CHAPTER 1 SCOPE OF THE STUDY

1.1 Background of the Study

Water resources in Vietnam are characterized by severe water shortage in the dry season and, on the contrary, serious flood damages in the rainy season.

The water shortage in the dry season causes not only irrigation domestic and industrial water supply problems but also serious water pollution and saline water intrusion. Flood damages in the rainy season including agricultural production loss, human lives and important assets in densely populated urban areas are being accelerated due to recent remarkable urbanization.

As such, solution of the problems is of keen necessity of Vietnam, and several water resources development projects comprising mainly multipurpose dam based projects have been proposed by each province. However, since the proposed projects are not integrated as a basin-wide water resources development, the Ministry of Agriculture and Rural Development (MARD) has difficulty to determine the implementation sequence for these water resources developments. In order to overcome these constraints, the Government of Vietnam has come to conclusion that an integrated approach to water resources development and management is unavoidable, and had a strong intention to carry out a study on nationwide water resources development and management.

In order to materialize the study, the Government of Vietnam requested to the Government of Japan the technical assistance of the Study on Nationwide Water Resources Development and Management Master Plan (the Study). In response to request of the Government of Vietnam, the Government of Japan decided to conduct the Study within the general framework of the technical cooperation between the Government of Japan and the Government of Vietnam signed on October 20, 1998.

1.2 Objectives of the Study

The objectives of the Study are:

(1) To formulate a master plan for nationwide water resources development and management,

(2) To conduct a feasibility study for selected priority projects, and

(3) To pursue technology transfer to counterpart personnel in the course of the Study.

1.3 Study Area

The Study covers the following 14 major river basins:

1) Bang Giang and Ky Cung River basin
2) Red and Thai Binh River basin
3) Ma River basin
4) Ca River basin
5) Thach Han River basin
6) Huong River basin
7) Vu Gia-Thu Bon River basin
8) Tra Khuc River basin
9) Kone River basin
10) Ba River basin
11) Sesan River basin
12) Srepok River basin
13) Dong Nai River basin
14) Cuu Long River basin

Location map of the above 14 major river basins is shown in Figure 1.1

1.4 Scope of the Study

The Study has been undertaken in the following manner in the two phases:

Phase I : [Basic Study and Formulation of Master Plan]

a) Formulation of a master plan for nationwide water resources development and management in 14 major river basins

Phase II : [Formulation of Integrated River Basin Management Plan(s) for the Selected River Basin(s) and Feasibility Study on Priority Projects]

a) Formulation of an integrated river basin management plan for the Huong River basin (Phase 2-1)
b) Formulation of an integrated river basin management plan for the priority river basin selected from 14 river basins (Kone River basin, Phase 2-2)
c) Feasibility study for the priority projects to be selected from the priority river basin (Phase 2-3)

1.5 Implementation Organization

Institute of Water Resources Planning, Ministry of Agriculture and Rural Development(MARD) act as the counterpart body to the JICA Study Team and also as the coordinating body in relation with other governmental and non-governmental organizations concerned in Vietnam for the smooth implementation of the Study.

The JICA Study Team is headed by the Team Leader who is responsible for maintaining a close liaison with the MARD, JICA and agencies concerned. He is also responsible for planning activities and monitoring the progress of the entire study for ensuring its timely and efficient completion. The members of the Study Team and the members of the Advisory Committee are presented in Table 1.1

The Steering Committee was organized in February 2002, chaired by the Vice Minister of MARD. The Committee consists of MARD, Ministry of Planning and Investment, Vietnam National Mekong Committee and Peoples Committee related to the Study. The members of the Steering Committee are presented in Table 1.2

1.6 Study Schedule and Activities

(1) General Schedule

Phase I : Basic Study and Formulation of Master Plan during a period from September 2001 to July 2002,

Phase II-1 : Formulation of Integrated River Basin Management Plan for the Huong River Basin, during a period of October 2001 to July 2002, including

1) 1st Works in Vietnam
2) 1st Works in Japan.

Phase II-2, II-3 :

Formulation of Integrated River Basin Management Plan for the Selected River Basin(Kone River basin) and Feasibility Study on Priority Projects during a period of August 2002 to September 2003, including

1) 2nd Works in Vietnam
2) 2nd Works in Japan
3) 3rd Works in Vietnam
4) 3rd Works in Japan.

(2) Activities in the Works in Vietnam

In accordance with the objectives of the Study and schedule, the works in Vietnam were conducted in October 2001 through March 2002 for Phase I, and from August 2002 through March 2003 for the Phase II study. The third works in Vietnam was conducted from July to August 2003 for the discussion on the Final Report.

As a part of the works in Vietnam, the following field survey works have been carried out on sub-contract basis:

Phase I

(i) Inventory survey works

Period	:	November 2001 to January 2002
Scope of Works	:	Collection of meteo-hydrological data of 14 major river basins and for succeeding F/S as well as topographic maps

(ii) Hydro-meteorological observation

Period	:	December 2001 to March 2002
Scope of Works	:	Installation of hydro-meteorological stations and their observation in Ma River and Kone River basins, respectively

Phase II-1

(iii) Hydro-meteorological observation

Period	:	December 2001 to March 2002
Scope of Works	:	Installation of hydro-meteorological station and their observation in Huong River basin

(iv) Topographical survey

Period	:	December 2001 to February 2002
Scope of Works	:	River survey in the Huong River, Lagoon survey and Sea survey

(v) Environmental Impact Assessment (EIA)

Period	:	December 2001 to March 2002
Scope of Works	:	EIA study in the Huong River basin

Phase II-2

(vi) Hydro-meteorological observation

Period	:	August 2002 to March 2003
Scope of Works	:	Hydro-meteorological observation in Kone River basin

(vii) River survey

Period	:	September to November 2002
Scope of Works	:	River cross section survey along the Kone River

(viii) Initial Environmental Examination (IEE)

Period	:	August to November 2002
Scope of Works	:	IEE in the Kone and Ha Thanh River basins

Phase II-3

(ix) Topographic survey

Period	:	December 2002 to January 2003
Scope of Works	:	Topographic survey including mesh survey and digitizing topographic maps for Dinh Binh dam site and Van Phong weir site

(x) Environmental Impact Assessment (EIA)

Period	:	December 2002 to March 2003
Scope of Works	:	EIA on the priority projects in the Kone River basin

(xi) Geological investigation

Period	:	December 2002 to February 2003
Scope of Works	:	Geological investigation in Dinh Binh dam site, Van Phong weir site and river improvement area in the Kone River basin

(3) Workshop, Technical Transfer Seminar and Presentation Seminar

Workshops and Seminars were held in the course of the Study in the following manner:

(a) Workshop

	Workshop	Subject	Date
(i)	Inception Workshop	Inception Report	November 2001
(ii)	1st Workshop	Progress Report (2)	March 2002
(iii)	2nd Workshop	Progress Report (3)	December 2002
(iv)	3rd Workshop	Interim Report(2)	March 2003

(b) Technical transfer seminar

	Seminar	Subject	Date
(i)	1st T.T.Seminar	- Formulation of flood control plan in the study - Application of computer software in runoff analysis - Application of computer software in irrigation planning/management - Alternative study in Huong River basin	September 2002
(ii)	2nd T.T.Seminar	- Achievement of Water Resources Development in Japan - River Plans in Japan - Planning Concept and Methodology on Multi-purpose Dam - Planning Methodology of Flood Control - Irrigation Planning for Better Operation and Maintenance	August 2003

(c) Presentation seminar

	Seminar	Subject	Date
(i)	Presentation Seminar	- Achievement of Water Resources Development in Japan - Recommendation and Overall Outcome of the Study - Formulated Water Resources Development and Management Plan - Planning Methodology of Flood Control - Formulated Agricultural Development Plan in the Study	August 2003

(4) Reports

In the course of the study, the following reports have been prepared and submitted to MARD to date:

	Report	Main Subject	Submission
(i)	Inception Report	Scope of works, work plan and work schedule	October 2001
(ii)	Progress Report (1)	Work progress of Phase I and Phase II-1	January 2002
(iii)	Progress Report (2)	Work progress of the formulation of the master plan for nationwide water resources development and management in 14 major river basins as well as the formulation of the integrated river basin management plan for the Huong River basin (Phase 2-1)	March 2002
(iv)	Interim Report (1)	Master plan for nationwide water resources development and management in 14 major river basins as well as the integrated river basin management plan for the Huong River basin (Phase 2-1)	August 2002
(v)	Progress Report (3)	Work progress on the formulation of the integrated river basin management plan for the Kone River basin (Phase 2-2)	December 2002
(vi)	Interim Report (2)	The integrated river basin management plan for the Kone River basin (Phase 2-2) and the Feasibility study for the priority projects in the Kone River basin (Phase 2-3)	March 2003
(vii)	Draft Final Report	All results of the Study	July 2003
(viii)	Final Report	All results of the Study incorporating the comments for the Draft Final Report	September 2003

This is the Main Report, as a part of the Final Report, covering the Master Plan for nationwide water resources development and management in 14 major river basins(Phase I).

CHAPTER 2 PRESENT CONDITION OF THE STUDY AREA

2.1 River and Flood Control

2.1.1 Objective 14 Rivers

The following 14 rivers are the objective rivers in the Study and Figure 2.1 shows the general locations of those rivers:

	Rivers		Catchment Area (C.A. in Vietnam), km^2
1)	Bang Giang River	:	11,250
2)	Red and Thai Binh River	:	169,000 (87,840)
3)	Ma River	:	31,060 (20,190)
4)	Ca River	:	29,850 (20,460)
5)	Thach Han River	:	2,550
6)	Huong River	:	3,300
7)	Vu Gia – Thu Bon River	:	11,510
8)	Tra Khuc River	:	5,200
9)	Kone River	:	3,640 (incld. Ha Thanh River)
10)	Ba River	:	14,030
11)	Sesan River	:	11,530
12)	Srepok River	:	12,030
13)	Dong Nai River	:	39,580 (35,410)
14)	Cuu Long	:	795,000 (37,870)

2.1.2 Bang Giang River Basin

(1) River

The Bang Giang River originates in China, flowing down to the southeast entering into Vietnam and flows into China again to the southeast. The Bang Giang River, in Vietnam, flows down along the mountainous and narrow valleys and flows into China, and accordingly does not face the East Sea in Vietnam. The river system of the Bang Giang and Ky Cung River basin is shown in Figure 2.1.

The catchment area of the Bang Giang and Ky Cung River basin is 11,250 km^2. The length of Bang Giang River is 165 km and that of the Ky Cung River is 250 km.

The longitudinal profiles of the Bang Giang River and the Ky Cung River are shown in Figure 2.3.

In the Bang Giang River basin, there is no major flood control structure even though there are many small reservoirs for irrigation purposes.

(2) Flood Control

It is reported that floods of short duration, but causing significant damage, are a threat to economic activities in the basin. More than 75% of the annual rainfall occurs between May and September. Flow discharges in the rainy season can be as high as 10 - 15 times of those in the dry season. It is also reported that in the Ky Cung River basin, heavy rains in July regularly inundate 10,000 ha of agricultural land every year.

At present, there is no flood control infrastructure in the Bang Giang and Ky Cung River basin. Accordingly, heavy rains in July regularly inundate 10,000 ha of agricultural land in the Ky Cung River basin every year.

2.1.3 Red and Thai Binh River Basin

(1) River

The Red River originates in China, flowing down to the southeast entering into Vietnam and finally discharges into the East Sea. The river, before entering into Vietnam, is called Nguyen River, changes the name to the Red River in Vietnam, flows down in the plain area between the Hoang Lien Son Range and Con Voi Range to the southeast, flows in the midst of the capital city of Vietnam, Hanoi, flows down in the middle of the red river delta, and finally discharges into the East Sea.

The Thai Binh River originates in Vietnam to the north of Hanoi, flows to the southeast, finally discharges into the East Sea. Just on the south of Hanoi, the Duong River bifurcates from the Red River and joins the Thai Binh River to the east. To the north of the estuary of the Thai Binh River, there exists the famous port of Hai Phong.

The river system of the Red and Thai Binh River basin is shown in Figure 2.4.

The catchment area of the Red and Thai Binh River is 169,000 km^2 in total and the catchment area in Vietnam is 87,840 km^2. The area of the delta is totally in Vietnam and the area is estimated at 17,000 km^2. The length of Red River in Vietnam is 328 km.

The Da River has the catchment area of 52,600 km^2 and the river length is about 980 km, some 45 % thereof in China and 55 % in Vietnam. The Lo River has the catchment area of 39,000 km^2 of which 22,748 km^2 is in Vietnam. The length of the Lo River is 470 km.

The longitudinal profile of the Red River is shown in Figure 2.5.

(2) Flood Control

The causes of big floods in the Red River Delta are monsoons such as tropical monsoon from the North Indian Ocean, equator monsoon from the south and monsoon from the Pacific Ocean, and climate turbulences such as front, tornado, storm, tropical storm, circulation of remote storm. The combination of these monsoons and climate turbulences cause heavy rain over the basins of the Da, the Thao, the Lo, the Cau, the Thuong, and the Luc Nam Rivers. These, in turn, cause big floods in the Red River Basin. Thus caused big floods bring about the failure of dike, the erosion of riverbanks, the destruction of bank protection works, and the deposition of sediment at unwanted locations including irrigation canals.

During the 20th century there have been over 20 major breaches in the dike system. In Hanoi, Alarm Level 2 (10.50m) was exceeded on 78 occasions in the period of 1902 to 1993, and Alarm Level 3 (11.50m) was exceeded on 27 occasions with the maximum water level of 14.7m to 14.8m being caused by the August 1971 flood that was almost leading to the failure of dike but the water level fell to 14.1m and the casualty of dike failure did not happen. (It is noted that the above maximum water levels of 14.7m to 14.8m are ones under the original state of dyke without dyke breaching.)

In Hanoi City, the parapet wall along the Red River is constructed with the crown elevation of 15.05m.

The existing reservoirs and dyke system will protect the Red River delta against 1971 flood (estimated at 0.8% probability) but the existing dyke system needs the everlasting maintenance.

In the delta, a comprehensive system of dykes, with a total length of about 3,000 km, has been established over a period of around one thousand years to protect the low-lying land, its infrastructure and people. These dykes are deteriorating and require continual rehabilitation to maintain their effectiveness, resulting in high maintenance costs.

Under these situations, the Government of Vietnam has recently approved the new flood control strategy to protect the Red River Delta as follows:

The design discharge of flood control of the present system is 37,800 m^3/s at Hanoi and the design high-water level is 13.4 m at Hanoi. The flood control facilities are the existing dikes and the existing reservoirs in the basin. The design scale of the present flood control system is 0.8 % (1/125 return period).

The design discharge of flood control of the medium term is 42,600 m^3/s at Hanoi and the design high-water level is the same with that of the present system. The flood control facilities are the existing dikes, the existing reservoirs and the additional reservoir of Dai Thi. The design scale of flood control of the medium term is 0.4% (1/250 return period).

The design discharge of flood control of the long term-1 is 48,500 m^3/s at Hanoi and the design high-water level is the same with that of the present system. The flood control facilities are the existing dikes, the existing reservoirs and the additional reservoirs of Dai Thi and Son La with the flood control volume of 7,000 MCM of the Da River. The design scale of flood control of the long term-1 is 0.2 % (1/500 return period).

The design discharge of flood control of the long term-2 is more than 48,500 m^3/s at Hanoi and the design high-water level is the same with that of the present system. The flood control facilities are the existing dikes, the existing reservoirs and the additional reservoirs of Dai Thi and Son La with the flood control volume of more than 7,000 MCM of the Da River. The design scale of flood control of the long term-1 is less than 0.2 % (1/500 return period).

2.1.4 Ma River Basin

(1) River

Ma River basin is located in the northwest region of Vietnam bordering Laos on the west. The upstream basin is located in Vietnam, the middle basin is located in Laos, and the downstream basin is located in Vietnam. Accordingly the Ma River is an international river.

The catchment area of the Ma River basin is 31,060 km^2 of which the catchment area in Vietnam is 20,190 km^2. The Chu River is a main tributary of the Ma River in the basin, located in the downstream area.

The catchment area of the Chu River is 7,500 km^2 of which 65% are located in Laos and 95% of the Chu River's catchment area is mountains. The Chu River joins the Ma River at Giang confluence at 26 km upstream of Ma River mouth. The river system of the Ma River basin is shown in Figure 2.6.

The longitudinal profile of the Ma River is shown in Figure 2.7.

(2) Flood Control

The present dyke system of the Ma River in the downstream reaches of the confluence with the Chu River has the discharge carrying capacity of about 7,000 m^3/s. But this is estimated based on the bankfull discharge without any freeboard.

In 1962, the breach of the dike system of the Ma River occurred and the basin experienced the serious flooding. But since then no breach of the dike system was experienced in the Ma River. On the other hand, the Buoi River, a tributary of the Ma River on the left side, have experienced the breach of the dike system in 1984, 1985 and 1996.

The breach of the dike system of the Buoi River in 1996 occurred on July 25. On this occasion, breach of the dike occurred at 8 locations. This breach influenced the agricultural land of 1,143 ha, population of 23,200 and 3,900 families. After the breach of the dike, the elevation of the dike on the left side of the Buoi River was raised by 2.23m. The scale of the objective flood of the Buoi River is 10%, 10-year probable flood.

The Chu River, a main tributary of the Ma River, is provided with dike system for a return period of 50 years. The Chu river dyke system has been improved for protection against the historical flood water level of 13.92m at Xuan Khanh that occurred in 1962 (probability = 2.5%).

Currently the average height of the Chu River is some 7 to 8m, and 10 m at some locations. However, this height is lower than the required flood protection height by 0.4 m to 3.0 m.

Along the Chu River's dyke there are many bank protection works, groins and sluices under the dike, which were built 50-60 years ago and are seriously degraded. Accordingly dike safety is menaced in the rainy season.

2.1.5 Ca River Basin

(1) River

The Ca River originates in Laos, flowing down to the southeast direction, enters into Vietnam, flows still to the southeast direction along the Pu Lai Leng Range, flows on the southern side of Vinh City, the capital city of Nghe An province, and finally flows into the East Sea. The Ca River is called as the Lam River in the Ha Tinh province, the southern side province of the Nghe An province.

The catchment area of the Ca River is 29,850 km^2 in total, of which that in Vietnam is 20,460 km^2. The length of the Ca River is 544 km, of which 400 km is in Vietnam. The river system of the Ca River basin is shown in Figure 2.8.

The longitudinal profile of the Ca River is shown in Figure 2.9.

(2) Flood Control

There do not exist any large-scale multipurpose reservoir in the upstream basin. Accordingly the narrow and steep slope basin brings about an abrupt flood in the downstream and causes serious damage to the agriculture sector that is the major basin economic activities.

Since there is no large-scale multipurpose reservoir, the salinity along the Ca River in the downstream basin reaches up to 20 km in March. Any additional withdrawal of river water worsens the salinity intrusion situation.

Recent flooding occurred in 1954, 1978 and 1988. These flooding occurred due to the breach of dike system. At the location where the railway crosses the Ca River, the dike was breached in 1954. In 1954, 1973, 1974, 1978, 1988, and 1996, piping phenomena reaching the inland occurred. In 1954, the piping continued for 16 days and finally the dike was breached. But in 1978, the piping continued for 9 days and the breach of dike did not take place.

From the flooding experience in 1978, the banquette of the dike was constructed on the inland side.

The present design discharge of the Ca River here is 10,500 m^3/s and the occurrence probability is 1.25 %, the return period of 80 years.

2.1.6 Thach Han River Basin

(1) River

The Thach Han River (another name is the Quang Tri River) originates in the Truong Son mountain range at an elevation of some 800m. Its length is 125 km, and the catchment area is 2,550 km^2. The major tributaries of the Thac Han River are the Rao Quan River and the Cam Lo River.

The Cam Lo River originates on the southern slope of Mr. Thu Lu with the elevation of about 1,150 m and joins the Thac Han River at 10 km upstream of the river mouth. On the other hand, the Rao Quan River originates with the low elevation of only about 600 m and joins the Thach Han River at about 86 km upstream of the river mouth. The river system of the Thach Han River basin is shown in Figure 2.10. The longitudinal profile of the Thach Han River is shown in Figure 2.11.

(2) Flood Control

The dike system of the Thac Han River is provided on both sides of the Thac Han River in the downstream reaches for protection against early floods. But due to the big run off discharges in the major flood season, the dike is overtopped every year.

The Thach Han River basin is habitually suffering from flooding and riverbank erosion. In 1999 flood, 56 people were killed by the flood. Some 661 km local road was influenced and more than 100 bridges and culverts were damaged. Landslide caused was 551,300 m^3. The paddy field of about 9,000 ha was influenced and many irrigation facilities were damaged.

Other than the flooding damages, the river basin is also suffering from riverbank erosion and blown sands from the sand dune to agricultural land. Some 30,000 ha agricultural land is suffering from blown sands from sand dune along the sea.

Against the blown sands, windbreak forest has been constructed between the paddy field and the sand dune along the sea. But this is a part of the whole project.

In the Thac Han River basin, flood control in the major flood season is not aimed at. The dike with 3-sided revetment for early flood control seems to have been functioning well. The present river in the downstream reaches has the discharge carrying capacity of about 2,000 m^3/s at bankfull capacity. The river bank erosion is one of the major issues in this river basin. Bank revetment works have bee constructed only partly due to financial issues.

2.1.7 Huong River Basin

(1) River

The Ta Trach River originates on the northern slope of Bach Ma Range in Vietnam, flows to the north direction, changes the name to the Huong River after the joining of the Huu Trach River in the upstream of Hue City, flows in the midst of Hue City, and after the joining of the Bo River in the downstream of Hue City, discharges into the Tam Giang Lagoon that is the biggest lagoon in Vietnam. The lagoon has two openings to the East Sea, namely the Thuan An Mouth on the north and Tu Hien Mouth on the south. The other major river in the Huong River basin that flows into the lagoon is the Truoi River. The river system of the Huong River basin is shown in Figure 2.12.

The catchment area and the length of the Huong River is 3,300 km^2 and 102 km including the Ta Trach River, respectively. The longitudinal profile of the Huong River is shown in Figure 2.13.

Tão Long Barrage is located about 4 km upstream of the river-mouth of the Huong River. This was constructed in 1973 for the purpose to stop the salinity intrusion along the Huong River. But since the barrage was so much deteriorated, the reconstruction of the barrage was planned and a new barrage is now under construction at about 40 m downstream of the present location.

(2) Flood Control

Along the lagoon, the sea dike has been constructed with the crown elevation of about 1.2 m above mean sea level to protect the agricultural land from wave intrusion. Along the Huong River, there exist no river dike system to protect the Hue City and the agricultural land from flooding.

The downstream basin of the Huong River has been flooded 3 to 7 times every year. In Hue City, there exist the world cultural heritages of Nguyen Dynasty. The heritages are wooden buildings and easy to be damaged when inundated. During a flood, sea dikes are often overtopped by about 1.5 m and collapse.

The present river reaches along the Hue City have the discharge carrying capacity of about 2,000 m^3/s at bankful capacity.

The flood in November 1999 seriously damaged this basin. The flood water level in 1999 flood in Hue City reached to 5.90 m. This flood was the biggest one since the flood in 1953. Recorded 24-hour rainfall on November 2, 1999 was 1,422mm. The flood water level in 1999 flood in Hue City reached to 5.90 m. The number of death and missing due to this flood was 373. The number of houses washed away by the flood was 25,000. The total damage was estimated at US$ 160 million. The sand bar of the lagoon was washed away at 3 locations. Accordingly the number of the opening of the lagoon to the sea became 5 together with the previous 2 openings. The new 2 openings were closed by the littoral drift afterwards. The remaining one opening located at Hoa Duan district was closed by the construction of road by using concrete blocks by the local government for restoring the local traffic since there exist many settlements on the sand bar.

2.1.8 Vu Gia - Thu Bon River Basin

(1) River

The Thu Bon River, in the upstream basin called as the Tranh River, originates on the northern slope of Truong Son Range in Vietnam, flows down to the north and the northeast, flows in the midst of Hoi An City, and finally pours into the East Sea.

The Vu Gia River, one of the major rivers in the basin, called as the Bung River in the upstream basin, originates on the eastern slope of the Truong Son Range, flows down to the east, joins the Cai River on the way, and finally discharges into the East Sea in Da Nang City.

The Thu Bon River and the Vu Gia River is connected each other about 36 km upstream of the river-mouth of the Thu Bon River. The river system of the Vu Gia - Thu Bon River basin is shown in Figure 2.14.

The catchment area of the Vu Gia - Thu Bon River is estimated at 11,510 km^2 including that of the Tranh River. The length of the Thu Bon River is 201 km including that of the Tranh River. The longitudinal profile of the Thu Bon River is shown in Figure 2.15.

(2) Flood Control

Since the slope of the Thu Bon River is thus very steep, the flood water level rises very quickly by about a few meters per hour. Due to this, in the small and steep slope basin, many lives and properties are often lost due to floods.

The riverbank erosion is serious during flood and the sediment load is much. The Thu Bon River often changes the river course during flood and often changes the location of the river-mouth since the sediment load is much. Houses and agricultural land along the river are lost at places due to those.

In 1996, 99 people were killed by the flood and the property damage was about 220 billion VND, while 1n 1998, 79 people were killed and the property damage was about 564 billion VND.

The flood in November 1999 damaged the Thu Bon River basin very seriously. Inundation depth on the National Road No.1 was more than 1.5 m and the inundation continued for about 3 to 7 days. The total inundation area was about 1,000 km^2.

In the rainy season of 2000, the situation of connection between the Vugia River and the Thu Bon River changed. Previously 20 % of the Vugia River went toward the Thu Bon River through the connection channel and the remaining 80 % of the river discharge went toward Da Nang City. But due to the erosion activities of the river, a new channel was formed just on the upstream side of the connection channel from the Vugia River to the Thu Bon River, forcing one village on the river side to resettle to another place. Now 80 % of the river discharge of the Vugia River goes toward the Thu Bon River and the remaining 20 % of the Vugia River goes toward Da Nang City. Due to this, the river discharge of the river to Da Nang City decreased so much in a dry season causing a serious problem of salinity intrusion. Due to this salinity intrusion, the municipal water intake is seriously influenced and the irrigation water supply for 10,000 ha is now in short.

Even though this river basin has been suffering from serious flood damage in the past, there has not been prepared any flood control plan in this river basin. The present river reaches in the downstream reaches of the Vu Gia River has the discharge carrying capacity of about 1,000 m^3/s at bankfull capacity and that of the Thu Bon River is estimated at about 600 m^3/s.

2.1.9 Tra Khuc River Basin

(1) River

The Tra Khuc River originates on the northern slope of Truong Son Range with an elevation of some 1,200 m, flows to the north in the hilly and mountainous area, changes the river course to the east in the plain after the joining of the Dak Re River, and discharges to the East Sea near Quang Ngai City. The river system of the Tra Khuc River basin is shown in Figure 2.16.

The catchment area of the Tra Khuc River is 5,200 km^2. The length of the Tra Khuc River is 126 km. The longitudinal profile of the Tra Khuc River is shown in Figure 2.17.

(2) Flood Control

At present, there are no any flood control structures except the dike system around Quang Ngai City. The discharge carrying capacity of the Tra Khuc River in its downstream reaches is estimated at about 4,000 m^3/s at bankfull capacity.

In 1964, there was a breach of dike system of Tra Khuc River and Quang Ngai City was completely inundated. The inundation water level reached up to 8.82 m.

In the alluvial plains, since there is no dike system, the plains have been often inundated. In October 1986, the plain around the river confluence area was inundated up to the elevation of 15.19 m. In 1996, 7,410 ha of agricultural land was inundated with the water level of 20.2 m. It is calculated that the flood water level may reach up to 19.12m and 6,590 ha of fields will go under water with a flood of 10 % occurrence probability.

Other than flooding, the riverbank erosion is another serious issue in this river basin. Due to landslide and riverbank erosion, about 500 ha agricultural land has been lost so far. Accordingly the protection of agricultural land is the most concerned issue for Quang Ngai Province.

2.1.10 Kone River Basin

(1) River

The Kone River originates on the eastern slope of Truong Son Range, flows down to the southeastern direction, changes the river course to the east in Tay Son, and discharges to the East Sea in the north of Quy Nhon. The river system of the Kone River basin is shown in Figure 2.18. The longitudinal profile of the Kone River is shown in Figure 2.19.

The catchment area of the Kone River is 3,640 km^2 and the river length is 160 km.

(2) Flood Control

The existing discharge carrying capacity of the Kone River in the downstream reaches is estimated at about 500 m^3/s only at bankfull capacity.

Floods often hit the Binh Dinh Province, causing loss of production and living conditions. In 1999 flood, 73 people were killed, 21 people were injured, 50,000 houses were affected, schools and clinics were inundated, 12,203 ha of paddy field were damaged, and crops, domestic animals and fertilizers were destroyed. Earth dams, gates, weirs and other irrigation works were destroyed, and canals, embankments, bridges and roads were damaged. Fishing boats sunk, shrimp ponds were destroyed, and stores of shrimps, fish and salt were swept away. Total loss is estimated at US$22 million.

2.1.11 Ba River Basin

(1) River

The Ba River originates on the southeastern slope of the Truong Son Range in Vietnam, flows down to the southern direction, changes the direction to the southeastern direction after the joining of the Ia A Yun River at A Yun Pa, changes the river direction to the east after the joining of the Hinh River from the south, and pours into the East Sea near Tuy Hoa. The river system of the Ba River basin is shown in Figure 2.20.

The catchment area of the Ba River is 14,030 km^2. The length of the Ba River is 392 km being the longest among those of the rivers in the central region of Vietnam. The longitudinal profile of the Ba River is shown in Figure 2.21.

(2) Flood Control

In the Ba River basin, there are no substantial flood control measures. The present discharge carrying capacity of the Ba River is estimated at about 11,000 m^3/s at bankfull capacity.

The countermeasures for the farmers are adaptation of cropping patterns and harvesting before the flood season. Therefore agricultural flood damage in the area downstream of the Dong Cam Project is rather minor.

On average, big floods occur every two years, submerging up to 60% of total cultivated area in the lower basin to a depth of 1-3 meters and hundreds of houses with nearly 300,000 people.

It is reported that the flood damage due to No. 8 typhoon in 2001 was about 400 billion VND. In 1993, the flood peak discharge was 21,000 m^3/s. Tuy Hoa City is inundated every year.

2.1.12 Sesan River Basin

(1) River

The Sesan River originates on the southwest slope of Truong Son Range in Vietnam with the elevation of some 1,500 m, flows down to the south, gradually changes the river course to the southwest and enters into Cambodia. In Cambodia, the river joins the Cuu Long River and flows down back to Vietnam.

The elevation of the river is still higher than 100 m in Vietnam and accordingly enters into Cambodia before forming the alluvial plain. The catchment area of the Sesan River is 11,530 km^2 including that in Cambodia. The length of the Sesan River in Vietnam is 252 km and 270 km in Cambodia. The river system of the Sesan River basin is shown in Figure 2.22. The longitudinal profile of the Sesan River is shown in Figure 2.23.

(2) Flood Control

The majority of floods in the Sesan River basin are due to the summer monsoon. These floods occur in the period of July to October. But the biggest flood in the river basin occurred due to a typhoon. The biggest flood at the Kontum hydrological gauging station along the Krome River, one of the major tributaries of the Se San River occurred in October 1972. The instantaneous peak flow of this flood was estimated at about 4,000 m^3/s. The second biggest flood occurred in November 1996. The instantaneous peak flow was 3,620 m^3/s at Kontum station. This flood was also due to a typhoon. According to the probability analysis on flood peak discharge at Kontum station conducted by PECC1 and SWECO in 1997, the probable flood with the return period of 100 years is 5,895 m^3/s.

Since the Sesan River basin is located in the hilly and mountainous area, the flooding damage seems to be limited. Accordingly no flood control plan has been prepared so far yet.

2.1.13 Srepok River Basin

(1) River

The Srepok River originates on the western slope of Lam Vien Plateau in Vietnam, flows down to the east, changes the direction to the north in the middle of the basin, and flows out of Vietnam to Cambodia to the west direction. The river joins the Cuu

Long River in Cambodia and finally flows into Vietnam again in the Cuu Long Delta. The river system of the Srepok River basin is shown in Figure 2.24.

The catchment area of the Srepok River basin is 12,030 km^2 including that in Cambodia. The length of the Sre Pok River is 556 km, of which that in Vietnam is 291 km and that in Cambodia is 265 km. The longitudinal profile of the Srepok River is shown in Figure 2.25.

(2) Flood Control

Due to dense forest cover and soil retention in the upper basin, the heavy runoffs occur nearly two months after the rainy season, and then there is no serious flooding problem at present. But due to slash-and-burn farming in the upper basin, the forest is gradually being lost and the erosion in the basin is in progress.

2.1.14 Dong Nai River Basin

(1) River

The Dong Nai River, as the Da Nhim River in the upstream reaches, originates on the southern slope of Mt. Hon Giao in Lam Vien Plateau, flows down to the south-southwest direction, further flows to the west and south in hilly areas, flows close to Ho Chi Minh City after the joining of the Saigon River, and finally pours into the East Sea.

The major tributaries of the Dong Nai River are the West Vam Co River, the East Vam Co River, the Saigon River, the Be River, and the La Nga River.

The West Vam Co River and the East Vam Co River originate in Cambodia, flow down to the southeast to Vietnam, join each other in the south of Ho Chi Minh City, and join the Dong Nai River 21.0 km upstream of the river-mouth of the Dong Nai River.

The Saigon River, having a catchment area slightly in Cambodia, flows down to the south and southeast, flows along the Ho Chi Minh City in its downstream reaches, joins the Dong Nai River 59.5 km upstream of the river-mouth of the Dong Nai River. The catchment area of the Saigon River at the confluence with the Dong Nai River is 4,717 km^2.

The Be River, having a catchment area also slightly in Cambodia, flows down to the southwest and the south, joins the Dong Nai River 150.5 km upstream of the river-mouth of the Dong Nai River. The catchment area of the Be River is 7,427 km^2.

The La Nga River originates in Vietnam, flows down to the southwest, joins the Dong Nai River 198.2 km upstream of the river-mouth of the Dong Nai River. The river system of the Dong Nai River basin is shown in Figure 2.26.

The catchment area of the Dong Nai River is 35,410 km^2 including that in Cambodia.

The longitudinal slope of the Dong Nai River in the upstream reaches is very steep with an average slope of about 1/230 or steeper. But in the reaches downstream of the Tri An reservoir, the longitudinal slope of the Dong Nai River is very gentle with an average slope of about 1/4,500. The river length of the Dong Nai River is some 570 km. The longitudinal profile of the Dong Nai River is shown in Figure 2.27.

(2) Flooding

The Dong Nai River basin experienced serious floods in the year 1932, 1952, 1964 and 1978. The flood in 1952 is considered as the recorded largest flood in the past. Since 1978, there has occurred no serious flood in the Dong Nai River basin.

The flood in 1952 occurred on October 18-24. The flood peak discharge is reported to have been about 12,000 m^3/s at Bien Hoa with a return period of 80 to 100 years. The flood was caused by a typhoon with the long-lasting rainfall over a wide area.

The flood in 1978 occurred in the period from the end of August to the beginning of September. The return period of the 1978-flood is estimated to have been about 10 years. Presently there is no serious flooding problem around Ho Chi Minh Ciy except drainage congestion thanks to the existing large scale reservoirs located in the upstream basin. Other than flooding around Ho Chi Min City, major flood prone areas in the Dong Nai River basin are as follows:

Cat Tien and Ta Lai areas	:	Upper reaches of the Dong Nai River
Tanh Linh and Duc Linh areas	:	La Nga River
Tan Uyen and Vinh An areas	:	Middle reaches of the Dong Nai River
Long Thanh, Thu Duc and Nhon Trach areas	:	Lower reaches of the Dong Nai River

2.1.15 Cuu Long River Basin

(1) River

The Cuu Long River originates in Tay Tang Mountains in Tibet, flows down to the south through Myanmar, Thailand, Laos, and Cambodia, flows into Vietnam, and finally pours into the East Sea in Vietnam.

The Cuu Long River, after entering Cambodia, joins the Tonle Sap River just upstream of Phnom Penh City, and bifurcates into the Bassac River and the Cuu Long River. The both rivers enter into Vietnam and are connected by the Vam Nao River in the upstream reaches of Long Xuyen. The Bassac River further flows down to the south-southeast, flows through Can Tho City, and diverges to a few branches and all branches discharge to the East Sea. The Cuu Long River flows down to the southeast, also diverges to a few branches near Vinh Long City, and all branches discharge to the East Sea.

The catchment area of the Cuu Long River is 795,000 km^2 and that in Vietnam is 37,870 km^2. The length of the Cuu Long River is 4,200 km.

(2) Flood Control

More than 25 % of the Cuu Long River Delta in Vietnam is flooded every year for about 6 months of rainy season. Northern delta is inundated due to floods from the river and southern delta is inundated due to drainage congestion since the area is a low-lying area.

The inundation of the delta spreads very widely, is un-controllable, and extends over a long period of time. Accordingly the life style and the copping pattern in the delta have been adjusted to this situation. Although there exist the urgent and great necessity to protect the life and properties in the delta from flooding, there exists the desire to accept flooding to certain extent in the delta to reclaim the low-lying area with sediment and to bring into the nutriment for fresh and brackish water fishery.

2.2 Domestic and Industrial Water Use

2.2.1 Domestic Water Use

Domestic water supply is understood to cover for the water needs of individual households, institutions (e.g. offices, hospitals and schools), and commercial enterprises (e.g. business, hotels, restaurants and shops). Water demands from industries are discussed separately.

There is an important difference between water demand and water use. Water demand is what people would use if they have unrestricted access to a well functioning water system of a particular standard. Water use is what people actually consume, which can be much lower than water demand because of limited supply from an over-stretched and poor functioning water supply system. Water demands are usually prescribed by government regulations, which reflect the governments ideas and aspirations to what level of service they want to serve the population. These guidelines form a basis for design of new or extended water supply systems and can be used for water demand forecast. But one should first assess how the current situation compares to these guidelines and how likely it is that at some point in the future a situation occurs, which meets the guidelines, if at all.

The guideline values for domestic water demand are set by the Ministry of Construction (MOC) and are as follows:

Urban water demand = 150 lpcd (liter/capita/day)

Rural water demand = 45 lpcd (liter/capita/day)

It should be understood that urban water demand of 150 lpcd fits the situation in modern Europe where every house has flushed toilets and where water consuming appliances as washing machines and dish washers are commonly used. On the other hand, modern countries such as the United States and Japan have much higher per capita water demands. The per capita demand in the United States is reported to be more than 200 lpcd. In Japan, the national average water demand was reported to be

323 lpcd. This is certainly not the case in Vietnam yet. For example; per capita water use in the Netherlands is 127-litre per capita per day, in the United Kingdom water consumption of metered connections were found to be 136 litre per capita per day, (source: Ofwat on data 1998-1999). For the Vietnamese situation a guideline value of 150 lpcd is quite generous and plans to increase this value to 200 lpcd is not going to improve hygiene or quality of service but will in the short term only encourage waste and losses. The main consideration is whether the pace of development is going to surpass the guideline values and people start to use more water than was prescribed. The whole question of water demand forecast simply starts at an assessment of the present situation.

2.2.2 Industrial Water Use

The existing situation need to be established, followed by a projection based on existing plans and trends. The existing industrial demands were obtained from the following sources:

- Interviews with the DARD departments and Water Supply Companies in some of the river basins.
- The World Bank's report on Vietnam Water Resources Assistance Programme – Central Coast River Basins, November 17, 2000.
- Typical Industrial Water Use derived from Municipal and Industrial Water Supply and Disposal, D. Boggs, ADB, May 1995.
- Various other reports and papers.

It was found that almost all of the industrial activity in the country takes place in the Red River Basin and around Ho Chi Minh City. The Dong Nai river basin, with Ho Chi Minh City at the centre, accounts for approximately 85% of all industrial production. The industrial centres in the North adding another 10%. The rest of the country only represents approximately 5% of the countries industrial output.

2.3 River Environment

2.3.1 Natural Environment

(1) Flora and Fauna

According to the statistic study results done by National Centre for Natural Science and Technology Institute of Geography, flora in Vietnam has 10,192 species, 2,298 genera, 285 families, distributed as following under the term of phyla:

- Psilotophyta: 1 family, 1 genus, and 1 species
- Equisetophyta: 1 family, 1 genus, and 2 species
- Isoetophyta: 1 family, 1 genus, and 1 species
- Lycopodiophyta: 2 family, 4 genus, and 54 species
- Polypodiophyta: 28 family, 138 genus, and 632 species
- Gymnospermae: 8 family, 22 genus, and 52 species

- Angiospermae: 244 family, 2131 genus, and 9450 species

According to “Some Basic Characteristics of Vietnam Flora, 1999”, the abundance of Vietnam flora is thought to attribute to many reasons. Situated in monsoon tropic climate area, much sunny, rainy, humid, Vietnam has many advantageous factors for the existence and the development of many tropical species. On the other hand, due to the complicated topographical conditions, flora in Vietnam also has lots of representative specific traits of near tropical and temperate climatic belt.

Vietnam also has a wealth of fauna varieties. According to “Vietnamese Studies,” 1998, there are some 276 species of mammals, 828 species of birds, 180 species of reptiles, 80 species of amphibians, 472 species of freshwater fish, some 2,038 species of sea fish, and thousands of invertebrate species. These species have a great number of local varieties; some endemic ones, which have a scientific and economic value. Vietnam is one of the parts of the world that has not yet been studied systematically.

(2) Ecological Units

Several bio-geographical classifications, by which a country or a region is divided into smaller units, are proposed in Vietnam. In the “Biodiversity Action Plan,” 1994, terrestrial bio-geographical units (bio-units) were proposed, by which Vietnam was divided into 11 bio-units on the basis of plant species composition and distribution of landforms and climates. Wikramanayake *et al*. (1997) provided 16 ecological regions, or *Ecoregions*, within Vietnam, on which a focus for conservation planning is increasingly being used.

Based on the 16 Eco-regions, the 14 river basins are composed as follows:

Ecoregions of 14 River Basins

River Basin	Ecoregions contained*															
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1. Bang Giang & Ky Cung Rivers	X															
2. Red and Thai Binh Rivers	X	X	X	X												
3. Ma River	X			X												
4. Ca River	X			X	X	X										
5. Thach Han River				X		X										
6. Huong River				X		X	X									
7. Thu Bon River				X			X									
8. Tra Khuc River				X			X	X								
9. Kone River							X	X	X							
10. Ba River							X	X	X	X						
11. Dong Nai River								X		X	X	X	X	X	X	
12. Sesan River							X		X							
13. Srepok River									X	X	X					X
14. Cuu Long River													X	X	X	

*Note: The *Ecoregions* contained are as follows.

1. Northern Indochina Subtropical Forests

9. Cardomom Mountains Moist Forests

2. Gulf of Tonkin Mangroves
3. Red River Fresh-water Swamp Forests
4. Northern Vietnam Coastal Forests
5. North-east Indochina Montane Forests
6. Annamite Range Moist Forests
7. Kon Tum Montane Forests
8. Southern Vietnam Coastal Forests
10. Da Lat Montane Forests
11. Eastern Indochina Pine Forests
12. Eastern Indochina Moist Forests
13. Tonle Sap-Mekong Peatswamp Forests
14. Tonle Sap Fresh-water Swamp Forests
15. Gulf of Thailand Mangroves
16. Central Indochina Dry Forests

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

Table 2.1 shows the area of natural forests and Special-use Forests within each *Ecoregion*. *Ecoregions* vary in size and so do the area of natural forests. The coverage rates of natural forests and that of Special-use Forests within *Ecoregions* give the basis for further protection, meaning that the smaller the coverage rates, the higher the vulnerability.

Three *Ecoregions* in Cuu Long Delta Area, namely, Tonle Sap-Mekong Peatswamp Forests, Tonle Sap Fresh-water Swamp Forests and Gulf of Thailand Mongroves, have almost no remaining natural forest cover. Four *Eecoregions* in northern Vietnam, namely, Northern Indochina Subtropical Forests, Gulf of Tonkin Mangroves, Red River Fresh-water Swamp Forests and Northern Vietnam Coastal Forests, have low coverage rates of both natural forest and Special-use Forests within each *Ecoregion*. This indicates that the forests in Red River Delta and its surrounding area have been modified by human activities and today need an enough consideration of environmental protection. Two *Ecoregions* in southern Vietnam, namely, Southern Vietnam Coastal Forests and Eastern Indochina Moist Forests, have also relatively low coverage rates, suggesting the high priority for environmental consideration.

(3) Precious Species

During 1990-92, the Institute of Ecology and Biological Resources, National Center of Natural Sciences and Technology in collaboration with concerned branches, has determined precious animal species for bringing them into the Red Data Book of Vietnam, for a basis for drafting protection measures of rare, valuable genetic resources of the tropical forests. The book was revised in 2000 and a total of 359 species are listed in the "Red Data Book of Vietnam, Volume 1. Animals," including 80 animals, 81 birds, 54 reptiles and amphibians, 70 fishes and 74 invertebrates as the following table:

Red Book Categories in Vietnam (Fauna)

Taxa/ Category	Endangered	Vulnerable	Threatened	Rare	Undetermined	Total
Mammals	34	25	0	21	0	80
Birds	13	6	32	30	0	81
Reptiles/Amphibians	8	19	16	11	0	54
Fishes	7	20	12	29	2	70
Invertebrates	9	22	9	31	3	74
Total	**71**	**92**	**69**	**122**	**6**	**359**

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

Table 2.2 shows the number of precious species of terrestrial fauna by status of preciousness listed in the book in 14 river basins. For the comparison by basin, the number of precious species per unit area of 1,000 km^2 was calculated in the right-most column, indicating a kind of density of precious species identified in each basin. The table revealed that Red and Thai Binh Rivers basin holds the most in number followed by the Dong Nai River basin and Ba River basin. As for the density of the precious species identified, the Thach Han River basin has the highest figure, followed by Huong River basin. The reason for this seems to attribute to that these two basins have relatively small surface areas and yet have a variety of natural environment consisting of coastal region, hilly land and high mountains of Truong Son Mountain Range. Accordingly, this has enriched the biodiversity and contains a lot of precious species. This fact, combined with high pressure of development along the coastal lands, might have brought about the high density of vulnerable species.

"Red Data Book of Vietnam, Volume 2. Plants" lists a total of 344 species of precious plants, including higher-ranked plants and fungi. The number of precious species of terrestrial flora by status of preciousness in 14 river basins is illustrated in Table 2.3.

In comparison by basin, it was revealed that the Huong river basin has the highest density of precious species per unit area of 1,000 km^2, followed by the Thach Han river basin. This fact that these two river basins scored the highest density is in line with that for terrestrial fauna as mentioned above. It is, therefore, estimated that the reason for the high density attribute to the same conditions that these two basins have relatively small surface areas and yet have a variety of natural environment consisting of coastal region, hilly land and high mountains. On the other hand, relatively larger basins such as Red and Thai Binh rivers basin, Cuu Long river basin and Dong Nai river basin have smaller density of precious species. This is apparently because these basins do not increase its biodiversity in proportion to the increase of the whole surface area.

(4) Nature Conservation Areas

There are several categories with regard to the nature conservation areas: Protected Area, Wetlands, and those related to International Convention such as Ramsar Sites and World Heritage Sites. In this respect, Protected Areas are composed of Special-use Forests, Marine Protected Areas and Man and the Biosphere Reserves. In addition, there are other areas that are not designated as aforementioned areas, including Natural Forests, Watershed Protection Forests and so on. In this study, environmental consideration is to be placed on all the areas mentioned above.

Table 2.4 shows the number and surface areas of Nature Conservation Areas in the 14 river basins. Marine Protected Areas is not included in the table because all the Marine Protected Areas are located outside the 14 river basins.

Amongst the basins, Red and Thai Binh Rivers Basin leads both in number (39 in total) and the surface area (801,377 ha in total), followed by Cuu Long River basin with the total number of 16, and by Dong Nai River basin with that of 15. As for the total area, Ca River follows the Red and Thai Binh Rivers Basin with the total surface area of 212,009 ha, followed by the Srepok River basin (176,029 ha). Regarding the coverage rate of nature conservation areas for the total surface area (total surface area of provinces in each river basin), Huong River basin leads with 27.42%, followed by Thach Han River basin (15.89%) and Sesan River basin (14.63%).

High coverage rate of nature conservation areas literally means that these basins are covered by environmentally valuable area with a high surface occupation rate. On the contrary, the river basin with low coverage rate indicates that these basins are covered by the valuable areas with a low percentage. This, however, does not mean that little attention should be paid to the basins, but the feature of the valuable area should be considered for its proper conservation. Those basins with high coverage rate or large area of conservation areas should be given sufficient considerations as a whole.

Regarding the nature conservation areas related to International Convention, there is one Ramsar Site, Xuan Thuy, located in Red River basin at present. In addition, there are four World Heritages: Ha Long bay adjacent to the Red River Delta, Hue City in Huong River basin, Hoi An ancient town and My Son sanctuary in Vu Gia-Thu Bon River basin (Quang Nam province).

(5) River Water Quality and Salinity Intrusion

River water quality and salinity intrusion of the 14 rivers are summarized in Table 2.5.

a) River water quality

As a whole, there is no seriously polluted river with organic materials or heavy metals, except for some reaches near highly populated cities or industrial estates. Remarkable and significant features of water quality of these rivers are that they show the turbid appearance, or high suspended solids, and relatively high concentrations of Biochemical Oxygen Demand (BOD_5) or

Chemical Oxygen Demand (COD), exceeding the Limitation Value A (usable as a source for domestic water supply with appropriate treatment) of Surface Water Quality Standard of Vietnam (TCVN 5942, 1995), although they are consistent with the Limitation Value B (usable as a source for the purposes other than domestic water supply).

Suspended Solids (SS) recorded more than 30 mg/l in most rivers, BOD_5 and COD were more than 4 mg/l and 10 mg/l, respectively, in many cases. Nevertheless, Dissolved Oxygen (DO) recorded high concentration of more than 6 mg/l (the Limitation Value A), in most cases. This indicates that the river water is suitable for aquatic organisms and for the use of aquaculture.

There are several rivers whose Nitrogen as Ammonia ($N\text{-}NH_4^+$), Nitrate ($N\text{-}NO_3^-$) and/or Nitrite ($N\text{-}NO_2^-$) exceeded the Limitation Value A, including the Cau and Nhue rivers in the Hong-Thai Binh river basin. This implies that these rivers are affected by fertilizers containing nitrogen and/or by effluent from livestock and/or poultry and so on.

b) Salinity intrusion

Salinity intrusion is a serious problem of major rivers of Vietnam in dry seasons, especially in the southern area. It can intrude up to deeper than 50 km in such rivers as the Dong Nai and the Cuu Long. Low land areas near river mouth are suffering from the high salinity concentration in not only surface water but also groundwater, which affects to domestic water use and irrigation over crop lands seriously. It lasts during dry season for several months, or sometimes, up to 10 months.

In the central area of Vietnam, the salinity intrusion is also a serious problem but limited to 15-20km reach from river mouth in general. In several river basins, there are remedial measures having been made to prevent the saline water intrusion or expansion through river channels, including constructions of a barrage or a weir, and establishments of an embankment along the river channel. A dilution from other fresh water source was also done to alleviate salinity problem.

In the northern area of Vietnam, i.e. Red, Ma, and Ca rivers, the salinity intrusion is not serious problem in comparison with those in southern and central areas, due to the topographical characteristics and the elevation at the river mouths.

2.3.2 Social Environment

(1) Inland Waterways

Vietnam has 2,360 rivers with a total length of 41,900 km. Of this, the total navigable inland waterways are about 19,500 km, and about 8,000 km is currently used as navigation.

The main inland waterways comprise about 2,500 km in the north mainly in Red River system and 4,500 km in the south mainly in Cuu Long River system including Dong Nai and Saigon rivers. The central government (Ministry of Transport and Communication; MOTC) manages 6,231 km waterways of Red and Cuu Long River systems. In the two delta areas, almost 50% of total goods is transported by ship/vessel using rivers or sea. Especially in Cuu Long delta, the inland waterway plays an important role between Ho Chi Minh city and Can Tho, accounting for about 80% of total cargo. Regarding the other river systems, inland waterway transport is also playing an important role but limited to local freight transport.

According to MOTC, almost 90% of total passengers move through road in whole nation. Inland waterway plays a marginal role in passenger transport, and is also limited to the delta areas in terms of inter-provincial movement of passengers.

Although the existing conditions of waterways and their activities are not clearly known due to the lack of data and information, the following seems to be major problems:

- Seasonal fluctuation in depth in the river system
- Sedimentation in the river system and insufficiency of dredging work even though regularly required

(2) Forestry

The land use status and forest area in 14 River basins are shown in Tables 2.6 and 2.7, respectively.

The average rate of forest cover in 14 basins is 34.5 %. Among these, it is noted that the forest area is estimated only at about 8 % in Cuu Long River basin and in Red River Delta. On the other hand, more than half of area is covered by the forest in Sesan and Srepok River basins. Regarding the other basins, the rate of forest cover in their areas is approximate 30~45 %.

In Ba, Sesan, and Srepok River basins, most of their forest areas are classified as natural forests. Among the natural forests in their basins, more than half of areas is designated as productive forest. This suggests that the natural forests in their basins would be suffered from the exploitation for timber, firewood or other forestry product by the local communities and people, and that the degradation of their watershed would be caused. Besides, it is noted that the afforested rate in total forest lands in Red River Delta and in Cuu Long River basin are 54 % and 72 % respectively.

(3) Fishery

The data and information on inland fishery activities are very limited for respective river basin. The followings are based on the available information.

Table 2.8 shows the estimated amount of fish captured in the fresh water by regions. The southern Vietnam is ranked as the region which has the highest catching capacity, followed by the northern Vietnam. According to the Ministry of Fisheries, the amount of fish in south is captured mainly in Cuu Long and Dong Nai River basins, whereas that in north is mainly in Red & Thai Binh Rivers basin. The catch of fresh-water fish in central and highlands area accounts for less than 5 % of whole catch, respectively.

The feature on the inland aquaculture is shown in Table 2.9. Among 14 river basins, Cuu Long River basin leads the most production of inland aquaculture, followed by Dong Nai River basin and by Red & Thai Binh Rivers basin.

(4) Health Condition (Water-borne Diseases)

The morbidity and mortality of major water-borne diseases in 14 river basins are summarized as shown in Table 2.10, based on the available data on health condition.

In Thach Han River basin, the morbidity of dengue fever and malaria is considerably high, whereas one in Ma River basin is low. In Sesan River basin, the morbidity of malaria is much higher than that of any other basins.

Regarding the dengue fever, the morbidity in Ba River and Vu Gia-Thu Bon Rivers basins is somewhat high compared with other basins, while one in Red and Thai Binh Rivers and Ma River basins is much low.

Besides, in Cuu Long and Dong Nai River Basins, the morbidity of diarrhea/gastroenteritis of infectious origin are relatively high. This might mean that the accessibility of safe water in these basins is poor.

(5) Cultural and Historical Heritage

Among 33 Cultural and Historical Environmental Sites (CHESs) in all Vietnam, which are designated as one of nature conservation areas, 28 CHESs are located in 14 river basins on provincial basis. The number and surface area of CHESs in each river basin are summarized in Table 2.4.

The greater part of 28 CHESs is designated in order to protect their historical sites or unique landscapes. The details on each site are shown in Table 2.11.

Besides, there are 4 Would Heritage Sites adopted by UNESCO in Vietnam as mentioned before.

(6) Ethnic Minorities

Kinh group is a majority population in the country. About 86 % of all Vietnamese falls into this group. In addition to the Kinh, there is a range of ethnic minorities, particularly in the highlands, and these minorities are classified into 53 groups except Kinh.

Kinh is much predominant in the greater part of 14 river basins. However, the portion of Kinh group is low in Ban Giang & Ky Cung Rivers basin, Thai Binh River basin, upper area of Red River basin, and Sesan River basin. Especially in Bang Giang & Ky Cung Rivers basin, the portion of Kinh group is estimated only at 12 %, and Tay and Nung groups are predominant.

The characteristics of distribution of ethnic minorities in 14 river basins are summarized as follows:

1) Among 53 ethnic minorities except Kinh, most of population of 21 groups concentrates in Thai Binh River basin and upper area of Red River basin. In addition, more than half of whole population of Tay, Thai, Muong, and Kho-mu groups inhabit in this area. And also, Thai and Muong groups are predominant in Ma River basin, and Thai and Kho-mu groups in Ca River basin.
2) Regarding Dong Nai River basin, most population of 4 groups (Co-ho, Xtieng, Ma, and Chu-ru) are predominant ethnic minorities. More than half of population of Hoa and Cho-ro groups are living in the basin.
3) In Sesan River basin, most of population of 4 groups (Xo-dang, Gie-Trieng, Brau, and Ro-man) inhabits. Among these, the whole population of Brau and Ro-man groups is less than 500.
4) Other characteristics on distribution are as follows.
   a. Ca River basin: Tho and O Du groups
   b. Thach Han River basin: Bru-Van Kieu and Ta-oi groups
   c. Huong River basin: Co-tu and Ta-oi groups
   d. Vu Gia-Thu Bon Rivers basin: Co-tu and Co groups
   e. Tra Khuc River basin: Hre and Co groups
   f. Ba River basin: Gia rai group
   g. Srepok River basin: E-de and Mnong groups
   h. Cuu Long River basin: Kho-me group

Some of ethnic minorities have their own peculiar living style and social structure. The adequate consideration should be given to these minorities in case of developing and implementing the water resources management plan from the view point of mitigating the social impact on their living condition, if any.

2.4 Activities of Water Resources Development and Management

2.4.1 Law/ Regulation and Institution Related to Water Resources

(1) Present Situation

The Government of Vietnam is aiming at the industrial development, resulting in development of urbanization and industrialization and further increase of water demand.

The above brings about serious water deficit in the dry season and seriously increases flood damages in the rainy season due to increase of assets in the densely populated urban areas. Water pollution also widely occurs.

As such, an efficient management of water resources is increasingly becoming an important and essential. However, role and responsibility of concerned administrative agencies, etc. are not definite and the management is not functioning favorably. Actual management at present is limited to each sector independently. Thus, establishment of widely well-controlled and integrated management is essential.

Under the said situation, the new law on water resources has been examined and prepared. The new law on water resources was approved by the National Assembly in May 1998 and was enforced from January 1999.

With the above new law, a frame to cope with national complicated water problem was established. However, enforcement of the law is still on the way of shifting to the new law, and the detailed enforcement regulations of the new law including concrete establishment of each new organization are under examination at present. Hence, actual management at present is still being made independently in each sector.

Presently, the Government has established the NWRC (National Water Resources Council) with the MARD as the coordinating body. The River Basin Organization(RBO)has been also established in the three(3) river basins of Red River, Dong Nai River and Cuu Long River as well as Huong River basin where the Board of Management of the Huong River Projects acts as a RBO. Further the Government is proceeding the detailed enforcement regulations towards enforcement of the new law on water resources. Establishment of RBO in the other river basins is important subject of the Government.

(2) New Law on Water Resources

The new law on water resources which was approved by the National Assembly in May 1998 and enforced in January 1999 is composed of ten (10) chapters and seventy five (75) articles, of which ten (10) chapters are enumerated as below:

Chapter I	:	General Provisions
Chapter II	:	Protecting the Water Resources
Chapter III	:	Exploitation and Use of Water Resources
Chapter IV	:	Preventing, Combating and Overcoming the Consequences of Floods and Other Harmful Effects of Water
Chapter V	:	Exploitation and Protection of Water Conservancy Work
Chapter VI	:	International Relations in Water Resources
Chapter VII	:	State Management of Water Resources
Chapter VIII	:	Specialized Inspection on Water Resources

Chapter IX : Rewards and Handling of Violations

Chapter X : Implementation Provisions

Of Seventy five (75) articles of the new law in 10 chapters, noteworthy points of the new law are as follows:

1) Management Competence of the State on Water Resources (Article 58).

a) The Government adopts state unified management of the water resources.

b) The Ministry of Agriculture and Rural Development is responsible to the Government for implementing state management functions of water resources.

c) Ministry of Science Technology and Environment, Ministry of Industry, Ministry of Fishery, Ministry of Transportation, ministries, ministerial-level agencies, and Governmental agencies implement state management functions to water resources as delegated by the Government.

d) Peoples' Committees of provinces and cities under the Central are responsible for state management of water resources in their locality in accordance with this law and other regulations of the law, and the decentralization of the Government.

2) National Water Resources Council (Article 63)

a) The Government establishes the National Water Resources Council (NWRC) which functions as the advisor to the Government to decide matters on water resources within the Government's duties and authorities.

b) NWRC comprises: the Council's Chairman is a Deputy Prime Minister, the standing member is the Minister of Agriculture and Rural Development, and other members are representatives from ministries, sectors and some experts and scientists.

3) Management Activities for River Basin Planning (Article 64)

a) The management activities of river basin planning includes:

- Establish, submit, and monitor the implementation of the river basin plans to ensure overall administration and planning in coordination with local administration,
- Coordinate with related agencies of ministries, sectors, and localities in basic investigation, inventory and assessment of water resources of the river basin, and in establishment and monitoring the implementation of the sub-basin plans.
- Recommend solutions for disputes of water resources in river basin.

b) The River Basin Organizations (RBO) are established and are the government organizations belonging to Ministry of Agriculture and Rural Development to manage basin-level water resources development planning.

4) Protecting, Exploiting and Using Water Resources, Preventing, Combating and Overcoming the Harm caused by Water (Article 5)

Protection, exploitation and use of water resources and hydraulic works have to follow the river basin plan approved by state authorized agency to ensure the systematic character of the river basin- not to be divided in accordance with the administrative boundary.

5) Issuing Permits for Exploitation and Use of Water Resource (Article 24)

a) Organizations and individuals that exploit and use water resources must apply for a (water use) license from the state authorized agencies, except the cases regulated in the following.

b) The cases of exploitation, use of water resources that do not have to apply for license are:

- Exploit and use surface and ground water for domestic consumption in households,
- Exploit and use surface and ground water in small scale for agriculture, forestry, aquaculture, raising and handicraft production and other purposes,
- Exploit and use seawater to produce salt and raise aquaculture in households, and
- Exploit and use rain water, surface water and seawater in the entrusted or rented land according to the regulations of Land Law, this Law and other regulations.

2.4.2 Law/Regulation and Institution Related to Environment

(1) Primary Laws on Environmental Protection

The framework Law on Environmental Protection (LEP) was passed by the National Assembly on 27 December 1993, and came into effect on 10 January 1994. The 55 articles of the LEP broadly establish the country’s policies on environmental protection. The LEP is a very broad and general document which sets out only a basic framework. In the Law, however, roles and obligations of the nation, organizations and individuals for the protection of environment are strictly stipulated regarding the development, protection, management of land, forest, water and mineral resources, and the management and controls of production facilities, toxic substance and waste in the form of solid, gas and/or liquid.

(2) Legislation on Environmental Impact Assessment (EIA)

The EIA system in Vietnam is implemented through Articles 17 and 18 of the LEP and a series of implementing regulations, particularly Decree 175/CP and Decree 26/CP. Organizations, individuals when constructing, renovating production areas, population centers or economic, scientific, technical, health, cultural, social, security and defense facilities, proponents of other socio-economic development projects, must submit EIA reports.

Chapter III of Decree 175/CP contains requirements for the submission of EIA by investors and enterprises, both foreign and local. Provisions prescribing the format and content of EIA reports are set out in the appendices of Decree 175/CP.

The MONRE is the responsible authority of the approval of EIA. The EIA can, however, be appraised by the local DOSTE and further be submitted to MONRE for approval because the local DOSTE has the knowledge of local conditions. The approval of an EIA report is required before an overseeing authority can approve a project or authorize its implementation. In December 1994, the former MOSTE issued “Decision 1807-QD/MTg” for the organization and operation of EIA Appraisal Council to establish EIA Appraisal Councils and environmental licensing. At the national level, the Appraisal Council is an advisory body to the MONRE, while at the local level, the Appraisal Council advises the chairman of the People’s Committee (PC) of provinces or cities, assisting in considering scientific and technical issues related to environmental protection.

According to “Circular No. 490/1998/TT-BKHCNMT,” all the investment projects, regardless of domestic or foreign ones, must follow the EIA procedure. In this connection, the investment projects are divided into two categories: Class I projects that require the EIA report to be prepared, submitted and evaluated, and Class II projects which are all other kinds of projects. Class I projects, which are listed in Table 2.12, include such projects that may potentially cause environmental pollution in a wide area, that may easily cause environmental problems, and that difficult to be controlled and whose environment standards are difficult to be determined.

(3) Institution on Environmental Protection

a) National Level

Environmental management in Viet Nam is administered on a national level by the Ministry of Natural Resources and Environment (MONRE). The environmental arm of MONRE, the Vietnam Environmental Protection Agency (VEPA), is the body specifically tasked with the environmental protection mandate. Apart from MONRE, the various line Ministries have Environment Divisions within their hierarchy. The Environment Divisions within these ministries are entrusted with the environmental issues arising in the course of their respective ministries’ activities or jurisdiction. In addition to the ministries, there are a lot of agencies, committees, departments and research centers which may have powers and jurisdiction equivalent to those of a conventional ministry.

b) Mandate of MONRE and VEPA

The MOSTE (predecessor of the present MONRE) was created in 1993 form the former State Committee for Science and Technology, to assist the Vietnamese Government in formulation of the national strategy, policy, and planning for managing science, technology and environment.

Vietnam Environmental Protection Agency (VEPA), a Department within MONRE, is directly responsible for the environmental management and protection on a nationwide scale. The responsibilities of the VEPA are set out in Decision No. 545-QD/TCCB dated 7 October, 1993 by the former MOSTE. VEPA is composed of the following divisions: Pollution Control Div., Policy Div., EIA Div., Inspection Div., International Relation Div., Training and Awareness Div., Monitoring Div. as well as other administrative divisions.

c) Provincial / City Level

The Law of Environmental Protection spells out the responsibilities of the Provincial People's Committees (PC) regarding the protection of the environment. Each of the Provincial PC has a Department of Science, Technology and Environment (DOSTE), which is responsible for environmental management on a local level. DOSTE, under the Provincial PC, is supposed to be responsible for the following:

- Preparation of annual State of the Environment report;
- Environmental monitoring; and
- Appraisal of Environmental Impact Assessment reports.

The institutional charts of provincial DOSTEs are anticipated being reformed as DONREs (Departments of Natural Resources and Environment), in line with the change of the central ministry (MONRE from MOSTE). However, it will take several years for reformation of provincial departments according to the officials of MONRE

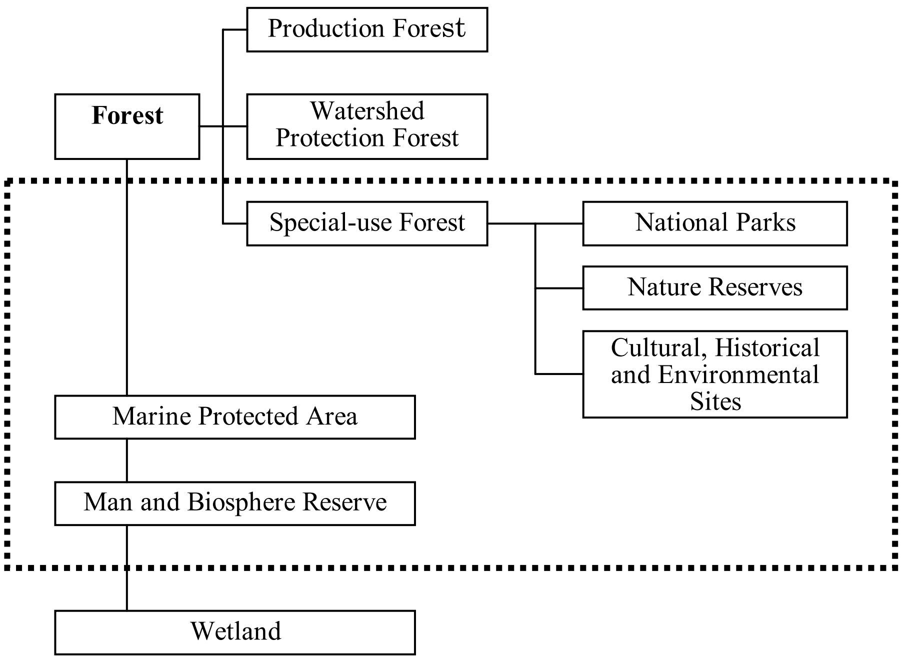
(4) Protected Areas System

Protected areas in Vietnam are composed of three categories: 1) Special-use Forest, 2) Marine Protected Area and 3) Man and the Biosphere Reserve (MABR). Special-use Forest is one of the classification of forests consisting of the following three categories: 1) National Park, 2) Nature Reserve and 3) Cultural and Historical Site. Other categories of forests are production forests and watershed protection forests, which are determined from the view points of forestry, conservation of watershed and protection of erosion. Wetland is another important category on environmental protection. However, Wetland is not included protected area institutionally, but is designated for awareness of ecological importance. The relationship of these is depicted in the figure below. The status and the number of the protected areas are listed in the table below:

Number of Decreed and Proposed Protected Areas in Vietnam

Category Decreed	Decreed	Proposed	Total
Special-use Forest	93	71	164
Marine Protected Area	0	24	24
Man and Biosphere Reserve	1	0	1
Total	94	95	189

Source: Documents of Birdlife International, 2001



Category of Classification

(5) Environmental Standard

In Vietnam, before the promulgation of the Law of Environmental Protection, there were certain standards relating to the environment and public health, which were set by the Health Ministry, the General Measurement and Standard Department. Yet, they were largely based on WHO's regulations. Afterward, 60 standards were adopted between 1978 and 1991.

In 1995, the former MOSTE canceled 8 outdated standards and issued 71 Vietnamese standards including 20 on air and emissions, 35 on water and sewage, 11 on land, 4 on noise and 1 on waste paper. In late 1996, the former MOSTE stipulated 8 new standards regarding pollution from vehicles.

In the case that the applicable standard is inadequate, not regulated or not applicable, the project proponent must take permission to apply the equivalent standards of the countries that have provided the technology and equipment to Vietnam or apply the equivalent ones of a third country. At the permission issued by MONRE, then the standard can be applicable.

(6) Legal Framework on Land Acquisition and Resettlement

Since 1992, the new Constitution has provided a legal basis for land compensation. Organizations and individuals have been given State-owned land for long-term use. The land use rights include those to transfer, lease, inherit, and mortgage lands. The Constitution 1992 stipulates that in case that the State requires the properties, the State can purchase or acquire those properties from organizations or individuals with compensation at the current market price.

Based on the above concept on land use rights, the Land Law 1993 provides a comprehensive framework of land administration. Some of important issues which are relevant to land use, acquisition, and resettlement, are as below.

- The State reserves the right to allocate land and determine its usage.
- Organizations, families, and individuals who have been allocated land have the right to exchange their land for another piece, to rent the land, to transfer their land use right to another party, and to inherit the land use right.
- The People's Committees at all levels (province, district and commune) are responsible for the administration and management of land issues in their jurisdiction.
- The State reserves the right for land expropriation in case of national defense, security, and national/public interest. In these cases, the land user will be compensated for loss of possessions.
- Before land is expropriated, the user should be informed of the reason of expropriation, time schedule, plan for resettlement, and options for compensation.

Among several decrees on land issues, Decree No. 22/CP 1998 provides a substantial context, concerning compensation levels and other allowances for properties acquired for national/public interest.

(7) Institution on Land Acquisition and Resettlement

Ministry of Finance is the main agency responsible for developing the policies on compensation for organizations, families, and individuals whose land is acquired. On a specific project basis, the executing bodies are in charge of planning for resettlement and compensation issues, and local authorities at all levels are in charge of implementing the resettlement plan through the council for land acquisition and compensation which is established after the promulgation of land acquisition decision. The council is disbanded after completion of compensation and related assistance for affected people. Following is the summary of institutional responsibilities for land acquisition / resettlement plan.

- Preparation of plan: Project proponent
- Review of plan: Ministry of Planning and Investment, Superior ministries of the project
- Approval of plan: Government (superior ministries of the project), Provincial people's committee
- Implementation of the plan: Local authorities
- Monitoring: Project proponent, Local authorities
- Evaluation: Project proponent, Local authorities, Third party (if necessary).

2.5 Activities of International Aid Agencies and Donor Countries

A considerable number of donors is active in the water resources sector and many projects are going on. Effective co-ordination of these activities is essential. For that reason MARD has created the International Support Group and Steering Board. The co-ordination of water resources management issues are dealt with in the Thematic Ad-hoc Group 2 (TAG2) of the ISG.

Presently most of the assistance in the water resources sector is provided through the following international aid agencies and donor countries:

- Asian Development Bank (ADB)
- World Bank
- Japan Bank for International Co-operation (JBIC)
- Japan International Co-operation Agency (JICA)
- Danish International Development Assistance (DANIDA)
- Australian Agency for International Development (AusAID)
- United Nations Development Programme (UNDP)
- Agence Française de Développement (AFD)
- The Netherlands
- Norway
- Sweden

Most of the donor countries concentrate on an integrated approach of the water resources development, in which the water resources management and capacity building go together with the development of physical infrastructure.

A summary of the current, recently completed and soon-to-start assistance activities in water resources management, institutional development and capacity building is presented in Appendix-A.

2.6 Present Condition of Agriculture

In connection with the agriculture, its development policy and development target should be discussed together with the present condition. Hence, the present condition of agriculture is presented in Chapter 4 "Agriculture" to which reference is made.

CHAPTER 3 METEO-HYDROLOGICAL ANALYSIS

3.1 Run-off Analysis

3.1.1 Objectives of the Natural Runoff Analysis

A keystone for the formulation of a plan for nation-wide water resources development and management in 14 river basins is the assessment of the water resources potential of these basins. The Water Resources Potential of a basin is defined as the volume of water, with an adequate quality, that can be made available for satisfying water demands. These demands can be related to agricultural, domestic and industrial water requirements but also to hydropower, navigation, wetland development and conservation, fish and wildlife, recreation and waste assimilation.

The volume that can be made available depends on the volume that enters the basin in the form of precipitation (and possible inter-basin groundwater flow) and the volume that leaves uncontrolled the basin in the form of:

- evapotranspiration;
- groundwater flow and
- surface runoff

In the absence of (surface) storage reservoirs, the availability of water in the course of time is directly related to the instantaneous runoff and the available groundwater volume. If groundwater availability is not taken into account, as is the case in the present study, the (surface) water resources potential of the basin corresponds essentially with the basin runoff only. The creation of storage potential in the basin, either by reservoirs or otherwise, can increase the water resources potential of the basin.

In the present planning exercise, the natural flow regime at the respective base points, is taken as the starting point for the assessment of the water resources potential of the respective basins. The terms of reference of the present study indicate that this natural flow regime is to be established on the basis of at least 10-year series of monthly flows at the respective base points.

Besides the assessment of the water resources potential, the runoff analysis aims at the establishment of the series that will be used for the water balance analysis and the formulation of measures to overcome water deficits, if any.

3.1.2 Approach to the Natural Runoff Analysis

The natural runoff has been defined as the volume of water that would pass monthly through the base point of the basin in the absence of the withdrawal of water for agricultural, domestic or industrial purposes and assuming that no artificial storage is taken place in the catchment. The natural runoff has been estimated for the present land use and vegetation conditions in the basins.

Although the Terms of Reference call for the use of the latest 10-year discharge record for the runoff analysis of the 14 river basins, it is understood that the discharge series of 10 years is to be considered as a minimum. For the present study the aim is to use runoff series between 10 and 25 years, subject to the availability of reliable data.

The base point of a basin has been defined as the location beyond which the use of the runoff of the basin for irrigation and for domestic and industrial purposes on Vietnamese territory is no longer practical. In principle, the location of the base point corresponds with the point where either the basin debouches into a saline water body, or where the river leaves Vietnamese territory.

For the assessment of the natural runoff of the basins, use has been made, to the extent possible, of historic runoff information in the form of discharge data. Only in case the historic discharge data gave insufficient information, rainfall data have been used either to generate or to complete runoff series.

The assessment of the natural runoff supposes that the impacts, if any, of human interventions such as discharge regulation or water withdrawal are corrected for in the series of historic discharge observation data. Such correction has not always been possible as a consequence of lack of the pertinent information. In such cases, preference has been given to older data series, prior to the major interventions, rather than guessing the impact of the regulation measures on the more recent data series.

For the basins that discharge into the sea within Vietnam, a distinction has been made between the upper and middle catchment area on one side and the lower area on the other side. The lower area coincides generally with the area where most economic activities and corresponding water demands are concentrated. Available runoff data, on the other hand, refer as a rule to the upper and middle catchment area. Discharge measurements in the lower areas are normally hampered by the influence of the tides.

The runoff of the lower areas has been estimated under the assumption that these areas are fully used for agricultural purposes and that water management measures are in place that prevent water to runoff before the agricultural demand has been met. The runoff of these areas is, consequently, supposed to correspond with the net rainfall (rainfall minus evapotranspiration) and assuming that a storage of 50 mm needs to be filled before actual runoff takes place.

Over the last years comprehensive water resources development studies have been carried out for a number of basins. If in the framework of those studies relevant runoff series were compiled, these series have been used with due care in the present analysis. This approach was found more appropriate than generating new series in the limited timeframe of the present analysis, that, moreover, has a broader scope than the mentioned specific basin studies. This approach has been followed for the following basins:

- The Red River basin (used source: 1994 Red River Delta Master Plan, Binnie & Partners et all.)
- Sesan basin (used source: 1999 National Hydropower Plan Study, SWECO et all.)
- Dong Nai basin (used source 1996 Master Plan study on Dong Nai river and surrounding basins water resources development, JICA, Nippon Koei)
- Cuu Long Delta basin (used source: 1993 Cuu Long Delta Master Plan, NEDECO)

Details of the methodology that has been followed in the compilation of the runoff series in each individual basin are presented in the corresponding sections.

3.1.3 Data Base Preparation

For the series of monthly runoff that have been compiled in the framework of the present study, use has been made of daily discharge and rainfall data. The maximum length of discharge series was set at 25 years. For that reason, the time for which data were collected corresponds to the period 1976 – 2000.

The stations that have been used were selected from the network of hydro-meteorological stations under operation of the Hydro Meteorological Service (HMS). Criteria used for this selection of the stations refer to:

- discharge stations with maximum coverage of the basin, or of the main tributaries;
- duration of record more than 10 years and continuing operation;
- maximum four discharge measurement stations per basin;
- maximum eight meteorological stations per basin, with appropriate spatial distribution and adequate record length;

The selected stations and the corresponding periods of observation are presented in the respective section related to each basin.

The selected data were merely made available in the form of copies of hand-written data compilation sheets from the HMS. These data have be transcribed into data sets in Excel. These transcribed basic data form the principal data base.

It is noted here, that the use of the original data set in the form of hand-written data compilation sheets seems to be outdated. For many years already water resources studies are being carried out in Vietnam making use of modern data processing tools. It is anticipated that the original data sets must have been digitised already several times by different parties. It is strongly recommended that the information from observations that are conscientiously done by the HMS, is scrutinised and validated centrally and made available to the users of this information in a digital way. Such approach not only avoids the duplication of work and the possible introduction of errors, but will also contribute significantly to the quality of the results of the analyses that are being carried out with the help of these data sets.

3.1.4 Institutional Arrangements

The basic data that have been used in the compilation of the runoff series of the basins originate from the Hydro-Meteorological Service of Vietnam. The data have been obtained through the Institute of Water Resources Planning of the Ministry of Agriculture and Rural Development.

It is understood that several water resources related institutions, both at central and provincial level, tend to collect or initiate the collection of project related basic information. Such information, as far as not transferred to the HMS, is anticipated to be available in the different institutions and in the provinces. Very few of this information has been collected in the framework of the present project, mainly due to time limitations and in view of the character of the planning exercise. It is considered essential that in following planning stages also the provincial and project related sources of valuable basic information are more intensively tapped.

3.2 Runoff Analysis for 14 River Basins

(1) Bang Giang and Ky Cung

The Bang Giang and the Ky Cung are both part of the upper limit of the Tay Giang basin that debouches into the East Sea (South China Sea) near Hong Kong.

The two tributaries have their confluence at Long Zhou in China, some 20 km east of the border inside China. For the location map of the basin reference is made to Figure 3.1

For the assessment of the availability of water in the Vietnamese part of the Bang Giang and Ky Cung basin, an estimate has been made of the natural runoff at the locations where the two tributaries of this basin leave the Vietnamese territory. The catchment area of the respective sub-basins at the boundary with China is as follows:

Ky Cung	6,790 km^2
Bang Giang	4,460 km^2

The 15 years natural runoff series for both the Ky Cung and the Bang Giang sub-basins have been compiled with the help of the historical runoff series of Lang Son, Van Mich and Ban Gioc for the period 1960 – 1974.

The Ky Cung runoff is estimated assuming that the combined Lang Son / Van Mich runoff per km^2 is representative for the entire sub-basin within the Vietnamese territory.

The Bang Giang runoff is estimated under the assumption that the average of the runoff per km^2 of the Van Mich and the Ban Gioc catchments is representative for the Bang Giang sub-basin within the Vietnamese territory.

On the basis of the generated monthly runoff series, the monthly natural runoff for different levels of dependability has been assessed as shown in the following table. It is noted that the dependable monthly runoff volumes have been calculated for each month separately. As a consequence, the succession of, for instance, 10% dry months should not be considered as a 10% dry year.

Dependable Monthly Natural Runoff at the Boundary with China

(A= 11,250km^2) unit million m^3

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
50%	116	93	109	183	315	831	1,238	1,502	917	429	225	145
75%	96	85	87	117	208	550	837	1,031	650	314	181	118
90%	81	79	71	79	143	379	588	735	476	237	149	98

(2) Red River and Thai Binh

Runoff of the Red River and Thai Binh basin has extensively been addressed in the framework of the Red River Delta Master Plan, 1994, the National Hydropower Plan Study, 1999 and the Red River Basin Water Resources Management project, 2001. The latter presents information about water resources data, rather then analysing the data. The location map of the Red River and Thai

Binh basin is presented in Figure 3.2.

For the estimate of runoff and water availability at the base point of the Red River and Thai Binh basin, use is made of the results of the previous studies.

The runoff is analysed at Son Thay (Red River basin runoff). The run-off of the Thai Binh sub-basin at Pha Lai, where the Thai Binh meets the Red River Delta, is considered of minor importance at the entire Red River – Thai Binh basin level, since this runoff, estimated at some 4,000 Mm^3 per year, corresponds with some 3% of the basin runoff only.

The duration curve of monthly discharges has been established for each station and for each month. From these curves the discharges with different levels of dependability have been assessed, as presented in the following tables.

Dependable Monthly Natural Runoff at Hoa Binh (A= 51,800km^2)

unit : million m^3

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
50%	1,449	1.041	916	970	1,719	5,336	10,589	11,809	7,615	4,768	3,017	1,965
75%	1,219	894	785	772	1,153	3,904	8,458	9,640	6,238	4,068	2,306	1,579
90%	1,098	815	715	674	907	3,237	7,391	8,534	5,535	3,698	1,962	1,385

Dependable Monthly Natural Runoff at Yen Bai (A= 48,000km^2)

unit : million m^3

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
50%	866	673	617	697	1,010	2,137	3,310	4,610	3,673	2,773	1,727	1,144
75%	736	579	507	552	749	1,556	2,526	3,709	2,917	2,259	1,345	919
90%	667	529	451	480	626	1,287	2,148	3,255	2,540	1,997	1,158	807

Dependable Monthly Natural Runoff at Son Tay (A= 144,000km^2)

unit : million m^3

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
50%	3,384	2,593	2,380	2,721	4,659	11,293	19,879	23,221	16,595	10,899	6,925	4,442
75%	2,870	2,245	2,027	2,173	3,326	8,371	15,763	19,107	13,448	9,183	5,342	3,595
90%	2,601	2,058	1,840	1,899	2,717	6,994	13,715	16,997	11,855	8,291	4,572	3,166

Dependable Monthly Natural Runoff at Vu Quang (A= 37,000km^2)

unit : million m^3

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
50%	994	826	820	964	1,828	3,633	5,633	6,111	4,347	2,811	1,868	1,230
75%	799	651	637	722	1,301	2,551	4,399	4,776	3,305	2,255	1,402	996
90%	700	564	547	607	1,061	2,063	3,792	4,119	2,804	1,976	1,180	877

For the assessment of the availability of water in the Red River Delta, the effect of the Hoa Binh reservoir needs to be taken into account. However, this effect is subject to the operating rules that are applied in the Hoa Binh scheme.

For the current operation policy for Hoa Binh and Thac Ba simulations were carried out of the Son Tay runoff for the period 1957 – 1990 in the framework of the Red River Delta Master Plan Study. The results of these simulations show that the reservoirs contribute considerably to the low flows during the period December – May. The effects for different levels of dependability are presented in the following table:

Mean Monthly Water Availability at Son Tay
in Mm^3 with Different Levels of Dependability

	December	January	February	March	April	May
Natural runoff						
75%	3,594	2,871	2,246	2,028	2,172	3,327
90%	3,166	2,601	2,058	1,840	1,900	2,716
Effect reservoirs						
75%	482	937	1,123	1,446	1,555	1,553
90%	723	1,071	1,245	1,446	1,555	1,553
Water availability						
75% (round)	4,071	3,803	3,368	3,482	3,732	4,875
90% (round)	3,884	3,669	3,295	3,294	3,447	4,259

(3) Ma

For the selection of the data series to be used for the assessment of the water resources potential of the Ma Basin, it has been recognised that for such assessment, and the eventual planning of the use of this potential, it is inevitable to consider the two main catchments, the Chu sub-basin and the Ma Basin upstream of the confluence with the Chu river. The Yen river basin borders the Chu basin, in the lower part there is no clear divide between these two basins. In the present study, the Yen river is considered as a sub-basin of the Ma river. For the location map of the Ma basin reference is made to Figure 3.3.

For the preparation of the monthly natural runoff series of the Ma basin just downstream of the confluence of the Buoi and Ma rivers, use has been made of the observed discharges at Cam Thuy. These discharges are considered natural, the impact of minor storage facilities upstream of Cam Thuy on the river discharges at this station is considered negligible as are the withdrawals upstream of Cam Thuy for water supply and irrigation. Since the discharges at Cam Thuy represent almost 90% of the Ma catchment at the Buoi confluence, it is deemed acceptable to apply a simple area proportionality factor for the estimate of the natural runoff at this confluence.

For the preparation of the monthly runoff series of the Chu sub-basin just downstream the confluence with the Am river (total catchment area: 7,460 km^2), use has been made of the observed discharges at Cua Dat. The discharges observed at Cua Dat represent 83% of the natural runoff of the sub-basin at the Am confluence. For that reason, it is also for this sub-basin deemed adequate to apply an area proportionality factor for the calculation of natural runoff.

Finally, the series of the monthly runoff of the entire Ma basin at its base point has been prepared by summation of runoff of both sub-basins and the runoff of the lower basin, which has been estimated on the basis of the net rainfall on this lower area as explained in the previous section. The dependable basin runoff has been estimated as follows:

Dependable Monthly Natural Runoff in the Whole Basin (A= 31,060km^2)

unit : million m^3

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
50%	538	407	410	415	683	1,151	1,828	2,501	2,541	1,832	972	671
75%	451	342	345	342	556	851	1,382	1,824	1,880	1,306	739	561
90%	384	292	295	288	462	648	1,074	1,373	1,433	963	577	478

(4) Ca

Availability of water in the Ca basin is most important in the lower section of this basin downstream of Do Luong. At this location Ca waters are diverted to the coastal area north of the Ca basin. The natural runoff at Do Luong is therefore an important factor in the assessment of the water resources potential of Ca basin. For the location map of the basin reference is made to Figure 3.4.

The runoff that is observed at Dua, corresponds with the runoff of more than 98% of the catchment area at Do Luong. It is therefore considered justified to derive the natural runoff at Do Luong directly from the discharge series of Dua station.

The runoff of the lower basin has been has been estimated on the basis of the net rainfall on this area. The dependable discharges are as follows:

Dependable Monthly Natural Runoff in the Whole Basin (A= 29,850km^2)

unit : million m^3

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
50%	714	564	546	547	897	1,219	1,573	2,623	4,315	4,444	1,839	952
75%	605	482	464	472	694	895	1,187	1,924	2,916	2,914	1,258	775
90%	521	419	400	413	551	677	922	1,457	2,049	1,994	894	645

(5) Thach Han

The only record of discharge observations in the Thach Han basin refer to Rao Quang measurement station where during a period of three years (1983 – 1985) the discharge was observed of a catchment of 159 km^2, or 7% of the total Thach Han basin. This record is not considered adequate for the analysis of the basin runoff. For the location map of the basin reference is made to Figure 3.5.

Rainfall data, however, are available to a greater extent, allowing for the estimate of the basin runoff on the basis of a rainfall – runoff relation. The following rainfall data have been collected for this purpose:

Station	Longitude	Latitude	Province	Observation Period
Khe Sanh	106.50	16.38	Quang Tri	1976-2000
Thach Han	107.14	16.45	Quang Tri	1976-2000
Dong Ha	107.05	16.50	Quang Tri	1976-2000

Based on this assumption, the runoff of the Thach Han basin has been generated with the help of the Sacramento rainfall – runoff concept and using the series of area rainfall on the Thach Han basin. The model was set up for the Thach Han sub-basin upstream of the Thach Han weir. The area of this sub-basin amounts to 1,390 km^2, or 62% of the entire catchment area.

The runoff of the entire Thach Han basin is composed of the runoff at the Thach Han weir, increased by the contribution of the Cam Lo river and the Vinh Phuoc river and the runoff of the lower area. This latter runoff has been estimated on the basis of the net rainfall on this area of 370 km^2. The contribution of the Cam Lo and Vinh Phuoc, with a joint area of 790 km^2, has been estimated on the assumption that the specific runoff of these sub-basins is the same as that of the Thach Han sub-basin.

The dependable monthly runoff is calculated as follows:

Dependable Monthly Natural Runoff in the Whole Basin (A= 2,550km^2)

unit :million m^3

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
50%	243	135	94	63	75	78	71	113	320	850	836	513
75%	191	107	75	47	50	48	43	68	189	612	587	384
90%	154	87	61	36	35	31	27	43	117	456	427	296

(6) Huong

Special treatment has been given to the generation of the series of monthly runoff in this basin as shown in Figure 3.6. This special approach is related to a consequence of the fact that in this basin no long records of discharge observations are available.

For the generation of series of runoff in the respective sub-basins of the Huong, use has been made of rainfall-runoff modelling. The runoff series have been generated with the help of area rainfall series of the period 1977 – 2000 that have been compiled on the basis of the set of collected daily rainfall data at five stations.

With the help of the rainfall – runoff modelling series have been generated for several key locations in the basin. The dependable monthly runoff volumes at Co Bi, Tuan and for the entire basin are presented below.

Co Bi (A=720km^2) unit : million m^3

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
50%	95	48	33	32	45	41	32	32	85	298	363	251
75%	58	30	22	21	32	27	21	22	52	205	254	181
90%	38	20	16	16	23	18	15	15	33	147	185	135

Tuan (A=1,460km^2) unit : million m^3

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
50%	210	109	71	52	68	69	53	57	148	589	726	498
75%	144	79	53	35	40	40	32	36	84	370	497	354
90%	102	59	40	24	26	24	20	23	51	243	353	260

Entire Basin (A=3,300km^2) unit : million m^3

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
50%	342	166	112	86	120	122	90	95	431	1,497	1,623	989
75%	220	118	81	56	76	71	55	61	243	976	1,153	691
90%	148	87	61	38	51	44	36	41	144	663	847	500

(7) Vu Gia and Thu Bon

For the assessment of the water availability in the Thu Bon basin, an estimate has been made of the natural runoff of the basin at the confluence of the Thu Bon and Vu Gia tributaries at Ai Nghia. Upstream of this confluence 9,010 km^2, or some 87%, of the entire Thu Bon basin (excluding the Tam Ky basin) is situated. In the flat area downstream of this confluence the runoff conditions are essentially different from the upstream area as a consequence of topographic and land use features. The runoff of this lower part is, therefore, treated separately. For the location map of the basin reference is made to Figure 3.7.

For the estimate of the natural runoff at Ai Nghia, use has been made of historical discharge series at Nong Son in the Thu Bon sub-basin and Thanh My in the Vu Gia sub-basin. For the present study it is considered appropriate to use the 1984 – 2000 discharge series for the estimate of the natural runoff of the basin.

In addition to these discharge data, the rainfall data at six stations have been used for the hydrological analysis.

The discharges observed at Nong Son represent the runoff of 3,130 km^2, or some 87%, of the 3,590 km^2 Thu Bon sub-basin. It is, therefore, considered acceptable to estimate the runoff of the entire sub-basin by assuming the ratio between the entire sub-basin area and the observed area to be the same as the ratio between the respective discharges. In this way, the monthly Thu Bon sub-basin discharges have been estimated by multiplying the observed monthly discharges at Nong Son with the factor 1.147.

The series of monthly discharges of the Vu Gia sub-basin at the confluence with the Thu Bon has been derived by applying 95% of the specific runoff at Thanh My for the entire sub-basin. By this approach, the runoff during the flood season is likely to be overestimated. This, however, is not considered of relevance for the elaboration of the water balance of the Thu Bon basin.

The runoff series that has been generated in accordance with above described approach for the entire Thu Bon basin for the period 1984 – 2000. This runoff includes the runoff of the Thu Bon and Vu Gia sub-basins and the runoff from the 1,370 km^2 lower area, the runoff of which has been estimated on the basis of the net rainfall on that area. The Tam Ky basin has not been included in the Thu Bon basin runoff. The dependable basin runoff has been calculated as follows:

Dependable Monthly Natural Runoff in the Whole Basin (A=10,460km^2)

unit :million m^3

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
50%	1,492	845	637	515	734	635	524	584	1,141	4,344	5,617	3,953
75%	1,169	682	522	387	523	464	409	428	777	2,768	3,832	2,760
90%	939	562	437	300	385	349	327	323	549	1,845	2,716	1,997

(8) Tra Khuc

The Tra Khuc basin is composed of a number of sub-basins that each has its own exit to the sea. The main sub-basin is the Tra Khuc itself and the second important one is the Ve sub-basin. Other smaller sub-basins, among them the Tra Cau, enter the common coastal zone of the Tra Khuc basin. The location map of the basin is presented in Figure 3.8.

Daily discharge data in the basin are scarce. The following data have been collected and processed.

Station	Longitude	Latitude	Catchment	Tributary	Observation Period
Son Giang	108.34	15.02	2,440km^2	Tra Khuc	1987-2000
An Chi	108.49	14.59	814km^2	Ve	1987-2000

The period of 14 years only is considered short for making a proper assessment of the natural runoff and water availability in the basin. Therefore, efforts have been made to extent the series to a longer period. The following two methods have been investigated:

1. Correlation with rainfall, for which data are available as from 1976,
2. Correlation with the neighbouring catchment area of Thu Bon.

Especially for the main Tra Khuc sub-basin, the correlation with Thu Bon basin is considered adequate for being used for the extension of the Tra Khuc runoff series. It has, therefore, been decided to use the relations with the Thu Bon discharges for the extension of the series, rather than the runoff rainfall relations derived from the multiple regression analysis. It is anticipated, however, that in further planning phases a proper rainfall –runoff modelling will generate more accurate results.

The runoff has been composed of:

- Tra Khuc runoff by multiplying the Son Giang discharge with the area proportionality factor of 1.24;
- Ve runoff at An Chi
- Runoff from the smaller basins with total area of 510 km^2, assuming that the runoff from this area per km^2 corresponds with the combined Thra Khuc – Ve runoff per km^2;
- The runoff from the lower (and coastal) area estimated with the help of the net rainfall on this area.

The dependable monthly runoff of the entire Tra Khuc basin has been calculated as follows:

Dependable Monthly Natural Runoff in the Whole Basin (A= 5,200km^2)

unit :million m^3

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
50%	740	377	273	200	295	293	231	230	515	2,083	3,169	1,801
75%	573	305	215	150	203	201	170	161	332	1,304	2,141	1,142
90%	454	252	173	116	145	143	129	117	223	856	1,504	758

(9) Kone

Only one discharge measurement station with adequate record length has been identified in the Kone basin. This station, Cay Muong, has been used as base station for the assessment of the basin runoff. For the location map of the Kone basin, reference is made to the Figure 3.9.

Station	Longitude	Latitude	Catchment	Tributary	Observation Period
Cay Muong	108.52	13.56	1,677km2	Kone	1976-1977 1979-2000

In the Kone River basin a clear distinction can be made between the upper and middle catchment on one side and the lower catchment on the other side. This lower catchment consists essentially of the deltaic zone that has its apex at Binh Thanh just upstream of the Bay Yen weir in the Kone River. This apex is some 30 km upstream of the Kone river mouth.

The natural monthly discharge series derived for the Cay Muong station represents the runoff of the upper 1,677 km^2 of the Kone basin. This upper area corresponds with 75% of the catchment that drains through Binh Thanh and to 56 % of the total catchment excluding the low-lying delta area. The area of this lower area has been measured at 640 km^2.

To arrive at natural monthly discharges at Binh Thanh and from the entire catchment, it is concluded that no substantial error is introduced with the assumption that the basin rainfall and the upper catchment rainfall are the same.

The area factors that have been used to convert the Cay Muong measured discharges to the Binh Thanh and the total middle and basin runoff are respectively 1.34 and 1.79.

The runoff series that has been generated in accordance with above described approach for the entire Kone River basin for the period 1976 – 2000 (with exception of 1978). This runoff includes that runoff from the lower area, that has been estimated with the help of the net rainfall on this area. The length of the series is considered sufficient for the purpose of the study, reason why no effort has been made to fill the 1978 gap in the series. The dependable basin runoff has been calculated as follows:

Dependable Monthly Natural Runoff in the Whole Basin (A= 3,640km^2)

unit : million m^3

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
50%	218	135	108	87	109	122	98	100	162	819	1,107	514
75%	165	106	85	69	83	86	76	72	104	463	659	288
90%	128	84	69	56	65	62	61	53	70	278	413	171

(10) Ba

For the assessment of the natural runoff at basin level, the measured discharges at Cung Son furnish an excellent starting point. At this location passes the runoff of 88% of the entire Ba catchment and more than 90% of the upper and middle catchment. For the location map of the Ba River basin reference is made to Figure 3.10.

For the conversion of measured discharges at Cung Son into natural runoff, the upstream developments at the Ia Yun Ha reservoir and Song Hinh reservoir need to be taken into account.

Since the details on the Ia Yun Ha reservoir operation were not available in time for the present analysis, it has been decided to select the runoff series prior to the completion of the reservoir for being used in the water balance analysis. This series of monthly runoff, covering the period 1977 – 1989. These series have been derived directly from the Cung Son discharge data, using an area multiplication factor of 1.096 to arrive at the natural runoff of the entire middle and upper basin, and adding the runoff of the lower 440 km2 basin area by applying the net rainfall approach. The dependable basin runoff has been calculated as follows:

Dependable Monthly Natural Runoff in the Whole Basin (A= 14,030km^2)

unit :million m^3

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
50%	397	212	145	111	210	329	355	609	948	1,640	2,246	860
75%	302	168	113	79	140	200	244	388	709	956	1,454	532
90%	236	136	91	58	97	127	173	259	546	588	984	345

(11) Sesan

The Se San basin has been studied extensively in view of the development of the hydropower potential in this basin. Recent studies of, especially, the Sesan 3 project (Feasibility Study by SWECO, 1999) and Sesan 4 (SWECO, 1997 and Halcrow, 1998) present long series of monthly runoff at both sites, covering respectively 68% and 81.5% of the Vietnamese part of the Sesan basin. The discharge series have reportedly been prepared by PECC1. For the location map of the Vietnamese part of the Sesan basin reference is made to Figure 3.11.

From the monthly runoff series presented in the above mentioned study, the 1976 –1997 series at the Se San 4 site have been selected for the estimate of the basin runoff at the base point of the basin, i.e. the location where the Sesan river leaves the Vietnamese territory.

The generated monthly runoff series at the base point assumes that the specific discharge of the entire Vietnamese part of the basin corresponds with the runoff per km^2 obtained from the Se San 4 series. The Se San 4 series have, consequently been multiplied by a factor 1.236. The dependable runoff at the base point has been calculated as follows:

Dependable Monthly Natural Runoff at the International Boundary (A=11,530km^2)

unit :million m^3

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
50%	572	406	375	356	514	799	1,188	2,017	2,054	1,839	1,333	872
75%	489	343	320	295	404	589	939	1,632	1,621	1,504	1,033	710
90%	425	294	277	250	325	447	760	1,348	1,310	1,254	821	590

(12) Srepok

Most of the runoff of the 12,030 km^2 Vietnamese catchment area of the Srepok basin is observed at the Ban Don station, that covers 10,700 km^2 of the basin. In the present study, it is assumed that impact of the existing infrastructures is minor and that the observed runoff at Ban Don corresponds broadly with the natural basin runoff. For the location map of the Vietnamese part of the Srepok basin reference is made to Figure 3.12.

The series of observed daily discharges at the Ban Don station has readily been used for the generation of the natural runoff series of the entire Vietnamese part of the Srepok basin for the period 1977 – 2000. It has been assumed that the specific runoff of the catchment area between Ban Don and the Cambodian border corresponds with the specific discharge of the area upstream of this station. The dependable runoff at the base point has been calculated as follows:

Dependable Monthly Natural Runoff at the International Boundary

(A=12,030km^2) unit : million m^3

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
50%	410	233	187	186	337	538	747	1,032	1,358	1,718	1,199	844
75%	306	185	149	139	242	369	591	794	1,103	1,360	849	564
90%	235	150	122	106	179	263	479	627	915	1,102	622	392

(13) Dong Nai

In the present study, the Dong Nai basin has been defined as the catchment that is drained through the Dong Nai river and the Saigon river, and that has its base point at the confluence of both rivers at Ho Chi Minh City. The total basin area at that confluence amounts to 29,120 km^2. For the location map of this basin reference is made to Figure 3.13.

The Master Plan Study under JICA on the Dong Nai River and surrounding basins was completed in 1996. In the framework of this study, the series of monthly runoff have been generated for a number of potential dam sites in the basin. The runoff was generated with the help of the Tank model, using 29 years of historical rain fall series (1964 – 1992). The model was calibrated with the help of historical series of daily discharge observations at gauging stations in the different sub-basins.

The runoff series that were generated for these locations have been used as basis for the estimate of the entire basin runoff at the base point. The total area covered by these two locations corresponds with 87% of the entire basin.

The dependable runoff at the base point has been calculated for the period

1984-2000 as follows:

Dependable Monthly Natural Runoff at the Confluence with Saigon River

($A=29,120km^2$) unit : million m^3

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
50%	777	349	266	319	751	1,982	3,542	4,649	5,472	5,979	3,465	1,617
75%	700	318	245	256	501	1,576	3,022	4,036	4,747	5,254	3,026	1,410
90%	638	292	228	210	348	1,282	2,619	3,554	4,176	4,676	2,679	1,247

(14) Cuu Long River Delta

The generation of series of natural runoff of the Mekong basin is impracticable. Numerous discharge regulating infrastructure is in place in the basin. The implementation of a rainfall-runoff model for the entire basin would lack possibilities of calibration if the operation of existing infrastructure would not be taken into account. Such exercise would go far beyond the scope of the present study. The location map of the Cuu Long Delta is presented in Figure 3.14.

Even the assessment of the actual, regulated, runoff at the base point of the Mekong basin is extremely complicated. Discharge measurements in the Cuu Long main branches, Mekong and Bassac, are not available. Measurement of these discharges is seriously hampered by the tidal fluctuation. The most downstream station outside of the tidal influence is located at Kratie in Cambodia. Daily discharges at this location are available only until 1969. Moreover, the Tongle Sap system, located downstream of Kratie, has a strong regulating effect on the discharges before the Mekong runoff enters the Cuu Long basin.

As a consequence of these complications, the following methodology has been used:

- monthly discharge data at Kratie have been obtained from the Cuu Long Delta Master Plan studies, (1990 – 1993, NEDECO);
- the regulating effect of Tonle Sap has been derived from the monthly series of flow to and from Tonle Sap at Prek Kdam, prepared for the period 1960 – 1971 by the Netherlands Delta Team in 1974;
- these two series allow the preparation of the series of monthly runoff at the Vietnam – Cambodia border, corresponding with the inflow into the Cuu Long Delta, for the period 1960 – 1971;
- extension of this series to 25 years (1960 – 1984) has been achieved by averaging the regulating effect of Tonle Sap, assuming that during the years 1972 - 1984 the monthly discharges at Prek Dam correspond with the average of the monthly discharges derived from the 1960 – 1971 values;
- the contribution of the Cuu Long Delta itself to the Mekong basin runoff has

been estimated on the basis of the monthly net rainfall on the Cuu Long Delta. For this estimate the series of daily rainfall (1978 – 2000) at Can Tho have been used.

Based on this approach a series of monthly runoff of the Mekong basin at its base point has been estimated for the period 1960 – 1984. Based on this series the following dependable runoff has been calculated.

Dependable Monthly Natural Runoff

(A= 37,870km^2) unit : million m^3

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
50%	18,046	9,381	7,288	6,296	9,063	27,269	47,577	80,752	87,292	73,335	51,421	32,289
75%	15,895	8,233	6,500	5,636	7,304	20,746	37,718	67,990	76,089	64,509	47,561	29,721
90%	14,179	7,319	5,864	5,102	6,015	16,220	30,603	58,237	67,241	57,477	44,336	27,585

3.3 High Flow Analysis

3.3.1 Objectives of the High Flow Analysis

Flood damage mitigation is another essential element in the formulation of the Master Plan for Water Resources Development and Management in the fourteen basins. This element is of major concern in those basins where extensive deltaic and coastal floodplains are threatened frequently by flooding. The high flow analysis has therefore concentrated on those basins where such conditions prevail. Also for the other basins, viz. Bang Giang and Ky Cung, Sesan and Srepok, the occurrence of floods have been analysed on the basis of existing information.

The high flow analysis aims basically on the formulation of flood mitigation measures, rather than on the assessment of design discharges for the construction of dams. From the flood control point of view, it is anticipated that protection levels will range in the order of 10% for agricultural areas to 1% for urban areas. (Protection levels of 10% and 1% mean that protection is provided against floods occurring on the average in 9 of the 10 years or 99 of the 100 years respectively). For the design of dams normally safety levels against dam break are maintained that are much stricter and return periods for design floods are of the order of 1000 years and more.

The main objective of the present analysis is, therefore, the estimate of flood levels, in terms of peak discharges and flood volumes, that probably occur at the location where the flood prone area begins. Estimates are made for floods with a probability of occurrence per year of respectively 10%, 5%, 2% and 1%. Where appropriate also other probabilities are indicated.

3.3.2 Methodology

Flood discharges and volumes have, in principle, been estimated on the basis of a frequency analysis of available historic peak discharge and rainfall data. The latter data have merely been used for the estimate of flood volumes. Only in the basins in which the availability of historic discharge information was considered inadequate for such approach, a rainfall-runoff approach has been used, or use has been made of the results of the high flow analysis in an adjacent catchment.

In view of the different meteorological and catchment characteristics, a distinction has been made between the northern, central and southern basins. For the central basins with extremely high flood runoff during the main flood season, not only these main floods have been analysed, but also the so-called "early flood". There are some rivers for which analysis of discharge bifurcation to small branches is not conducted at this study level, thus requiring further detailed discharge distribution analysis in the subsequent stage of the study.

3.3.3 High Flow Analysis for 14 River Basins

(1) Bang Giang and Ky Cung

Data on monthly instantaneous peak flows are available for the Lang Son station in the Ky Cung catchment for the period 1958 – 2000. From this series the following probable discharges have been calculated assuming a Log-normal and Pearson-3 probability distribution respectively:

Probable Yearly Peak Discharges at Lang Son in the Ky Cung Sub-basin

(Unit: m^3/s)

Return Period in years	2	3	5	10	20	50	100
Log- Normal Function	1,153	1,473	1,862	2,394	2,945	3,718	4,343
Pearson 3 Function	1,185	1,551	1,960	2,471	2,952	3,555	3,998
Round average	1,200	1,550	1,950	2,450	2,950	3,650	4,200

The catchment area upstream of the Lang Son station amounts to 1,560 km^2. The specific peak discharge at that location is, consequently, calculated at some 770 l/s/ km^2 at the once in two year flood, increasing to some 2,700 l/s/ km^2 during the once in 100 years flood.

The concentration time of the basin is estimated of the order of 1-2 days. It is, therefore, anticipated that intensities corresponding with one to two day rainfall are indicative for the peak floods.

For both the Ky Cung sub-basin and the Bang Giang sub-basin, the maximum one-day and two day rainfall has been analysed.

By the rainfall analysis, it can be estimated that the following flood volumes may pass, assuming a runoff of some 60% of the rainfall volume, at the mentioned locations.

Approximate Peak Discharges (m^3/s)

Return period in years	**2**	**3**	**5**	**10**	**20**	**50**	**100**
Ban Lai Dam-site	1,000	1,200	1,500	2,000	2,300	2,800	3,200
Lang Son	1,200	1,550	1,950	2,450	2,950	3,650	4,200
Ky Cung at border crossing	4,500	5,000	6,000	6,500	8,000	9,000	10,000

Estimated Flood Volumes (Mm^3)

Return period in years	**2**	**3**	**5**	**10**	**20**	**50**	**100**
Ban Lai Dam-site	30	35	40	45	50	60	70
Lang Son	70	80	90	100	120	140	150
Ky Cung at border crossing	350	400	450	500	600	700	750
Bang Giang at border crossing	250	280	300	350	400		500

(2) Red and Thai Binh

Flood runoff of the Red River and Thai Binh basin has extensively been addressed in the framework of the Red River Delta Master Plan, 1994. This study recommended on the basis of an extensive analysis that it would be prudent to assume a log normal distribution of extreme values for designing the flood protection measures in the Red River Delta.

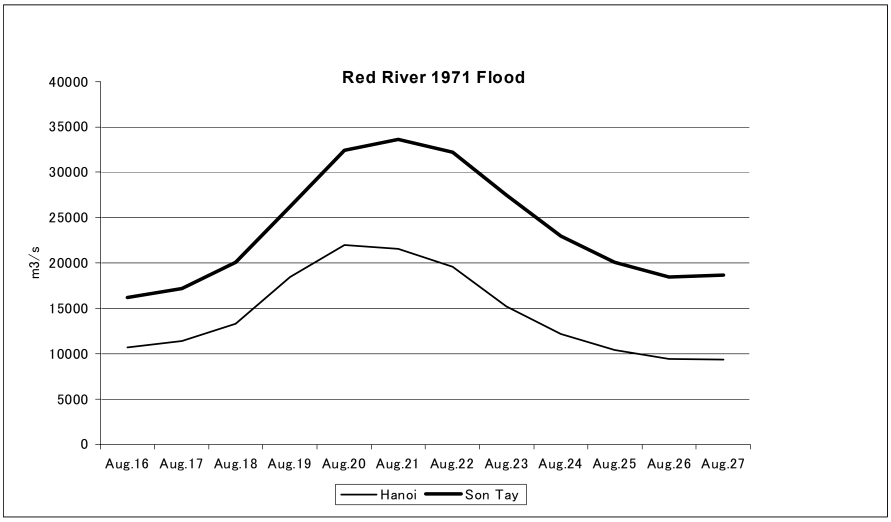
Maximum instantaneous discharges for the years 1956 – 1986 (so prior to the functioning of the Hoa Binh reservoir) were used for the statistical analysis of flood discharges. The data after 1986 when the Hoa Binh Dam commenced its operation were not used, since the flood discharges to downstream were ones which were already regulated by the reservoir and not proper for the use in the statistical analysis. The log normal distribution function on the basis of historic observation gives the following probable peak discharges for Son Tay and Hanoi:

Estimated peak discharges (m^3/s)						
Return period	10 years	20 years	50 years	100 years	500 years	1000 years
Son Tay	23,500	27,000	32,050	35,730	46,390	51,580
Hanoi	16,150	18,020	20,540	22,230	26,860	28,970

In connection with the probable discharges at Hanoi(the Red River), the following is noted:

The Red River bifurcates to the Red River and the Duong River in the downstream of Son Tay. Although the discharges at Hanoi in the Red River after the bifurcation are as shown in the above table on the basis of the statistic analysis with historical observations, the discharges in the Duong River are not always the difference between the discharge at Son Tay and the discharge at Hanoi due to the possible right bank overflow between Son Tay and Hanoi in the occurrence of large floods. The discharges of the Duong River are not shown due to lack of data for the said right bank overflow in the historical events.

The maximum peak discharges observed at these locations refer to the 1971 flood with following hydrograph.



It is observed that the discharges in Son Tay were still rising while in downstream located Hanoi the peak already had passed. This phenomena could be explained by a sudden diversion of flood waters between Son Tay and Hanoi, possibly caused by a dike breach.

The corresponding flood volumes at Son Tay over 8 days flood duration are as follows (source Red River Master Plan):

year	Qmax (m^3/s)	Estimated Return Period	8- day Flood Volume (Mm^3)
1968	24,000	11 years	12,960
1969	28,300	25 years	16,500
1945	33,500	64 years	18,800
1971 1)	38,400	141 years	19,600

1) see above note on 1971 Son Tay peak discharges

For the same historic floods the contribution from the different sub-basins to the peak discharge was estimated as follows (source Red River Master Plan):

year	Qmax (m^3/s)	Hoa Binh (Da River)	Yen Bai (Thao River)	Phu Ninh (Lo River)
1968	24000	39%	28%	25%
1969	28300	54%	17%	31%
1945	33500	54%	20%	25%
1971 1)	38400	38%	25%	39%

1) see above note on 1971 Son Tay peak discharges

(3) Ma

Flood Runoff Chu Sub-basin

The flood runoff of the Chu basin has been estimated at Cua Dat, just upstream of the flood prone area of the Chu basin. Instantaneous yearly peak discharges at Cua Dat stations have been collected and processed for the period 1976 – 2000. It is noted that the availability of only twenty five observed maximum year discharges provides a rather weak basis for the frequency analysis of peak discharges.

The frequency analysis has been carried out using a number of probability distribution functions. The goodness-of-fit tests and the confidence intervals indicate that the normal distribution describes best the probability of occurrence of the peak discharges. Also the Log Pearson, Gumbel and Goodrich give above average results. The results of the frequency analysis are summarised below for these distribution functions.

Estimated Peak Discharges at Cua Dat with Corresponding Return Period Unit: m^3/s

Return Period	10 years	20 years	50 years	100 years
Normal	3,565	3,912	4,302	4,563
Log-Pearson	3,771	4,745	5,328	6,031
Gumbel	3,587	4,123	4,816	5,336
Goodrich	3,577	3,934	4,360	4,634
Average round values	3,650	4,200	4,700	5,150

For the estimate of volumes of floods that are generated by 1,2 and 3-day peak rainfall on the Chu basin, an analysis has been made of the daily rainfall data from the rainfall stations upstream of Bai Thuong, the downstream location of the upper and middle Chu catchment.

Maximum Yearly n-day Rainfall Volume in Mm^3

	upstream Bai Thuong(7460km^2)			upstream Cua Dat (6170 km^2)		
Return period	1 day	2 days	3 days	1 day	2 days	3 days
10 years	1,335	1,992	2,346	1,104	1,648	1,940
20 years	1,507	2,264	2,663	1,246	1,873	2,203
50 years	1,716	2,589	3,092	1,419	2,141	2,557
100 years	1,880	2,842	3,405	1,555	2,351	2,816

Flood Runoff Ma basin

For the estimate of probable peak discharges, use could be made of the estimated peak discharges at Xa La and Cua Dat, assuming Creager type of relation between the respective flood discharges. This relation assumes that the peak discharge is proportional to A to the power $A^{-0.05}$, with A is the catchment area. The respective catchment areas are as follows:

Xa La	6,430 km^2
Cua Dat	6,170 km^2
Cam Thuy	17,500 km^2
Ma – Chu confluence	28,000 km^2

Based on these areas, the following proportionality factors are calculated:

Cam Thuy / Xa La	1.40
Cam Thuy / Cua Dat	1.42
Ma – Chu / Cam Thuy	1.15

For a first estimate of peak discharges at Cam Thuy, use is made of the average of the probable discharges at Xa La and Cua Dat, and applying the above mentioned proportionality factors. The result is as follows:

Estimated Peak Discharges at Cam Thuy with Corresponding Return Period

Unit: m^3/s

Return Period	10 years	20 years	50 years	100 years
Peak Discharge	4100	4800	5500	6100

Similarly, the peak discharges of the Ma river downstream of the Chu confluence can be estimated, applying the area related Creager proportionality to the Cam Thuy discharges.

Estimated Peak Discharges at Ma – Chu Confluence

Unit: m^3/s

Return Period	10 years	20 years	50 years	100 years
Peak Discharge	4,700	5,500	6,300	7,000

From above analysis it became apparent that an adequate rainfall – runoff modelling is essential for a more accurate estimate of the probable floods in the lower part of the basin.

For the estimate of volumes of floods that are generated by 1,2 and 3-day peak rainfall on the Ma basin upstream of the flood prone area, an analysis has been made of the daily rainfall upstream of Ma - Buoi confluence. These rainfall intensities correspond with the following n-day precipitation volumes on the Ma basin upstream of the Ma – Buoi confluence (19,820 km^2)

Maximum Yearly n-day Rainfall Volume Upstream Ma – Buoi Confluence in Mm^3

Return period	10 years	20 years	50 years	100 years
1 day	2,800	3,100	3,600	3,900
2 days	4,200	4,700	5,500	6,000
3 days	5,000	5,700	6,600	7,300

(4) Ca

The flood prone area of the Ca basin is situated downstream of Do Luong. At this location Ca waters are diverted to the coastal area north of the Ca basin. The peak discharges at Do Luong are therefore an important factor in the formulation of flood mitigation measures in the Ca basin.

Discharges measured at Dua station correspond to more than 98% of the catchment area at Do Luong. As a consequence, peak discharges at Do Luong are expected to deviate from the Dua peak discharges by less than 1%. It is, therefore, considered justified to derive the peak discharges at Do Luong directly from the discharge series of Dua station. From the 1976- 2000 discharge series at Dua, the yearly maximum daily discharges were collected and a frequency analysis has been carried out.

Several probability distribution functions have been assumed for the estimate of the peak discharges with corresponding return periods. The results of the most likely distribution functions are presented below:

Estimated Peak Discharges at Dua with Corresponding Return Period

Unit: m^3/s

Return Period (years)	2	5	10	20	50	100
Log Normal	3,329	5,246	6,656	8,090	10,106	11,712
Pearson-3	3,426	5,507	6,862	8,118	9,716	10,874
Log Pearson	3,218	5,351	7,066		11,756	14,162
Gumble	3,484	5,468	6,781	8,041	9,672	10,894
Average round values	3,400	5,400	6,800	8,200	10,300	11,900

For the estimate of volumes of floods that are generated by 1,2 and 3-day peak rainfall on the Ca basin upstream of the flood prone area, an analysis has been made of the daily rainfall upstream of Do Luong.

Maximum Yearly n-day Rainfall Volume on Ca basin Upstream Do Luong
(21,130 km^2) (unit : Mm^3)

Return period	1 day	2 days	3 days
2 years	1,800	2,600	2,900
5 years	2,500	3,600	4,000
10 years	3,000	4,200	4,700
20 years	3,400	4,800	5,400
50 years	4,000	5,700	6,300
100 years	4,400	6,300	7,000

(5) Thach Han

Long series of historic data of flood events in the Thach Han basin are absent. On the other hand, long records of daily rainfall in the Thach Han basin exist, allowing for a frequency analysis of storm events in the basin. However, no discharge measurements during storm events are available. For the neighbouring Huong basin, rainfall - runoff modelling was done and calibrated. The calibration results, in the form of parameters for the Sacramento model, have been used for the Thach Han basin as well, in combination with the area rainfall data of this basin.

Frequency analyses were carried out using both the Gumbel and the Log-Normal probability distribution functions. The analyses were carried out for the yearly maximum area rainfall values and for the "early flood" rainfall values (maximum rainfall in period January – August). The results (averaged and rounded Gumbel and Log Normal values) are given in the tables below.

One Day Maximum Year Rainfall in mm

Return Period (years)	2	10	20	50	100
Upper and middle Thach Han basin	175	275	315	370	410

One day Maximum "early flood" Rainfall in mm

Return Period (years)	2	10	20	50	100
Upper and middle Thach Han basin	95	170	200	245	275

These values are substantially lower than the estimated peak rainfall in the Huong basin. During the main flood season, the Huong rainfall intensities are over 50% higher than in the Thach Han basin. During the early flood season this difference is of the order of 30%.

For the simulation of the flood runoff, a hourly distribution of the above daily rainfall values is assumed similar to the distribution in the Huong basin. The estimated peak discharges and corresponding flood volumes resulting from a one day storm are as follows.

Main Flood at Thach Han Weir

Return Period (years)	2	10	20	50	100
Peak discharge (m^3/s)	1830	3,500	4,300	5,200	6,100
Flood volume (Mm^3)	95	200	250	310	360
Runoff Coefficient	0.39	0.54	0.57	0.61	0.63

Early Flood at Thach Han Weir

Return Period (years)	2	10	20	50	100
Peak discharge (m^3/s) Flood volume (Mm^3)	870 35	1,800 90	2,300 120	3,000 170	3,500 200
Runoff Coefficient	0.26	0.39	0.44	0.50	0.53

The confluences of the Vinh Phuoc and the Cam Lo river with the Thach Han river are situated in the flood prone area. If flood control measures are taken that prevent waters from both the Thach Han, the Vinh Phuoc and the Cam Lo to spill or divert from the respective river channels, than peak discharges at the Cam Lo confluence could be estimated by applying a Creager factor to the Thach Han weir peak discharges. This implies that the peak discharges at the Cam Lo confluence would be some 20% higher than the peak discharges with corresponding return period at Thach Han weir.

(6) Huong

Long series of historic data of flood events in the Huong basin are absent. The estimate of probable floods on the basis of a frequency analysis of historic data is, therefore, not feasible. On the other hand, long records of rainfall in the Huong basin exist, allowing for a frequency analysis of storm events in the basin. Moreover a number of flood events and corresponding rainfall were registered on an hourly basis, allowing the calibration and verification of rainfall runoff modelling under flood conditions.

Flood modelling with the help of rainfall – runoff modelling has been carried out with the help of the Sacramento model for the land-phase of the runoff generation, while the outflow of this land-phase was routed through the tributaries using the standard Muskingum method.

In addition to the Sacramento modelling, the modelling of the floods in the Huong basin has also been done with the help of the Mike 11 rainfall-runoff simulation module NAM.

Frequency analyses were carried out using both the Gumbel and the Log-Normal probability distribution functions. The analyses were carried out for the yearly maximum area rainfall values and for the “early flood” rainfall values (maximum rainfall in period January – August). The results (averaged and rounded Gumbel and Log Normal values) are given in the tables below:

One day maximum year rainfall in mm

Return Period (years)	2	5	10	20	50	100
Bo upstream Co Bi	260	365	440	505	600	665
Huu Trach upstream Binh Dien	285	355	400	450	500	550
Ta Trach upstream Duong Hoa	340	425	475	525	590	635
Lower Huong basin	240	345	425	495	585	655

One day maximum "early flood" rainfall in mm

Return Period (years)	2	5	10	20	50	100
Bo upstream Co Bi	85	130	165	195	235	270
Huu Trach upstream Binh Dien	85	155	210	260	335	400
Ta Trach upstream Duong Hoa	100	185	260	330	420	495
Lower Huong basin	95	160	210	255	320	365

Two-day maximum year rainfall in mm

Return Period (years)	2	5	10	20	50	100
Bo upstream Co Bi	390	565	690	805	965	1,085
Huu Trach upstream Binh Dien	400	545	640	725	845	935
Ta Trach upstream Duong Hoa	470	635	745	850	980	1,080

Two-day maximum "early flood" rainfall in mm

Return Period (years)	2	5	10	20	50	100
Bo upstream Co Bi	115	180	225	275	345	400
Huu Trach upstream Binh Dien	115	210	290	375	510	625
Ta Trach upstream Duong Hoa	135	260	360	475	650	805

Three-day maximum year rainfall in mm

Return Period (years)	2	5	10	20	50	100
Bo upstream Co Bi	450	690	855	1,020	1,240	1,405
Huu Trach upstream Binh Dien	475	675	810	935	1,110	1,240
Ta Trach upstream Duong Hoa	550	770	915	1,055	1,240	1,380

Three-day maximum "early flood" rainfall in mm

Return Period (years)	2	5	10	20	50	100
Bo upstream Co Bi	130	200	250	295	365	420
Huu Trach upstream Binh Dien	130	225	310	400	525	630
Ta Trach upstream Duong Hoa	150	275	380	495	670	815

Four-day maximum year rainfall in mm

Return Period (years)	2	5	10	20	50	100
Bo upstream Co Bi	510	800	1,000	1,205	1,470	1,680
Huu Trach upstream Binh Dien	545	800	970	1,140	1,360	1,530
Ta Trach upstream Duong Hoa	630	905	1,090	1,270	1,510	1,690

Four-day maximum "early flood" rainfall in mm

Return Period (years)	2	5	10	20	50	100
Bo upstream Co Bi	140	210	260	305	370	420
Huu Trach upstream Binh Dien	135	240	320	405	535	640
Ta Trach upstream Duong Hoa	160	290	400	515	685	825

Five-day maximum year rainfall in mm

Return Period (years)	2	5	10	20	50	100
Bo upstream Co Bi	560	885	1110	1340	1645	1880
Huu Trach upstream Binh Dien	585	860	1050	1230	1475	1660
Ta Trach upstream Duong Hoa	670	970	1170	1370	1630	1825

Five-day maximum "early flood" rainfall in mm

Return Period (years)	2	5	10	20	50	100
Bo upstream Co Bi	155	225	270	320	380	430
Huu Trach upstream Binh Dien	145	250	330	415	540	645
Ta Trach upstream Duong Hoa	170	300	405	525	685	825

The estimated peak discharges and corresponding flood volumes resulting from the one day design storm are as follows:

		Return Period (years)	10	20	50	100
Cobi	Main Flood	Peak discharge (m^3/s)	3,900	5,100	6,700	7,800
		Flood volume (Mm^3)	200	250	320	370
		Runoff Coefficient	0.65	0.69	0.74	0.76
	Early Flood	Peak discharge (m^3/s)	1,000	1,250	1,600	2,000
		Flood volume (Mm^3)	40	60	80	100
		Runoff Coefficient	0.35	0.41	0.47	0.51
Tuan	Main Flood	Peak discharge (m^3/s)	9,800	11,400	13,400	15,100
		Flood volume (Mm^3)	490	570	660	730
		Runoff Coefficient	0.77	0.79	0.81	0.83
	Early Flood	Peak discharge (m^3/s)	3,100	4,400	6,400	8,400
		Flood volume (Mm^3)	140	200	300	390
		Runoff Coefficient	0.40	0.47	0.55	0.61

(7) Vu Gia and Thu Bon

The flood prone area of the Thu Bon basin is situated downstream of the confluence of the Thu Bon and Vu Gia river. At this confluence the sub-catchments of Thu Bon and Vu Gia have an area of 3,590 km^2 and 5,420 km^2 respectively. The discharges of 87% of the Thu Bon sub-catchment are observed at Nong Son. In the Vu Gia sub-catchment observations are available of only 34% of the area, at Thanh My.

Several probability distribution functions have been assumed for the estimate of the peak discharges with corresponding return periods. The results of the most likely distribution functions are presented below:

Estimated Peak Discharges at Nong Son (Unit: m^3/s)

Return Period (years)	2	5	10	20	50	100
Log Normal	5,433	7,505	8,888	10,150	11,956	13,276
Pearson-3	5,542	7,667	8,964	10,129	11,564	12,583
Log Pearson	5,324	7,486	9,045		12,844	14,622
Gumble	5,466	7,526	8,890	10,198	11,892	13,161
Average round values	5,400	7,500	8,900	10,300	12,100	13,400

Estimated Peak Discharges at Thanh My (Unit: m^3/s)

Return Period (years)	2	5	10	20	50	100
Log Normal	3,304	4,831	5,894	6,907	8,353	9,447
Pearson-3	3,387	4,987	5,909	6,904	8,044	8,861
Log Pearson	3,175	4,914	6,271	7,449	9,881	11,697
Gumble	3,373	4,910	5,928	6,902	8,168	9,115
Average round values	3,300	4,900	6,000	7,000	8,000	9,800

Assuming a Creager type of relation between the peak discharges and the catchment area, a first approximation of the peak flows at the confluence of the Vu Gia and the Thu Bon (total catchment area: 9,010 km^2) is as follows:

Approximate Peak Discharges at the Vu Gia- Thu Bon Confluence (Unit: m^3/s)

Return Period (years)	2	5	10	20	50	100
Peak Discharge	8,000	10,500	12,500	14,000	17,000	19,000

The concentration time of the basin is estimated of the order of 1 day. It is, therefore, anticipated that intensities corresponding with one day rainfall are indicative for the peak floods. For both the Thu Bon sub-basin and the Vu Gia sub-basin, the maximum one-day rainfall has been analysed.

Maximum Yearly One-day Area Rainfall Volume on the Vu Gia - Thu Bon Basin

	Return period in years					
	2	5	10	20	50	100
Volume in Mm^3	1,700	2,200	2,500	2,800	3,300	3,600

Early floods may occur as a consequence of high rainfall intensities during the period prior to main wet season. Here the early floods are defined as the floods that are a result of storms in the period January – August. For this period of the year the high flow analysis has been carried out similarly to the analysis for full years. The results are as follows:

Estimated Early Flood Peak Discharges

(Unit: m^3/s)

Return Period (years)	2	5	10	20	50	100
Peak Discharge: Nong Song	700	1,400	2,000	2,600	3,400	4,000
: Thanh My	400	900	1,400	1,900	2,500	3,100
: Vu Gia-Thu Bon Confluence	1,000	2,000	2,800	3,700	4,800	5,800

Maximum Yearly Early One-day Area Rrainfall Volume in Mm^3

on the Vu Gia - Thu Bon basin

Return period in years					
2	5	10	20	50	100
600	9,100	1,100	1,400	1,700	1,900

(8) Tra Khuc

For the estimate of the probable peak discharges in the Tra Khuc river, use has been made of the historical discharge data of the Son Giang station. Recorded instantaneous maximum discharges were available for only fourteen years. This provides a weak basis for the frequency analysis. The results of the analysis are, nevertheless, summarised below for the maximum yearly floods.

Yearly Maximum Discharges at Son Giang (Unit: m^3/s)

	5 years	10 years	20 years	50 years	100 years
Log Normal	8,257	9,967	11,701	13,865	15,578
Pearson 3	8,489	10,098	11,563	13,369	14,664
Gumbel	8,348	10,001	11,588	13,641	15,180
Goodrich	8,606	9,915	11,058	12,277	13,042
Average round values	8,500	10,000	11,500	13,500	15,000

Yearly Early maximum discharges at Son Giang (Unit: m^3/s)

	5 years	10 years	20 years	50 years	100 years
Log Normal	884	1,273	1,729	2,416	3,028
Log Pearson	832	1,241	1,637	2,644	3,512
Gumbel	1,064	1,425	1,771	2,220	2,555
Average round values	950	1,300	1,700	2,400	3,000

For the estimate of flood volumes corresponding with the above mentioned peak discharges, an analysis has been made of the one-day area rainfall in the upper and middle Tra Khuc basin.

One Day Maximum Area Rainfall main Flood Season in mm

Return Period (years)	2	5	10	20	50	100
Upper and middle Tra Khuc basin	230	315	370	425	495	550

One Day Maximum "Early Flood" Rainfall in mm

Return Period (years)	2	5	10	20	50	100
Upper and middle Tra Khuc basin	65	100	120	145	175	200

The corresponding rainfall volumes on the upper and middle 3,030 km2 of the Tra Khuc basin are as follows.

Estimated one-day rainfall Volumes in Mm^3 on Upper and Middle Tra Khuc basin

Return period	2 years	5 years	10 years	20 years	50 years	100 years
Main flood season	700	1,000	1,100	1,300	1,500	1,700
Early flood season	200	300	350	450	550	600

It is anticipated that during the early floods this runoff percentage will be lower and could be of the order of 50% or even less.

(9) Kone

For the estimate of the probable peak discharges in the Kone river, use has been made of the historical discharge data of the Cay Muong station.

Frequency distribution analyses were carried out with the above series of maximum discharges. It is noted that the availability of only twenty five observed maximum year discharges provides a rather weak basis for the frequency analysis of peak discharges. The results are summarised below for the yearly maximum peak discharges at Cay Muong:

Unit: m^3/s

Return period (years)	2	5	10	20	50	100
Log Normal	2,137	3,443	4,401	5,135	6,205	7,005
Pearson 3	2,201	3,653	4,469	5,141	5,977	6,577
Gumbel	2,256	3,621	4,424	5,145	6,078	6,778
Goodrich	2,125	3,779	4,506	5,072	5,760	6,211

A Creager type area relation is assumed for the peak discharges. The peak discharge at Binh Thanh (catchment area = 2,350 km^2) is 1.157 times the peak discharge at Cay Muong (catchment area = 1,667 km^2). For the Cay Muong peak discharges the average value of the above estimated probable discharges has been taken.

Peak Discharges at Binh Thanh with Corresponding Return Period (years)

(Unit: m^3/s)

2	5	10	20	50	100
2,500	4,200	5,100	5,900	6,900	7,700

Early Flood Peak Discharges at Dai Binh with Corresponding Return Period

(Unit: m^3/s)

2	5	10	20
160	310	430	560

For the estimate of volumes of floods that are generated by 1-day peak rainfall on the Kone basin, an analysis has been made of the daily rainfall data from the rainfall stations upstream of the apex of the Kone delta at Binh Thanh.

Maximum Yearly n-day Rainfall Volume on Kone Basin

Upstream Binh Thanh (2,250 km^2) (Mm^3)

Return period	2 years	5 years	10 years	20 years	50 years	100 years
1 day	380	503	583	657	758	831
2 days	535	714	833	939	1,089	1,197
3 days	606	797	919	1,031	1,188	1,301

Maximum Early (January – September) 1-day Rainfall at Binh Tuong in mm

Return period in years	2	5	10	20	50	100
Log-normal	73	105	128	150	178	200
Gumbel	75	106	128	149	175	195

The corresponding early storm volume in Mm^3 on the Kone basin upstream of Dai Binh is estimated as follows:

Return period in years					
2	5	10	20	50	100
170	240	300	350	400	450

(10) Ba

For the estimate of the probable peak discharges in the Ba river, use has been made of the historical discharge data of the Cung Son station. For this analysis only 13 years of records of monthly instantaneous peak discharges were available in this study.

Unit: m^3/s

	2 y	5 y	10 y	20 y	50 y	100 y
Log Normal	5,460	9,665	13,029	16,793	22,006	26,477
Pearson 3	5,590	10,480	13,876	17,143	21,350	24,468
Gumbel	6,010	10,655	13,731	16,681	20,499	23,360
Goodrich	5,945	10,584	13,525	16,113	19,441	21,737
Averaged round values	5,800	10,400	13,500	17,000	21,000	24,000 [1)]

[1)] Reportedly a 24000 m^3/s flood was observed in 1938, while in 1964 a flood of 21,850 m^3/s was reported.

A similar analysis has been carried out with the maximum yearly early flood events.

Unit: m^3/s

	2 y	5 y	10 y	20 y	50 y	100 y
Log Normal	719	1,136	1,443	1,752	2,195	2,545
Gumbel	753	1,185	1,470	1,744	2,099	2,365
Averaged round values	750	1,150	1,450	1,750	2,150	2,500

For the estimate of flood volumes corresponding with the above mentioned peak discharges, an analysis has been made of the n-day area rainfall in the upper and middle Ba basin. For this analysis the following series of historic daily rainfall data have been used:

The analyses were carried out for the yearly maximum area rainfall values and for the “early flood” rainfall values (maximum rainfall in period January – August). The results (averaged and round Gumbel and Log Normal values) are given in the tables below:

Upper and middle Ba basin (mm)

	Return Period (years)					
	2	5	10	20	50	100
1-day maximum area rainfall main flood	110	155	180	210	250	275
1-day maximum “early flood” rainfall	45	60	75	85	100	110
2-day maximum area rainfall main flood	150	220	265	310	370	420
2-day maximum “early flood” rainfall	60	80	95	105	125	135
3-day maximum area rainfall main flood	165	245	290	340	405	455
3-day maximum “early flood” rainfall	70	100	115	130	150	165

The corresponding rainfall volumes on the upper and middle basin are as follows:

Estimated Yearly n-day Rainfall Volumes in Mm3 on Upper and Middle Ba Basin

Storm	2 years	5 years	10 years	20 years	50 years	100 years
One-day storm	1,400	2,000	2,300	2,700	3,200	3,600
Two-day storm	1,900	2,800	3,400	4,000	4,800	5,500
Three –day storm	2,100	3,200	3,800	4,400	5,300	5,900

Estimated Early n-day Rainfall Volumes in Mm3 on Upper and Middle Ba Basin

Return period	2 years	5 years	10 years	20 years	50 years	100 years
One-day storm	600	800	1,000	1,100	1,300	1,400
Two-day storm	800	1,000	1,200	1,400	1,600	1,800
Three –day storm	900	1,300	1,500	1,700	1,900	2,100

It is anticipated that the peak discharges at Cung Son are produced by two-day storms.

(11) Sesan

Data on monthly instantaneous peak flows are available for the Kon Tum station in the Dak Bla sub-catchment for the period 1978 – 2000. From this series the following probable discharges have been calculated assuming a Log-normal, Pearson-3 and Gumbel probability distribution respectively:

Probable Yearly Peak Discharges at Kon Tum in the Dak Bla Sub-basin

(Unit: m^3/s)

Return Period years	2	5	10	20	50	100
Log-nor.	1,465	2,071	2,482	2,877	3,411	3,815
Pears.3	1,497	2,124	2,510	2,861	3,292	3,600
Gumbel	1,482	2,087	2,487	2,872	3,369	3,742
Round average	1,500	2,100	2,500	2,900	3,400	3,750

The catchment area upstream of the Kon Tum station amounts to 3,056 km^2. The specific peak discharge at that location, is consequently calculated at some 490 l/s/ km^2 at the once in two year flood, increasing to some 1,200 l/s/ km^2 during the once in 100 years flood.

Twenty five years daily area rainfall series have been compiled and the following one-day probable rainfall intensities have been calculated assuming a log-normal distribution of the yearly maximum values.

Maximum One Day Area Rainfall on the Dak Bla Sub-basin (mm)

Return period in years	2	3	5	10	20
Full year	87	100	113	130	145
January - August	74	87	101	119	137

(12) Srepok

To estimate the flood runoff in the Srepok basin, an analysis has been made of the observed peak flows in the basin and of the rainfall intensities. Data on monthly instantaneous peak flows are available for the Ban Don for the period 1977 – 2000. From this series the following probable discharges have been calculated assuming a Log-normal, Pearson-3 and Gumbel probability distribution respectively:

Probable Yearly Peak Discharges at Ban Don in the Srepok Basin (Unit: m^3/s)

Return Period years	2	3	5	10	20	50	100
Log-nor.	1,403	1,709	2,049	2,498	2,952	3,538	4,632
Pears.3	1,438	1,764	2,114	2,538	2,929	3,407	3,753
Gumbel	1,431	1,739	2,082	2,513	2,926	3,460	3,861
Round average	1,450	1,750	2,100	2,550	2,950	3,500	4,100

The catchment area upstream of the Ban Don station amounts to 10,700 km^2. The specific peak discharge at that location, is consequently calculated at some 135 l/s/ km^2 at the once in two year flood, increasing to some 400 l/s/ km^2 during the once in 100 years flood.

The area rainfall has been estimated on the basis of the average day rainfall in the following stations:

- Buon Ma Thuot;
- Cau 42
- Giang Son and
- Duc Xuyen.

The following probable area rainfall has been calculated, assuming a log-normal probability distribution:

Maximum Yearly Area Rainfall on the Srepok Basin (mm)

Return period in years	2	3	5	10	20	50	100
One-day	89	106	125	150	175	205	229
Two-day	117	146	178	222	268	326	373

(13) Dong Nai

Flood runoff in the Dong Nai basin has been addressed by Nippon Koei (1996) in the Master Plan Study on Dong Nai River and Surrounding Basins Water Resources Development. In the National Hydropower Plan Study by SWECO et al, reference is made to design flood estimates prepared by PECC2 for the different hydropower projects, no further analysis on basin flood runoff is presented in the 1999 Phase-1 report of that study. The VWRAP study on Dam Safety Issues, carried out by HASKONING in 2001 and which included the Dau Tieng reservoir in the Saigon basin, concentrates on design discharges for dams, rather than on flood damage mitigation issues.

JICA Master Plan Study in 1996 concluded that insufficient historic data on peak discharges are available for making a frequency analysis of flood events. As a result, the approach of Flood Runoff Modelling was followed, using the Storage Function simulation method. The flood runoff analysis was carried out for several locations, mainly existing or potential dam sites. The most downstream locations that were analysed are:

- Tri An in the Dong Nai river (catchment area: 14,025 km^2)
- Dau Tieng in the Saigon river (catchment area: 2,700 km^2).

The flood runoff analysis was carried out for the 20 and 100 year return period only. For the three locations mentioned above, the following flood discharges were calculated:

Return Period	20 years	100 years
Tri An	6,459 m^3/s	8,265 m^3/s
Dau Tieng	2,351 m^3/s	3,197 m^3/s

If a Creager type of relation is assumed between the peak discharges, than it could be estimated from these figures that peak flows at Hoa An (catchment area: 22,594 km^2) and the Saigon – Thi Tinh confluence could approximately be as follows:

Return Period	20 years	100 years
Hoa An	8,000 m^3/s	10,000 m^3/s
Saigon Thi Tinh confluence	3,000 m^3/s	4,000 m^3/s

(14) Cuu Long River Delta

The flood runoff of the Mekong basin enters the Cuu Long Delta along various ways. Prior to entering Vietnam, already a substantial volume of the flood runoff is diverted from the river system to flooded areas in Cambodia. This volume has been estimated at 5 –10% of the river discharge. Moreover, a considerable part of the flood discharge is diverted to the Great Lake through the Tonle Sap.

Efforts have been made in past and are still being made to estimate the peak discharges and flood volumes that eventually enter the Cuu Long Delta, either through the two branches of the river system, or via overland flow. An analysis made of the 1978 flood flows indicate that some 20% of the flood waters enter Vietnam overland.

The order of magnitude of the flood flows can be derived from the peak discharges at Kratie. Series of maximum day discharges are available from this station for the period 1924 – 1969. From these series, the following discharges have been estimated with the help of a number probability functions.

Estimated Peak Discharges Kratie, Based on Discharge Series 1924 - 1969

(Unit: m^3/s)

Return period			
10 years	20 years	50 years	100 years
61,500	64,500	68,000	70,000

It is noted that the Coefficient of Variation of the yearly peak discharges is remarkably low. With a mean value of peak discharges of 52,657 m^3/s, and a standard deviation of 6,637 m^3/s, the C_v amounts to 0.126 only. It is anticipated that further peak attenuation between Kratie and the Vietnamese border will even reduce this value.

CHAPTER 4 AGRICULTURE

4.1 General

In the 1990s, in addition to far-reaching reforms in agriculture involving de-collectivization, allocation of land to farmers and liberalization of prices and markets, there was also major investment in rural infrastructure. Consequently, agriculture, forestry and fishery sector (, so called broadly as agriculture sector) growth averaged 4% over the period 1991-1997. Performance in 1998 was disappointing with 2.8% growth due mainly to drought-affected low harvests, and partially to the effect of Asian economic crisis. A bumper rice crop, as well as growth in fisheries and livestock in 1999, boosted agricultural growth to 5.2%. Agricultural growth is estimated to have grown by around 4% in 2000.

The agriculture sector accounts for about 23.8% of GDP in 1999 at constant price of 1994, of which agriculture sub-sector accounts for about 81.8%, forestry for 4.4%, and fishery for 13.8%. Approximately, half of the gross value of agricultural production comes from food crops, while industrial crop account for 16.7%, fruit crops 6.1%, vegetables and beans 5.9%, and livestock 18.7%.

4.2 Present Agriculture Situation in Vietnam

4.2.1 Agricultural Household and Agricultural Land

A total agricultural household in Vietnam is 10,981 thousand in 1998 increasing 32% from 8,315 thousand in 1985. A total agricultural land is estimated at 8,080 thousand ha increasing 16% from 6,942 thousand ha in 1985. Thus, the agricultural land to the agricultural household is gradually decreasing to 0.74 ha in 1998 compared with 0.83 ha in 1985. While this down ward trend can be seen particularly in the Northwest and Northeast regions, the Southeast and Central Highlands regions have shown the noticeable increase of the agricultural land.

Consequently, agricultural land holding per household is generally larger in southern area than in northern area; the smallest is in Red River Delta region of 0.25 ha, and largest is in Central Highlands region of 1.82 ha.

4.2.2 Land Resources and Agricultural Land Use

(1) Land Resources and Soil

Vietnam has a total area of about 329,241 km^2. Lowland occupies only around 69,000 km^2, about 21% of the country's area. The rest is characterized by hills, mountain ranges, and upland plateaus. The lowland extends mainly in two major delta areas, the Red River delta in the north and the lower Cuu Long delta in the south. These two delta areas cover 79% of the total lowland and the remainder is scattered in the major river valleys along the narrow coastal plains located between the two deltas.

The following table shows the recent land use condition in the country.

Land Use in Vietnam by Region (Unit: 1,000 ha)

	Total		Agriculture		Forestry		Homestead		Specialized	
	Area	%	Area	%	Area	%	Area	%	Area	%
Red River Delta	1,478.8	100.0	857.6	58.0	119.0	8.0	91.3	6.2	233.0	15.8
Northeast	6,532.6	100.0	897.9	13.7	2,673.9	40.9	58.8	0.9	204.2	3.1
Northwest	3,563.7	100.0	407.4	11.4	1,037.0	29.1	15.5	0.4	58.5	1.6
North Central Coast	5,150.1	100.0	725.3	14.1	2,222.0	43.1	52.8	1.0	231.3	4.5
South Central Coast	3,306.7	100.0	545.6	16.5	1,166.3	35.3	32.4	1.0	211.9	6.4
Central Highlands	5,447.6	100.0	1,233.6	22.6	2,993.2	54.9	33.1	0.6	137.1	2.5
Southeast	3,473.3	100.0	1,707.8	49.2	1,026.2	29.5	58.1	1.7	233.3	6.7
Cuu Long Delta	3,971.3	100.0	2,970.2	74.8	337.8	8.5	101.2	2.5	223.5	5.6
Whole Country	32,924.1	100.0	9,345.4	28.4	11,575.4	35.2	443.2	1.3	1,532.8	4.7

Source: Statistical Yearbook 2000, General statistical Office

(2) Agricultural Land Use

Of the total agricultural land of 8,080 thousand ha, paddy land accounted for 52.1% and the remaining is used for other purpose, particularly for upland crops. However, the share of paddy land versus upland varies considerably by regions. Both deltas of the Red River and the Cuu Long, where the lands are flat and the soils are quite fertile, are the major production areas of paddy and their share of paddy land accounts for a high rate of 85.8% and 76.3%, respectively. Then North Central Coast and Southeast regions having flat plains in their coastal parts follow at 58.4% and 51.7%, respectively. In the Cuu Long delta, it is possible to harvest three crops of paddy per year, whereas in the Red River delta farmers usually grow two crops of paddy and one of maize. Vegetables and some fruits are also grown in the delta areas.

4.2.3 Structure of Agricultural Employment

According to official estimates, 38.7 million people or 50.5% of the total population were employed in 1999, and around 80% of the active labor force were self-employed, of whom over 60% were self-employed farmers[1].

[1] World Bank, Country Economic Review of Vietnam, November 2000

4.2.4 Agricultural Production

The production structure of agriculture in Vietnam is dominated by rice, which accounts for half the gross value of agricultural output.

In 1985, Vietnam cultivated only 5,720thousand ha of paddy with an average yield of 2.77 ton/ha and an output of 15,860thousand tons, then in 1999, these figures are 7,650 thousand ha, 4.10 ton/ha, and 31,390 thousand tons. For 13 years, paddy area, yield and output have increased by 33.7%, 48.0%, and 97.9%, respectively. These achievements are considered as the results of the reforms in agricultural mechanisms and policy in line with Resolution No.10 (1988) so called as “Doi Moi”; paddy land is allocated to farmers for long-time use; farmer households are considered as independent economic units. Thus, the output of rice allowed Vietnam to become one of great export countries. The exported quantity has increased from 1.4 million tons in 1989 to 3.8 million tons in 1998.

Planted Area and Production Volume in 1999 by Regions

(Unit: 1,000ha;1,000tons)

	Paddy			Other cereals			Industrial Crops			
							Annual**		Permanent***	
	Area	%	Output	Area	%	Output*	Area	%	Area	%
Red River Delta	1,048.2	13.7	5,692.9	141.7	11.6	426.9	66.9	7.5	3.9	0.3
Northeast	690.3	9.0	2,574.1	318.9	26.1	709.6	108.5	12.2	49.9	4.0
Northwest	133.0	1.7	379.2	135.5	11.1	258.1	36.7	4.1	9.6	0.8
North Central Coast	677.8	8.9	2,652.8	233.2	19.1	476.8	147.5	16.5	48.1	3.9
South Central Coast	435.1	5.7	1,704.3	87.9	7.2	171.6	101.3	11.3	52.1	4.2
Central Highlands	134.2	1.8	413.6	100.1	8.2	278.9	74.6	8.4	337.1	27.0
Southeast	542.8	7.1	1,696.1	164.0	13.4	488.4	221.4	24.8	614.8	49.3
Cuu Long Delta	3,986.7	52.1	16,280.8	39.0	3.2	49.8	136.0	15.2	132.2	10.6
Whole Country	7,648.1	100.0	31,393.8	1,220.3	100.0	2,860.1	892.9	100.0	1,247.7	100.0

Note: * Paddy equivalent
** Includes cotton, jute, rush, sugarcane, soybean, and tobacco etc.
*** Includes tea, coffee, rubber, pepper, coconut, and cashew, etc

Source: Statistical Data of Vietnam; Agriculture, Forestry and Fishery 1975-2000

While rice and other cereals (mainly maize) remain the most important component of agricultural production, there has been some diversification to industrial crops in recent years. Their share in the gross value of agricultural production has gone up from 13.5% in 1990 to 20.5% in 1999 or 2.5 times during the same period as shown in the succeeding table.

The major producing areas of specific crops at present are: the Cuu Long Delta and the Red River Delta for rice, the Central Highlands and Southeast regions for coffee; northern mountains and midland areas for tea; Southeast region for rubber, Southeast, the Cuu Long Delta and some northern provinces for fruits, and Lam

Dong Province in Southeast region and the Red River Delta region for vegetables.

Gross Output of Agricultural Crops (At constant price of 1994)

(Unit:Bill. Dongs)

	Total		Food Crops		Vegetable and Beans		Industrial Crops		Fruit Crops	
	Value	%	Value	%	Value	%	Value	%	Value	%
1985	41,951.3	100.0	28,079.5	66.9	2,852.9	6.8	5,717.5	13.6	4,179.7	10.0
1990	49,604.0	100.0	33,289.6	67.1	3,477.0	7.0	6,692.3	13.5	5,028.5	10.1
1999	82,945.6	100.0	52,738.1	63.6	5,946.6	7.2	16,976.7	20.5	6,193.4	7.5
1999/1985	2.0		1.9		2.1		3.0		1.5	
1999/1990	1.7		1.6		1.7		2.5		1.2	

Source: Statistical Data of Vietnam; Agriculture, Forestry and Fishery 1975-2000

4.2.5 Animal Production

The value of livestock production increased 68.6% or annual growth rate of about 4.4% on average over the period 1990 to 1999. However, its share in the gross output value of agricultural production registered only a modest increase from 16.6% in 1990 to 16.8% in 1999.

The poultry increased drastically with an average annual growth rate of 6.8% from 98,200 thousand heads in 1990 to 166,400 thousand head in 1998.

4.2.6 Fishery Production

Fishery sector, though accounting for only about 14% of the total agricultural output, has become a major exporter of the economy, accounting for 31% of the agricultural export value and about 9% of the total export value of the country. Exports increased on the average of around 17% per year for the 10 years by 1999. The fishery sector's output increased by 7.3% at constant price of 1994, of which the aquacultural output rose at the rate of 8.7% per year. In 1999, the fishery output came up to 1,882 thousand tons; export value reached US$971 million. Aquacultural areas covered over 535 thousand ha as shown below.

Gross Output of Fishery (at 1994 Constant price)

	1989 Bill. Dong	1999 Bill. Dong	Annual Growth Rate
Total	7,845.0	17,425.0	7.3
Aquaculture	2,363.0	5,448.0	8.7
Catching	5,482.0	11,977.0	8.0

Source: GSO, Statistical Data of Vietnam Agriculture, Forestry and Fishery, 1975-2000

According to the Strategy for Socio-Economic Development 2001-2010, a target of fishery production for 2010 is 3.0 - 3.5 million tons, of which one third comes from aquacultural production, and the export turnover of fishery product is US$3.5

billion.

4.3 National Agriculture Development Strategy

4.3.1 Socio-Economic Development Strategy for 2001-2010

The ninth congress of the communist party of Vietnam, held on 19-22 April 2001, decided upon the Socio-Economic Development Strategy for 2001-2010. This includes the following agriculture, forestry, fishery and rural economy sectoral development strategies:

- To speed up agricultural and rural industrialization and modernization geared toward forming a large-scale commodity agriculture relevant to market demands and ecological conditions of individual regions;
- To design a rational agricultural production structure;
- To enhance the scientific and technological potentials in agriculture, particularly biotechnology combined with information technology;
- To continue developing and basically complete the water conservancy system for protection from salinization, freshwater conservation and flood control, ensuring safe and proactive irrigation and drainage for agricultural production and livelihood of farmers; and
- To vigorously develop industry and services in the rural area.

Through the implementation of the above strategies, the agriculture, forestry and fishery sector aims at the following targets:

- To ensure an average annual growth rate of 4.0 - 4.5% for agricultural output (including aquaculture and forestry).
- To attain a total food grains output of about 40 million tons by 2010.
- The share of agriculture in GDP shall be to amount to around 16 - 17 %
- To accomplish 5 million ha afforestation program.
- To attain US$9-10 billion of export turnover of agricultural, forest and aquatic products.

4.3.2 Agriculture and Rural Development in 2001-2010

Based on the Socio-Economic Development Strategy for 2001-2010 mentioned above, the Ministry of Agriculture and Rural Development (MARD) prepared the following two plans:

- Strategy for Agriculture and Rural Development for 2001-2010
- Five-year Plan on Agriculture and Rural Development in 2001-2005

(1) Strategy for Agriculture and Rural Development in 2001-2010

This Strategy has been formulated after fully evaluating the achievements in the preceding ten years, agricultural advantages and disadvantages in the country, and conditions for development. The basic standpoint of the Strategy may be summarized as follows:

- To ensure food security and food staff to meet with high increasing domestic demand;
- To improve farmer's living standard through increasing agricultural productivity and increasing socio-economic effectiveness;
- To strengthening production relationship among sectors through integration such as between agriculture and forest, agricultural production and processing industry, etc;
- To consider adequate linkage between urban and rural in the process of modernization and industrialization in rural areas;
- To give fully environmental consideration in the process of agricultural and rural development for sustainable development of rural areas; and
- To assure people participation in agricultural and rural development.

Under the above basic standpoints, the development objectives to be attained by the year 2010 are as follows:

- To attain agricultural production growth of 4.0-4.5% per year and agro-processing industrial growth of 10-12%; Average production per capita will be 350-380 kg of food, 30-40 kg of all-kind of meats, 20-25 kg of fish, 120-140 kg of fruits, 12-15 kg of sugar; nutrition of 2,500-2,800 kcal per capita/day; 50% of working force is in agriculture and the remaining 50% is in industrial and services jobs through shifting from agriculture;
- To reclaim land for expanding more 1 million ha of arable land;
- To increase the forest cover up to 40-50% in general and 50-60% at vital points and watershed areas;
- To achieve agricultural, forest and fishery export turnover of US$ 10 billion, of which US$ 6-7 billion from agriculture and forestry and US$ 3 billion from fishery.
- To create jobs for 8 million labor in rural areas; to double farmer's income; to eradicate poverty households and to reduce poor households to 10-15%; and
- To structure a component rate on agriculture-industry-service sectors in rural area at 50-25-25 against 80-10-10 at present.

(2) Five-year Plan on Agriculture and Rural development in 2001-2005

In the development plan, there are three scenarios regarding the growth rate: i.e. 4.8% (low scenario), 5.5% (medium scenario) and 6.0% (high scenario). The expected growth rates of each of the three sectors in the agriculture are shown in the following table:

Expected Growth Rate of Agriculture Sectors Under Scenario

	Low Scenario	Med. Scenario	High Scenario
Agriculture, forestry and fisheries as a whole	4.8%	5.5%	6.0%
1) Agriculture	3.5%	3.9%	4.1%
a) Crops	2.6%	2.9%	2.9%
- Food production	1.0%	1.3%	1.3%
- Cash crops	7.0%	7.4%	7.5%
b) Livestock	6.8%	7.7%	8.5%
c) Agricultural services	2.8%	3.4%	3.8%
2) Forestry	4.1%	4.6%	5.0%
3) Fisheries	11.9%	13.6%	15.0%

Under the above plan, production targets of the major crops and sub-sectors in 2005 are as follows:

a) Food Crops: Food production is expected to reach 36.7-37.0 million tons by the year 2005. The composition of food crops is 34.0-34.2 million tons of paddy and 2.5-2.8 million tons of maize. The average annual growth rate is expected to be in the range of 1.2-1.4% over the five-year period. Given this output, after subtracting the amount to meet domestic demand, the country is expected to export about 4 million tons in each year. Eighty-five to 90 % of the increase in paddy production will be attributed by increasing planted area and the remaining 10-15% increasing productivity. The corresponding figures in the case of maize are 95% and 5%.

b) Coffee: By the year 2005, the planted area of coffee is expected to remain stable at 450 thousand ha, and its production around 860 thousand tons, of which 800 thousand tons will be for export.

c) Tea: Tea production is expected to expand by 105 thousand ha and an output of 100-105 thousand tons in the year 2005. Of which, 60 thousand tons will be for export.

d) Fruit trees: The planted area of fruits trees is expected to maintain the level of 570 thousand ha and the production is projected to reach 2.98 million tons by the year 2005. A majority of which will be for domestic consumption and the remaining portion will be for export.

e) Vegetables: The total planted area of vegetables will be increased to 410 thousand ha from 345 thousand ha in 2000, and their production will reach to 5.2 million tons.

f) Livestock: The direction is to expand the production of livestock greatly. The targets are 4.5-5.2 million head of caws and cattle, 22 million head of pigs, and 250-300 million head of poultry.

g) Fisheries: The total production of fisheries is projected to reach 2.30-2.45 million tons in the year 2005, of which 1.20- 1.25 million tons come from fisheries exploitation and the remaining 1.1-1.2 million tons come from fisheries farming. The value of fisheries export is estimated at US$2.3-2.5 billion in that year.

4.4 Direction of Agricultural Development in 14 River Basins

Directions of the agricultural development are described for the following items in the respective 14 river basins.

1) Agricultural land use, production and yield
2) Direction for agricultural development
3) Agricultural land use plan for 2020

It is noted that a classification method of the paddy cropping has been adopted in explanation of the production and yield in this Study. It is a method that the paddy cropped in the rainy season is at first fixed on the name of rainy season paddy because it would be a basis of cropping pattern of the paddy. Then, paddies cropped in the other seasons than the rainy season are classified with use of winter (W), spring (S), summer (S) and autumn (A). It is also noted that this classification and naming method was adopted in the Sector Review Study for the Water Resources Development, August 1992, Ministry of Water Resources in Vietnam.

In addition, it is noted that the land use plan of 2010 has at first been established for the future mainly with reference to the Agriculture in Vietnam – 61 Provinces and Cities, MARD, NIAPP, 2001. Then, the land use plan of 2020 has been prepared in consideration of the socio-economic framework plan. In this section, the land use plans of 2020 are presented below for the respective 14 river basins.

4.4.1 Bang Giang and Ky Cung River Basin

(1) Agricultural Land Use, Production and Yield

(a) Agricultural land use

Agricultural land in the basin is estimated to consist of 70% of the agricultural land of Cao Bang province and 40% of Lang Son Province. Both provinces are basically situated in the under-developed rolling and mountainous areas with strongly intersected topography.

There is about 68,000 ha of agricultural land in the basin of which 66,900 ha (98%) has been used for cultivated land, and remaining of 1,100 ha has not been developed yet. This potential cultivation land can be utilized for agriculture development in the future.

Of the 66,900 ha of cultivated land, 62,800 ha (94%) is for annual crop lands, and the rest is for perennial crop lands. The present land use and prevailing cropping pattern in the basin are shown in Figure 4.1.

(b) Production and yield

Based on the existing statistical data* and other relevant documents, agricultural production and crop's yield in the basin are estimated as follows:

Crops	Cultivated Area (ha)	Yield (ton/ha)	Production(ton)
Paddy	43,000	3.6	156,800
Maize	25,000	2.1	52,000
Cassava (rain-fed)	10,000	6.5	65,000
Sweet Potatoes (irrigated)	2,000	6.5	13,000
Groundnut (irrigated)	1,000	1.2	1,200
Sugarcane	1,800	38.8	70,000
Fruits (rain-fed)	4,500	-	-
Tea (rain-fed)	600	2.8	1,680
Coffee (rain-fed)	100	0.7	70
Other	7,000	-	-

(2) Direction for Agriculture Development

The principal thrust of the agricultural development in the basin is to ensure the food security through increasing productivity of food crops. In addition to this, agricultural diversification shall be promoted by developing specific indigenous crops such as yellow tobacco, walnut, high quality soybean and specific fruits such as plum, litchi, persimmon, etc. Production target of major crops in the basin is as follows:

- Food crops: The paddy area in the basin will be maintained at the present level. Food security shall be assured by increasing productivity of food crops. In order to increase productivity, it is necessary to promote intensive cultivation practices, to

* includes Statistical Data of Vietnam 1975-2000 (GSO), Socio-Economic Statistical Data of 61 Province, 2001 (GSO), and Agriculture in Vietnam-61 Provinces, 2001.

improve existing irrigation facilities, and to change rain-fed fields to irrigated fields.

- Other annual crops: Other annual major crops in the basin are vegetables, soybean, groundnut, sesame and tobacco. These crops shall be developed positively both in planting area and productivity.

4.4.2 Red River Basin

(1) Agricultural Land Use, Production and Yield

(a) Agricultural land use

The Red River Delta is a principal food center in the North. The Delta provides about 20% of Vietnam's rice (6,355 thousand tones in 1999), and almost 66% of the basin's paddy area lies in the Delta. On the other hand, the Northern highlands area have a poor socio-economic infrastructure and only 11% of its total area has been developed for agricultural production, representing the lowest land use ratio in the whole country.

There is about 1,628,000 ha of agricultural land in the basin of which 1,485,000 ha (91%) has been used for cultivated land and remaining of 143,000 ha has not been developed yet. Of the cultivated land, 1,307,000 ha (88%) is for annual crops lands and the rest of 178,000 ha is for perennial crop lands. The present land use and cropping pattern are shown in Figure 4.2.

(b) Production and Yield

Crops	Cultivated Area (ha)	Yield (ton/ha)	Production (ton)
Paddy	1,884,000	5.4	10,255,500
Maize	170,000	3.0	512,500
Soybean	39,000	1.6	62,000
Groundnut	34,000	1.6	54,000
Sugarcane	16,000	56.9	910,000
Tea	82,000	3.39	277,600
Coffee	25,000	1.4	34,000
Other (fruits, vegetables,)	501,000	-	-

(2) Direction for Agricultural Development in the Red River Basin

The Red River basin is consisted with two agro-ecological zones: the Red River Delta and the Northern Mountainous and Midland Zone. The direction for agricultural development of each Zone described in the Strategy for Agricultural and Rural Development for 2001-2010 is as follows:

Red River Delta

For the coming 10 years the Red River Delta shall be developed with a high technique agriculture, intensive labor use and high commodity productivity and quality, to meet the basin demand and export and to raise income value per hectare. Direction of agriculture and rural development in the Red River Delta by 2010 will be as follows:

- Food Production: Main task of this area is to secure food to meet basin demand. Continue to develop food production by increasing productivity with intensive farming practices and promoting the production of high quality rice. Besides, production of rice for export shall be recommended to improve paddy farmers' income. By 2010, targets of paddy production shall be 1,151,000 ha of paddy area with a total rice production of about 6.0-7.2 million tones. Of the total rice production, 1 million tones will be exported to abroad and another 1 million tones sold for domestic markets. The area for winter-spring maize shall be expanded 200,000 ha by 2010, of the production 800,000 ton will be for export to other basin.
- Vegetable, flower, and semi-tropical fruit tree production: Vegetables are planted to serve for domestic consumption. Its planting areas by 2010 would be 150,000 ha with productivity of 2.7 million tones of which 0.5 million tones for export to other basins. Flower and ornamental tree production are one of promising advantageous crops for the Delta and expected to be US$100 million per year. Fruit trees' planting shall be promoted for longan and litchi (33,000 ha), banana (20,000 ha), pineapple (2,000 ha) and citrus fruit trees (8,000 ha), respectively.

Northern Mountainous and Midland Zone

(Refer to Bang Giang and Ky Cung River Basin.)

4.4.3 Ma River Basin

(1) Agricultural Land Use, Production and Yield

(a) Agricultural land use

Almost all of agricultural land is mainly belong to Thanh Hoa province located in the North Central Coast Zone. In calculating of a total agricultural land area in the Ma river basin, it is estimated at 105 % of the total agricultural land of Thanh Hoa province because the river basin includes a small portion of agricultural land area of Hoa Binh and Nghe An provinces.

The total cultivated lands are estimated to be about 247,000 ha. In addition to the cultivated lands, it is also estimated that there are about 75,000 ha of potentially arable land in the upper-middle basin.

Of the 247,000 ha of cultivated land, about 218,000 ha is for annual crop lands and the rest of 29,000 ha is for perennial crop lands. The present agricultural land use and prevailing cropping pattern in the basin are shown in Figure 4.3.

(b) Production and yield

Crops	Cultivated Area (ha)	Yield (ton/ha)	Production(ton)
Paddy	266,000	3.9	1,024,200
Maize	42,000	2.5	105,000
Cassava (rain-fed)	13,000	5.5	71,500
Sweet Potatoes	28,000	6.0	168,000
Groundnut	16,000	1.4	22,400
Sugarcane	18,000	54.7	984,000

(2) Direction for Agricultural Development in the Ma River Basin

Taking the national agricultural development plan and the socio-economic development plan of Thanh Hoa province into consideration, the basin agricultural development plan may be summarized as follows:

- Food security: Food production is to ensure the local people's demand for food. Highly intensive paddy cultivation shall be promoted through spreading more high yielding varieties of paddy and maize and intensifying agricultural land use, in particular double cropping.
- Strategic major products are: sugarcane, groundnut, coffee, rubber, and tea. To promote the production of these crops, specialized-production zones shall be formed for efficient production and export. Sugarcane areas are in 34,000 ha in 2010. Groundnut is mainly in a total cultivated area of 20,000 ha in 2010. Coffee, tea, rubber and fruits trees will mainly be increased in the mountainous and hilly areas where unused land exists with a target area of 7,500 ha for coffee, 9,000 ha for tea, 11,000 ha for rubber, and 23,000 ha for fruits, respectively, in 2010.

4.4.4 Ca River Basin

(1) Agricultural Land Use, Production and Yield

(a) Agricultural land use

Agricultural land in the basin is consisted of 95% of the agricultural land of Ha Tinh province and 85% of Nghe An Province.

There are about 242,000 ha of agricultural lands in the Ca basin of which 194,000 ha have been cultivated (80%), the rests have not been developed yet.

The cultivated lands consisted annual crop lands and perennial crops lands of which annual crops land occupy about 91% of the cultivated lands and perennial crop lands occupy only 6,000 ha. The present land use and prevailing cropping pattern in the basin are shown in Figure 4.4.

(b) Production and yield

Crops	Cultivated Area (ha)	Yield (ton/ha)	Production(ton)
Paddy	261,000	3.5	924,100
Maize	22,000	2.1	47,000
Sweet Potatoes	18,000	3.1	56,000
Groundnut	12,000	0.8	9,300
Sugarcane	8,000	62.3	498,000
Rubber	3,000	0.7	2,100
Tea	2,000	3.5	7,000
Coffee	1,000	1.0	1,000
Other	12,000	-	-

(2) Direction for Agricultural Development in Economic Zone (North Central Coast Zone)

Based on the both Nghe An and Ha Tinh provinces development plan (agricultural sector) and fully considering the national agricultural development plan for the North Central Coast Zone, the basin agricultural development plan may be summarised as follows:

- Food crops: While a small portion of rain-fed paddy areas of about 6,000 ha located in Nghe An province will be converted to subsidiary crop fields, paddy fields shall basically be maintained the same level as at present. The increase of food production shall be attained through increasing productivity. In order to do so, dissemination of new advanced cultivation technologies and improving/ constructing irrigation facilities are essential. Maize will increase in mountainous areas with a high growth rate through expanding its planting area and increasing productivity. Cassava and sweet potatoes are main food products in hilly and mountainous areas, particularly in Ha Tinh province. These crops shall be converted into high value crops as far as possible.
- Industrial crops: Major industrial crops in the basin are groundnut, sugarcane, coffee, tea, and rubber. These products can be exported to domestic and international markets.

4.4.5 Thach Han River Basin

(1) Agricultural Land Use, Production and Yield

(a) Agricultural land use

The agricultural land of the basin is estimated to be about 32,000 ha or 40% of the total agricultural land of Quang Tri province.

The agricultural lands are categorized into four: i) paddy lands of 10,000 ha, ii) 4,400 ha of annual crop lands, iii) 6,600 ha of perennial crop lands and iv) potential cultivated land of 10,000 ha. The last category will be used for the cultivated land in future. The present agricultural land use and cropping patterns in the basin are shown in Figure 4.5.

(b) Production and yield

Crops	Cultivated Area (ha)	Yield (ton/ha)	Production (ton)
Paddy	19,000	3.7	70,000
Maize	1,000	2.0	2,000
Groundnut	1,600	1.4	2,200
Rubber (rain-fed)	4,400	0.7	3,080
Coffee	1,200	0.8	970
Other	6,700	-	-

(2) Direction for Agricultural Development in the Thach Han River Basin

Agricultural development direction of major crops for the year 2010 is as follows:

- Food security: Food production is important to ensure the inhabitant's food demand in the basin. Highly intensive paddy cultivation shall be promoted to attain a yield of 4.5 tons/ha in 2010. Such other food crops as maize and sweet potatoes shall also be expanded through introducing advance technology and new crop varieties. Special attention should be paid to irrigation works to supply water adequately.
- Rubber: Rubber is weighed up as the first strategic plant of the basin in terms of economic benefits and environmental protection. Development direction for the year 2010 is to increase its planted area and yield by 17,300 ha and 19,500 tons, respectively.

4.4.6 Huong river Basin

(1) Agricultural Land Use, Production and Yield

(a) Agricultural land use

Since agricultural lands are mostly located in the low-lying flat plains of the Huong river with ground level ranging between -1.5m and +1.0m, it is conveniently used for paddy cultivation. Agricultural lands in the hill side or located at the elevated areas even in the plain are used for upland crop cultivation.

Agricultural lands of 43,000 ha in the Huong river basin are estimated to cover 95 % of a total agricultural lands of Thua Thien Hue province. Of the agricultural land in the basin, about 97% (39,500 ha) is for annual crops lands and the rest (3,500 ha) is for perennial lands. The present land use and prevailing cropping pattern in the basin are shown in Figure 4.6.

(b) Production and yield

Crops	Planted area (ha)	yield (ton/ha)	Production (ton)
Paddy	48,500	4.3	210,250
Maize	1,000	2.4	2,400
Cassava (rain-fed)	4,000	7.0	28,000
Sweet potatoes	6,000	7.0	38,250
Groundnut	4,000	1.5	5,800
W-S (irrigated)	1,500	2.0	3,000
W-S (rain-fed)	500	1.0	500
Sugarcane (rain-fed)	3,000	35.0	105,000
Other	6,000	-	-

(2) Direction for Agriculture Development in the Huong River Basin

Production target of major crops in the Huong River basin is as follows:

- Food production: Food production is important to ensure the people's food demand in the basin. Highly intensive paddy cultivation shall be promoted through spreading more high yielding varieties for paddy and maize and intensifying agricultural land use, in particular stable double cropping over the areas of about 20,000 ha. In addition, expansion of planting areas of other food crops like maize, cassava and sweet potatoes shall be promoted in the hilly areas.
- Strategic major agricultural products are: groundnut, rubber, and tobacco. To promote the production of these crops, special-production zones shall be formed for efficient production and export: Groundnut is mainly in 5,000 ha in 2010; Rubber is well planted in the hilly area of 5,000 ha; Tobacco is planted in a total area of 1,000 ha.

4.4.7 Thu Bon River Basin

(1) Agricultural Land Use, Production and Yield

(a) Agricultural land use

The Thu Bon River basin stretches over Quang Nam province and Da Nang city. Agricultural land in the basin is estimated at 111,800 ha which is consisted of the whole agricultural land in Quang Nam province and 50% of agricultural land in Da Nang city.

Of the total agricultural land of 111,800 ha, 92,000 ha (82%) has been used currently as cultivated lands. About 85,000 ha or 93% of the cultivated lands is for annual cropland and remaining of 7,000 ha for perennial cropland. There are a few area left for agriculture development use in the future.

The present land use and prevailing cropping pattern in the basin are shown in Figure 4.7

(b) Production and yield

Crops	Cultivated Area (ha)	Yield (ton/ha)	Production(ton)
Paddy	104,000	3.5	366,000
Maize	2,000	2.0	4,000
Cassava	12,000	5.3	64,000
Groundnut	7,000	2.1	14,600
Sugarcane	6,000	37.0	222,000
Fruit	2,500	-	-
Tea	2,000	-	-
Other annual crops	12,000	-	-
Other perennial crops	2,400	-	-

(2) Direction for Agriculture Development in the Thu Bon River Basin

In order to support the basin economic development, it is essential to attain sustainable agricultural development with the following targets:

- Food security: The total paddy area in the basin shall maintain at the present level. However, the production of rice shall be increased more through increasing paddy yields under the intensive farming methods and the expansion/upgrade of irrigated area. Besides, other food crops such as maize, sweet potatoes and cassava shall be increased both in areas and yields.

- Perennial crops: In the highlands area, planting of perennial industrial crops shall be promoted vigorously in order to supply raw materials for processing industries and to increase export products. Promising industrial perennial crops include cinnamon, tea, and mulberry.

4.4.8 Tra Khuc River Basin (Quang Ngai)

(1) Agricultural Land Use, Production and Yield

(a) Agricultural land use

The Tra Khuc basin extends into Quang Ngai province located in the South Central Coast Zone. Agricultural land of 82,000 ha in the basin is estimated at about 95 % of the agricultural land of Quang Ngai province.

The agricultural lands are classified into four: paddy areas of 38,000 ha, annual subsidiary crop areas of 20,300 ha, perennial crop areas of 10,700 ha, and potential cultivation lands of 13,000 ha. The present land use and prevailing cropping pattern in the basin are shown in Figure 4.8.

(b) Production and yield

Crops	Cultivated Area (ha)	Yield (ton/ha)	Production(ton)
Paddy	85,000	3.7	315,000
Sweet Potatoes	4,000	4.8	19,000
Groundnut	9,200	0.8	7,140
Maize	6,000	2.8	16,500
Sugarcane	12,000	48.1	577,500
Rubber	1,000	0.5	500
Coconut	6,000	6.0	36,000
Coffee	1,000	1.0	6,000
Other	23,300	-	-

(2) Direction for Agricultural Development in the Tra Khuc River Basin

In order to support the provincial economic development, it is essential to attain sustainable agricultural development with the following targets:

- Food security: Convert some paddy fields under rain-fed conditions into other high value crops fields though keeping paddy cultivation area constantly at the level of 80,000 ha. Increase the average paddy yield from 3.8 tons/ha to 4.5 tons/ha in 2010 to attain the production of 360,000 ton. Annual food per capita will be at 300 kg/ head/ year in 2010.

- Crops diversification and promotion of exportable products for domestic and abroad: Agricultural structure should be changed to increase a share of livestock breeding, aquaculture, and agricultural service sectors with reducing the share of cultivation sector. Regarding to the cultivation sector, development priority should be given to high value industrial crops (annual and perennial), and develop agricultural processing industry.

4.4.9 Kone River Basin

(1) Agricultural Land Use, Production and Yield

(a) Agricultural land use

There are about 82,000 ha of arable land in the basin of which 71,000 ha (91%) has been used for cultivated land, and remaining of 11,000 ha has not been developed yet. Of the 71,000 ha of cultivated lands, 58,000 ha (82%) are for annual crops lands and the rest are for perennial crops lands.

The present land use and prevailing cropping pattern in the basin are shown in Figure 4.9.

(b) Production and yield

Crops	Cultivated Area (ha)	Yield (ton/ha)	Production(ton)
Paddy	110,000	3.8	414,000
Maize	2,000	2.0	4,000
Cassava (rain-fed)	8,000	8.3	66,400
Groundnut	7,000	1.4	10,000
Sugarcane	7,000	44.0	308,000
Cashew (rain-fed)	6,000	-	-
Other perennial crops (coconut, etc.)	7,000	-	-

(2) Direction for Agriculture Development in the Kone River Basin

In order to support the provincial economic development, it is essential to attain sustainable agricultural development with the following targets:

- Food security: Convert some paddy fields under rain-fed conditions into other high value crops fields. However, total amount of paddy production shall be increased through increasing paddy yields with intensive farming methods and expansion of irrigated area up to 93% of total paddy fields. While maize shall be increased both area and yield to achieve 5,000 ha with average yield of 4.9 tons/ha in 2010, cassava shall be decrease both area and yield to convert the area into more high value crops such as groundnut, soybean and potatoes.

4.4.10 Ba River Basin

(1) Agricultural Land Use, Production and Yield

(a) Agricultural land use

Agricultural land in the basin is estimated to be consisted of 95% of the agricultural land of Gia Lai province and 65% of Phu Yen province. Topography of the Ba River basin makes a narrow and long shape basin from upstream to downstream.

There are about 309,000 ha of agricultural lands in the basin of which 283,000 ha (92%) have been used for cultivated lands, and remaining of 26,000 ha have not been developed yet. These unused potential agricultural lands can be utilized for agriculture development in the future. Of the 283,000 ha of the cultivated lands, 166,500 ha (59%) are for annual crop lands and the rest (116,500) are for perennial crops lands.

The present land use and prevailing cropping pattern in the basin are shown in Figure 4.10.

(b) Production and yield

Crops	Cultivated Area (ha)	Yield (ton/ha)	Production(ton)
Paddy	90,000	3.6	323,700
Maize	12,250	2.1	24,750
Sweet Potato	4,000	2.0	20,000
Groundnut	5,000	1.2	6,000
Cassava (rain-fed)	18,000	6.5	117,000
Sugarcane	23,000	46.5	1,070,000
Coffee (rain-fed)	43,000	1.4	60,200
Tea	1,000	3.2	3,200
Other annual crops(vegetables, etc.)	116,000	-	-
Other perennial crops (cashew, etc)	72,500	-	-

(2) Direction for Agriculture Development in the Ba River Basin

The major thrusts for agriculture development in the basin has been given to: a) increase of 30-40% in agricultural production over the period 2000-2010, b) increase industrial crops particularly coffee, rubber and sugarcane, and c) develop agro-processing industries.

- Food crops: Concentrate on intensive cultivation on food crops to meet the unceasingly high consumption demand in the basin and for export. Particularly, cropping intensity shall be pursued through promoting either triple cropping (2 paddy crops and 1 food crop) or double rice cropping (or 1 rice crop and 1 food crop). Other staple food crops of cassava, sweet potatoes and maize shall be increased in hilly and mountainous areas.

- Industrial crops: Major strategic industrial crops in the basin are sugarcane, coffee, rubber, and cashew.

4.4.11 Sesan River Basin

(1) Agricultural Land Use, Production and Yield

(a) Agricultural land use

Sesan River basin extends over Kon Tum province and a part of Gia Lai province. Thus, agricultural land in the Sesan River basin is estimated at 165% of the total agricultural land of Kon Tum province.

There are about 113,700 ha of agricultural land in the basin of which 105,000 ha (92%) has been used for cultivated land, and remaining of 8,700 ha has not been developed yet. Of the 105,000 ha, 64,000 ha (61%) is estimated to be used for annual crops land and the rest (41,000 ha) is for perennial crops land. The present land use and prevailing cropping pattern in the basin are shown in Figure 4.11.

(b) Production and yield

Crops	Cultivated Area (ha)	Yield (ton/ha)	Production(ton)
Paddy	32,000	2.3	74,300
Maize (rain-fed)	7,000	2.0	14,000
Cassava (rain-fed)	12,000	9.5	114,000
Sweet Potato (rain-fed)	500	7.0	3,500
Groundnut (rain-fed)	700	1.0	700
Sugarcane	6,300	47.0	296,000
Rubber (rain-fed)	20,000	1.4	28,000
Coffee	16,000	1.8	28,800
Other annual crops (vegetables, etc)	11,500	-	-
Other perennial crops	5,000	-	-

(2) Direction for Agriculture Development in the Sesan River Basin

Taking the national agricultural development plan and the socio-economic development plan of Kon Tum and Dac Lac provinces into consideration, the basin agricultural development direction may be summarized as follows:

- Food security: In order to ensure the basin food security, food production should be strengthened through: expanding irrigation areas and increasing productivity for paddy; and accelerating the use of hybrid variety for maize.
- Perennial and annual industrial crops:

  To expand the industrial crops production, particularly coffee, rubber, and cashew through expanding planting areas and increasing productivity, replacing old trees of these crops into new ones. Sugarcane also expands in areas of high soil fertility.

To establish special production zones of these crops.

4.4.12 Srepok River Basin

(1) Agricultural Land Use, Production and Yield

(a) Agricultural land use

The Srepok River basin lies in the Dak Lak province. The agricultural land in the basin is estimated to 60% of the agricultural land of Dac Lak province. In view of topographic feature, the basin is characterized by mountains, gently undulating plateaus and flat alluvial lowland lies in wider valleys.

There are about 235,000 ha of agricultural land in the basin of which 218,000 ha (93%) has been used for cultivated land, and remaining of 17,000 ha has not been developed yet. These unused potential agricultural lands can be utilized for agriculture development in the future.

Of the 218,000 ha, only about 73,000 ha (33%) is estimated to be used for annual crops lands and the rest (145,000 ha) is for perennial crops lands. The present land use and prevailing cropping pattern in the Srepok River basin are shown in Figure 4.12

(b) Production and yield

Crops	Cultivated Area (ha)	Yield (ton/ha)	Production(ton)
Paddy	37,000	3.5	130,400
Maize	22,000	3.4	73,800
Cassava (rain-fed)	2,000	10.0	20,000
Sweet Potato (rain-fed)	2,000	7.0	14,000
Groundnut (rain-fed)	8,000	1.2	9,600
Sugarcane	4,000	58.8	235,000
Rubber (rain-fed)	16,000	0.6	22,400
Coffee	105,000	1.6	163,000
Other annual crops (vegetables, etc)	50,000	-	-
Other perennial crops	22,500	-	-

(2) Direction for Agriculture Development in the Srepok River Basin

Taking the national agricultural development plan and the agricultural development plan of Dac Lac province into consideration, the Srepok River basin agricultural development direction may be summarized as follows:

- Food security: In order to ensure the basin food security, food production shall be strengthened through: expanding irrigation areas and increasing productivity and cropping intensity for paddy; and accelerating the use of hybrid variety for maize. However, upland paddy areas should be minimized by converting upland paddy into high value crops such as coffee, cashew land.

- Perennial and annual industrial crops:

  To expand the industrial crops production, particularly coffee, rubber, and cashew through expanding planting area and increasing productivity by irrigation and replacing old trees of these crops into new ones: By 2010, coffee area should be expanded to 240,000 ha with output of 350,000 tones; 50,000-70,000 ha with 23,000 tons of dry latex for rubber; and 15,000 ha with 7,200 tones for cashew. Sugarcane also expands in areas of high soil fertility.

  To establish specialized production zones of these crops

4.4.13 Dong Nai River Basin

(1) Agricultural Land Use, Production and Yield

(a) Agricultural land use

There are about 1,476,000 ha of agricultural land in the basin of which 1,398,000 ha (95 %) has been used as cultivated land, and remaining of 79,000 ha has not been deployed yet. These unused arable lands can be utilized for agriculture development in the future.

Of the 1,398,000 ha of cultivated land, 690,000 ha (49%) is used for annual crops lands and the rest (708,000 ha) is for perennial crops lands. The present land use and prevailing cropping pattern in the basin are shown in Figure 4.13.

(b) Production and yield

Crops	Cultivated Area (ha)	Yield (ton/ha)	Production(ton)
Paddy	498,000	3.0	1,490,900
Maize	10,000	3.0	30,000
Soybean	28,000	0.9	25,200
Sweet Potato	40,000	5.7	228,000
Groundnut	80,000	1.3	107,500
Cassava (rain-fed)	34,000	10.0	340,000
Sugarcane	65,000	47.8	3,110,000
Rubber	495,000	1.2	594,000
Cashew	84,000	0.7	58,800
Fruits	43,000	-	-
Other annual crops	442,000	-	-
Other perennial crops (cashew, etc)	10,000	-	

(2) Direction for Agricultural Development in South East Zone

The Dong Nai River Basin is located in the South East Zone. The direction for agricultural development in the zones is stipulated in the Strategy for Agricultural and Rural Development for 2001-2010. The basic development direction in the Zone is as follows:

Direction for agricultural development in the basin is to produce commodity agro-products with high competitiveness and value, special attentions are given to development of industrial crops, fruit trees, ornamental trees, animal husbandry, and processing industry in conjunction with concentrated commodity-based production area.

- Food production: By 2010, areas for rice cultivation in the basin will be 300,000 ha with productivity of 1.3 million tones. Maize production will also be developed for providing feed for animal husbandry and materials of processing industry: areas of maize plantation will be reached at 150, 000 ha by 2010 with productivity of 601,500 tones.
- Rubber plantation: While rubber plantation expects to be kept present situation in terms of areas and productivity, the investment to rubber plantations will be accelerated for intensifying land use of the plantations.

4.4.14 Cuu Long Delta Basin

(1) Agricultural Land Use, Production and Yield

(a) Agricultural land use

The Cuu Long Delta basin in the Southern parts of Vietnam covers about 4 million ha of land, which equals 12% of the total area of the nation. The Delta has a tropical climate and is characterized by lowland, fertile soils and dense network of rivers and canals.

The total land area of 12 provinces, with the exclusion of 35% of the areas in Long An province, amounts to just over 3.81 million ha. Of this area, 2.60 million ha is currently used for agriculture purposes.

There is about 2,596,000 ha of agricultural lands in the Delta of which 2,439,000 ha (94%) have been used for cultivated lands. Of the cultivated lands, 2,088,000 ha (86%) are estimated to be for annual crop lands and the rest (351,000 ha) are for perennial crop lands. The present land use and prevailing cropping pattern in the basin are shown in Figure 4.14.

(b) Production and yield

Crops	Cultivated Area (ha)	Yield (ton/ha)	Production(ton)
Paddy	3,382,000	4.2	14,323,400
Maize	6,000	3.2	19,200
Cassava (rain-fed)	10,000	9.0	90,000
Beans	6,000	2.8	16,800
Sugarcane	65,000	55.2	3,585,000
Fruit	188,000	-	-
Coconut	71,000	5.0	355,000
Other annual crops	66,000	-	-
Other perennial crops (cashew, etc)	92,000	-	-

(2) Direction for Agricultural Development Plan for Cuu Long Delta Basin

The basic development direction in the Cuu Long Delta stipulated in the Strategy for Agricultural and Rural Development for 2001-2010 is as follows:

Direction for agricultural development in the basin is to focus on promoting an integrated agriculture, diversifying production and pushing up local advantages, such as food production, foodstuff, animal husbandry, fruit tree, aquaculture and catching.

- Food production: Food production will be developed at certain level with an area of 3,898,800 ha. Rice cultivation by 2010 will be allocated with 1,930,000 ha and annual rice export of 4 million tones. Besides, maize will also be developed by 2010 with an area of 100,000 ha and productivity of 549,000 tones.
- Sugarcane: Keep area for sugarcane plantation stabilized for providing materials for 8 sugar plants in the basin. By 2010, there 80,000 ha of sugarcane will be intensified for meeting with productivity of 5.6 million tones of sugar.

4.5 Agricultural Land Use Plan for 2020

Taking the basin-wide agricultural development plan of each objective river basin as well as the national agricultural development plan for Northern Mountainous and Midland Zone into consideration, the agricultural land use plan and cropping pattern in 2020 of each river basin is proposed as shown in Figures 4.15 to 4.28, respectively.

CHAPTER 5 ESTABLISHMENT OF SOCIO-ECONOMIC FRAMEWORK PLAN

5.1 Socio-economic Condition

5.1.1 National Socio-economy

(1) General

The Socialist Republic of Vietnam (Vietnam) occupies the easternmost part of Indochina and is bordered by China on the north, by the Gulf of Tonkin on the east, by the South China Sea on the southeast, by the Gulf of Thailand on the southwest, and by Cambodia and Laos on the west with a total area of 329,241 sq km. Hanoi is the capital of Vietnam, and Ho Chi Minh City is the country's largest city.

Vietnam is administratively divided into 57 provinces and 4 municipalities (Hanoi, Hai Phong, Ho Chi Minh City, and Da Nang).

(2) Population

According to the latest population and housing census as of April 1, 1999, the population of Vietnam was 76,323 thousand, yielding a population density of about 232 persons per sq. km as shown in Table 6.1. The urban population was 18,077 thousand (23.7%) and the rural population was 58,246 thousand (76.3%).

Results of Population and Housing Censuses 1989 and 1999

Unit: 1,000 persons

Year	Total	Male	Female	Urban	Rural
1989	64,376	31,231(49%)	33,145(51%)	12,473(19%)	51,903(81%)
1999	76,323	37,469(49%)	38,854(51%)	18,077(24%)	58,246(76%)
Average annual growth rate (1989-1999):	1.7%	1.8%	1.6%	3.8%	1.2%

The total population increased by 11.95 million during 10 years from 1989 to 1999 according to the results of censuses in 1989 and 1999. The average annual growth rate of the population is about 1.7% in the same period. The average annual growth rate of urban population is relatively high at 3.8%, while that of rural population is low at 1.2% in the same period.

Table 5.2 shows the average population and the average annual growth rate of population by province. The population growth rates of the central highlands region including Dak Lak Province and the Southeast region including Ho Chi Minh City are remarkably high. Table 5.3 shows that the urban population growth rates of the two regions are high at more than 5% in the recent five years. It is probably due to influx of rural population into urban areas for jobs.

Table 5.4 shows number of household and family size by province. The average family size is about 4.6 and it does not show large difference among provinces, urban, and rural. However, the density of household varies largely from province to province as shown in Table 5.5. Hanoi is the most dense at 697 households/km2 followed by Ho Chi Minh City with 485 households/km2. On the other hand, Northwest and Central Highlands regions are still scarce.

(3) National Economy

(a) Gross Domestic Product

Gross Domestic Product (GDP) of Vietnam in 1999 was 399,942 billion Dongs (approximately US$ 28.7 billion) and GDP per capita in the same year was 5.2 million Dongs (approximately US$ 370) as shown in Table 5.6.

Average annual growth rate of GDP during 10 years from 1989 to 1999 was 7.5% on a constant price basis, while that of GDP per capita was 5.8%. However, those during three years from 1996 to 1999 decelerated to 6.2% and 4.6%, respectively due to the influence of the regional economic crisis. Yearly changes of GDP and GDP per capita are shown in Figures 5.1 and 5.2, respectively.

GDP by industrial origin is shown in Table 5.7. GDP of agriculture, forestry and fishery accounted for 42%, while industry and construction accounted for 23%, and services accounted for 35% in 1989. However, during 10 years from 1989 to 1999, the industrial structure had changed gradually as shown in Figure 5.3. Agriculture, forestry and fishery decreased their ratio to 25% while industry & construction and services increased their ratios to 34% and 40%, respectively. The average annual growth rates of the sectors are 3.9%, 10.5%, and 7.6%, respectively during 10 years from 1989 to 1999 on a constant price basis. More detailed breakdown of GDP by economic activity is given in Table 5.8. Although the ratio of agriculture in GDP has been declining year after year, it is still the largest economic activity in GDP and is of the utmost importance to Vietnam since it is providing a living for more than 60% of the labor force.

(b) Agriculture

a) Agricultural Production

Paddy is the major production in Vietnam. About 70% of farmlands have been occupied by paddy cultivation as presented in Table 5.9. Production of paddy was about 25 million tons including spring, autumn, and winter cultivation in 1995 but it increased by 6.4 million tons to 31.4 million tons in 1999 as shown in Table 5.10. The yield of paddy also increased from 44.3 quintal/ha in 1995 to 48.8 quintal/ha in 1999 for spring cultivation as shown in Table 5.11.

Total production of paddy was 31.4 million tons in 1999. Out of this production, spring, autumn, and winter paddy occupied 45%, 28%, and 27%, respectively. The production and yield of each paddy crops from 1995 to 1999 shows increasing trends.

Maize, sweet potatoes, and cassava are the next major food production in Vietnam occupying 6.5%, 2.5%, and 2.1% of the farmlands in 1999, respectively.

Major annual industrial crops are sugar cane, peanut, and soybean, which produce 17.7 million tons, 318 thousand tons, and 147 thousand tons in 1999, respectively. The cultivation area of industrial crops was increased, while the yields of the crops were also increased year by year.

Main multi-year industrial crops are tea, coffee (Robusta), rubber, pepper, and coconut. The productions of these crops were 70,000 tons, 510,000 tons, 249,000 tons, 31,000 tons, and 1,104,000 tons, respectively in 1999. The production areas of each crop are shown in Table 5.9.

Livestock farming is also a important agricultural activity in Vietnam. Breeding of buffaloes, cattle, pigs, and poultry has been widely carried out and these numbers are approximately 2,956 thousand, 4,063 thousand, 18,886 thousand, and 179.3 million heads in 1999. The gross output of livestock farming was approximately VND22,000 billion, which accounted for 18% of agricultural output and growing more than 5% annually as shown in Table 5.12.

b) Export of Agricultural Production

Vietnam is the second largest rice and coffee exporter in the world. The exported amount of rice varied from 3,477,000 tons to 4,508,000 tons per year during these four years from 1997 to 2000. However, export turnover of rice changed depending on the international market price of rice and it has been dropping recent years. In 1998, the exported volume of rice was 3,749,000 tons that was equivalent to 1,024 million US Dollars and it accounted for 11% of total export. In 2000, the export volume decreased to 3,477,000 tons and its export turnover was 668 million US Dollars. It accounted for only 4.6% of total export turnover.

Export of coffee (Robusta) is also the same situation. The exported volume of coffee was 382,000 tons that was equivalent to 594 million US Dollars and it accounted for 6.4% of the total export in 1998. However the price of coffee dropped sharply in 2000 and 2001. The export volume increased almost twice to 734,000 tons but on the contrary, its turnover decreased to 501 million US Dollars.

Not only the prices of rice and coffee, but also those of other agricultural crops fluctuate from year to year. Therefore, it is important to diversify the agricultural production and to improve the quality of crops. The major import and export commodities are shown in Table 5.13.

(c) Industry

Industrial gross output of Vietnam was VND245,828 billion (US$17.63 billion) in 1999. Between 1995 and 1999, industrial sector output grew at an average annual growth rate of 13%, and industrial GDP by 10.7%, well above whole GDP growth rate of 7% during the same period. The share of industrial sector in GDP has been increasing as shown in Figure 5.3 and the sector has been the main driving force of the economy's recent rapid growth. The government intends the sector to grow 10% per year by the official plans to 2010 and to turn the country into an industrialized country by 2020.

Approximately 30 % of all industrial output comes from food and beverage production (20%) and crude petroleum and natural gas (11%). The other sectors that account for more than 5% of total industrial output are chemical and chemical products, non-metallic mineral products, electricity, gas and fuel. Table 5.14 shows growth of industrial gross output for 5 years from 1995 to 2000. Most of the industrial sub-sectors have enjoyed their high annual growth reflecting the national industrial expansion. Particularly, the production of office equipment and computing machinery is growing remarkably. Several sub-sectors have expanded by more than 20% annually, notably leather tanning and processing, rubber and plastic products, fabricated metal products, office and computing equipment, electrical machinery and apparatus, and production and repairing other transport equipment.

(d) Service

The services sector is the largest contributor to the Vietnamese economy, accounting for 40% of the GDP. The service sector in Vietnam is diverse, ranging from self-employment in micro enterprises such as street food vending, small-scale trade, to large-scale trade enterprises. Wholesale and retail trade, real estate services, financial intermediation services, and tourism-related services such as hotels and restaurants have been the largest contributor of the high economic growth. Foreign direct investment inflows fueled growth in the real estate business such as office and apartments, and tourism-related services.

Tourism has become Vietnam's fourth largest foreign-exchange earner. The total number of visitors grew from 7,000 in 1986 to around 200,000 in 1990 and an estimated 1.8 million in 1999.

(e) Labor Force

According to the Population and Housing Census 1999, the population aged 13 years and over was 54,729 thousand. Out of the population, economically active population, defined as working and unemployed population who has intention to work was 38,211 thousand and it accounted for 70% of the population as shown in Table 5.15 and summarized below.

Economically Active Population in 1999 (1,000 persons)

	Total	Male	Female	Urban	Rural
1. Population aged 13 and over	54,729	26,386	28,343	13,881	40,847
2. Economically non-active	16,508	6,461	10,047	5,285	11,224
3. Economically active	38,211	19,920	18,291	8,594	29,617
- Worked	36,420	18,889	17,531	7,792	28,628
- Unemployed (has intention to works)	1,791	1,031	760	801	989
4. Unemployment ratio	4.7%	5.2%	4.2%	9.3%	3.3%

Source: Population and Housing Census Vietnam 1999, Completed Census Results

Unemployment ratio of Vietnam was 4.7% in 1999. Unemployment ratio of urban area was high at 9.3%, while that of rural area was 3.3%.

Table 5.16 shows labor force population by province as of April 1, 1999 based on the population in working age (male: 15-60 years old, female: 15-55 years old). The unemployment rates of the large cities such as Hanoi, Hai Phong, Da Nang, and Ho Chi Minh are relatively high at more than 7%. Provably this occurred because migrant workers from rural area come into urban area for job opportunities.

(f) Prices

Prices in Vietnam are relatively stable these two years in 1999 and 2000. Especially the prices of food and food services have gone down during the same period. This is probably due to influence of the drop of the international prices of foods. The prices of housing and building materials, pharmaceutical products and medical services, and education showed relatively high increasing rates among categories. The average annual increasing rate of general index was 4.9% from 1994 to 2000, while that of food is 5.6% during the same period.

Consumer Prices Index

Category	% change year on year						Annual
	1995	1996	1997	1998	1999	2000	average
Consumer Price Index	12.7	4.5	3.6	9.2	0.1	-0.6	4.9
- Food and food services	19.8	4.4	1.3	12.3	-1.9	-2.3	5.6
- Beverages and cigarettes				5.3	2.6	0.3	2.7
- Garments and footwear				2.3	1.9	0.4	1.5
- Housing and building materials				1.7	2.5	4.7	3.0
- Household equipment				2.5	3.5	2.3	2.8
- Pharmaceutical products and medical services				8.7	4.1	3.6	5.5
- Transport and postal services				3.0	1.6	1.9	2.2
- Education				9.6	3.8	4.1	5.8
- Culture, sports, and entertainment				1.3	1.9	0.9	1.4
- Other goods and services				4.0	3.1	4.1	3.7

Source: - Country Economic Review, Socialist Republic of Viet Nam, November 2000
- Statistical Yearbook 2000, GSO

Note: CPI of December of each year compared with December of previous year

(g) Export and Import

The merchandise trade balance of Vietnam runs a structural deficit, with exports covering approximately 70 to 90 % of imports. The export had been increasing faster than import and the trade deficit had narrowed until 1999. However, it widened again in 2000.

Merchandise Trade of Vietnam

	Trade Turnover (Million US$)					% Change Year on Year			
	1996	1997	1998	1999	2000	96-97	97-98	98-99	99-00
Export (FOB)	7,256	9,146	9,339	11,520	14,448	26	2	23	25
Import (CIF)	11,144	11,592	11,527	11,623	15,635	4	-1	1	35
Balance	-3,888	-2,446	-2,188	-103	-1,187				

Source: - General Department of Customs
- Country Report, Vietnam, July 2001, the Economic Intelligence Unit
- Country Profile 2001, Vietnam, the Economic Intelligence Unit

Table 5.13 shows import and export of major commodities. The major export commodities are crude petroleum, textile & clothing, marine products, and footwear, which account for 24%, 13%, 10%, and 10% of the total export turnover, respectively in 2000. As discussed in the subsection (3) Agriculture, Vietnam is the second largest rice and coffee exporter in the world. However, the export turnover of rice and coffee has been decreasing due to drop of their international market prices.

The major import commodities are machinery & equipment, petroleum products, leather & clothing, iron & steel, and fertilizers.

Japan remains Vietnam's largest individual trading partner in terms of export turnover (17.6% of total exports). The share of EU has gone up significantly in the last two years, from 16.1% in 1997 to 30.9% in 1999. Vietnam concluded the bilateral trade agreement with the United States in 2000 and this will accelerate Vietnam's affiliation to the World Trade Organization. Since the economy is slowing down in most regions of the world including the United States, EU, and Asia, the commodity exports will become a keen competition.

(h) Foreign Currency Exchange Rate

The State Bank of Vietnam is the central bank of the country. The crawling peg system, introduced in February 1999, allowed the interbank exchange rate to depreciate by a maximum 0.1% per day from the previous day's average interbank market rate. Foreign currency exchange rates against U.S. Dollar and Japanese Yen are summarized below.

Foreign Currency Exchange Rate (Vietnamese Dongs)

Currency	1996	1997	1998	1999	2000	Dec.3, 2001
One U.S. Dollar	11,038	11,683	13,268	13,943	14,168	15,068
One Japanese Yen	102	97	102	122	131	122.12

Source: 1996 - 2000: Country Profile 2001, Vietnam, the Economic Intelligence Unit
Nov.1, 2000: Vietcombank, Transfer, middle rate
Note: 1996 - 2000: Annual average rates

5.1.2 Regional Socio-economy of 14 River Basins

Socioeconomic condition of the 14 river basins is discussed in detail in Appendix-E, Supporting Report Volume I based on the existing studies and statistical data. Since the information of district level was not available at the Phase-I stage, the socioeconomic conditions of the river basins are on provincial level. The socioeconomic information such as population, GRDP, labor force, etc. is based on the data on the provinces, whose major part of territory is included in the pertinent river basin. The administrative boundaries and the objective 14 river basins are shown in Figure 5.4.

5.2 Development Plans of the Government

The government of Vietnam has socio-economic development plans in long-term, medium-term, and short-term. The long-term plan shows general picture that Vietnam is targeting to achieve by 2020. The medium-term plan shows general socio-economic targets as well as sectorial and regional plans till 2010. The short-term plan shows concrete tasks and norms for 2001-2005.

The outlines of the development plans, relating to establishment of the socio-economic framework for this study, are presented hereunder:

5.2.1 Socio-economic Goals Toward 2020

The 8th National Congress of the Communist Party of Vietnam was held in June 1996. The congress has approved the Political Report of the Central Committee. The report says, from now to the year 2020, Vietnam will strive strenuously to turn the country into an industrialized country. The goal of industrialization and modernization is to build Vietnam into an industrialized country with a modern technology, a rational economic structure, advanced production techniques, high standards of material and intellectual well-being, firm national defense and security, a prosperous people, a strong country, and an equitable and civilized society.

In the report, some concrete targets are also stated as summarized below:

- To increase GDP about 8 to 10 times of that in 1990.
- To complete basically national electrification.
- To increase the shares of industry and service sectors in GDP.
- To improve natural and social science and technology.
- To keep the state economic sector to perform a leading role together with the cooperative economic sector.
- To promote the individual, small owner and private capitalist economies.

5.2.2 Strategy for Socio-economic Development in the Period 2001-2010 presented at the 9th National Congress

(1) Achievement of 1991-2000 Socio-economic Strategy

The 9th National Congress of the Communist Party was convened in April 2001. In the congress, the evaluation of the implementation of the 1991-2000 socio-economic strategy was presented. Main achievement are as summarized below:

Results of the 1991-2000 Socio-economic Strategy

Item	Results of the 1991-2000 Socio-economic Strategy
GDP growth	2.07 times of GDP in 1990 in real term
- Share of Agriculture in GDP	38.7% in1991 to 24.3% in 2000
- Share of Industry in GDP	22.7% in 1991 to 36.6% in 2000
- Share of Service sector in GDP	38.6% in 1991 to 39.1% in 2000
Domestic savings	27% of GDP in 2000
Poor household (Vietnamese standard)	Reduced from 30% in 1991 to 10 % in 2000
Population growth rate	Lowered from 2.3% in 1991 to 1.4% in 2000
Average life expectancy	Gained from 65.2 years in 1991 to 68.3 years in 2000
Creation of new job opportunity	Annually over 1.2 million new job opportunity created

With the above-mentioned results, the evaluation said that, in general, most of the main targets set by the 1991-2000 Socio-economic Strategy have been fulfilled. At the same time, weakness and inadequacies were also pointed out such as the inadequate economy's efficiency, inappropriate production practices, poor investment and business environment, poor quality of education and training, and difficulties in people's lives.

(2) Overall Goals of 2001-2010 Socio-economic Strategy

The overall goals of the ten-year 2001-2010 Strategy are 1) to bring Vietnam out of underdevelopment, 2) to improve noticeably the people's material, cultural and spiritual life, and 3) to lay the foundations for making Vietnam a modern-oriented industrialized country by 2020.

The specific goals of the Strategy are as summarized below:

Target of the 2001-2010 Socio-economic Strategy

Item	Target of the 2001-2010 Socio-economic Strategy
GDP	At least double the GDP of 2000 by 2010
Agriculture, forestry, and fishery	Share in GDP: 16 - 17% by 2010 Average annual growth rate: 4.0-4.5% Annual export turnover: US$9-10 billion in 2010 (Export of aquatic products: US$3.5 billion in 2010)
Industry and construction	Share in GDP: 40 - 41% by 2010 Average annual growth rate: 10-10.5% To employ 23-24% of the labor force in 2010 Share in the total export: 70-75% in 2010
Service sector	Share in GDP: 42 - 43% by 2010 Average annual growth rate: 7-8% To employ 26-27% of the total labor force in 2010
Domestic savings	Over 30% of GDP by 2010
Export growth rate	More than double growth rate of GDP by 2010
Share of agriculture labor	To drop to around 50% of the workforce by 2010
Human Development Index (HDI)	To rise substantially
Population growth rate	To drop to 1.1% by 2010
Unemployment rate (Urban)	Below 5% by 2010
Trained labor	To rise to around 40%
Schooling	To ensure schooling to all school-age children
Poor household	To eliminate the category of hungry households, To reduce quickly the number of poor households.

(3) Sectoral Development Orientations

The sectoral development orientations in the Socio-economic Development Plan 2001-2010 of the following major sectors are presented in Appendix-C, while those of agriculture, forestry, and fishery sectors have already been discussed in Chapter 4, Agriculture:

(a) Industry and construction

(b) Energy

(c) Water supply

(d) Services

(4) Regional Development Orientations

(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. The capital, Hanoi is also included in the region. Major regional orientations are:

- 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. Commercial center of the nation, Ho Chi Minh City, is also included in this region. Major regional orientations are:

- 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,
- 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 are:

- 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,
- 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 are:

- 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,
- 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 are:

- 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,
- 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 are:

- 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.

5.2.3 Five-Years Plan for Socio-economic Development from 2001 to 2005

The five-year (2001-2005) plan for socio-economic development was set with the following major development and key tasks:

- To strive to achieve an annual average economic growth rate higher than that of the previous five years (annual GDP growth of 7%), and to prepare for the next five years.
- To develop a multi-sector economy and to shift the economy structure and labor structure in the direction of increasing the proportion of industry and services.
- To increase investment for social and economic development; to improve economic structure in both key economic zones and areas in extreme difficulty in harmony.
- To expand external trade and improve its efficiency; to consolidate the existing market and expand new markets, to attract external capital and technology, to implement bilateral and multi-lateral commitments, etc.
- To continue the renovation and create a basic all-round change in the development of education and training, science and technology.
- To deal with social problems effectively: generating more jobs, reducing unemployment in urban areas and lack of jobs in rural areas, to reform the regulations on salary, to eliminate hunger and reduce poverty, etc.

The plan also has the following key norms on socio-economic development:

Key Norms of Five Year Plan for Socio-economic Development from 2001 to 2005

Item	Key Norms of Five-Year Plan for Socio-economic Development from 2001 to 2005
GDP	At least double the GDP of 1995 by 2005 with an average annual growth rate of 7.5%
- Agriculture, forestry, and fishery	Average annual growth rate: 4.3% Value increase: 4.8% p.a. Share in GDP: 20-21% by 2005
- Industry and construction	Average annual growth rate: 10.8% Value increase: 13% p.a. Share in GDP: 38-29% by 2005
- Service sector	Average annual growth rate: 6.2% Value increase: 7.5% p.a.

	Share in GDP: 41-42% by 2005
Export turnover	Annual growth: 16%
Junior secondary school attendance rate	80% by 2005
High school attendance	45% by 2005
Population growth rate	1.2% in 2005
Poor household	To reduce to 10% in 2005
Domestic production of medicines	To meet 40% of the needs in 2005
Malnutrition of children	To reduce to 22-25% in 2005
Average life expectancy	To raise to 70 years in 2005
Clean water supply	60% of the rural population in 2005

5.3 Socio-economic Development Framework

5.3.1 Development Scenarios and Framework

Socio-economic framework plan for the target year 2020 has been set by the study team for estimation of the future water demand and flood damage. The socio-economic framework includes the following items:

i) Population (urban and rural population, increasing rates including urbanization)
ii) Gross Regional Domestic Product (amount, sector component, and growth rate)
iii) GRDP per capita

(1) Population Projection

Population projection of the major provinces in the 14 river basins has been prepared by the study team for the years, 2001, 2005, 2010, 2015, and 2020 based on the results of the questionnaire survey for the related provinces. However, the population targets of some provinces are not complete. Therefore, when population target of province is not available at all, population projection prepared by GSO was applied. In this case, urban and rural population was estimated by the study team from the present population distribution and past trend of population increase. When the population target of province is available but information is not complete, the following arrangements were made by the study team:

If some intermediate population is not available, it is estimated by applying the same increasing rate for the period.

If population targets in 2010 and/or 2020 are not available, the average annual increasing rate of 1.1% (national target) was applied to estimate the population.

The results of the population projection by river basin are shown in Table 5.17.

(2) Economic Development

Vietnamese economy enjoyed its high performance of more than 8% in terms of the annual GDP growth rate from 1992 to 1997. However it has slowed down due to influence of the regional economic crisis and natural calamities such as droughts and floods. The decline of prices of major agricultural crops in international market also reduced Vietnam's export turnover. It will not be easy for Vietnam to continue high economic performance under the ongoing worldwide recession.

On the contrary, Vietnam has a lot of future potential for economic development. The bilateral trade agreement with the United States and future affiliation with the World Trade Organization (WTO) will accelerate Vietnam's international trade. Its rich natural and human resources, potential domestic market, cost competitiveness in the international market must contribute greatly to the economic development of the country.

In Vietnam, each province has its economic development target by sector. The economic development targets of the objective provinces are collected by the questionnaire survey with assistance of IWRP. Some data from the provinces are not complete or appropriate but they are the official targets and esteemed as much as possible.

However, when the economic development targets of provinces are not available at all, those prepared by MPI were applied. When the economic development targets are available but those in 2010 and/or 2020 are not available, the same growth rates as previous period were applied to estimate the future growth targets.

The total of the economic growth targets of the whole provinces and cities almost conforms to the socio-economic development plan of the country as a whole. Economic development plans of the 14 river basins in this study, therefore, are established based on those provincial targets.

The following three development scenarios might be envisioned for the socio-economic development of the provinces in the river basins:

a) Medium development scenario

This scenario is based on the provincial economic development targets which almost conform to the Socio-economic Development Plans of the Government until the years 2005, 2010, and 2020 as discussed in subsection 6.2 and the provincial targets discussed above.

b) Higher development scenario

This scenario is to attain higher economic growth than the provincial development targets by 10% in terms of annual economic growth (If the annual economic growth rate of the medium development scenario is 10%, the higher development scenario attains the annual economic growth of 11%).

c) Lower development scenario

This scenario is to attain lower economic growth than the provincial development targets by 10% in terms of annual economic growth (If the annual economic growth rate of the medium development scenario is 10%, the lower development scenario attains the annual economic growth of 9%).

The medium development scenario will be utilized as the base, and those of the higher and/or the lower development scenarios are examined to establish optimum water utilization plans. The economic development targets based on the three development scenarios are presented in Table 5.18.

5.3.2 Development Targets of the Provinces in the River Basins

In accordance with the three development scenarios, macro-economic targets (medium development scenario) for the objective provinces in the river basins for the years 2001, 2005, 2010, 2015, 2020 are respectively specified. Since the Red and Thai Binh River Basin is extensive and its socio-economic characteristics varies from mountainous areas to plain areas, the development targets are set dividing into two; Red River Delta and the other areas of the basin.

(1) 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

The area has achieved a high economic growth at a rate of 10.5% per annum in terms of GRDP from 1995 to 2000.

Per capita GRDP of the basin was estimated to be VND2,967 thousand in 2000, which was far lower than national average of VND5,717 thousand. It is forecasted that per capita GRDP will reach VND11,430 thousand in 2020 with an annual growth rate of 7.0%.

(2) 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

Average population growth rate has been gradually decelerated for these 10 years in the basin. The same deceleration trend will continue over the next decades.

The area has achieved a high economic growth at a rate of 9.2% per annum in GRDP from 1995 to 2000. Approximately 37% of GRDP of Red River Delta was earned by Hanoi at present but its ratio will drop gradually to 12 % in 2020.

Per capita GRDP of the basin was estimated to be VND4,708 thousand in 2000, which was lower than national average of VND5,717 thousand.

(3) Red and Thai Binh River Basin (Outside of Red River Delta)

(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)

Average population growth rate has been gradually decelerated for these 10 years from 2% in 1990 to 1.4% in 2000 in the basin. The same trend will continue over the next decades.

The area has achieved a high economic growth at a rate of 8.3% per annum from 1995 to 2000.

Per capita GRDP of the basin was estimated to be VND2,613 thousand in 2000, which was less than half of the national average of VND5,717 thousand.

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

(4) 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

Average population growth rate has been dropped from 1.5% in 1991 to 0.8% in 2000. The same growth trend will continue over the next decades.

The area has achieved a high economic growth at a rate of 7.3% per annum in terms of GRDP from 1995 to 2000.

Per capita GRDP of the basin is targeted at VND2,357 thousand in 2001 and VND15,620 thousand in 2020 (in 2000 price). This means per capita GRDP will grow with an annual growth rate of 6.4%, which is faster than the national average of 6.4%.

(5) 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

Average population growth rate has been dropped from 1.4% in 1991 to 0.9% in 2000.

The area has achieved a high economic growth at a rate of 7.2% per annum from 1995 to 2000.

Per capita GRDP of the basin was estimated to be VND2,718 thousand in 2000, which was almost half of the national average of VND5,717 thousand. During the period from 2001 to 2020, it is forecasted that per capita GRDP will grow with an annual growth rate of 6.1%.

(6) 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

Average population growth rate has been dropped from 2.2% in 1991 to 1.0% in 2000.

The area has achieved a high economic growth at a rate of 8.6% per annum from

1995 to 2000.

Per capita GRDP of the basin was estimated to be VND2,890 thousand in 2000, which was almost half of the national average of VND5,717 thousand. During the period from 2001 to 2020, it is forecasted that per capita GRDP will grow with an annual growth rate of 6.2%, which is almost same as national average of 6.4%.

(7) 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

Population growth of the Huong River basin has been relatively stable between 1.2% and 1.6% per annum during the last decade.

The area has achieved an economic growth at a rate of 6.3% per annum from 1995 to 2000.

Per capita GRDP of the basin was estimated to be VND3,251 thousand in 2000, which was lower than national average of VND5,717 thousand.

(8) Vu Gia-Thu Bon River Basin

(Objective Provinces: Da Nang and Quang Nam)

Average population growth rate has been dropped from 1.7% in 1991 to 1.2% in 2000. The same relatively low increasing trend will continue over the next decades.

The area has achieved a high economic growth at a rate of 9.2% per annum from 1995 to 2000.

Per capita GRDP of the basin is targeted at VND3,591 thousand in 2001 and VND17,312 thousand in 2020 (in 2000 price). This means per capita GRDP will grow with an annual growth rate of 8.6%, which is far faster than the national average of 6.4%.

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

(9) 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

Average population growth rate has been dropped from 1.3% in 1991 to 0.6% in 2000.

The area has achieved a high economic growth at a rate of 8.6% per annum from 1995 to 2000.

Per capita GRDP of the basin was estimated to be VND2,813 thousand in 2000, which was almost half of the national average of VND5,717 thousand. During the period from 2001 to 2020, it is forecasted that per capita GRDP will grow with an annual growth rate of 6.4%, which is slightly faster than the national average of 6.4%.

(10) 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

Average population growth rate has been dropped from 1.6% in 1991 to 1.1% in 2000. The same trend will continue over the next decades.

The area has achieved a high economic growth at a rate of 8.9% per annum from 1995 to 2000.

Per capita GRDP of the basin was estimated to be VND3,099 thousand in 2000, which was far smaller than the national average of VND5,717 thousand. During the period from 2001 to 2020, it is forecasted that per capita GRDP will grow with an annual growth rate of 6.7%, which is faster than the national average of 6.4%.

(11) 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

The Ba River basin has had a high population growth during the last decade. Average population growth rate has been between 2.7% to 3.0% per annum. It will slow down a little bit over the next decades.

The area has achieved a high economic growth at a rate of 10.8% per annum from 1995 to 2000.

Per capita GRDP of the basin was estimated to be VND2,913 thousand in 2000, which was almost half of the national average of VND5,717 thousand. During the period from 2001 to 2020, it is forecasted that per capita GRDP will grow with an annual growth rate of 6.7%, which is faster than the national average of 6.4%.

(12) 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

The Dong Nai River basin has had a high population growth during the last decade. Annual population growth rate has been between 2.4% to 2.8%. Relatively high growth trend will continue over the next decades.

The area has achieved a high economic growth at a rate of 9.1% per annum from 1995 to 2000.

Per capita GRDP of the basin is targeted at VND7,402 thousand in 2001 and VND12,940 thousand in 2020 (in 2000 price). This means per capita GRDP will grow with an annual growth rate of 3.0%, which is slower than the national average of 6.0%, since the basin already has the highest per capita GRDP among 14 river basins.

(13) 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

The Se San River basin has had a high population growth during the last decade. Average population growth rate has been between 3.1% and 3.5% per annum. The same relatively high growth trend will continue over the next decades.

The area has achieved a high economic growth at a rate of 10.6% per annum from 1995 to 2000.

Per capita GRDP of the basin was estimated to be VND2,586 thousand in 2000, which was less than half of the national average of VND5,717 thousand. During the period from 2001 to 2020, it is forecasted that per capita GRDP will grow with an annual growth rate of 4.9%, which is slower than the national average of 6.4%.

(14) 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

The Srepok River basin has had an extremely high population increasing during the last decade. Average population increasing rate has been between 3.9% and 8.0% per annum. The same relatively high increasing trend will continue over the next decades.

The area has achieved a high economic growth at a rate of 14.7% per annum from 1995 to 2000.

Per capita GRDP of the basin is targeted at VND2,814 thousand in 2001 and VND6,783 thousand in 2020 (in 2000 price). This means per capita GRDP will grow with an annual growth rate of 4.7%, which is slower than the national average of 6.4% due to pressure of rapid population increase.

(15) 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

Population growth of the Cuu Long River Delta has been dropped gradually from 1.3% in 1991 to 1.1% in 2000.

The area has achieved a high economic growth at a rate of 7.8% per annum from 1995 to 2000.

Per capita GRDP of the basin is targeted at VND4,341 thousand in 2001 and VND19,470 thousand in 2020 (in 2000 price). This means per capita GRDP will grow with an annual growth rate of 8.2%, which is faster than the national average of 6.4%.

The macro-economic targets of the provinces by river basin are shown diagrammatically in Figure 5.5.