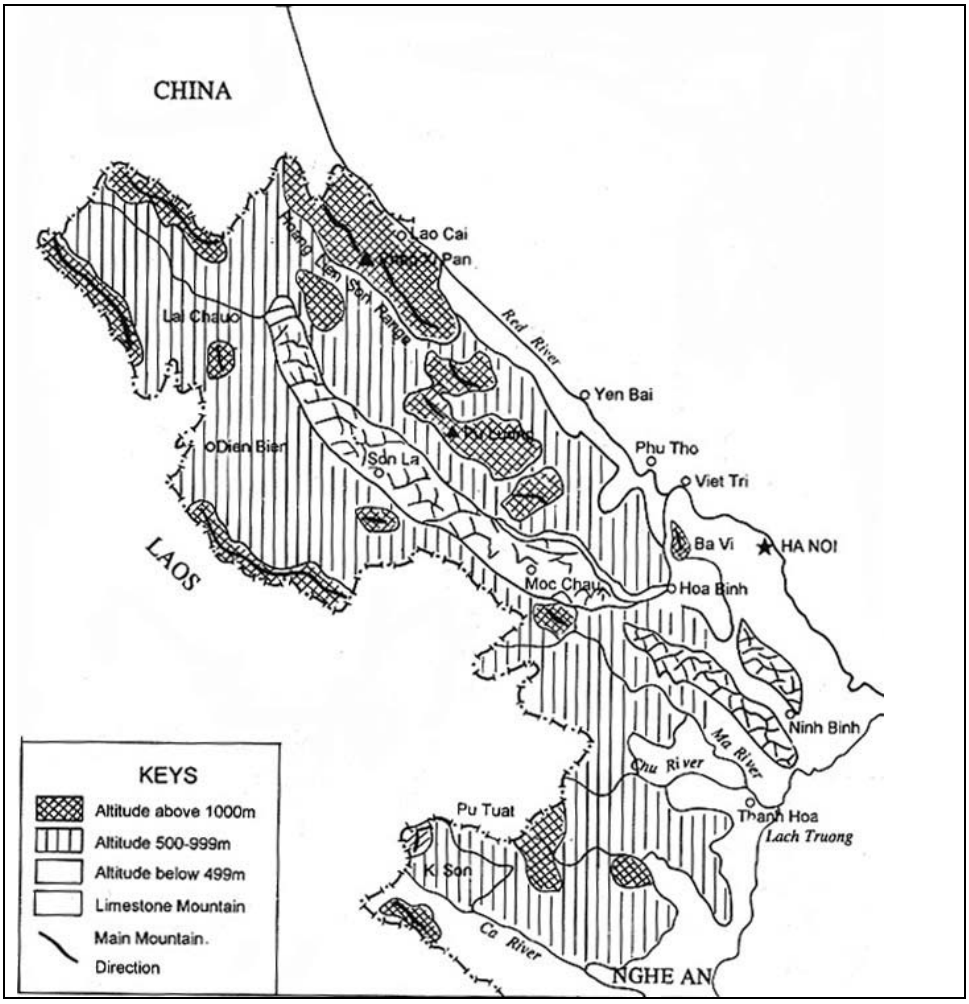
1.2.2 Mountain System in Northwest Region

Mountains in the northwest have unique features owing to tectonic activity. Moving from east to west, one first meets the Hoang Lien Son Range, narrow in width and 180km long, with Fansipan (3,433m).

The strength of orogenic movements combined with the erosion of metamorphic magma rocks has given rise to unique topographical features. The limestone plateau running from Phong Tho to Nho Quan and close to the sea is 400km long and 25km wide. Near Lai Chau, the Da River cuts through the chain of plateau, 800-900m deep separating the Son Chai and Ta Phung Plateau. Moving down to the Son La Plateau, the altitude is only 600-700m, but on reaching the Moc Chau plateau, it rises again to 1,000m. After Moc Chau, the plateau gradually decreases in altitude, eventually to turn into undulating hills. To the extreme west, is the Ma River mountain range running for 500km with peaks rising to 1,800m high up to the Son La plateau and another towards the mountainous region of Thanh Nghe, after which it slopes abruptly down towards the sea, with a trace of basaltic eruptions in Nhu Xuan – Phu Quy and a series of undulating hill.



1.2.3 Mountain System (3) in the Northern Truong Son Range

The Northern Truong Son Range, running from northwest to southeast, stretches from the right side of the Ca River to the Hai Van Pass. Due to irregular tectonic movements, the mountains were thrown up in rough curves, having two asymmetrical flanks; the western flank slopes towards the Mekong valley, and the eastern falls abruptly to the coastal plains. The wavy line of the range is the watershed between the two basins.

The Truong Son Range comprises many peaks leading up to the Mu Gia Pass–including Pu Lai Leng 2,711m and Rao Co 2,235m The mountain is covered with rain forest. At the Keo Nua Pass (960m), the mountains are higher again and extremely rugged. Some small plains are found in this region, namely valleys of the Con, Ngan Pho and Gianh Rivers. Hoanh Son range presents a major barrier between two southern plains of Nghe Tinh and Quang Binh.

Moving through the Ngang Pass, the limestone massif of Ke Bang, Khe Ngang is only 1,000m high, but very rugged, with very few rivers or streams and access. At an altitude of 300-400m, a patch of volcanic soil, 20,000ha in area, covers the undulating hills extending from Vinh Linh to Lao Bao. Southbound are marble mountains, with plains between the foothills and the sea. The Hai Van Pass forms the frontier between the northern and southern of Truong Son Range.

1.2.4 Mountain System(4) in the Southern Truong Son Range

The Southern Truong Son Range running from the Hai Van Pass to eastern Nam Bo has its origin in the Kon Tum massif, with its ancient flexures and depressions dating from the Mesozoic. The western side gently sloping and the eastern side falling abruptly to the sea. Basalt eruptions concentrated in three areas from Kon Tum to Buon Me Thuot, to Di Linh and towards eastern side. The orientation and topography of the southern Truong Son Range is thus quite different from the northern, with hills and mountains to the east and plateau to the west.

a) Northern Central Highlands:

The Central Highlands comprise a system of plateau belonging to the southern Truong Son Range and extending from the foot of Ngoc Linh Mountain to eastern Nam Bo. The hills and mountains to the east are of various kinds: granitic peaks in Kon Tum region (Ngoc Linh at 2,598m) and the comparatively low hills in Quang Nam – Da Nang region. To the south the mountains of Khanh Hoa encircle a coastal plain at the extreme southern end of Trung Bo.

The Kon Plong plateau lies between An khe and Ngoc Krinh at an altitude ranging

from 1,100 to 1,300m, and is covered by a layer of basalt. The altitude decreases to 500m southwards. South of Kon Tum is the plateau of Pleiku, one of the two largest in the Central Highlands, with the Chu Hong Drong peak (1,025m).

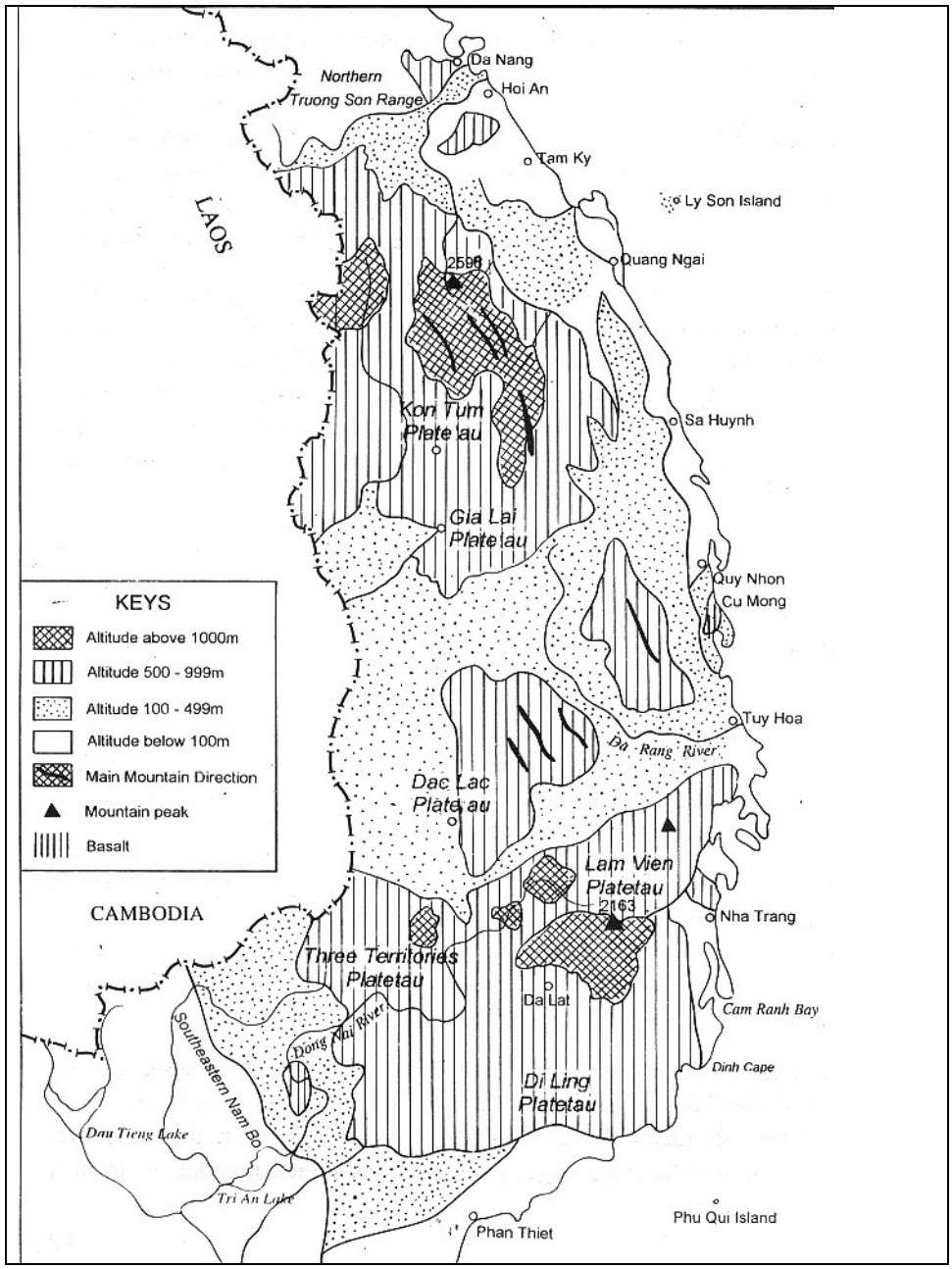
In the Central Highlands there are not only mountains and plateaux, but depressions and plains as well; the An Khe area (15km wide, 45km long, at an altitude of 400-500m).

b) Southern Central Highlands:

Buon Me Thuot plateau is largely covered by basalt and 90km long. Its width is 70km from west to east, with an altitude of 500m only at its center. The Di Linh Plateau is shaped like a valley lying east-west, with an altitude of 1,000m falling gradually to 500m. The basalt cover has been largely eroded away, but some remaining peaks stand out with heights of 1,200m. Notable also is the Da Lat peneplain, whose altitude varies between 1,600m and 1,400m. This may be an ancient valley, the original flat surface of which had been better preserved than in other mountainous regions of Vietnam.

c) Southern region:

At the end of southern Truong Son Range is the basaltic land around the Be and Dong Nai Rivers, the Nam Bo Rivers, the Nam Bo depression being dotted with a line of hills lying in a northwest-southeasterly direction, forming an elevated plain extending from Loc Ninh to Ba Ria with a height of 200-300m above sea level.


Da Nang
Northern
Truong Son Range
Hoi An
Tam Ky
Ly Son Island
LAOS
2598
Quang Ngai
Kon Tum
Plateau
Sa Huynh
Gia Lai
Plateau
Quy Nhon
Cu Mong
KEYS
Altitude above 1000m
Altitude 500 - 999m
Altitude 100 - 499m
Altitude below 100m
Main Mountain Direction
Mountain peak
Basalt
Tuy Hoa
Ba Rang River
Dac Lac
Plateau
Lam Vien
Platetau
2163
CAMBODIA
Nha Trang
Three Territories
Platetau
Da Lat
Cam Ranh Bay
Dong Nai River
Southeastern Nam Bo
Dinh Cape
Di Ling
Platetau
Dau Tieng Lake
Tri An Lake
Phan Thiet
Phu Qui Island

1.3 Plains

If mountains and hills were formed through a process of lifting and erosion, the plains were mainly formed in the resulting depressions and built up from river and sea alluvium. In Vietnam the plains system lies along the meridian and in a north-west-southeasterly direction; each plain borders mountains or hills to the west and the sea to the east.

Vietnam has three plains systems – Bac Bo, the Trung Bo coast and Nam Bo. Their common characteristic is the great amount of alluvial deposit, but man-made dyke systems are preventing the enrichment of these plains.

1.3.1 Bac Bo Plain System

The plain of Bac Bo is 16,000km^2, the second largest after the Nam Bo plains. The surface is quite flat, most of the land belonging to the Cainozoic sedimentary era. Some of the hills that remain are 50m to 70m in height. The alluvial plains are between 10m and 0.3m high. Altitude never exceeds 25m and decreases as reaching the sea.

The rivers have elevated banks, with system of built dykes for preventing floods. This has divided the plains into separated sections - the Ha Nam Ninh area between the Day, Red and Phu Ly Rivers, the Vinh Yen area between the Red, Lo and Ca Lo Rivers.

Near the coast there appear lines of sand dunes 2 or 3m high, with up to 25 parallel lines forming a dune system. The dunes often rise one or two meters above the level of nearby paddy field. Villages and productive fields are concentrated there, and close to the sea grow rows of casuarinas trees. Between the sand dunes are low-lying areas, no more than half 1km wide. Alluvial islands are now linking up to become part of the continent at a rate of 80-100m per year, especially at the month of the Red River. In other areas the coastline is being eroded and is sinking, as at the mouth of the day River.

1.3.2 Coastal Trung Bo Plain System

These spread over an area of 14,000km^2, and consist of flat areas extending from Thanh Hoa to Thuan hai (a distance of 1,000km) but by mountain ranges running from the Truong Son Range to the sea.

The Thanh Nghe Tinh plains cover an area half the size of the Bac Bo plains and were formed by sedimentation from the Ma, Ca and smaller rivers. As the mountains run towards the sea, they divide the plains into many smaller areas, especially in Nghe Tinh, such as Thach Ha, Cam Xuyen and Ky Anh. Dunes and lagoons occur to the sea, and to the west valleys cut deeply into the mountain ranges.

The Binh Tri Thien plains are 2,150km^2 in area, extending from south of the Ngang Pass to the Hai Van Pass and comprise many small plains running parallel to the mountains of the

northern Truong Son Range and the Gulf of Bac Bo. Moving southwards, the plains gradually widen, for example the Ben Hai, Thach Han and Hung River plains. Like other coastal plains, those of Binh Tri Thien have continuous lines of high sand dunes and many lagoons, some quite long, like Tam Giang lagoon.

The Quang Nam – Nghia Binh plains (4,350km^2), lies to the south of the Hai Van Pass to the north of the Cu Mong Pass, is made up of the deposits of the many river valleys. The best known of these are Thu Bon, Tra Khuc, and Binh Dinh. Sand dunes and lagoons occur close to the sea.

However most of the area is comprised of alluvial terraces and sand dunes, and except in places such as Tuy Hoa, Tuy Phong, and Phan Thiet where the alluvial deposits are quite recent and thus more fertile, the area is unproductive.

1.3.3 Nam Bo Plain System

The Nam Bo plains cover an area 61,000km^2 and are part of the Mekong-Dong Nai system – the largest in Vietnam.

The Eastern Nam Bo plains cover 23,745km^2 with a depth of 100m of semi-peneplain and 200m thick-basaltic red soil forming parts of the three provinces of Dong Nai, Song Be and Tay Ninh. The plains are the only ones in Vietnam not submerged during the rainy season. Being near the subtropical zone, the development of the region thanks to the cultivation of cash crops.

The western Nam Bo plains, almost 40,000km^2 in area, were formed from alluvial deposits in the Cuu Long delta. The large area covered by the plain with a gradient of only 1cm/km, explaining for difficult drainage in rainy season. Since accumulation of sediment does not occur evenly; the topography varies from place to place. The plain of Reeds (530,000ha) and the Ha Tien plain (300,000ha) usually experience flooding in the rainy season and drought in the dry season. Small low-lying marshy areas are found in Kien Giang, Minh Hai (although here there is no system of dykes).

Most of the delta area is submerged during the monsoonal season or sometimes at high tide. But there are also elevated areas, such as that between the Tien and the Hau Rivers with rounded hillocks on the banks of rivers and vestiges of coastal sand dunes.

In coastal areas, the soil is covered by large expanses of mangroves – U Minh and Ca Mau (almost 300,000km^2) where alluvial sedimentation can be observed. Although the Nam Bo delta is large and fertile, it can be difficult to cultivate. Half the area is submerged during the rainy season while the other half retains high levels of salinity during the dry season. Many problems have to be solved-removal of acidity, reduction in salinity, improvement of acid sulpate soil, provision of fresh water (in the dry season), flooding control (in the rainy

season), and the composition and rotation of crops. These problems have to be overcome in order to bring about satisfactory productivity increases.

2 GEOLOGY

In Vietnam, there exist almost all sedimentary and volcanogenic formations covering from Archean to Holocene ages as described hereunder.

Formation	Geological formation
Archean	- Archean formation are distributed in the Kontum Massif Kontum Massif - Consist of ultrametamorphic, mafic granulite, hypersthene and bearing plagiogneiss, mica schist - Rich in sillimanite, cordierite intercalated with thin beds of calciphyre and marble. Total thickness are 7,000m - Passing upward to metapelite rich in sillimanite in the upper part.
Lower-middle Proterozoic formation	- Found mainly on Kontum Massif and west of Bac Bo. The lower part composed of amphibolite, biotite – bearing gneisses with interbeds of amphibolite - Having an isotopic dating of 2,300 My, 6,000m thick. - The upper part comprise gneisses and mica schist bearing disthene, sillimanite, graphite and garnet, intercalated with quartzite, marble and amphibolite, 2,500-3,000 thick. Rock furnish an isotopic dating of about 1,700 My
Upper proterzoic – Lower Cambrian	- Exposed in Chay, Bu Khang rivers and basin of Ma river. Total thickness of 4000-5000 m, mica schist with interbeds of marble and amphibolite. - In Sapa and Poco rivers: quartzite and dolomite marble, 200-800m thick, dating as Vendain (600-700 My) unconformably lie on older rocks. - Northern margin of Kontum Massif : mica schist, intercalated with amphibolite found in the northern margin of Kontum Massif. - Paleozoic widely distributed in Vietnam - Its formations distributed in Bac Bo - Consist of quartzsericite schist, cherry-calcareous schale, some limestone bearing apatite on the right side of Red river, or green schist from mafic effusive in Ma and Lo river basins. Total thickness of 4,000 – 5,000 m.
Upper Cambrian-Lower Ordovician	- Thickness from 1,000 to 1,900 with calcareous bearing trilobite, quartzite sandstone exposed in Bac Thai, Cao Bang, Ha Giang and West of Bac Bo, lying conformably on Middle Cambrian. - Northern margin of Kontum massif, west Danang and Hue are distributed green schist (metabasalt, metandesite) intercalated with sericite schist.
Ordovician-silurian formations	- Composed of rhythmic terrigenous sediments and chert bearing graptolites, 1,000 to 2,000 m thick, largely in Bac Bo, North of Trung Bo. - In the Da river basin are conglomerate, limestone, cherty limestone bearing corals and brachiopods.
Silurian – lower Devonian formations	- Consist of shale, sandstone, limestone, distributed in north and west of Bac Bo and north of Trung Bo. - Only Phia Phuong formation includes sericite schist intercalated with porphyrictic rhyolite.

Lower Devonian formations	- Comprise conglomerate, sandstone, siltstone and shale of 2,000 in thickness, bearing fish remains, ostracods, unconformably lying upon older sediments. - Distributed in east and north of Bac Bo. Lower-Middle Devonian formations largely found in northern Vietnam containing much corals and brachiopods, with sandstone, shale and some limestone. - Middle Devonian consists mainly limestone in Bac Bo, sandstone and shale in north of Trung Bo, 800-900m thick. - Middle-Upper Devonian comprises limestone, argillite, sandstone, shale and banded limestone bearing manganese with a lot of corals and microfauna. Those sediments are also met in north and west of Bac Bo and central of Trung Bo (Long Tho).
Carboniferous formations	- Consist of conglomerate, sandstone, siltstone, shale, chert, coaly shale and interbeds of foraminiferas, bearing limestone, 100-200m to 600-700m thick, unconformably cover Devonian sediments at Muong Xen and Quy Dat. - Carnoniferous-Permian limestone of 500-2,000 in thickness bearing numerous foraminiferas is largely distributed in Bac Bo and North of Trung Bo. - Upper Carnoniferous- Permian formation in west Bac Bo contain limeston, basalt, and in Tay Nguyen (central highlands) and Nam Bo, andesite, dacite and rhylite
Upper Permian	- Having a new sedimentary cycle of limestone, siltstone, shale and bauxite in east of Bac Bo, North of Trung Bo, Nam Bo and thick beds of basalt in west of Bac Bo. - Those rocks unconformably cover older formations, but conformably lie beneath Lower Triassic.
Lower Trissic formations	- The formations are composed of sandstone, siltstone, shale bearing ammonoids and bivalves of 2,000m thick, sometime intercalated with felsic effusive (north of Bac Bo) or mafic one (south of Bac Bo). - Middle Trissic consist of terrigenous sediments and felsic effusive in east of Bac Bo or limestone passing upwards to terrigenous sediments in west Bac Bo, 2000-3000m thick, bearing in abundance bivavels and some ammonoids. The formations lie conformably on Lower Trissic. - In North of Trung Bo and Kontum massif, Middle Trissic effusive unconformably covers metamorphic rocks. Middle-Upper Trissic in east of Bac Bo is represented by continental red rocks and west of Bac Bo consist of black shale, sandstone and lime stone. Upper Trissic coal-bearing formations were formed in graben-like depressions at Hon Gai, Nong Son, bearing in abundance plant remains, in Da river basin – bivalvels.

Lower-Middle Jurrassic	- Distinguished in two types of sequences: (i) continental red-colored type, found in north of Bac Bo (Ha Coi, Nam Po), 600-1,000m thick; (ii) marine on with grey terrigenous sediments bearing ammonites and bivalves, distributed in central of Trung Bo and Nam Bo (Tho Lam, Ban Don). Upper Jurrassic-Cretaceous comprise terrigenous sediments intercalated with felsic and alkaline effusive in west of Bac Bo (Tu Le), sandstone and andesite in south of Trung Bo, but in Phu Quoc island sound red-colored sandstone and siltstone. - Upper Cretaceous has 2 section types: (i) continental red beds in west of Bac Bo (Yen Chau) and north of Trung Bo; (ii) felsic and subalkaline effusive in west of Bac Bo (Ngoi Thia), dacite and rhyolite in south of Trung Bo (Da Lat). The sequences here attain a thickness of 1,400-1,800m
Cenozoic sediments	- Bearing flora, spores and pollens or foraminiferas. In Pu Sam Cap Paleogene are trachyte and leucitophyre. - In Hanoi and Cuu Long depression, it comprises conglomerate, sandstone and siltstone. Neogene consist of coal, bearing terrigenous sediments in Bac Bo and terrigenous sediments with thick interbeds of basalt in south Trung Bo and Nam Bo. Pliocene-Pleistoncene sediments comprise an intercalation of clay and silt in Cuu Long depression. - The cover of tholeitic basalt and deleritic one in Bao Loc Plateau and Song Be, Xuan Loc, Vinh Linh, 90-140 thick, dated as late Miocene-Pleistoncene - Quaternary sediments are composed of alluvial, deluvial beds intercalated with marine ones, largely in Bac Bo, Nam Bo Plains and coastal areas. Basalt also found in north and south of Trung Bo and Nam Bo.

3 RIVER AND FLOOD CONTROL

3.1 Bang Giang River Basin

(1) River Basin

Bang Giang River basin is located in the northeast region of Vietnam bordering China on the north and the east. The western and southern side of the basin is the Red River and Thai Binh River basin. The Ngan Son Range is the watershed border between the Bang Giang River basin and the Red River & Thai Binh River basin on the northwest. The general location of the basin is shown in Figure A.1.

(2) 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 major tributary of the Bang Giang River is the Ky Cung River originating in Vietnam. The Ky Cung River flows down to the northwest, turns the direction to the east in the middle of the basin and flows into China solely and joins the Bang Giang River in China. The river system of the Bang Giang and Ky Cung River basin is shown in Figure A.2.

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 A.3. The elevation of the bank of the Bang Giang River is between 130 m and 380 m inside Vietnam. The elevation of the Ky Cung River is between 120 m and 570m. The slopes of the both rivers are very steep with 1/20 to 1/1,000. Thus both rivers are in mountainous and hilly area.

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

(3) Flooding

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.

(4) Flood Control Measure

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.

3.2 Red and Thai Binh River Basin

(1) River Basin

Red and Thai Bing River basin is located in the northern region of Vietnam bordering China on the north and Laos on the northwest. The southwestern side of the basin is the Ma River basin with the watershed of Su Xung Chao Chai Range and Moc Chau Plateau. The northeastern side of the basin is the Bang Giang River basin, and the southern side of the basin is the East Sea. The general location of the basin is shown in Figure A.1.

(2) 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 major tributaries of the Red River are the Lo River and the Da River. The Lo River originates in China, flows down to the southeast, and enters into Vietnam. In Vietnam, the Chay River as the tributary of the Lo River joins the Lo River at the reaches downstream of Thac Ba reservoir, and then joins the Red River downstream of Viet Tri upstream of Hanoi. The Da River originates also in China, flows down to the southeast, enters into Vietnam, and joins the Red River just upstream where the Lo River joins the Red River. The river system of the Red and Thai Binh River basin is shown in Figure A.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 A.5. The elevation of the river is between 0.0 m and 120 m. The slope of the river varies between 1/1,200 in the upstream and 1/17,000 in the delta near the East Sea.

Two major hydropower projects have been constructed in the Red River basin. Hoa Binh reservoir on the Da River has a total storage capacity of about 9.5 billion m^3. Thac Ba reservoir on the Chay River has a total active storage capacity of 1.2 billion m^3.

Both are multipurpose reservoirs and besides hydropower contribute to flood control downstream. Hoa Binh, for example, is expected to reduce the peak flood level of the 1971 flood at Hanoi (the largest since hydrologic recording commenced) by 1.5 m (from 14.8 m to 13.3 m).

Floods are a major problem in the Red River Basin. 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.

(3) Flooding

Floods in this basin are generated by typhoons and tropical depressions that bring prolonged heavy rainfall over the basin. 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 just prior to the failure of dike when it fell to 14.1m.

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

In the mountainous areas of the basin, because of the steep terrain, flash flooding is common. Numerous towns in these areas suffer from frequent and severe flooding, but despite the damage and disruption caused annually, it is not considered economically feasible to protect them.

(4) Flood Control Measure

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.

Based on the following studies, the Government of Vietnam has recently approved the new flood control strategy to protect the Red River Delta from probable floods of 0.5 % to 0.2 % occurrence probability.

Water Resources Development Strategy by 2010 (issued by MARD in August 1999), the following strategies are determined:

- Increase security of Red and Thai Binh river dikes to resist to floodwater level of 13.1 m in Hanoi, and 7.21 m at Pha Lai.
- Enhance sustainability of sea dikes, saline prevention dikes in coastal areas to resist to winds of grades of 9 and 10 in combination with medium tides.
- Establish secure areas from flood inundation.
- Ensure structure security (reservoirs, dikes, culverts, ...).

Red River Delta Master Plan (issued by MOSTE in June 1995), the feasibility study on the following reservoirs are recommended:

Sonla Reservoir (low)	:	Da River
Dai Thi	:	Lo River
Bac Me	:	Lo River

3.3 Ma River Basin

(1) River Basin

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 northwestern side of the Ma River basin is the Red River & Thai Binh River basin and the southwestern side is the Ca River basin. The general location of the Ma River basin is shown in Figure A.1.

(2) 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 A.6.

The longitudinal profile of the Ma River is shown in Figure A.7. The longitudinal slope of the Ma River is very steep in the upstream basin ranging from 1/10 to 1/300. The longitudinal slope of the Ma River is very gentle in the downstream basin ranging from 1/4,000 to 1/6,100.

The longitudinal slope of the Chu River is also very steep in the upstream basin ranging from 1/10 to 1/300. The longitudinal slope of the Chu River in the downstream basin is very gentle ranging from 1/4,000 to 1/6,100, nearly the same with that of the Ma River.

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.

(3) Flooding

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.

(4) Flood Control Measure

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. Necessary freeboard should be given to the dyke system of the Ma River. The present dyke system is also deteriorating somehow and needs the everlasting maintenance.

3.4 Ca River Basin

(1) River Basin

Ca River basin is located in the north central region of Vietnam facing the East Sea on the east and bordering Laos on the west. The northern side of the basin is the Ma River basin. The general location of the Ca River basin is shown in Figure A.1.

The basin's characteristics are very similar to those of the Ma River basin in respect of climate, population, occurrence of typhoon and the deterioration of facilities related to water resources.

(2) 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 Ngeh An province. Major tributaries are the Hieu River, the Nam Mo River, and the Ngan Sau River.

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 A.8.

The longitudinal profile of the Ca River is shown in Figure A.9. The slope of the Ca River is very steep in the upstream basin ranging from 1/10 to 1/300 in Laos and 1/400 in Vietnam. But the slope of the Ca River in downstream basin in Vietnam is very gentle ranging from 1/4,000 to 1/5,700.

(3) Flooding

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 width of the banquette is 5.0 m.

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.

(4) Flood Control Measure

Some hundreds kilometers river embankment and 80 km sea dike have been constructed. But these dikes are high enough to protect areas from ordinary flood or sea wave. But the cross-sectional profile is not appropriate at many locations compared to the design standard. In the same manner with the Ma River, the dike system of the Ca River is high enough. The banquette provided on the inland side of the dike for the purpose of seepage countermeasure is currently used as the public road. This is also being used as the inspection road of the river. For the purpose of inspection road, the surface elevation of the banquette is slightly low since the riverside is rather difficult to see from the banquette in an inspection car. The existing dyke system in the downstream reaches has the discharge carrying capacity of about 10,000 m^3/s at bankfull capacity. But in the same manner with the other river dyke system, the present condition needs the everlasting maintenance.

3.5 Thach Han River Basin

(1) River Basin

The Thach Han River basin is located in the north central region of Vietnam facing the East Sea on the east bordering Laos on the west. The southern side of the Thach Han River basin is the Huong River basin. The general location of the basin is shown in Figure A.1.

(2) 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 A.10.

The longitudinal slope of the Thach Han River is very steep in its upstream basin ranging from 1/10 to 1/300. The longitudinal slope of the Cam Lo River and that of the Rao Quan River are also very steep more than 1/300. The longitudinal slope of the Thach Han River becomes rather gentle in its downstream reaches ranging from 1/2,500 to 1/4,000. The longitudinal profile of the Thach Han River is shown in Figure A.11.

The dike system of the Thach Han River is provided on both sides of the Thach 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. Once the earth dike is overtopped, the dike is washed away and rehabilitation cost is needed. Accordingly the present dike is provided with concrete revetment on the both slopes and crown so that the dike would not be damaged when the dike is overtopped by major floods.

(3) Flooding

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.

In the flood, the electrical facilities were inundated and electric poles fell and accordingly the telecommunications during the flood were interrupted. In fishing ports along the seacoast, fishing boats are driven out to sea by typhoons since mooring facilities are lacking.

In 1999 flood, the South Thach Han Irrigation System that was constructed in 1990 was totally 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.

(4) Flood Control Measure

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. The bank revetment works still need more.

3.6 Huong River Basin

(1) River Basin

The Huong River basin is located in the south central coast region of Vietnam facing the East Sea on the east and bordering Laos on the west. The northern side of the Huong River basin is the Thac Han River basin and the southern side of the Huong River basin is the Thu Bon River basin. The general location of the basin is shown in Figure A.1.

(2) 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 A.12.

The catchment area of the Huong River is 3,300 km^2. The length of the Huong River is 102 km including the Ta Trach River.

The longitudinal profile of the Huong River is shown in Figure A.13. The elevation of the river ranges from 500 m above mean seal level to 0 m. The river slope is very steep in its upstream basin ranging from 1/100 to 1/700/. The river slope becomes rather gentle with some 1/2,500 in the reaches from the river-mouth to the proposed dam site of Ta Trach reservoir.

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.

The sketch of the Tão Long Barrage is shown in Figure A.14. The basic structure is that the number of the opening of the barrage is 15 and one lock for inland water navigation is to be provided. According to the model test of the barrage, the river discharge through the barrage will be 6,600 m^3/s when the same scale of 1999 flood occurs in the river basin, of which the peak discharge was some 13,000 m^3/s - 14,000 m^3/s.

Along the lagoon, the sea dike has been constructed with the crown elevation of about

1.2m 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.

(3) Flooding

The downstream basin of the Huong River has been flooded 3 to 7 times every year. During the flooding, a wide area is inundated and even the wheeled traffic becomes interrupted. 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.

In 1985, a big flood occurred due to a typhoon. Many houses were destroyed, many ships were capsized and more than 1,000 people were killed by the typhoon and the flood,

The flood in November 1999 seriously damaged this basin. 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.

(4) Flood Control Measure

The Vietnamese Government is planning to implement the Tra Trach Dam Project, of which main purpose is of the flood control of the Tra Trach River and to protect the Hue City.

3.7 Vu Gia - Thu Bon River Basin

(1) River Basin

The Thu Bon River basin is located in the south central coast region of Vietnam facing the East Sea on the east and bordering Laos on the west. The northern side of the Thu Bon River basin is the Huong River basin and the southern side of the Thu Bon River basin is the Sesan River basin. The general location of the Thu Bon River basin is shown in Figure A.1.

(2) 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 A.15.

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 A.16. The longitudinal slope of the river is very steep in the upstream reaches with the slope ranging from 1/10 to 1/100. On the other hand, the slope in the downstream reaches is very gentle with some 1/5,000.

(3) Flooding

As can be seen in the figure of the longitudinal profile of the river, the headwaters elevation is very high with the elevation of some 2,400 m, being the highest among the objective 14 river basins. With the longitudinal distance of only about 32 km from the headwaters, the elevation of the river becomes 200m. The slope of the Thu Bon River is thus very steep.

Accordingly 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.

(4) Flood Control Measure

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.

Presently as of 2001, the implementation of the urgent flood disaster restoration and mitigation project is expected by the Quang Nam Province. This is mainly to rehabilitate the flood damage due to the flood in 1999. This project includes some non-structural measures for flood damage mitigation especially in Hoi An City, the old city having a famous historical heritage and forming one of the tourism industry centers in Vietnam.

3.8 Tra Khuc River Basin

(1) River Basin

The Tra Khuc River basin is located in the south central coast region of Vietnam facing the East Sea on the east. The west side of the Tra Khuc River basin is the Sesan River basin and the southern side of the Tra Khuc River basin is the Kone River basin.

The general location of the Tra Khuc River basin is shown in Figure A.1.

(2) 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 A.17.

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 A.18. The longitudinal slope of the river is very steep in the upstream reaches ranging from 1/10 to 1/100. With the longitudinal distance of about 40 km from the headwaters, the elevation of the river drops from some 1,200 m to 100m. The longitudinal slope of the river is still not so gentle in its downstream reaches ranging from 1/1,100 to 1/1,900.

At present, there are no any important flood control structures except the dike system around Quang Ngai City.

(3) Flooding

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.

Flood traveling time used to be about 10 hours but it has become about 3 hours in recent years mainly due to deforestation in the upstream basin because of slash-and-burn farming, the narrow river-width due to sediment deposition, and increase of rainfall intensity.

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.

(4) Flood Control Measure

The above-mentioned proposal of dike system construction to protect Quang Ngai city and the proposals of construction of Nuoe Trong Dam Project and Son Ha (Hai Gia) reservoir have been proposed separately. These proposals should be studied as the integrated plan for flood control, power generation, water supply, and the environmental preservation of the downstream basin including the salinity intrusion control. 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. This capacity is still far small compared with the required level of flood control in this river basin.

3.9 Kone River Basin

(1) River Basin

The Kone River basin is located in south central coast region of Vietnam facing the East Sea on the east. The western side of the Kone River basin is the Ba River basin and the northern side of the basin is the Tra Khuc River basin. The general location of the Kone River basin is shown in Figure A.1.

(2) 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 A.19.

The longitudinal profile of the Kone River is shown in Figure A.20. The longitudinal slope of the Kone River is very steep in its upstream reaches ranging from 1/10 to 1/100. The longitudinal slope of the Kone River in its downstream reaches ranges from 1/1,200 to 1/2,300, being not so gentle like other rivers.

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

(3) Flooding

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.

(4) Flood Control Measure

The target of flood control of Din Binh Dam is the standard one in Vietnam, namely the protection of agricultural land from early flood with the probability of 10%. Since the river basin in its downstream does not have a city close to the river vulnerable to flooding of the river, the Din Binh Dam may form a basic portion of the flood control basic plan of the Kone River basin. 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.

3.10 Ba River Basin

(1) River Basin

The Ba River basin is located in the south central coast region of Vietnam facing the East Sea on the east. The northwestern side of the Ba River basin is the Se San River basin, the northeastern side of the Ba River basin is the Kone River basin, and the southwestern side of the Ba River basin is the Srepok River basin.

The general location of the Ba River basin is shown in Figure A.1.

(2) 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 A.21.

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 A.22. The longitudinal slope of the Ba River is very steep in the upstream basin ranging from 1/10 to 1/500. The longitudinal slope of the Ba River is still rather steep in its downstream reaches with the slope of about 1/1,300. The river basin in the upstream is very steep and narrow.

The major tributaries of the Ba River are the Ia A Yun River, the Kurong Nang River, the Kurong Hin River, and the Hinh River. In the Ba River basin, there is no dike system.

(3) Flooding

In the upstream basin, the basin erosion is in progress causing the sediment deposit problem in irrigation channels in the downstream basin. But the rainfall intensity in the upstream basin is not so intensive to cause destructive damage. The rainfall duration in the upstream basin is also not so long. The upstream basin has less influence of typhoons.

In the Ba River basin, there are no substantial flood control measures. Accordingly 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.

But in the downstream basin, the low-lying areas are suffering from serious flooding. Coastal areas are subject to typhoons and flooding. The flooding in the downstream basin is destructive even to human lives. The flooding in the downstream basin has been giving the serious influence to the economic activities of the Thach Tuan City that is the major

city in the basin. This also causes the environmental and health problems in the densely populated areas.

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.

(4) Flood control Measure

The discharge carrying capacity of the existing Ba River is estimated at about 11,000 m^3/s at bankfull capacity.

3.11 Sesan River Basin

(1) River Basin

Sesan River basin is located in the central highlands region of Vietnam bordering Cambodia on the west. The Sesan River basin is facing the Thu Bon River basin on the north, the Tra Khuc River basin, the Ba River basin, and the Srepok River basin on the southeast. The general location of the Sesan River basin is shown in Figure A.1.

(2) 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 A.23.

The longitudinal profile of the Sesan River is shown in Figure A.24. The longitudinal slope of the Sesan River is very steep in hilly and mountainous area with the slope ranging 1/10 to 1/500. The major tributaries of the Sesan River are the Krome River and the Nghe River.

(3) Flooding

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.

(4) Flood Control Measure

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.

3.12 Srepok River Basin

(1) River Basin

The Srepok River basin is located in the central highland region of Vietnam bordering Cambodia on the west. The northeastern side of the Srepok River basin is the Ba River basin and the southern side of the Srepok River basin is the Dong Nai River basin. The Srepok River basin is one of the richest forest areas in Vietnam. The general location of the Srepok River basin is shown in Figure A.1.

(2) 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 Srepok River is one of the tributaries of the Cuu Long River. Accordingly the Srepok River is an international river. The river system of the Srepok River basin is shown in Figure A.25.

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 A.26. The longitudinal slope of the Srepok River ranges from 1/200 to 1/1,500. In the same manner with the Se San River, the Srepok River enters into Cambodia with the elevation of some 150 m before forming the alluvial plain of the river.

(3) Flooding

Due to dense forest cover and soil retention in the upper basin, the heavy runoffs occur nearly two months after the rainy season. Accordingly 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. The sediment deposit can be seen in the river channels, reservoirs, and irrigation canals.

(4) Flood Control Measure

In the Srepok River basin, no flood control master plan has been prepared yet. As mentioned above, some reservoir projects that include some flood control purpose have been proposed.

3.13 Dong Nai River Basin

(1) River Basin

The Dong Nai River basin is located in the southeast region of Vietnam facing Cambodia on the west and the north. The southwest side of the Dong Nai River basin is the Cuu Long Delta basin. The general location of the Dong Nai River basin is shown in Figure A.1.

(2) River

The Dong Nai River, as the Da Nhim River in the upstream reaches, originates on the southern slope of Mr. 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 A.27.

The catchment area of the Dong Nai River is 39,580 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 A.28.

(3) 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

(4) Flood Control Measure

In the Dong Nai River basin, there exist the following reservoirs:

Reservoir	River	Completion	Catchment Area
1) Da Nhim	Dong Nai	1965 or before	775 km^2
2) Tri An	Dong Nai	1988	14,025 km^2
3) Ham Thuan	La Nga	under construction as of 1996	
4) Thac Mo	Be	1994	2,200 km^2
5) Dau Tieng	Saigon	1985	2,700 km^2

(Source: The Maser Plan Study on Dong Nai River and Surrounding Basins Water Resources Development, August 1996)

3.14 Cuu Long River Basin

(1) River Basin

The Cuu Long River basin is located in the Cuu Long River Delta region of Vietnam facing the East Sea on the east and bordering Cambodia on the west. The northeastern side of the Cuu Long Delta River basin is the Dong Nai River basin. The general location of the Cuu Long River basin is shown in Figure A.1.

(2) 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.

Some tributaries of the Cuu Long River such as the Sesan and the Srepok rivers originate in Vietnam, flow down to the west in Cambodia and join the Cuu Long River.

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.

(3) Flooding

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.

If the present flood embankment is heightened along the Cuu Long River and the flood is confined in the river, the river water level will be raised up and the high backwater effect may extend to the territory of Cambodia.

Even if hydropower generation and irrigation project is developed in upstream basin, it will not bring about substantial benefit for flood control, but it would bring about the benefit for low water improvement.

4 ACTIVITIES OF WATER RESOURCES DEVELOPMENT AND MANAGEMENT

4.1 Law/ Regulation and Institution Related to Water Resources

4.1.1 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 is proceeding with preparation of formation and detailed operation of NWRC (National Water Resources Council) and RBO (River Basin Organization), etc. and the detailed enforcement regulations towards enforcement of the new law, starting with three(3) river basins of Red river, Dong Nai river and Cuu Long river. Other river basins intend to follow the above three(3) river basins, although the detailed program is not definitive yet.

4.1.2. 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

Seventy five (75) articles of the new law are as seen in the list of content attached at the end of this sub-section, from which coverage of the new law on water resources can be found.

SOCIALIST REPUBLIC OF VIETNAM
Independence- Freedom- Happiness

THE LAW ON WATER RESOURCE

This Law was passed on the 20th of May, 1998
by the 3rd Section of the National Assembly of the
Socialist Republic of Vietnam, Xth Legislature.
Chairman of the National Assembly
NONG DUC MANH

Hanoi- 20 May 1998

List of Content of the LAW ON WATER RESOURCE

Chapter I: General Provisions

Article 1: Ownership of Water Resource
Article 2: Subjects and scope of regulation
Article 3: Explanation of water resource
Article 4: Management of water resource
Article 5: Protecting, exploiting and using water resource, preventing, combating and over coming the harm caused by water
Article 6: Policy of investment in developing water resource
Article 7: Financial policy on water resource
Article 8: International relations on water resource
Article 9: Acts under strict ban

Chapter II: Protecting the Water Resource

Article 10: Responsibility to protect the water resource
Article 11: Preventing and fighting deterioration and depletion of water resource
Article 12: Protecting underground water
Article 13: Protection of water quality
Article 14: Protection of the quantity of the source of water for living
Article 15: Protecting the quality of water in Agricultural protection, raising aquatic and marine product, in industrial production and mining
Article 16: Protecting water quality in other activities
Article 17: Protecting water resource in urban areas and concentrated population centers
Article 18: Discharging waste water into water resource
Article 19: Rights and obligations of organizations and individuals which are permitted to discharge waste water

Chapter III: Exploitation and Use of Water Resource

Article 20: Regulating and distributing water resource
Article 21: Diverting water from one rive basin to another
Article 22: Rights of organizations and individuals that exploit and use water resource
Article 23: Obligations of organizations and individuals that exploit and use water Resource
Article 24: Issuing permits for exploitation and use of water resource
Article 25: Exploitation and use of water resource for living
Article 26: Exploitation and use of water resource for agricultural production
Article 27: Exploitation and use of water resource for salt making and raising of aquatic and marine products

4.2 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 below:

Donor	Project	Status as of Mar. 2002
ADB		
	- Institutional design and preparation of decisions on formation and support of River Basin Organizations (RBO) (Red River Basin Water Resources Development Project)	Completed
	- Assistance to prepare decisions on formation and operation of National Water Resources Council (Red River Basin Water Resources Development Project)	Completed
	- Red River Basin Profile, assessment of data adequacy and resource data directory (Red River Basin Water Resources Development Project)	Current
	- Regulatory design study for bulk water resources allocation and waste water discharge licensing (Red River Basin Water Resources Development Project)	Completed
	- Basin Water Resources Management in Dong Nai and support for Dong Nai River Basin Organization	Completed
	- Inventory, screening and ranking of potential water resources management projects and the development of an investment strategy in the Central Region provinces.	Current
	- A second Red River Basin Sector Loan , including: - Strengthening of the Red River Basin Organization - Enhance water quality monitoring network - Water resources action plan and framework basin plan - Pilot testing water allocation and wastewater discharge licensing system	up-coming
	- Phuoc Hoa Project in the south	up-coming
World Bank		
	- Mekong Delta Water Resources Management Project, including: - Development of irrigation and water management works - Rural Water Supply - Lower Mekong River Basin Organization (together with AusAID)	Current
	- Screening of river basins in central Vietnam for possible assistance under the Vietnam Water Resources Assistance Programme (VWRAP)	Completed
	- Integrated Development of Thu Bon Basin (VWRAP)	up-coming
	- Dam Safety Management (VWRAP)	up-coming
	- Irrigation Modernization, including irrigation rehabilitation in five projects and reform of Irrigation Management Companies (VWRAP)	up-coming
JICA		
	- The present study (Study on Nation-wide Water Resources Development and Management)	Current

DANIDA		
	- Action Plan for Development of Water Resources in the Upper Srepok Basin	Completed
	- Support to Water Resources Management in Dak Lak	Completed
	- Water SPS, including: - Support for water resources institutes - Support for Rural Water Supply Strategy Implementation - Strategic planning and restructuring of Department of Water Resources and related training - Support to Hanoi Water Resources University - Support for establishment of water user registration and licensing system - Water rights administration and design of tariff and economic instruments	Current
AusAID		
	- Water Resources Management Assistance Project, including: - Mekong delta co-ordination mechanism - Capacity building National water Resources Council - National water resources data directory and data base	Current
	Netherlands	
	In co-operation with ADB: - Red River Basin Water Resources Management Project - Capacity Building For Water Resources Management, including strengthening the National Water Resources Council, Water Resources Investment Strategy for the Central Region and Water Resources Management in the Dong Nai River Basin - Second Red River Basin Sector Loan Project	up-coming
	- Day River Flood Diversion and Water Resources Development Project	Current
	- Vietnam Integrated Coastal Zone Management Project	Current
	- Natural Disaster Mitigation Partnership for Central Vietnam.	Current
	- EVN National Hydropower study, including data base development	Current

5 DATA AND INFORMATION AVAILABLE FOR THE PHASE I STUDY

5.1 Socio-economy

- Statistical Hand Book, 2000, GSO
- Socio-economic Statistical Data of 61 Provinces and Cities in Vietnam, Nov 1999, SPH.
- Statistical Yearbook-1999, GSO
- Statistical Yearbook- 2001, GSO
- Statistical Data of Vietnam Socio-economy 1975-2000, September 2000, SPH.
- VIIIth National Congress Documents, 1996
- 9th National Congress Document, 2001
- Vietnam's Socio-economic Development, 2001
- Global Economic Prospects and the Developing Countries, 2001, WB
- Vietnam Living Standard Survey (1997-1998), 2000, GSO.
- Population and Housing Census- Vietnam 1999- Completed Census Results, 2001, GSO
- Strategy for Socio-economic Development 2001-2010, CC
- Water Resources Development Strategy by 2010, 1999, MARD.
- Water Resources Development Policies of Vietnam, 1999, MARD.

5.2 Domestic and Industrial Water Supply

- ADB Red River Basin Water Resources Management Project, TA 2871-VIE, ADB website update February 2001.
- Analysis of Results of the Multiple Indicator Cluster Survey II (MICSII), Vietnam Committee for Protection and Care for Children, 2000.
- Basic Design Study Report on the Project for Expansion of Water Supply System in Hai Duong City in the Socialist Republic of Vietnam, JICA, February 1999.
- Feasibility Study- Da Nang Sanitation Project 1998.
- Ha Long City Water Supply and Sanitation Project, Sanitation Feasibility Study, 1998.
- Municipal and Industrial Water Supply and Disposal- Accommodating Growth. D. Boggs, Asian Development Bank, May, 1995.
- Staff Appraisal Report- Water Supply Project, May 20, 1997, WB
- Vietnam Water Resources Assistance Programme. Central Coast River Basin Development and Management- Phase 1 (River Basin Profiles for the Central Coast),

November 17, 2000, WB.

5.3 Environment

(1) Natural Environment

• Law, Policy and Institution	- Laws and Regulations on environmental protection and Environmental Impact Assessment (EIA)
	- Environmental Standards in Vietnam
• Ecology	- Overview of the natural environment in Vietnam
	- List of precious species in Vietnam (Red Data Book)
• Protected Area	- Overview of Protected areas system in Vietnam
	- List of protected areas
• Water Quality	- Overview of river water quality and saline water intrusion

(2) Social Environment

• Land Acquisition and Resettlement	- Overview of legal and institutional framework in Vietnam
	- Laws on land issues
	- Decrees or regulations for the procedure of land acquisition and resettlement
• Inland Waterways	- Overview of inland waterway aspects in Vietnam
• Forestry, Fishery	- Current conditions on forest, forestry product, and inland fishery
• Health and Sanitation	- Current conditions on health and sanitation
• Cultural and Historical Heritage	- List of cultural and historical environmental sites

5.4 Water Resources Development

- Vietnam Water Resources Assistance Program, Central Coast River Basin Development and Management- Phase 1, Draft Final Report, October 2000, WB.
- Vietnam Water Resources Sector Review, Main Report, A Joint Report by WB, ADB, FAO, UNDP and the NGO Water Resources Group in Cooperation with IWRP, May 1996.
- Water Resources Development Strategy to the Year 2010, MARD, August 1999.
- National Hydropower Plan Study, Inception (Phase 1) Report, Main Report, Sep 1999, EVN.

- Pre-Feasibility Study of Dai Thi Multipurpose Project in Gam River, Summary Report, March 1998, EVN.
- Feasibility Study of Ban Mai Multipurpose Project in Ca River, Main Report, August 1998, EVN.
- Pre-Feasibility Study of Ban La Multipurpose Project in Ca River, Summary Report, February 2000, EVN.
- Feasibility Study of Cua Dat Multipurpose Project in Chu River of Ma River Basin, Summary Report, December 1999, Province of Thanh Hoa.
- Study Report of Rao Quan Multipurpose Project in Thach Han River Basin, Summary Report, September 1999, MARD.
- Feasibility Study Report on Ta Trach Project Implementation, November 1999, MARD.
- Summary Report on Ta Trach Project Implementation, November 1999, MARD.
- Feasibility Study of Dong Tien Reservoir Project in Thu Bon River Basin, DARD.
- Pre-Feasibility Study of Nuoc Trong Reservoir Project in Tra Khuc River Basin, Summary Report, September 1999, MARD.
- Study of Dinh Binh Reservoir Project in Kone River Basin, Executive Summary, November 1999, Binh Dinh Province.
- Master Plan Study Report on Dong Nai River and Surrounding Basins Water Resources Development, Final Report, August 1996, JICA.

5.5 Irrigation Plan

(1) General Data

National Policy and Strategy

1) Socio-Economic Development Strategy for 2001 - 2010, Communist Party of Vietnam, 9th National Party Congress

Socio-economic Policy and Strategy

1) Vietnam 2010, Entering the 21st Century, Vietnam Development 2001, Overview, December 2000, WB, ADB, UNDP
2) Vietnam 2010, Entering the 21st Century, Vietnam Development 2001, Pillars of Development, December 2000, WB, ADB, UNDP
3) Vietnam 2010, Entering the 21st Century, Vietnam Development 2001, Partnerships for Development, December 2000, 22 Government-Donor-NGO Partnership Groups

Agriculture Policy and Strategy

1) Strategies for Agriculture and Rural Development in 2001 - 2010, Summary (Draft), May 2000, MARD, FAO

2) Agriculture - Forestry - Fishery and Rural Development Plan for 2001 - 2005 Period, November 2000, Dept. of Agriculture and Rural Development, MPI

Water Resources Policy and Strategy

1) Law on Water Resources, Apr. - May 1998, National Assembly Term 10, 3rd Session
2) Strategy for Water Resources Development by Year 2010, Aug. 1999, MARD

Environmental Policy and Strategy

1) Law on Environmental Protection, Dec. 1993, National Assembly Session IX 4th Meeting

(2) Overall Data on River Basins

All River Basins

1) The Sector Review Study for The Water Resources Development, Main Report and Annex 'Inventory of Water Resources Projects', Aug. 1992, MWR, Nippon Koei
2) Irrigation Rehabilitation Project, Staff Appraisal Report, Apr. 1995, MWR, WB
3) Vietnam Water Resources Sector Review, Main Report, May 1996, IWRP WB, ADB, FAO, UNDP, NGOs
4) Vietnam Water Resources Sector Review, Selected Working Papers, May 1996, IWRP WB, ADB, FAO, UNDP, NGOs
5) Preliminary Survey for Nationwide Water Resources Development and Management Study, May 2000, MARD, Nippon Koei

Selected River Basins

1) National Hydropower Plan Study Vietnam, Inception (Phase I) Report, Volume I: Main Report, Sept. 1999, EVN, SWECO, Statkraft, Norplan
2) Vietnam Water Resources Assistance Program, Central Coast River Basin Development and Management - Phase 1, Draft Final Report, October 2000, WB, COWI

(3) Data on Each River Basin

Bang Giang Basin

1) The Sector Review Study for The Water Resources Development, Main Report and Annex 'Inventory of Water Resources Projects', Aug. 1992, MWR, Nippon Koei
2) Vietnam Water Resources Sector Review, Main Report, May 1996, IWRP WB, ADB, FAO, UNDP, NGOs

Red/Thai Binh Basin

1) The Sector Review Study for The Water Resources Development, Main Report and Annex 'Inventory of Water Resources Projects', Aug. 1992, MWR, Nippon Koei
2) Red River Delta Master Plan, Background Reports 1 - 28, 1994 - 1995, MOSTE, UNDP, WB
3) Red River Delta Master Plan, Volume 1 Summary, June 1995, MOSTE, UNDP, WB
4) Red River Delta Master Plan, Volumes 2 The Present Situation, June 1995, MOSTE, UNDP, WB
5) Red River Delta Master Plan, Volumes 3 A Plan for The Future, June 1995, MOSTE, UNDP, WB
6) Red River Delta Master Plan, Volumes 4 Appendices, June 1995, MOSTE, UNDP, WB
7) Red River Delta Master Plan, Agriculture, Pre-Feasibility Study Volumes 1 - 3, June

1995, MOSTE, UNDP, WB
8) Red River Delta Master Plan, Rural Water Supply and Sanitation, Pre-Feasibility Study Volumes 1 - 3, June 1995, MOSTE, UNDP, WB
9) Red River Delta Master Plan, Rural Electrification, Pre-Feasibility Study Volumes 1 - 3, June 1995, MOSTE, UNDP, WB
10) Vietnam Water Resources Sector Review, Main Report, May 1996, IWRP WB, ADB, FAO, UNDP, NGOs
11) Second Red River Basin Water Resources Project, Inception Report (Amended), Mar. 1999, MARD ,ADB
12) Second Red River Basin Water Resources Project, Volume I Main Report (Draft), Aug. 1999, MARD, ADB
13) Second Red River Basin Water Resources Project, Volume II Appendices (Draft), Aug. 1999, MARD, ADB
14) Second Red River Basin Water Resources Project, Volume II Appendices (Revised Draft Final Report), August 2000, MARD, ADB
15) Second Red River Basin Water Resources Project, Volume III Supplementary Report No.1: Gia Thuan Irrigation System Rehabilitation Sub-Project (Draft), Aug. 1999, MARD, ADB
16) Second Red River Basin Water Resources Project, Volume III Supplementary Report No.2: Yen Bai Small-Scale Irrigation System Sub-Project (Draft), Aug. 1999, MARD, ADB
17) Second Red River Basin Water Resources Project, Volume III Supplementary Report No.3: Flood and Storm Control Sub-Project (Draft), Aug. 1999, MARD, ADB
18) Second Red River Basin Water Resources Project, Volume III Drawings: Gia Thuan Irrigation System and Yen Bai Irrigation System, July 1999, MARD, ADB
19) Second Red River Basin Water Resources Project, Volume VIII Supplementary Report on Loan Implementation Planning (Revised Draft Final Report), Aug. 2000, MARD, ADB
20) National Hydropower Plan Study Vietnam, Inception (Phase I) Report, Volume I: Main Report, Sept. 1999, EVN, SWECO, Statkraft, Norplan

Ma Basin

1) The Sector Review Study for The Water Resources Development, Main Report and Annex 'Inventory of Water Resources Projects', Aug. 1992, MWR, Nippon Koei
2) Irrigation Rehabilitation Project, Staff Appraisal Report, Apr. 1995, MWR, WB
3) Vietnam Water Resources Sector Review, Main Report, May 1996, IWRP WB, ADB, FAO, UNDP, NGOs
4) Vietnam Water Resources Assistance Program, Central Coast River Basin Development and Management - Phase 1, Profile for Ma River Basin, October 2000, WB, COWI

Ca Basin

1) The Sector Review Study for The Water Resources Development, Main Report and Annex 'Inventory of Water Resources Projects', Aug. 1992, MWR, Nippon Koei
2) Irrigation Rehabilitation Project, Staff Appraisal Report, Apr. 1995, MWR, WB
3) Vietnam Water Resources Sector Review, Main Report, May 1996, IWRP WB, ADB, FAO, UNDP, NGOs
4) National Hydropower Plan Study Vietnam, Inception (Phase I) Report, Volume I: Main Report, Sept. 1999, EVN, SWECO, Statkraft, Norplan

Thach Han Basin

1) The Sector Review Study for The Water Resources Development, Main Report and Annex 'Inventory of Water Resources Projects', Aug. 1992, MWR, Nippon Koei
2) Vietnam Water Resources Assistance Program, Central Coast River Basin Development and Management - Phase 1, Profile for Thach Han River Basin, October 2000, WB, COWI

Huong Basin

1) The Sector Review Study for The Water Resources Development, Main Report and Annex 'Inventory of Water Resources Projects', Aug. 1992, MWR, Nippon Koei
2) Vietnam Water Resources Assistance Program, Central Coast River Basin Development and Management - Phase 1, Profile for Huong River Basin, October 2000, WB, COWI

Thu Bon Basin

1) The Sector Review Study for The Water Resources Development, Main Report and Annex 'Inventory of Water Resources Projects', Aug. 1992, MWR, Nippon Koei
2) Irrigation Rehabilitation Project, Staff Appraisal Report, Apr. 1995, MWR, WB
3) Vietnam Water Resources Sector Review, Main Report, May 1996, IWRP WB, ADB, FAO, UNDP, NGOs
4) Vietnam Water Resources Assistance Program, Central Coast River Basin Development and Management - Phase 1, Profile for Thu Bon River Basin, October 2000, WB, COWI

Tra Khuc Basin

1) The Sector Review Study for The Water Resources Development, Main Report and Annex 'Inventory of Water Resources Projects', Aug. 1992, MWR, Nippon Koei
2) Irrigation Rehabilitation Project, Staff Appraisal Report, Apr. 1995, MWR, WB
3) Vietnam Water Resources Assistance Program, Central Coast River Basin Development and Management - Phase 1, Profile for Tra Khuc River Basin, October 2000, WB, COWI

Kone Basin

1) The Sector Review Study for The Water Resources Development, Main Report and Annex 'Inventory of Water Resources Projects', Aug. 1992, MWR, Nippon Koei
2) Vietnam Water Resources Assistance Program, Central Coast River Basin Development and Management - Phase 1, Profile for Kone - Ha Thanh - La Tinh River Basin, October 2000, WB, COWI

Ba Basin

1) The Sector Review Study for The Water Resources Development, Main Report and Annex 'Inventory of Water Resources Projects', Aug. 1992, MWR, Nippon Koei
2) Irrigation Rehabilitation Project, Staff Appraisal Report, Apr. 1995, MWR, WB
3) Vietnam Water Resources Sector Review, Main Report, May 1996, IWRP WB, ADB, FAO, UNDP, NGOs
4) Vietnam Water Resources Assistance Program, Central Coast River Basin Development and Management - Phase 1, Profile for Ba River Basin, October 2000, WB, COWI

Dong Nai Basin

1) The Sector Review Study for The Water Resources Development, Main Report and Annex 'Inventory of Water Resources Projects', Aug. 1992, MWR, Nippon Koei

2) Irrigation Rehabilitation Project, Staff Appraisal Report, Apr. 1995, MWR, WB
3) Vietnam Water Resources Sector Review, Main Report, May 1996, IWRP WB, ADB, FAO, UNDP, NGOs
4) National Hydropower Plan Study Vietnam, Inception (Phase I) Report, Volume I: Main Report, Sept. 1999, EVN, SWECO, Statkraft, Norplan

Sesan Basin

1) The Sector Review Study for The Water Resources Development, Main Report and Annex 'Inventory of Water Resources Projects', Aug. 1992, MWR, Nippon Koei
2) Vietnam Water Resources Sector Review, Main Report, May 1996, IWRP WB, ADB, FAO, UNDP, NGOs
3) National Hydropower Plan Study Vietnam, Inception (Phase I) Report, Volume I: Main Report, Sept. 1999, EVN, SWECO, Statkraft, Norplan

Srepok Basin

1) The Sector Review Study for The Water Resources Development, Main Report and Annex 'Inventory of Water Resources Projects', Aug. 1992, MWR, Nippon Koei
2) Vietnam Water Resources Sector Review, Main Report, May 1996, IWRP WB, ADB, FAO, UNDP, NGOs

Mekong Delta Basin

1) Mekong Delta Master Plan, Working Paper No. 3 Irrigation, Drainage and Flood Control, Sept. 1991, State Planning Committee, WB, Mekong Secretariat, UNDP, NEDECO
2) The Sector Review Study for The Water Resources Development, Main Report and Annex 'Inventory of Water Resources Projects', Aug. 1992, MWR, Nippon Koei
3) Vietnam Water Resources Sector Review, Main Report, May 1996, IWRP WB, ADB, FAO, UNDP, NGOs

5.6 Meteo-hydrological Data and Maps Collected by Inventory Survey

(1) Daily Rainfall

River Name	Station Name	Location		Province	Collected Data	Total
		Longitude	Latitude			Year
Bang Giang and Ky Cung	Dinh Lap	107.06	21.32	Lang Son	1976-2000	25
	Lang Son	106.46	21.50	Lang Son	1976-2000	25
	Ngan Son	105.59	22.26	Cao Bang	1976-2000	25
	Loc Binh	106.55	21.45	Cao Bang	1976-1978.1980-1989.1991-2000	23
	Cao Bang	106.14	22.39	Cao Bang	1976-2000	25
Red and ThaiBinh	Hanoi	105.51	21.01	Ha Noi	1956-2000	45
	Thai Binh	106.21	20.27	ThaiBinh	1976-2000	25
Ma	Thuong Xuan (Cua Dat)	105.14	19.49	Thanh Hoa	1976.1978-1990	14
	Bat Mot (BatBot)	105.03	20.01	Thanh Hoa	1976-2000	25
	Lang Chanh	105.14	20.09	Thanh Hoa	1976-2000	25
	Ba Thuoc (CanhNong)	105.13	20.21	Thanh Hoa	1976-1979.1981-1990	14
	Song Ma	103.44	21.04	Son La	1976-2000	25
	Tuan Giao (LaiChau)	103.25	21.35	Lai Chau	1976-2000	25
	Thanh Hoa	105.46	19.49	Thanh Hoa	1976-1985.1987-2000	24
Ca	Hoa Duyet	105.35	18.22	Ha Tinh	1976-2000	25
	Son Diem	105.20	18.30	Ha Tinh	1976-2000	25
	Do Luong	105.18	18.54	Nghe An	1976-2000	25
	Mon Son	104.55	18.53	Nghe An	1976-1990	15
	Con Cuong	104.53	19.02	Nghe An	1976-1989.1991-2000	24
	Nghia Khanh	105.20	19.26	Nghe An	1977-2000	24
	Quy Chau	105.06	19.34	Nghe An	1976-2000	25
	Muong Xen	104.08	19.24	Nghe An	1976-2000	25
	Vinh	105.40	18.40	Nghe An	1976-2000	25
Thach Han	Khe Sanh	106.50	16.38	Quang Tri	1976-2000	25
	Thach Han	107.14	16.45	Quang Tri	1976-2000	25
	Dong Ha	107.05	16.50	Quang Tri	1976-2000	25
Huong	Nam Dong	107.43	16.09	Thua Thien Hue	1977-2000	24
	Phu Loc	107.53	16.15	Thua Thien Hue	1978-1990	13
	Hue	107.34	16.25	Thua Thien Hue	1976-2000	25
	PhuOc	107.28	16.32	Thua Thien Hue	1977.1980-2000	22
	A Luoi	107.13	16.15	Thua Thien Hue	1976-2000	25
Vu Gia - Thu Bon	Tra My	108.14	15.21	Quang Nam	1977-2000	24
	Son Tan (HiepDuc)	108.05	15.35	Quang Nam	1976-2000	25
	Trao (Hien)	107.38	15.56	Quang Nam	1978-2000	23
	Thanh My	107.50	15.46	Quang Nam	1976-2000	25
	Ai Nghia	108.07	15.53	Quang Nam	1976-2000	25
	DaNang	108.11	16.02	Da Nang	1976-2000	25
Tra Khuc	Tra Bong	108.32	15.15	Quang Ngai	1976-2000	25
	Quang Ngai	108.47	15.09	Quang Ngai	1976-2000	25
	Ba To	108.45	14.46	Quang Ngai	1976-2000	25
	Gia Vuc	108.34	14.42	Quang Ngai	1977-2000	24
	Son Giang (Son Ha)	108.34	15.02	Quang Ngai	1977-2000	24
Kone	Binh Tuong (Cay Muong)	108.56	13.55	Binh Dinh	1976-2000	25
	Phu Cat	109.04	14.00	Binh Dinh	1976-2000	25
	Binh Quang (Dinh Binh)	108.48	14.08	Binh Dinh	1979-2000	22
	Vinh Kim	108.46	14.14	Binh Dinh	1982-2000	19
Ba	M' Drak	108.46	12.45	Dak Lak	1977-2000	24
	Son Hoa (Cung Son)	108.59	13.03	Phu Yen	1976-2000	25
	Tuy Hoa	109.17	13.05	Phu Yen	1977-2000	24
	Cheo Reo (A Yun Pa)	108.27	13.24	Gia Lai	1977-2000	24
	Chu Prong	107.52	13.44	Gia Lai	1978-1995.1997-2000	22
	An Khe	108.39	13.57	Gia Lai	1977-2000	24
Sesan	Dac Glei	107.45	15.04	Kon Tum	1977-78.1980-1984.1986-1995.1997-2000	21
	Dak To	107.50	14.40	Kon Tum	1977-2000	24
	Kon Tum	108.00	14.21	Kon Tum	1976-2000	25
	Pleiku	108.00	13.59	Gia Lai	1976-2000	25
Srepok	Buon Ho	108.16	12.55	Dak Lak	1977-2000	24
	Cau42 (Krong Buk)	108.22	12.46	Dak Lak	1976-2000	25
	Krong Bong	108.27	12.33	Dak Lak	1977-1990.1992-1995	18
	Giang Son	108.11	12.30	Dak Lak	1976-2000	25
	Buon Ma Thuot	108.03	12.40	Dak Lak	1977-2000	24
	Cau14	107.56	12.37	Dak Lak	1977-2000	24
	Duc Xuyen	108.59	12.18	Dak Lak	1978-2000	23
	Dak Mil	107.37	12.27	Dak Lak	1977-1993.1998-2000	20
DongNai	Tan Son Nhat	106.42	10.47	HCMC	1960-1993	32
Mekong Delta	Can Tho	105.47	10.02	Can Tho	1978-200	23

(2) Daily Discharge

River Name	Station Name	Location		Catchment Area (km^2)	Tributary Name	Collected Data	Total Year
		Longitude	Latitude				
Bang Giang and Ky Cung	Lang Son	106.45	21.50	1,560	Ky Cung	1958-2000	43
	Van Mich	106.22	22.06	2,360	BacGiang	1960-1974	15
	Ban Gioc	106.42	22.51	2,123	Quay Son	1960-1976	17
Red and ThaiBinh	Son Tay	105.30	21.09	143,600	Hong	1976-2000	25
	Chu	106.36	21.22	1,220	Luc Nam	1976-2000	25
	Lai Chau	103.10	22.04	33,800	Da	1976-2000	25
	Nam Muc	103.17	21.52	2,680	Nam Muc	1976-2000	25
	Ghenh Ga	105.11	21.51	29,600	Lo	1976-2000	25
	Chiem Hoa	105.16	22.05	16,500	Gam	1976-2000	25
	Thac Buoi (Gia Bay)	105.48	21.42	2,960	Cau	1976-1996	21
Ma	Cua Dat	105.17	19.52	6,170	Chu	1978-2000	23
	Xuan Khanh	105.34	19.55	7,460	Chu	1976-1978	3
	Cam Thuy	105.28	20.12	17,500	Ma	1976-1988.1995-2000	19
	Xa La	103.55	20.56	6,430	Ma	1976-2000	25
Ca	Yen Thuong	105.38	18.34	23,000	Ca	1976-2000	25
	Dua	105.02	18.59	20,800	Ca	1976-2000	25
	Hoa Duyet	105.35	18.22	1,880	Ngan Sau	1976-1981.1997-2000	10
	Son Diem	105.21	18.30	790	Ngan Pho	1976-1981.1997-2000	10
Thach Han	Rao Quang	106.42	16.41	159	RaoQuang	1983-1985	3
Huong	Thuong Nhat	107.41	16.07	208	Ta Track	1981-2000	20
	Truoi	107.46	16.15	70	Truoi	1992-1996	5
	Binh Dien	107.30	16.20	570	Huu Track	1979-1985	7
	Co Bi	107.25	16.28	720	Bo	1979-1985	7
	Duong Hoa	107.38	16.18	717	Ta Track	1986-1987	2
Thu Bon	Nong Son	108.03	15.42	3,130	Thu Bon	1976-2000	25
	Thanh My	107.50	15.46	1,850	Vu Gia	1984-2000	17
Tra Khuc	Son Giang	108.34	15.02	2,440	Tra Khuc	1987-2000	14
	An Chi	108.49	14.59	814	Ve	1987-2000	14
Kone	Cay Muong	108.52	13.56	1,677	Kone	1976-1977.1979-2000	24
Ba	Cung Son	108.59	13.02	12,800	Ba	1977-2000	24
	An Khe	108.39	13.57	1,440	Ba	1978-2000	23
Sesan	Kon Tum	108.01	14.20	3,056	Dak Bla	1978-2000	23
	Trung Nghia	107.52	14.25	3,320	Krong Poco	1990-1997	16
	Sa Binh	107.51	14.19	6,732	SeSan	1982-1990	9
Srepok	Giang Son	108.11	12.30	3,180	Krong Ana	1977-2000	24
	Ban Don	107.47	12.53	10,700	Srepok	1977-2000	24
	Duc Xuyen	108.59	12.18	3,080	Krong Kno	1978-2000	23
Mekong	Kratie	106.01	12.29	646,000	Mekong	1960-1969	10
	Prek Kdam	104.48	11.49	84,400	Tonle Sap	1960-1972	13

(3) Hourly Data ; Huong River basin

Year	Discharge			Rainfall		
	Thuong Nhat	Binh Dien	Co Bi	Nam Dong	A Luoi	Hue
1980		3/Nov-22/Nov	1/Nov-30/Nov	1/Nov-30/Nov	1/Nov-30/Nov	1/Nov-30/Nov
1981				1/Jun-30/Jun	1/Jun-30/Jun	1/Jun-30/Jun
	6/Nov-12/Nov	23/Oct-17/Nov	10/Oct-30/Nov	1/Nov-30/Nov	1/Nov-30/Nov	1/Nov-30/Nov
1983	27/Oct-2/Nov	23/Oct-11/Nov	8/Oct-30/Nov			1/Oct-30/Nov
1984	10/Oct-16/Oct	13/Oct-31/Dec	12/Oct-12/Nov	1/Oct-30/Nov	1/Oct-30/Nov	1/Oct-30/Nov
1985		17/Jun-24/Jun		1/Jun-30/Jun	1/Jun-30/Jun	1/Jun-30/Jun
	13/Oct-19/Oct		1/Oct-11/Dec			
2000	19/Aug-25/Aug					

(4) Hourly Data ; Ma River basin

	Discharge			Rainfall	
Year	Xa La	Cam Thuy	Cua Dat	Bai Thuong	Thanh Hoa
1963		9/Sep-15/Sep			20/Sep-26/Sep
1968		12/Aug-18/Aug			9/Sep-15/Sep
1972	27/Aug-2/Sep				
1973		24/Aug-30/Aug			22/Aug-28/Aug
1975	30/Aug-5/Sep	31/Aug-6/Sep			25/Aug-31/Aug
1976	6/Aug-12/Aug				
1980	1/Sep-30/Sep	14/Sep-20/Sep	13/Sep-20/Sep		
1988	1/Oct-31/oct		16/Oct-22/Oct		1/Oct-31/Oct
1991	12/Jul-18/Jul				
1992			18/Sep-24/Sep	15/Sep-21/Sep	1/Sep-31/Sep
1994	13/Jul-19/Jul				
			12/Sep-19/Sep	1/Sep-31/Sep	1/Sep-31/Sep

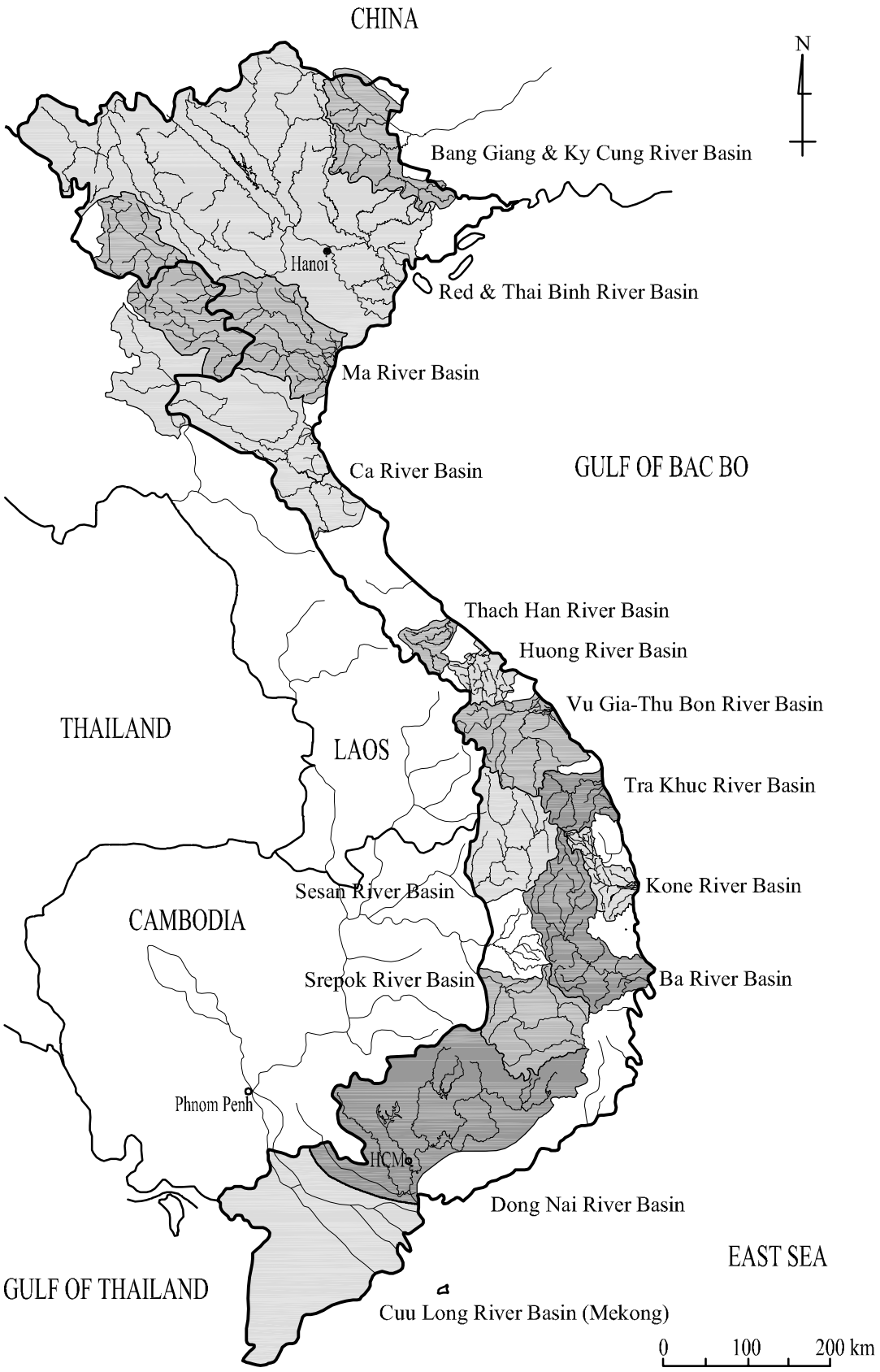
(5) Hourly Data ; Kone River basin

	Discharge	Rainfall		
Year	Cay Muong	Quy Nhon	Ba To	Hoai Nhon
1980	14/Nov-21/Nov	13/Nov-20/Nov		
1981	6/Nov-12/Nov	8/Nov-14/Nov	1/Nov-31/Nov	
1984				12/Oct-21/Oct
	5/Nov-11/Nov	1/Nov-7/Nov	1/Nov-31/Nov	
1985			11/Oct-17/Oct	
1987	16/Nov-23/Nov	1/Nov-30/Nov	18/Nov-24/Nov	
1990	1/Jun-26/Jun	1/Jun-30/Jun	12/Oct-18/Oct	1/Jun-30/Jun
1992	1/Oct-31/Oct	1/Oct-31/Oct	22/Oct-28/Oct	
1996	29/Nov-3/Dec	1/Nov-30/Dec	1/Nov-31/Dec	1/Nov-30/Dec
1998	1/Nov-2/Dec	1/Nov-28/Nov	1/Nov-31/Nov	1/Nov-31/Nov
1999	27/Nov-30/Dec	1/Dec-30/Dec	1/Dec-31/Dec	1/Dec-30/Dec

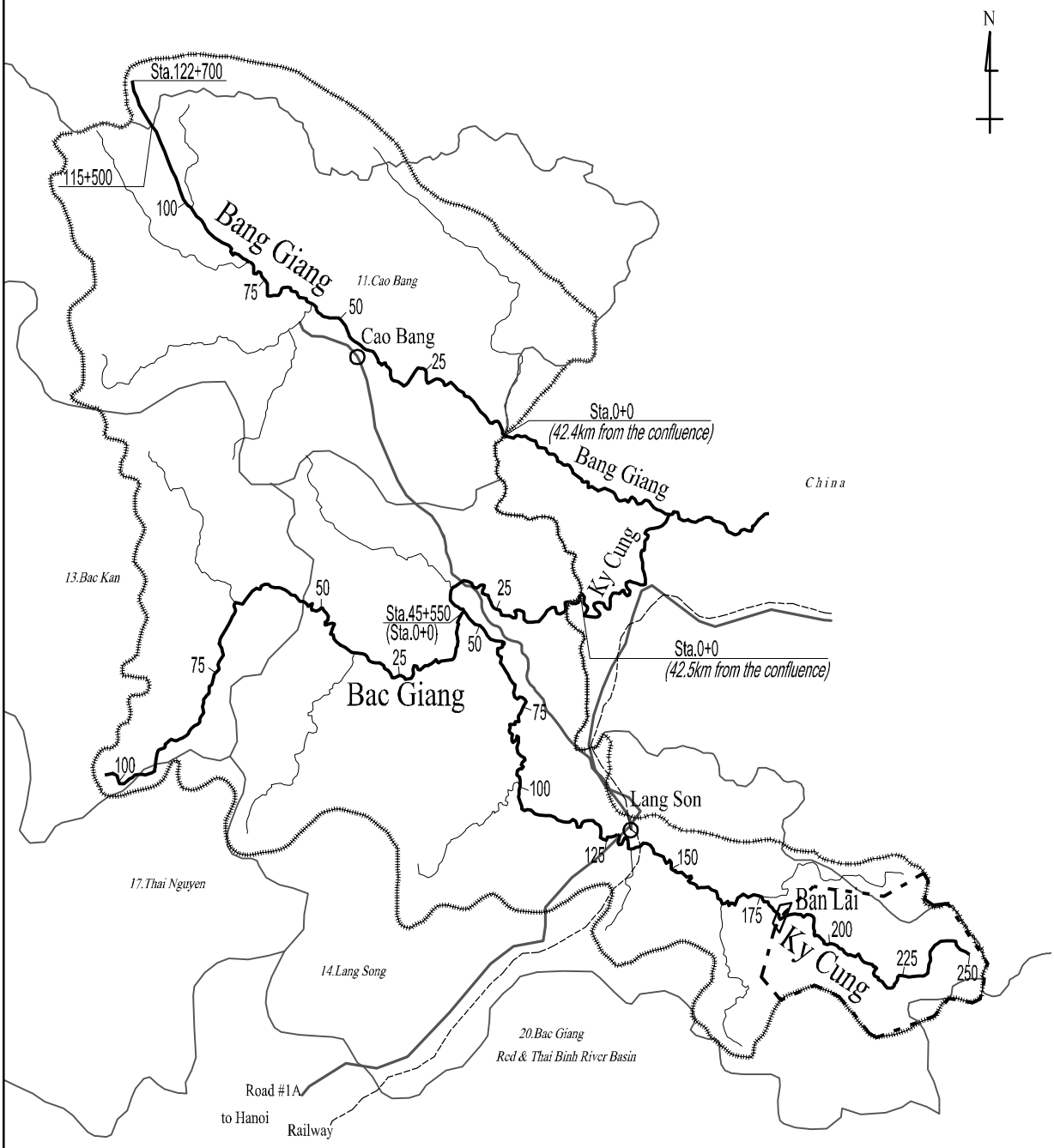
(6) Maps

- Topographic maps : 41 sheets map with the scale of 1/250,000 (Whole Vietnam)

  24 sheets map with the scale of 1/50,000 (Huong river basin)
- Geological map : 41 sheets with the scale of 1/1,000,000 of the whole country.



The Study on Nationwide Water Resources Development and Management in the Socialist Republic of Vietnam	**Figure A.1** **Location Map of 14 River Basins**
JAPAN INTERNATIONAL COOPERATION AGENCY	



Catchment Area : A=11,250km2

River Length

Bang Giang River : L=115.5km

Ky Cung River : L=250km

Bac Giang River : L=117km

(All above inside Vietnam)

: Major stream

: Basin boundary

: Proposed Reservoir

: National Highway No.1

: Railway

: Provincial/National Boundary

100 : Sta., Distance from the sea/confluence

14.Lang Song : Province

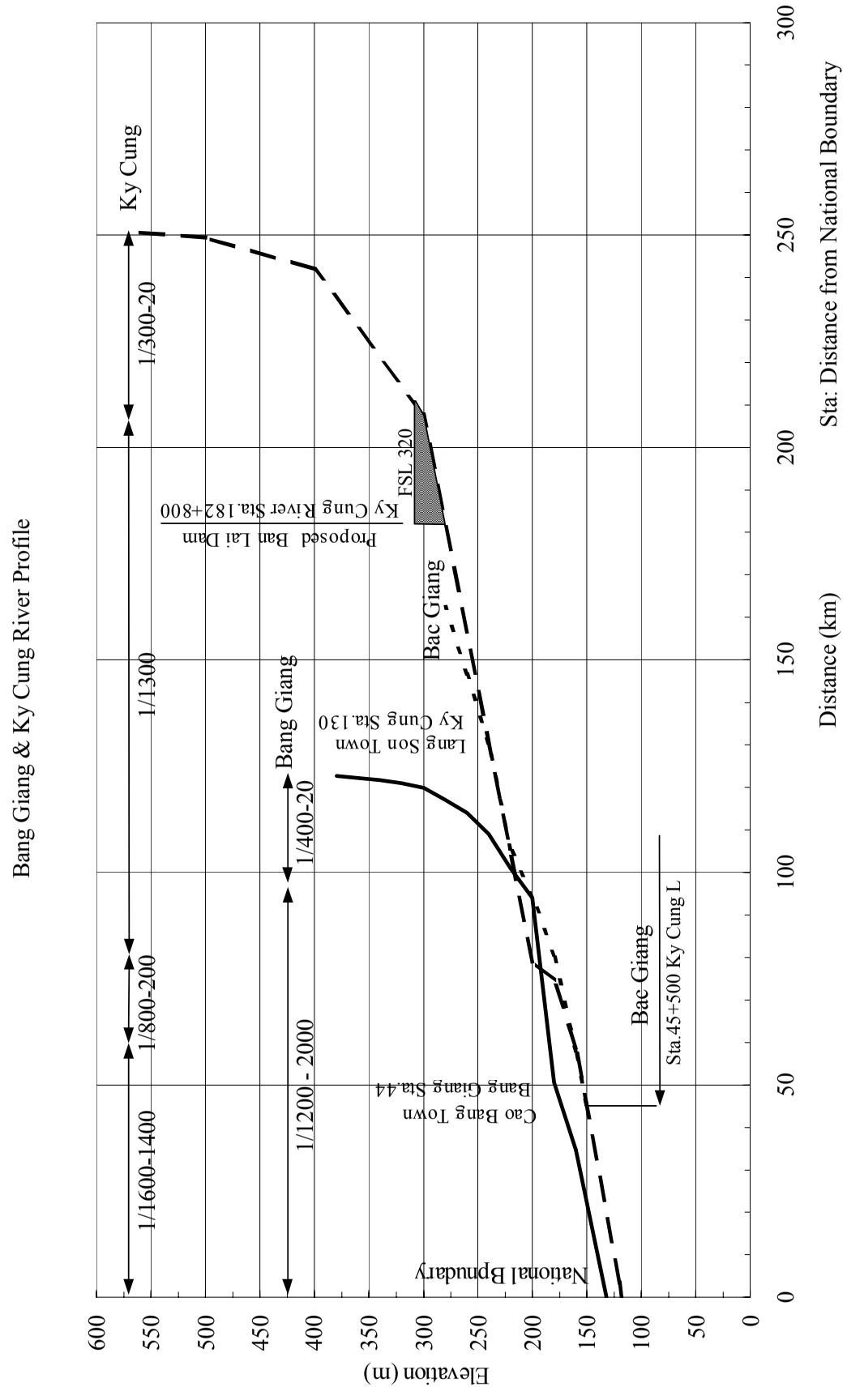
0 25 50km

The Study on Nationwide Water Resources Development and Management in the Socialist Republic of Vietnam

JAPAN INTERNATIONAL COOPERATION AGENCY

Figure A.2

River System of Bang Giang and Ky Cung River Basin



The Study on Nationwide Water Resources Development and Management in the Socialist Republic of Vietnam JAPAN INTERNATIONAL COOPERATION AGENCY	**Figure A.3** **Longitudinal Profile of Bang Giang & Ky Cung River**