flood control effect	Flood damage reduction amount by project in Million USD
(vi)	River maintenance flow	River discharge increase rate in the driest month by project to be calculated by "River discharge in the driest month with project/ River discharge in the driest month without project".
(vii)	Degree of poverty in river basin	Population in % below the poverty line in basin where the project belongs. (The poverty line is set at VND 1,287,000 of annual expenditure per capita)
(*viii)	Investment cost (Degree of financial difficulty)	Project investment cost in Million USD.
(*ix)	Resettlement (Adverse impact on social environment)	Number of people to be resettled by project.

Note: (*) Negative factor

The following summary table is to be prepared for the respective evaluation items, incorporating the above grade, scoring and value of projects:

Classification Criteria			Project Classification	
Grade	Range of Value	Score to be Given	Projects	Value of Projects
I	Higher than V_1	100	P1	V_{P1}
			:	
II	$V_2 - V_1$	80	P2	V_{P1}
			:	
III	$V_3 - V_2$	60	P3	V_{P1}
			:	
IV	$V_4 - V_3$	40	P4	V_{P1}
			:	
V	Lower than V_4	20	P5	V_{P1}
			:	

10.4.2 Overall Evaluation/Scoring of Projects and River Basins

Overall evaluation/scoring of projects and river basins are made as shown in Table 10.1 and in the following manner:

(1) Score of Project for Evaluation Item

The scores worked out as described in Sub-section 10.4.1.

(2) Weight on Evaluation Item Given in Each Basin

To be determined in due consideration of the government's regional development policy given in paragraph (1) of Sub-section 8.1.1, and of which main points are briefed below:

Red River Basin and Northern Key Economic Region

The Government's development policy for this region emphasizes:

i) To transform the economic and labor structures towards the industrialization, and

ii) To develop diverse cash crop agriculture by enhancing winter crop production and extending aquaculture together with staple food.

Southeast and Southern Key Economic Regions

The Government's development policy for the southeast and southern key economic regions including the Dong Nai River Basin emphasizes:

i) Promotion of industries including oil and gas exploitation, electricity, fertilizer, chemicals and accomplishment of industrial parks, export processing zones and high-tech zones, and

ii) Development of industrial crops and farm products processing industries for export.

North Central, Central Coastal Area, and Central Key Economic Regions

The Government's development policy for these regions particularly stresses:

i) To mitigate losses caused by natural calamities such as heavy floods and droughts, and

ii) To alleviate poverty in the central regions.

Weight on each evaluation item that was given in each river basin in line with the above Government's regional development policy is presented in Table 10.2.

As stated above, the Government’s regional development policy emphasizes industrialization, development of diverse cash crop agriculture and industrial crops and extending aquaculture together with staple food, etc. for northern and southern key economic regions. As such, relating high weight is given to the evaluation items of the industrial water supply and agricultural water

supply in the northern and southern key economic regions.

On the other hand, the Government's policy particularly stresses to mitigate losses caused by floods and to alleviate poverty for the central regions. Therefore, in the central regions, relatively high weight is given to the evaluation items of flood control effect and degree of poverty.

(3) Weighted Score of Project for Evaluation Item (WSPE)

WSPE = (Score of Project for Evaluation Item) x (Weight on Evaluation Item Given in Each Basin)

Sum of "WSPE" for all evaluation items represents the total score of each project and is referred for comparison of projects and determination of project implementation priority.

(4) Weight of Project in Basin (WPB)

In the case that the Master Plan is formulated with plural projects in one river basin, share of each project in the river basin should be considered in each evaluation item for evaluation of the river basin.

It is assumed that the role (or share) of each project in a basin is proportional to the evaluated value for project:

WPB= (Evaluated value for each project) / (Sum of evaluated values for all projects in a basin).

(5) Score of Basin for Evaluation Item (SBE)

SBE= (Weighted score of Project for Evaluation Item) x (Weight of Project in Basin)

Sum of the above contribution to the basin for all projects in the basin represents score of the basin in each evaluation item, which is shown in "Score of Basin for Evaluation Item" in Table 10.1.

(6) Total Score of Basin

Sum of "Score of Basin for Evaluation Item" for all the evaluation items will present the total score of each basin and will be referred for comparison of basins and determination of priority basin.

It is noted that the sum of weight of each project in a basin is equal to 1.0, and therefore a fair comparison of basins can be done with the above score of basin, i.e. the basin having more number of projects does not always result in the more advantageous score.

10.5 Evaluation by Each Item

(1) Domestic, Industrial and Agricultural Water Supply

Grading/scoring for 3 evaluation items of the domestic, industrial and agricultural water supply is made with contribution degree of each project which is calculated by (Project's water supply) / (Basin's water supply requirement in 2020).

Since projects meet demand increase from 2001 to 2020, the demand increase is considered to be the project's domestic, industrial and agricultural water supply.

Requirement of basin in 2020, demand increase of basin from 2001 to 2020, and contribution degree (%) are presented for each of domestic, industrial and agricultural water supply in Table 8.1.

It is noted that, in the case there are plural number of projects in a basin, the contribution degree is shared by each project in accordance with the effective storage of each multipurpose dam.

Contributions of the respective water supplies and result of grading/scoring made for water supply are given in Table 10.3.

(2) Power Generation and Flood Control Effect

Grading/scoring for both evaluation items of the power generation and flood control effect is made with the power energy (GWh/year) to be granted and flood damage reduction amount, respectively.

The power energy to be generated was referred to the study report conducted for each project.

The procedures to estimate the flood control effect by the proposed projects are discussed in Sub-section 9.1.5 "Economic Viability of the Projects".

Power generation and the estimated annual mean flood reduction benefit of each project as well as the grading /scoring are presented in Table 10.3.

(3) River Maintenance Flow

River maintenance flow is taken up to evaluate the improvement degree of river environment. Grading/scoring for the river maintenance flow is made with river discharge increase rate in the driest month to be calculated by river discharge in the driest month with project / river discharge in the driest month without project.

The river increase rate of each project and the result of grading /scoring made for river maintenance flow are given in Table 10.3.

(4) Degree of Poverty in the River Basin

In Vietnam, the survey on household living standard were conducted twice in the past as "The Vietnam Living Standards Surveys (VLSS) 92-93 and 97-98". The VLSS determined two poverty lines, following the World Bank method, food poverty line and general poverty line:

- The food poverty is people who do not have a level of expenditure to obtain food of 2,100 Kcal/person/day. The food poverty line 1997-1998 was VND 1,286,833.
- The general poverty is defined by adding some costs of non-food commodities to the food poverty. The general poverty line 1997-1998 was VND 1,789,871.

In the VLSS, poverty rates are available by region, not by province. Therefore, it should be assumed in the Study that poverty exists equally within the same region. Since water resources development projects greatly contribute to food production in rural areas, the food poverty rates in rural area have been taken into consideration for the evaluation of the degree of poverty in the river basins.

Since the Red and Thai Binh River Basin covers two regions of North Mountain & Midland and Red River Delta, the poverty rates are adjusted by proportion of the basin's rural population in both the regions in 1998.

The results of the surveys are summarized below:

Food Poverty Rates in Rural Area by River Basin (VLSS 1997-1998)

River Basin	Region	Food Poverty Rate in Rural Area (%)
1. Bang Giang & Ky Cung River	North Mountain and Midland	32.83
2. Red and Thai Binh River	Red River Delta and North Mountain and Midland	17.95
3. Ma River	North Central Coast	21.30
4. Ca River	North Central Coast	21.30
5. Thach Han River	North Central Coast	21.30
6. Huong River	South Central Coast	21.49
7. Vu Gia-Thu Bon River	South Central Coast	21.49
8. Tra Khuc River	South Central Coast	21.49
9. Kone River	South Central Coast	21.49
10. Ba River	South Central Coast	21.49
11. Dong Nai River	South East	3.11
12. Se San River	Central Highlands	31.48
13. Srepok River	Central Highlands	31.48
14. Cuu Long River Delta	Mekong Delta	12.81

Source: Vietnam Living Standard Survey 1997-1998, GSO
Note: The poverty rate in Red and Thai Binh River Basin was adjusted by proportion of the river basin's rural population of two regions (Red River Delta and North Mountain &Midland).

The food poverty rate of Bang Giang & Ky Cung River basin was the highest at 32.8%, followed by Se San and Srepok River basins at 31.5%. Meanwhile, that of Dong Nai River Basin is the lowest at 3.1%. The river basins in North and South Central Coast Regions are almost same on the order of 21%.

Table 10.3 presents the result of grading/scoring made for degree of poverty.

(5) Investment Cost

Investment cost is introduced in the evaluation item to evaluate the degree of financing difficulty. Investment cost was obtained from the study report conducted for each project, while investment cost was estimated where unavailable, and is summarized in Table 9.4.

The result of grading/scoring made for investment cost is shown in Table 10.3. As seen, investment cost is evaluated as the negative factor.

(6) Resettlement

Resettlement is introduced in the evaluation item for evaluating adverse impact on social environment. Number of affected people was obtained from the study report conducted for each project.

The result of grading/scoring made for resettlement is shown in Table 10.3.

(7) Weight Given in Each Evaluation Item

Weight was given to each evaluation item in due consideration of the Government's policy for each region and keen necessity of each river basin.

The Government's policy emphasizes mitigation of flood damage and alleviation of poverty in the Central region, while the policy stresses the importance of industrialization in the Northern and Southern regions. Weight given to each evaluation item in consideration of the above policy or keen necessity of each river basin are summarized below:

Item / Basin	Domestic Water Supply	Industrial Water Supply	Agricultural Water Supply	Power Gene-ration	Flood Control Effect	River Mainte-nance Flow	Degree of Poverty	Investment Cost	Resettle-ment
Bang Giang, Ky Cung	0.1	0.3	0.2	0.1	0.1	0.1	0.1	0.6	0.4
Ma	0.1	0.3	0.2	0.1	0.1	0.1	0.1	0.6	0.4
Ca	0.1	0.1	0.1	0.1	0.3	0.1	0.2	0.6	0.4
Thach Han	0.1	0.1	0.1	0.1	0.3	0.1	0.2	0.6	0.4
Huong	0.1	0.1	0.1	0.1	0.3	0.1	0.2	0.6	0.4
Vu Gia-Thu Bon	0.1	0.1	0.1	0.1	0.3	0.1	0.2	0.6	0.4
Tra Khuc	0.1	0.1	0.1	0.1	0.3	0.1	0.2	0.6	0.4
Kone	0.1	0.1	0.1	0.1	0.3	0.1	0.2	0.6	0.4
Ba	0.1	0.1	0.1	0.1	0.3	0.1	0.2	0.6	0.4
Sesan	0.1	0.3	0.2	0.1	0.1	0.1	0.1	0.6	0.4
Srepok	0.1	0.3	0.2	0.1	0.1	0.1	0.1	0.6	0.4

10.6 Overall Evaluation /Scoring of Projects and River Basins

Overall evaluation and scoring of projects and river basins is made in Table 10.4.

The overall evaluation and scoring of projects and river basins indicated the following ranking and classification.

Ranking of 11 River Basins

Ranking	River Basin	Basin's Score	Classification
1	Huong	30.3	Group A
2	Kone	24.0	
3	Sesan	20.0	
4	Ma	14.0	
5	Tra Khuc	10.0	
6	Vu Gia-Thu Bon	0.0	Group B
7	Ba	0.0	
8	Srepok	-9.84	
9	Thach Han	-14.0	Group C
10	Bang Giang and Ky Cung	-16.0	
11	Ca	-26.0	

Ranking of Projects(11 River Basins)

Ranking	Name of Basin	Name of Project	Score	Classification
1	Huong	Ta Trach	32	Group A
2	Kone	Dinh Binh	24	
3	Sesan	Dak Bla	20	
4	Ma	Cua Dat	14	
5	Tra Khuc	Nuoc Trong	10	
6	Huong	Huu Trach	6	
7	Ba	Song Ba Ha	0	
8	Vu Gia-Thu Bon	Song Cai	-8	Group B
9	Srepok	Buon Kuop-Chupong Kron	-10	
10	Srepok	Krong Buong	-12	
11	Srepok	Upper Krong Pach	-12	
12	Srepok	Upper Krong Buk	-12	
13	Thach Han	Rao Quan	-14	Group C
14	Bang Giang and Ky Cung	Ban Lai	-16	
15	Ca	Ban La	-26	
16	Vu Gia-Thu Bon	Ho Son Thanh II	-26	

Ranking is made through due evaluation on conceivable important factors such as the water shortage, flood, social and natural environment, poverty, and financing, etc. Thus, river basins and projects classified into Group A are considered to have relatively higher necessity and urgency for implementation, and can be an index for selection of the priority river basin, and / or priority projects, although the ranking is changeable in accordance with the evaluation criteria to be employed.

It is recommended, based on the study result, that the Huong and Kone River basins should be selected as the priority river basins for which the Integrated River Basin Management Plan will be formulated.

For the Huong River basin, it was agreed that the Integrated River Basin Management Plan be formulated in Phase 2-1 study. Hence, the Kone River basin is recommended to be selected as the priority basin for formulation of the Integrated River Basin Management Plan in Phase 2-2 study.

10.7 Implementation Schedule of Projects

An overall implementation program of the priority projects during from 2002 to 2020 for the 14 river basins is shown in Table 10.5.

The major facilities of projects comprise multipurpose dam, flood control facilities, irrigation and drainage facilities and domestic and industrial water supply.

As seen, several projects are planned to be completed by the nation's target year of 2020, requiring a sufficient financing and capability to manage the implementation of the projects. As such, it is noted that the implementation schedule is presented under the precondition that the said necessary arrangement can be done.

CHAPTER 11 CONCLUSIONS AND RECOMMENDATION

11.1 Conclusion

(1) A master plan for nationwide water resources development and management for 14 major river basins are formulated. The master plan consists of development components of the multipurpose dams, river improvement/dyking systems, agricultural development including irrigation/drainage systems and water supply for aquaculture and livestock, and domestic and industrial water supply in each river basin as well as the water resources management plan.

(2) Socio-economic framework plan for the target year 2020 has been set for estimation of the future water demand and flood damages. Population projections of the major provinces in the 14 river basins have been prepared for the years, 2001, 2005, 2010, 2015, and 2020 based on the results of the questionnaire survey for the related provinces.

Economic development plans of the 14 river basins in this study are basically established based on the economic development targets of provinces collected in the Study.

The established socio-economic targets are summarized below:

Socio-economic Targets

River Basin	Population (1,000)		GRDP (VND billion)		Per capita GRDP (VND 1,000)	
	2001	2020	2001	2020	2001	2020
Bang Giang & Ky Cung	1,234	1,530	3,821	17,488	3,096	11,430
Red River Delta	17,360	21,649	82,229	369,605	4,737	17,073
Red & Thai Bin outside delta	10,228	14,077	29,139	128,673	2,849	9,141
Ma	3,605	4,396	8,498	68,664	2,357	15,620
Ca	4,394	5,575	12,405	48,500	2,823	8,700
Thach Han	598	746	1,813	7,100	3,032	9,517
Huong	1,083	1,403	3,875	22,896	3,578	16,319
Vu Gia-Thu Bon	2,133	2,619	7,660	45,341	3,591	17,312
Tra Khuc	1,214	1,501	3,618	14,597	2,980	9,725
Kone	1,503	1,910	5,010	21,939	3,333	11,486
Ba	1,834	2,507	6,272	29,396	3,420	11,726
Se San	338	550	876	3,529	2,592	6,416
Srepok	1,940	3,325	5,460	22,552	2,814	6,783
Dong Nai	11,966	17,381	88,571	224,911	7,402	12,940
Cuu Long	16,832	21,509	73,071	418,777	4,341	19,470

Note: GRDP and per capita GRDP are in 2000 constant price.

(3) The water resources development plan is formulated in accordance with the major water supply requirement in terms of agricultural water demand, domestic and industrial water demand, water use for power generation and requirement for river maintenance flow, as stated in Chapter 6.

(4) Water balance analysis has been conducted. Water demand of each sector in each objective river basin, required water resources development to meet water demand and water balance situation of each basin are summarized in Section 7.4. Water resources development to meet water demand is a development of the multi-purpose dam(reservoir) at 1-2 locations in each river basin in addition to the existing reservoirs.

(5) The water resources development plan is also formulated for the flood control purpose in the Study except for the Red River/Thai Binh River basin, Dong Nai River Basin and Cuu Long River basin for which the flood control master plan have been formulated and authorized already.

Flood control measures in the formulated plan in the Study includes mainly the multi-purpose reservoir with a flood control space, as well as river improvement, dyking system and heightening of the existing dykes.

(6) The proposed major projects in each river basin are presented in Table 9.3, and its implementation cost of each river basin is summarized as follows:

	Project Cost	
River Basin	Million VND	Equivalent to Million US$
Bang Giang & KY Cung	3,580,717	238
Red & Thai Binh	-	-
Ma	11,111,689	737
Ca	12,838,780	852
Thach Han	3,419,005	227
Huong	3,717,229	247
Vu Gia-Thu Bon	14,881,578	988
Tra Khuc	2,068,870	137
Kone	3,825,525	254
Ba	10,630,547	706
Sesan	5,218,115	346
Srepok	8,787,162	583
Dong Nai	-	-
Cuu Long Delta	-	-
Total	**80,079,217**	**5,315**

(7) Economic analyses of the projects have been examined for the 11 river basins excluding 3 river basins with the authorized river basin master plan.

The results of the economic analyses showed the projects of Bang Giang & Ky Cung, Ca, Huong, Tra Khuc, Kone, Ba, and Srepok river basins have sufficient economic efficiency with EIRRs of more than 12%, which reflects the opportunity cost of capital in Vietnam. Especially the projects in the Central Coast Region such as Huong, Tra Khuc, Kone, and Ba show high economic efficiency with EIRRs of more than 15%.

Economic indicators are calculated and summarized below:

Economic Indicators

River basin projects	EIRR (%)	B/C Ratio	NPV (Million US$)
Bang Giang & Ky Cung	14.1	1.27	24.8
Ma	11.7	0.97	-7.5
Ca	12.5	1.06	16.2
Thach Han	11.2	0.91	-8.6
Huong	17.4	1.70	59.5
Vu Gia-Thu Bon	9.6	0.78	-81.8
Tra Khuc	19.8	2.12	60.5
Kone	15.4	1.40	35.3
Ba	15.6	1.44	103.9
Se San	9.9	0.79	-24.7
Srepok	13.5	1.16	33.9

Note: B/C and NPV are calculated with a discount rate of 12%.

(8) Priority river basins have been selected out of the 11 river basins excluding Red River basin, Dong Nai River basin and Cuu Long Delta. Priority projects have also selected out of projects in the said 11 river basins. The 11 river basins as well as projects have been examined in various aspects and evaluated as follows

Ranking	River Basin	Classification
1	Huong	Group A
2	Kone	
3	Sesan	
4	Ma	
5	Tra Khuc	
6	Vu Gia-Thu Bon	Group B
7	Ba	
8	Srepok	
9	Thach Han	Group C
10	Bang Giang and Ky Cung	
11	Ca	

Ranking	Name of Basin	Name of Project	Classification
1	Huong	Ta Trach	Group A
2	Kone	Dinh Binh	
3	Sesan	Dak Bla	
4	Ma	Cua Dat	
5	Tra Khuc	Nuoc Trong	
6	Huong	Huu Trach	
7	Ba	Song Ba Ha	
8	Vu Gia-Thu Bon	Song Cai	Group B
9	Srepok	Buon Kuop-Chupong Kron	
10	Srepok	Krong Buong	
11	Srepok	Upper Krong Pach	
12	Srepok	Upper Krong Buk	
13	Thach Han	Rao Quan	Group C
14	Bang Giang and Ky Cung	Ban Lai	
15	Ca	Ban La	
16	Vu Gia-Thu Bon	Ho Son Thanh II	

(9) The Huong River basin and the Kone River basin are selected as the most priority river basins and the study recommends to select the Kone River basin as the priority river basin for the Phase 2-2 study.

It is noted that the result of ranking is considered just a reference for the Government's decision, since the ranking will be changeable in accordance with conditions of evaluation.

11.2 Recommendations

(1) It is recommended that the Huong River basin and the Kone River basin are selected as the most priority river basins to be taken up for the Phase 2-1 and Phase 2-2 studies, respectively to formulate the integrated river basin management plan.

(2) (a) Flood warning and communication system

An urgent measure for flood damage mitigation, a flood warning and communication system shall be established so that the information of storm in the upstream reaches and/or waterlevel rising be informed to the related agencies and broadcast to the public. Such information will help the decision of required actions to be taken by the local government as well as evacuation activities in order to mitigate loss of lives and properties.

(b) Flood Hazard Map

Preparation of the flood hazard map is necessary with the past flood water levels thereat. To disclose the flood hazard information in terms of expected inundation area, depth, flood flow direction and evacuation is quite effective way to the local commune to aware of the flood risks in any rainy season.

(c) River Basin Management

Deforestation without intentional forestation activity will cause a problem of erosion, much sediment discharge and floods to the river course and it's downstream. Non-controlled land development for housing, industry and cultivation will create bare land and will cause problems similar to the deforestation.

In order to cope with the aforementioned issues, a river basin management plan shall be established incorporating (i) Land use management (control) and (ii) Forestation.

(d) Bank Protection

Bank erosion is a common issue of all rivers in Vietnam. Many houses and cultivated land are washed away due to bank erosion during floods every year. Bank protection works are presently provided at places by using a rigid type wet or dry masonry works for the rivers in Vietnam. But this type is very costly and once the foundation is lost due to river-bed scoring, it easily collapses.

It is recommended herein that a flexible and durable type bank protection works so called Kago Mat works be used widely for bank protection works for the rivers in Vietnam in view that it is flexible, durable, less costly, and suitable for protection of foot of the low water channel slope, even though the places where this type is applied should be studied beforehand. This type can easily follow the river-bed degradations.

(3) Appropriate actions are necessary to be taken for the proper water demand management in order to decrease excessive water consumption. Among several water saving measures, the water intake control will be the most effective way, for which the following water use management in each river basin is required:

1) Proper intake control by appropriate intake water measurement

2) Integration and coordination of water demand by an authority

The water demand schedule is to be coordinated in order that each water user could get adequate water allotment within available resources.

When drought situation is foreseen, an authority will coordinate all water users to cope with expected water deficit by adjusting water demands.

A river basin organization (an authority) which shall be independent from the water-use stakeholders will be the one to execute the use management activities.

(4) In the present situation that there are several reservoirs under the different operators and purposes including hydropower, water supply and flood control, the dam operating purpose and procedure are mutually different since that each of operators aims at the most appropriate operation in accordance with the own purposes.

However, such individual operating system is recommended to be improved to the integrated dam operating system in a main river basin under the coordination of an authorized water resources management body. Such integrated operation is particularly necessary when flood is being occurred and a river basin is in severe drought situation.

(5) Main issues in river environment aspect in the 14 river basins is river water quality which includes salinity water intrusion as well as the deterioration of water quality due to waste water discharge from domestic and industrial uses.

In order to improve such situation if any, a river environment management plan will include the following measure and activities:

(i) To establish / strengthen / maintain waste water management system

(ii) Monitoring system of river water quality

(iii) Management (control) system of required minimum river flow.

(6) The authorized river basin organization (the authority) shall be strengthened (Red River, Dong Nai River and Cuu Long River basins where RBOs have established; Huong River basin where the Board of management has established) or established early (for the other river basins) in the respective river basins to implement necessary water resources management. The following actions will be required for the strengthening and establishment of the organization:

1) To identify individually key issues involved in the respective river basins,

2) To determine the primary tasks of the organization in accordance with the present situation of the respective river basins including issues and requirement,

3) To formulate a specific action plan to execute the tasks, and

4) To undertake capacity building of the organization and training of the personnel.

(7) It is recommended that some specialists be dispatched with the following categories and tasks:

(a) Water resources management and coordination

Effective utilization of water resources through appropriate coordination between different sectors concerned, and between the central government and the local governments and authorities.

(b) Capacity building in the engineering and the institutional aspects

Establishment of a river basin organization (RBO or authority) has been recommended at earliest time in the southern central coastal area, aiming at appropriate water resources management in a basin including the water use management, the flood control management and river environmental management.

For smooth establishment of an organization or strengthening of the existing RBOs having been established recently, institutional capacity building of the organization as well as engineering capacity building of the personnel are to be executed by some experienced specialists.

Tables

Table 1.1 Members of the Study Team and Advisory Committee

	Name	Work Assignment
(1)	**Study Team**	
1	Shigeo OHNUMA /Norizo FUJITA	Team Leader
2	Masaki ITO	Deputy Team Leader/Water Resources Development and management
3	Toshikatsu IMAI	River Engineer(1)
4	Takuji KONO	River Engineer(2)
5	A.M.SUTMULLER /T.H.op ten NOORT	Hydrologist (1)
6	Akihiro MATSUDA	Hydrologist (2)
7	Hideo OHHATA	Sabo Planner
8	C.C. SEKINGTON	Disaster Prevention Planner
9	Tomoyasu KITA	Facility Design Engineer
10	Takuji KONO	Dam Design Engineer
11	Akihiro TAKATO	Construction Planner/Cost Estimate
12	Noritoshi MAEHARA	Economist
13	I.B.VAN BON / C.C. SEKINGTON	Water Use Planner
14	Takatoshi YAMAZAKI	Agronomist
15	Naoto MORIOKA	Agro-economist
16	Kuninobu NODA	Irrigation Planner (1)
17	J.S.T.FEKKES	Irrigation Planner (2)
18	Norihiko INOUE	Social Environmentalist
19	Hitoshi SAKAI	Natural Environmentalist
20	Kenichi SHIBATA	Satellite Image Analyst (1)
21	Chiyo KIGASAWA	Satellite Image Analyst (2)
22	Pucai YANG	Geologist /Geo-mechanical Engineer
23	Takaharu YAMAGUCHI	Coordinator
24	Toshio TSUKANO / Takashi HASHIMOTO	Interpreter
(2)	**Advisory Committee**	
1	Tsuneo UESAKA	Chairman
2	Yoshihiro ISHIBASHI / Yoshinao MORI	Member
3	Hiroshi OKUDAIRA	Member
4	Akira NIWA	Member
5	Mutsuya MORI	Member

Table 1.2 Members of the Steering Committee

	Name	Position
Chairman / Member	Nguyen Dinh Thinh	Vice Minister of MARD
Member	Pham Xuan Su	Director of Water Resources and Hydraulic Works Department, MARD
Member	To Trung Nghia	Director of Institute of Water Resources Planning, MARD
Member	Bui Nguyen Hong	Vice Director of Flood Control and Dyke Management Department, MARD
Member	Tran Dinh Hoi	Vice Director of Institute of Water Resources Research, MARD
Member	Vu Nang Dung	Director of National Institute for Agriculture Planning and Projection
Member	Nguyen Hong Toan	General Secretary of Vietnam National Mekong Committee, MARD
Member	Le Kien	Representative of Ministry of Planning and Investment

Table 2.1 The Area of Natural Forest and Special-use Forest within Ecoregions

Ecoregion	Total area (ha)	Natural Forest (ha/%)		Special-use Forest (ha/%)	
1. Northern Indochina Subtropical Forests	11,427,170	2,599,543	22.7	719,818	6.3
2. Gulf of Tonkin Mangroves	221,108	29,051	13.1	14,295	6.5
3. Red River Fresh-water Swamp Forests	1,080,826	9,219	0.9	5,067	0.5
4. Northern Vietnam Coastal Forests	2,324,576	233,624	10.1	87,037	3.7
5. North-east Indochina Montane Forests	557,750	452,749	81.2	134,984	24.2
6. Annamite Range Moist Forests	1,123,768	589,676	52.5	185,936	16.5
7. Kon Tum Montane Forests	2,683,772	1,495,318	55.7	169,488	6.3
8. Southern Vietnam Coastal Forests	3,287,860	732,075	22.3	135,006	4.1
9. Cardomom Mountains Moist Forests	54,697	30,839	56.4	12,639	23.1
10. Da Lat Montane Forests	1,902,517	1,165,439	61.3	98,646	5.2
11. Eastern Indochina Pine Forests	444,197	311,837	70.2	90,431	20.4
12. Eastern Indochina Moist Forests	2,874,009	789,213	27.5	65,756	2.3
13. Tonle Sap-Mekong Peatswamp Forests	1,287,320	2,805	0.2	43,221	3.4
14. Tonle Sap Fresh-water Swamp Forests	964,719	0	0.0	0	0.0
15. Gulf of Thailand Mangroves	1,523,190	2,062	0.1	7,146	0.5
16. Central Indochina Dry Forests	676,994	492,570	72.8	98,358	14.5
Total	**32,434,473**	**8,936,020**	**27.6**	**1,867,828**	**5.8**

Source: Expanding the Protected Areas Network in Vietnam for the 21 Century, 1999

Table 2.2 The Number of Precious Species of Terrestrial Fauna by Status of Preciousness Listed in Red Data Book of Vietnam

Ecoregion	Area(km^2)	Endangered	Vulnerable	Threatened	Rare	Undetermined*	Total	Total No per 1,000 km^2
1. Bang Giang & Ky Cung Rivers	10,640	9	26	18	23	2	78	7.3
2. Red and Thai Binh Rivers	87,840	31	54	33	50	1	169	1.9
3. Ma River	20,190	11	19	17	8	0	55	2.7
4. Ca River	20,460	16	32	25	17	0	90	4.4
5. Thach Han River	2,550	11	13	24	12	0	60	23.5
6. Huong River	3,300	9	13	25	12	0	59	17.9
7. Vu Gia-Thu Bon River	11,510	10	11	20	13	0	54	4.7
8. Tra Khuc River	5,200	5	6	18	10	0	39	7.5
9. Kone River	3,640	6	7	17	10	0	40	11.0
10. Ba River	14,030	17	26	29	20	0	92	6.6
11. Dong Nai River	35,410	24	36	31	31	0	122	3.4
12. Sesan River	11,530	15	25	19	14	0	73	6.3
13. Srepok River	12,030	19	22	16	17	0	74	6.2
14. Cuu Long River	37,870	8	23	17	19	0	67	1.8

*Status of preciousness in not determined.

Source: Red Data Book of Vietnam, Volume 1. Animals, 2000, MOSTE

Table 2.3 The Number of Precious Species of Terrestrial Flora by Status of Preciousness Listed in Red Data Book of Vietnam

Ecoregion	Area(km^2)	Endangered	Vulnerable	Threatened	Rare	Undetermined*	Total	Total No. per 1,000 km^2
1. Bang Giang & Ky Cung Rive	10,640	5	14	9	18	10	56	5.3
2. Red and Thai Binh Rivers	87,840	18	33	36	85	18	190	2.2
3. Ma River	20,190	2	5	6	4	8	25	1.2
4. Ca River	20,460	1	11	6	4	12	34	1.7
5. Thach Han River	2,550	2	4	4	7	5	22	8.6
6. Huong River	3,300	1	6	7	10	8	32	9.7
7. Vu Gia-Thu Bon River	11,510	2	11	9	10	10	42	3.6
8. Tra Khuc River	5,200	1	4	4	4	4	17	3.3
9. Kone River	3,640	1	3	4	4	4	16	4.4
10. Ba River	14,030	4	15	4	19	11	53	3.8
11. Dong Nai River	35,410	4	22	14	45	14	99	2.8
12. Sesan River	11,530	5	16	3	15	11	50	4.3
13. Srepok River	12,030	3	9	3	8	12	35	2.9
14. Cuu Long River	37,870	1	6	7	9	6	29	0.8

*Status of preciousness in not determined.

Source: Red Data Book of Vietnam, Volume 2. Plants, 2000, MOSTE

Table 2.4 Number and Surface Area of Nature Conservation Areas in 14 River Basins

Unit for surface area : ha

River Basin	National Park		Nature Reserve*		CHES**		Wetland		Total		
	No of Sites	Surface Area	No of Sites	Surface Area	No of Sit	Surface Area	No of Sites	Surface Area	No of Site	Surface Area	Coverage (%)
1. Bang Giang & Ky Cung Rive	0	0	3	23,640	3	5,928	0	0	6	29,568	2.78
2. Red and Thai Binh Rivers	5	89,270	20	590,300	9	24,487	5	97,320	39	801,377	9.12
3. Ma River	1	16,634	3	75,852	3	900	0	0	7	93,386	4.63
4. Ca River	0	0	3	211,409	1	600	0	0	4	212,009	10.36
5. Thach Han River	0	0	1	40,526	0	0	0	0	1	40,526	15.89
6. Huong River	1	22,031	1	33,900	1	14,547	2	20,000	5	90,478	27.42
7. Vu Gia-Thu Bon River	0	0	1	43,327	3	12,750	1	3,600	5	59,677	5.18
8. Tra Khuc River	0	0	0	0	1	5,000	1	3,600	2	8,600	1.65
9. Kone River	0	0	0	0	1	2,616	4	8,300	5	10,916	3.00
10. Ba River	0	0	3	66,290	1	8,876	7	11,570	11	86,736	6.18
11. Dong Nai River	1	38,900	5	79,603	3	4,940	6	45,892	15	169,335	4.78
12. Sesan River	0	0	2	99,711	0	0	1	6,450	3	106,161	9.21
13. Srepok River	1	58,200	4	111,631	1	6,000	3	198	9	176,029	14.63
14. Cuu Long River	1	7,612	7	27,642	1	3,495	7	30,313	16	69,062	1.82
Total	**10**	**232,647**	**53**	**1,403,831**	**28**	**90,139**	**37**	**227,243**	**128**	**1,953,860**	**7.07**

* There is one Man and the Biosphere Reserve within a Nature Reserve in Mekong River basin.

** CHES: Cultural and Historical Environmental Site

Source: Map of Nature Conservation Areas of Vietnam, April, 2001, NEA-MOSTE

Table 2.5 Summary of Current Conditions of Water Quality and Salinity Intrusion

No	River	Surface Water Quality	Salinity Intrusion
1	**Bang Giang & Ky Cung Rivers**	Slightly polluted with organics. No heavy metal contamination.	Estimated to be no problem because of located in an inland area.
2	**Red and Thai Binh Rivers**	Recorded relatively high concentrations of ammonia and nitrite, implying pollution by fertilizers and livestock.	No data available.
3	**Ma River**	No data available.	Intrudes up to 15 - 20 km from river mouth. Ham Rong water supply intake is likely to be suffering from salinity intrusion if no measure is made.
4	**Ca River**	River water shows turbid appearance and slight pollution with organics. No heavy metal contamination.	Intrudes up to 20 km in dry season. In wet season, salinity intrusion is not significant.
5	**Thach Han River**	Not polluted and river water is usable for domestic and industrial use.	Intrudes up to Dai Loc or Thach Han weir in dry seasons. Thirty five (35) ha of crop lands are affected by salinity intrusion.
6	**Huong River**	No organic pollution in the river, except for canals draining into it near Hue city. Recognized a problem of high coliform concentration.	Intrudes up to Moi Bridge located about 18 km from river mouth. Thao Long Barrage is now being constructed, which will alleviate the problem of salinity intrusion.
7	**Vu Gia - Thu Bon River**	Slightly polluted with organics. River water shows turbid appearance. Pollution form industry and wastewater is not seen.	The biggest problem of the river is salinity intrusion. Intrudes up to 15km inland.
8	**Tra Khuc River**	No organic pollution. BOD_5 concentration is relatively low. But polluted near drainage from Quang Ngai sugar mill.	Suffering from salinity intrusion, especially in Tra Bong downstream area, covering a 1,275 – ha cultivated land.
9	**Kone River**	There is a problem of pollution with mercury from gold mining.	Salinity intrusion is the biggest problem of the river, affecting aquaculture production.
10	**Ba River**	No data available. Water quality condition is estimated similar to those rivers draining to the East Sea.	Intrudes up to Ban Trach Bridge of Highway No.1.
11	**Dong Nai River**	River water shows turbid appearance and slight pollution with organics.	Salinity intrusion is serious problem in lowland area of the basin, lasting during all the dry season. Salinity intrudes as far as 70-80 km from river mouth at its maximum extent.
12	**Sesan River**	No organic pollution in the river. Recorded relatively high concentrations of ammonia, implying pollution by fertilizers and livestock.	Estimated to be no problem because of located in an inland area.
13	**Srepok River**	Estimated to be similar situation to that of Sesan river, because of located next to it in an inland area under the similar natural conditions.	Estimated to be no problem because of located in an inland area.
14	**Cuu Long River**	River water shows turbid appearance but no pollution with organics or heavy metal contamination, either.	Salinity intrusion is seen over the lowland area of Cuu Long river delta, intrudes up to more than 50 km from river mouth.

Source : "River Basin Profiles," World Bank. : Documents of IWRP

Table 2.6 Land Use Status in 14 River Basin (Provincial Basis)

River Basin	Unit	Total	Land Use Category				
			Agriculture Land	Forest Land	Specially Used Land	Residential Land	Unused Land
I. Bang Giang & Ky Cung River	thou. ha	1499.6	133.7	540.8	18.6	7.1	799.4
	%	-	8.9%	36.1%	1.2%	0.5%	53.3%
II. Red and Thai Binh River	thou. ha	10075.5	2029.2	3289.1	477.1	158.5	4121.6
	%	-	20.1%	32.6%	4.7%	1.6%	40.9%
(1) Red River Delta	*thou. ha*	*1478.8*	*857.6*	*119.0*	*233.0*	*91.3*	*177.9*
	%	*-*	*58.0%*	*8.0%*	*15.8%*	*6.2%*	*12.0%*
(2) Other	*thou. ha*	*8596.7*	*1171.6*	*3170.1*	*244.1*	*67.2*	*3943.7*
	%	*-*	*13.6%*	*36.9%*	*2.8%*	*0.8%*	*45.9%*
III. Ma River	thou. ha	1110.6	239.8	430.4	67.1	19.3	354.0
	%	-	21.6%	38.8%	6.0%	1.7%	31.9%
IV. Ca River	thou. ha	2254.3	294.1	926.0	104.9	21.7	907.6
	%	-	13.0%	41.1%	4.7%	1.0%	40.3%
V. Thach Han River	thou. ha	474.6	68.9	149.8	18.3	3.6	234.0
	%	-	14.5%	31.6%	3.9%	0.8%	49.3%
VI. Huong River	thou. ha	505.4	59.0	224.5	21.1	4.0	196.8
	%	-	11.7%	44.4%	4.2%	0.8%	38.9%
VII. Vu Gia-Thu Bon River	thou. ha	1166.4	123.0	481.8	63.5	9.8	488.3
	%	-	10.5%	41.3%	5.4%	0.8%	41.9%
VIII Tra Khuc River	thou. ha	513.5	99.1	144.2	20.8	6.6	242.8
	%	-	19.3%	28.1%	4.1%	1.3%	47.3%
IX. Kone River	thou. ha	602.6	116.9	193.7	29.4	6.4	256.2
	%	-	19.4%	32.1%	4.9%	1.1%	42.5%
X. Ba River	thou. ha	2054.1	500.3	916.7	69.1	14.1	553.9
	%	-	24.4%	44.6%	3.4%	0.7%	27.0%
XI. Dong Nai River	thou. ha	4365.5	2104.1	1497.5	248.3	69.1	446.5
	%	-	48.2%	34.3%	5.7%	1.6%	10.2%
XII. Sesan River	thou. ha	961.5	92.3	606.7	12.3	3.3	246.9
	%	-	9.6%	63.1%	1.3%	0.3%	25.7%
XIII. Srepok River	thou. ha	1960.0	524.9	1017.9	51.9	13.6	351.7
	%	-	26.8%	51.9%	2.6%	0.7%	17.9%
XIV. Cuu Long River	thou. ha	3522.1	2638.9	292.4	194.9	90.2	305.7
	%	-	74.9%	8.3%	5.5%	2.6%	8.7%
Total	thou. ha	**31065.7**	**9024.2**	**10711.5**	**1397.3**	**427.3**	**9505.4**
	%	**-**	**29.0%**	**34.5%**	**4.5%**	**1.4%**	**30.6%**

Source: Socio-economic Statistical Data of 61 Provinces and Cities in Vietnam, 2001, GSO