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MINISTRY OF SCIENCE, TECHNOLOGY AND ENVIRONMENT
PEOPLE'S COMMITTEE OF QUANG NINH PROVINCE
THE SOCIALIST REPUBLIC OF VIETNAM

THE STUDY ON ENVIRONMENTAL MANAGEMENT FOR HA LONG BAY

FINAL REPORT

VOLUME III
SUPPORTING REPORT 1

SEPTEMBER 1999

NIPPON KOEI CO., LTD.
METOCEAN CO., LTD.

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Volume I	Executive Summary
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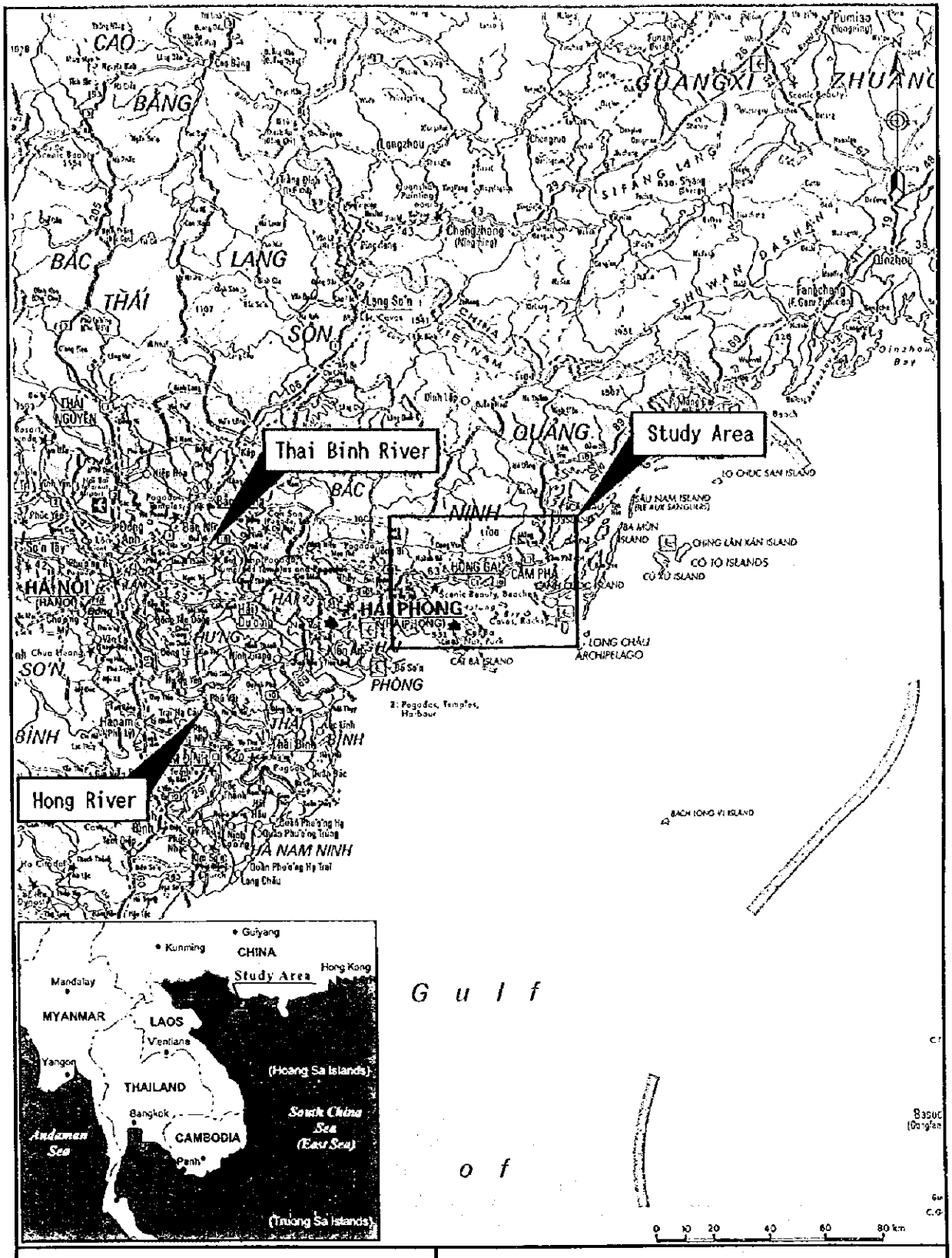
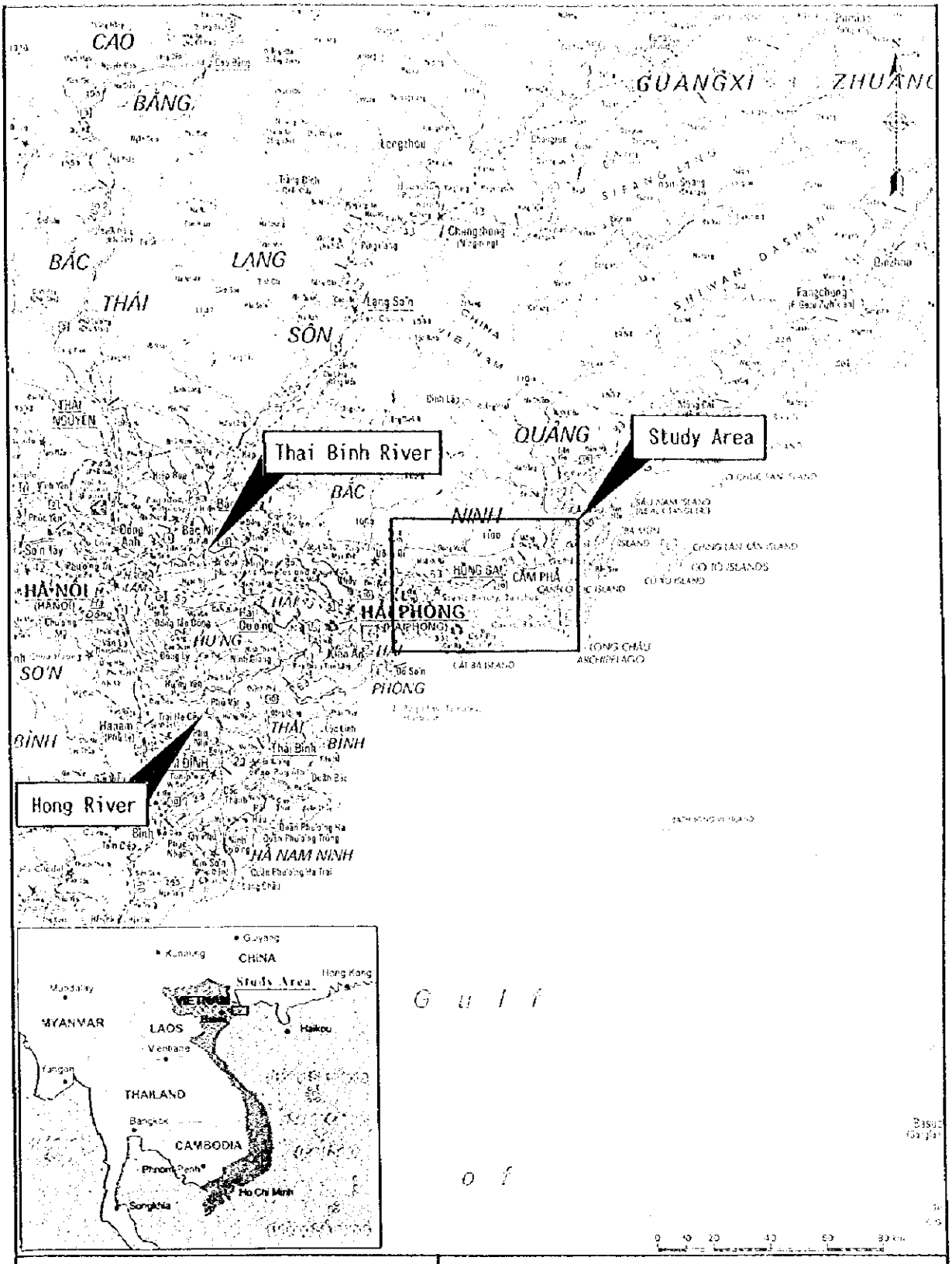


The Study on Envionmental Management for Ha Long Bay in the Socialist Republic of Vietnam	Location of Study Area
Japan International Cooperation Agency	



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THE STUDY
ON
ENVIRONMENTAL MANAGEMENT
FOR
HA LONG BAY

FINAL REPORT

Volume III Supporting Report 1

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ABBREVIATIONS

<Organization>

ADB	Asian Development Bank
BTED	Board of Tourist Ferry Dock
CBI	Carl Bro International
CEETIA	Center for Urban and Industrial Area Environment Technique
CIDA	Canadian International Development Agency
CMESRC	Center for Marine Environment Survey, Research & Consultation
CP	Counterpart
CP/T	Counterpart Team
CPUEC	Cam Pha Urban Environment Company
DANIDA	Danish International Development Agency
DARD	Department of Agriculture and Rural Development
DOC	Department of Construction
DOF	Department of Fisheries
DOI	Department of Industry
DOMAP	Department of Architecture Management and Planning
DOSTE	Department of Science, Technology and Environment
DOTOUR	Department of Tourism
DOT	Department of Transportation
DPI	Department of Planning and Investment
E/C	Executive Committee
EMD	Environmental Management Division
EU	European Union
FPA	Forest Protection Agency
GEF	Global Environmental Fund
GOV	Government of Vietnam
HIO	Haiphong Institute of Oceanology
HLESC	Ha Long City Environmental Sanitation Company
HLMB	Ha Long Bay Management Board
IAEA	International Atomic Energy Agency
ID	Inspection Division
IFIP	Institute of Forestry Investigation and Planning
IMSAT	Institute of Mining Science and Technology
ITDR	Institute of Tourism Development and Research
IUCN	International Union for Conservation of Nature and Natural Resources
JICA	Japan International Cooperation Agency
MOI	Ministry of Industry
MOSTE	Ministry of Science, Technology and Environment
MPI	Ministry of Planning and Investment
NACM	National Agency of Conservation and Museum
NEA	National Environmental Agency
OCDI	Overseas Coastal Development Institute
OECD	Organization for Economic Cooperation and Development
OECF	Overseas Economic Cooperation Fund
PA	Part Authority
QNPC	People's Committee of Quang Ninh Province
S/C	Steering Committee
SAN	Sanitation Company
SIDA	Swedish International Development Agency
STAD	Science, Technology and Administrative Division
STAMQ	Standards, Metrology and Quality Division
UNDP	United Nations Development Program

UNESCO	United Nations Educational, Scientific and Cultural Organization
UNICEF	United Nations International Children's Emergency Fund
UNIDO	United Nations Industrial Development Organization
QNEMA	Quang Ninh Environmental Management Authority
QNWSC	Quang Ninh Water Supply Company
VINACOAL	Vietnam National Coal Corporation
WB	World Bank
WHO	World Health Organization
WTO	World Trade Organization

<Plan and Project>

BAP	Biodiversity Action Plan
HLMP	Development Master Plan of Ha Long City for 1994-2010
EMS	Environmental Management System
HWSSP	Ha Long City Water Supply and Sanitation Project
NCS	National Conservation Strategy
NPESD	National Plan for Environment and Sustainable Development for 1991-2000
REPR	Resources and Environment Research Program
UNCED	United Nations Conference on Environment and Development
VCEP	Vietnam-Canada Environmental Project
VNNEAP	Vietnam National Environmental Action Plan

<EMP term>

AMZ	Active Management Zone
DZ	Development Zone
EMP	Environmental Management Plan
ERMU	Environmental Research and Monitoring Unit
IC	Implementation Committee
IPCU	Industrial Pollution Control Unit
CZ	Conservation Zone
SCZ	Special Conservation Zone
TFPU	Tidal Flats Protection Unit

<Economic term>

B/C	Benefit-cost ratio
BOT	Build, Operate and Transfer
CVM	Contingent Valuation Method
EIRR	Economic Internal Rate of Return
FDI	Foreign Direct Finance
FIRR	Financial Internal Rate of Return
GDP	Gross Domestic Products
L.S	Lump Sum
NPV	Net Present Value
ODA	Official Development Assistance
OVA	Objective Valuation Approach
SVA	Subjective Valuation Approach
TCM	Travel Cost Method
WTP	Willingness to Pay

<Chemical term>

BOD	Biochemical Oxygen Demand
COD	Chemical Oxygen Demand
DO	Dissolved Oxygen
IL	Ignition Loss

I-N	Inorganic Nitrogen
I-P	Inorganic Phosphorus
NH_4-N	Ammonia Nitrogen
NO_2-N	Nitrite Nitrogen
NO_3-N	Nitrate Nitrogen
O-N	Organic Nitrogen
O-P	Organic Phosphorus
PO_4-P	Phosphate
SPM	Suspended Particulate Matter
SS	Suspended Solid
TDS	Total Dissolved Solids
T-N	Total Nitrogen
T-P	Total Phosphorus
TSS	Total Suspended Solid

<Others>

CSP	Coal Shipping Port
EIA	Environmental Impact Assessment
GPS	Global Positioning System
F/S	Feasibility Study
HCO	Hon Con Ong
HNFP	Hon Net Floating Port
LD	Light and Dark
LEP	Law on Environmental Protection
M/M	Minutes of Meeting
O&M	Operations and Maintenance
PPP	Polluter Pay's Principle
RKR	Redfield-Ketchum-Richards
TCVN	Vietnam Standards
R&D	Research and Development
QN	Quang Ninh Province
SBR	Sequencing Batch Reactor
SOE	State Owned Company
S/W	Scope of Work
TOR	Terms of Reference
QA/QC	Quality Assurance and Quality Control
WWTP	Wastewater Treatment Plant

MEASUREMENT UNITS

Length

mm	millimeter
cm	centimeter
m	meter
km	kilometer

Extent

m^2	square meter
km^2	square kilometer
ha	hectare

Volume

m^3	cubic meter
l	liter

Weight

kg	kilogram
ton	metric ton

Time

sec	second
min	minute
hr	hour
yr	year

Currency

VND	Vietnamese Dong

Others

%	percent
‰	permill
°C	degree centigrade
10^3	thousand
10^6	million
10^9	billion
CV	cylinder volume
DWT, dwt	dead weight ton
GRT	gross ton
KV, KVA	kilovolt-ampere
MPN	most probable number

CHAPTER 1

PART I INTRODUCTION

CHAPTER 1 SCOPE OF THE STUDY

1.1 Background

The Socialist Republic of Vietnam has a population of approximately 76 million, and a land area of 332,000 km^2. The per capita Gross National Product (GNP) in 1995 was US$ 240, according to the Asian Development Bank, so Vietnam may be characterized as one of the less developed countries. However, since the 6th National Convention of Communist Party in 1986, Vietnam has been moving toward an open market economy with the policy known as "Doi Moi", and the economy is surging. Vietnam designates three regions that support this rapid economic growth as North, Central, and South Focal Economic Areas.

Ha Long city (population approximately 130,000 and land area 122.5 km^2), is the largest city in Quang Ninh province. Together with Hanoi city and Hai Phong city, it forms the North Focal Economic Area, or Triangle. To satisfy the need for port facilities in this region, the rehabilitation project of Cai Lan port, located in Bai Chay bay north of Ha Long city, is under way with financial aid from the Overseas Economic Cooperation Fund (OECF). Upon the completion of this port project, even greater social and economic development of the area is anticipated. Ha Long bay is located south of the rapidly growing Ha Long city and Cam Pha town, and is famous for the numerous islands and islets with their district geological characteristics. With the aesthetic seascape of these islands and islets, it is a major sightseeing spot in Vietnam, and was inscribed on the World Heritage List of UNESCO in 1994.

Ha Long bay and its surrounding area are, thus, precious in terms of both its natural environment and economic development. With the recent growth of the area, however, environmental destruction is getting serious. In particular, water is being rapidly polluted with domestic sewage, industrial wastewater, mining wastewater, and pesticides in the Bai Chay and Cua Ong areas. With the anticipated growth of industry and tourism, and accompanying increase in urban

area, the environmental conditions of Ha Long bay is expected to deteriorate rapidly in the future.

Therefore, the development of a comprehensive Environmental Management Plan for Ha Long Bay is acutely needed to achieve environmentally sound socioeconomic growth.

1.2 Objectives

The objectives of the Study on Environmental Management for Ha Long Bay in the Socialist Republic of Vietnam (the Study) are:

a) to formulate an environmental management plan for Ha Long bay that is compatible with nature conservation and human activities, and
b) to transfer technology to the counterpart personnel in the course of the Study.

1.3 Study Area

In accordance with the Scope of Work (S/W), the study area for macro analysis is i) Ha Long bay, where the area designated for the World Heritage and its buffer area exist, and ii) the hinterland area which may affect the environment of the bay. Thus, the study area for macro analysis includes Ha Long bay, Bai Chay bay, the Cua Ong area, and the eastern side of Cat Ba island as shown in Figure 1.3.1.

1.4 Framework of the Study

The Study was conducted from February 1998 to September 1999 (about 20 months in total) in two phases; the first phase was from February 1998 to December 1998 and the second phase was from January 1999 to September 1999. The study framework is shown in Figure 1.4.1.

1.5 Organization of the Study

1.5.1 Steering Committee, Executing Committee, and Counterpart Team

Through a meeting of the initial Steering Committee (S/C) held on 26 February 1998 for discussion of the Inception Report (IC/R), the overall organization of Vietnam side was set up for the actual implementation of the Study as follows:

a) The People's Committee of Quang Ninh Province (QNPC) is the main counterpart of the Study. The Ministry of Science, Technology and Environment (MOSTE) plays a national level coordination function to support the implementation of the Study, and

b) The Steering Committee (S/C), which consists of relevant ministries and organizations, is set up based on the Minutes of Meeting (M/M) on S/W for the Study signed on 19 September 1997. A list of S/C members is shown below.

Position in S/C		Name	Organization
1	Chairman	Mr. Ngo Dinh Tho	Deputy Chairman of QNPC
2	Deputy Chairman	Dr. Truong Manh Tien	Vice Director of National Environment Agency in MOSTE
3	Deputy Chairman	Mr. Vu Van Thanh	Director of DOSTE in QNPC
4	Member	Mr. Nguyen Dinh Hai	Deputy Division Head of M. of Industry
5	Member	Dr. Pham Trung Luong	Vice Director of ITDR in General Board of Tourism
6	Member	Mr. Bui Duc Nhuan	Vice Director of National Maritime Agency in M. of Transportation
7	Member	Mr. Nguyen Quoc Hung	Vice Director of NACM in M. of Culture and Information
8	Member	Mr. Nguyen Van Thai	Expert of DOMAP in M. of Construction
9	Member	Mr. Pham Quang Tho	Vice General Secretary in UNESCO Vietnam
10	Member	Mr. Nguyen Thi Thanh Ha	Ministry of Finance

Note: QNPC: People's Committee of Quang Ninh Province
MOSTE: Ministry of Science, Technology and Environment
DOSTE: Department of Science, Technology and Environment
ITDR: Institute of Tourism Development and Research
NACM: National Agency of Conservation and Museum
DOMAP: Department of Architecture Management and Planning

c) The Executing Committee (E/C) consists of relevant departments and organizations in QNPC, and was organized to coordinate activities in QNPC. A list of E/C members is shown below.

Position in E/C		Name	Organization
1	Chairman	Mr. Vu Van Thanh	Director of DOSTE in QNPC
2	Deputy Chairman	Dr. Tran Hong Ha	Expert of NEA in MOSTE
3	Deputy Chairman	Mr. Vu Quang Mon	Vice Director of Dept. of Planning and Investment
4	Member	Mr. Nguyen Van Long	Vice Director of Dept. of Finance
5	Member	Mr. Nguyen Van Tuan	Head of Ha Long Bay Management Board
6	Member	Mr. Dao Xuan Dan	Vice Director of Dept. of Construction
7	Member	Mr. Le Dinh Tram	Vice Director of Dept. of Agriculture and Rural Development
8	Member	Mr. Cao Tuy	Vice Director of Dept. of Fisheries
9	Member	Mr. Nguyen Duc Long	Vice Director of Dept. of Industry
10	Member	Mr. Nguyen Minh Hien	Vice Director of Dept. of Tourism
11	Member	Mr. Phung Anh Dai	Deputy Chairman of People's Committee of Ha Long City
12	Member	Mr. Pham Toan	Head of Technology Division of Dept. of Transportation
13	Member	Mr. Do Dang Duong	Head of Cultural Specialty Division of Dept. of Culture and Information

d) The Counterpart Team (CP/T) consists of the following 16 members mostly from QNPC and is set up for actual activities of the Study.

Position in CP/T		Name	Organization
1	Chief CP	Mr. Vu Van Thanh	Director of DOSTE in QNPC
2	Member	Mr. Nguyen Van Thanh	Dept. of Planning and Investment
3	Member	Mr. Nguyen Duong Thuat	Dept. of Finance
4	Member	Mr. Nguyen Manh Hai	Dept. of Construction
5	Member	Mr. Vu Quang Cu	Dept. of Construction
6	Member	Mr. Pham Quang Trung	Dept. of Agriculture and Rural Development
7	Member	Mr. Hoang Danh Son	DOSTE
8	Member	Mr. Pham Quang Vinh	DOSTE
9	Member	Mr. Vu Nam Phong	DOSTE
10	Member	Mr. Nguyen Quang Hao	Ha Long Bay Management Board
11	Member	Mr. Do Dang Duong	Dept. of Culture and Information
12	Member	Mr. Pham Toan	Dept. of Transportation
13	Member	Ms. Dang Thi Kim Van	Dept. of Tourism
14	Member	Mr. Le Duy Ky	Dept. of Fisheries
15	Member	Ms. Bui Thi Cuong	People's Committee of Ha Long City
16	Member	Mr. Bui Khuynh	Dept. of Industry

1.5.2 JICA Study Team

The JICA study team comprises 15 members consisting of the team leader and 14 experts including one coordinator as listed below.

	Designation / Work Assignment	Name
1	Team Leader / Environmental Management Plan	Yoichi IWAI
2	Hydrology / Water Pollution Analysis	Toshiyuki UJIIE
3	Regional Development / Land Use	Manoru OSADA
4	Water Quality Analysis	Donald MEISNER
5	Tide and Water Quality Simulation	Ikuro MITSUMOTO
6	Monitoring Plan	Kazuhiko DOHI/Yosiharu KON
7	Environmental Database	Tomoo AOKI
8	Sanitation (Sewage and Waste)	Michael GRAY
9	Pollution Control (Mining and Tourism)	Itaru OKUDA
10	Natural Environment / Landscape	Takashi SATO
11	Port Engineering	Kiyoshi MIZUTANI
12	Satellite Image Analysis	Kenichi SHIBATA/Fumiko Makita
13	Organization and Institution	Robert EVERITT
14	Economic and Financial Analysis	Hiroshi HASEGAWA
15	Coordinator	Seiji KIKUCHI/Ritsuko SATO

Note: Members in charge of Monitoring Plan and Coordinator were changed in the First Work in Vietnam (Part 2), and in charge of Satellite Image Analysis were changed in the Second Work in Japan.

FIGURES

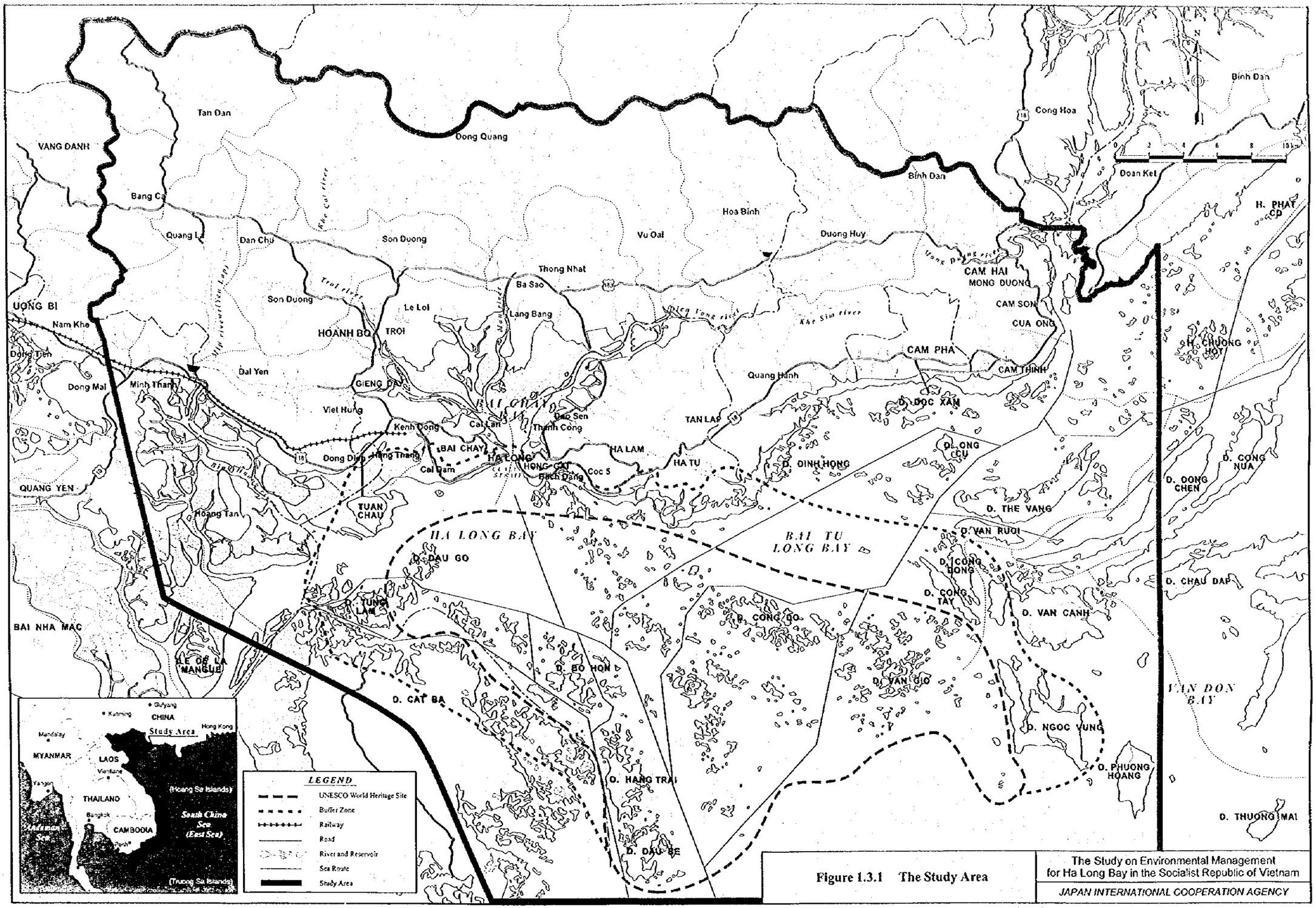

Figure 1.3.1 The Study Area

The Study on Environmental Management for Ha Long Bay in the Socialist Republic of Vietnam

JAPAN INTERNATIONAL COOPERATION AGENCY

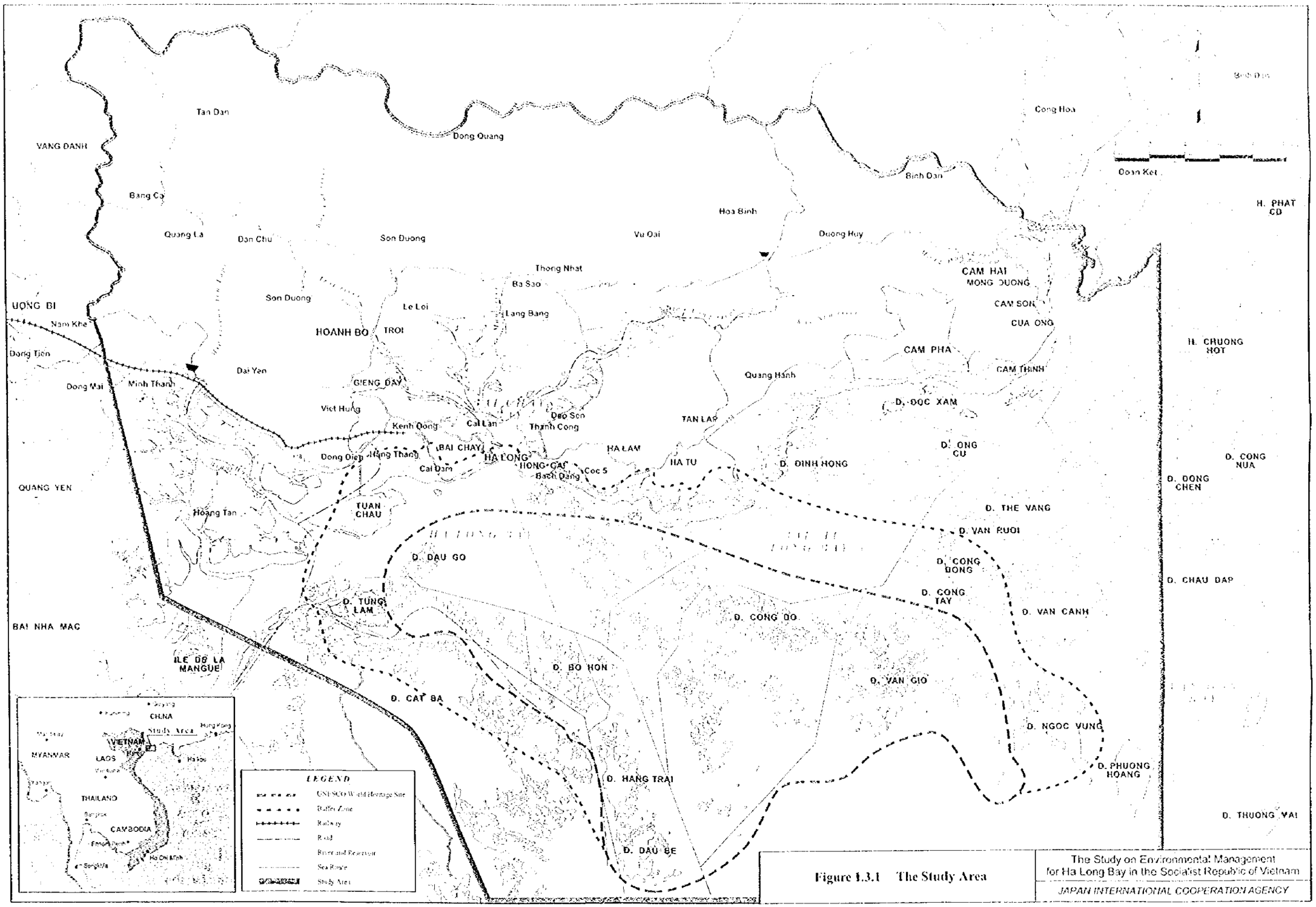

Figure 1.3.1 The Study Area

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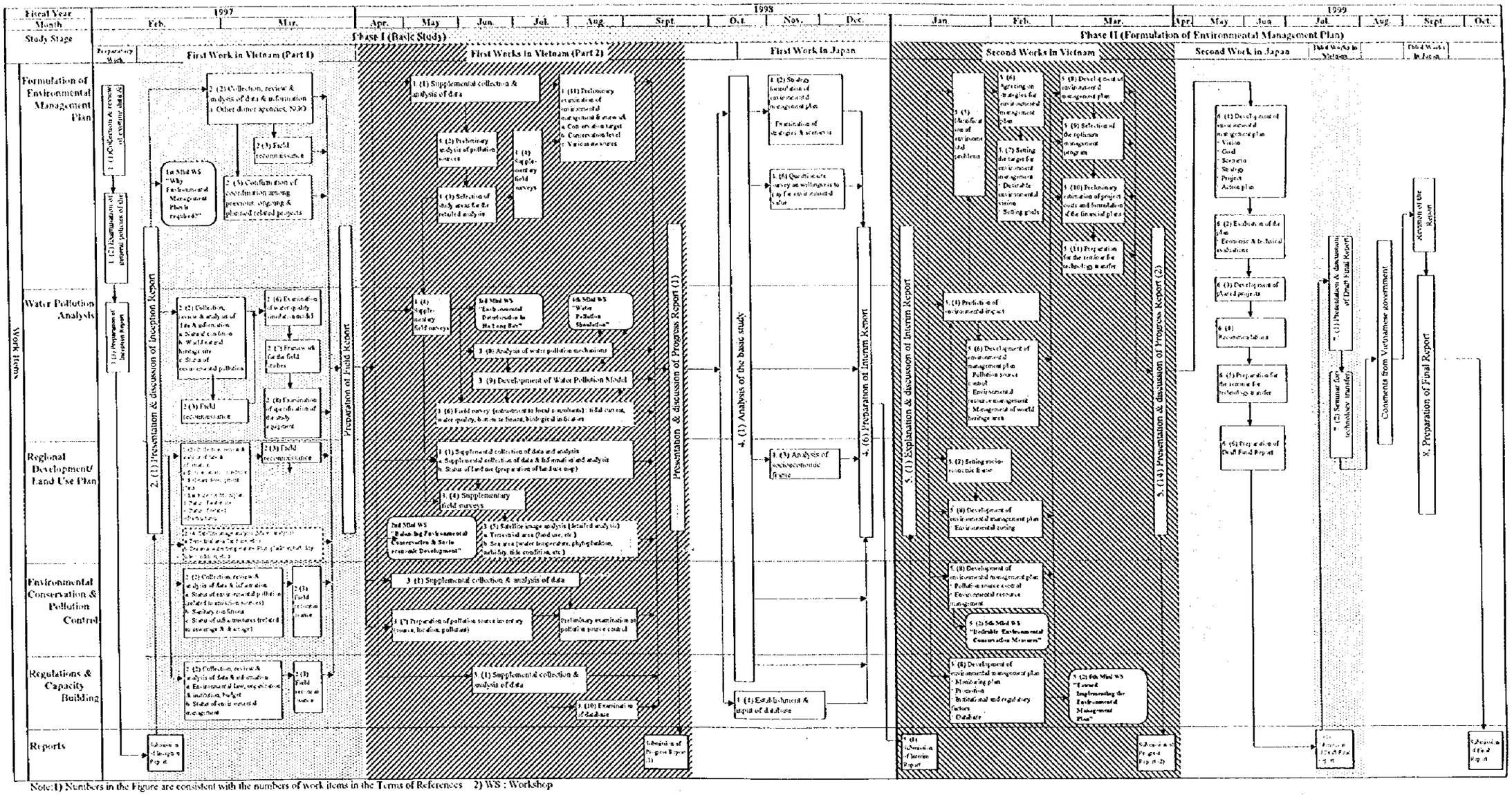


Note:1) Numbers in the Figure are consistent with the numbers of work items in the Terms of References 2) WS : Workshop

Figure 1.4.1 The Study Framework

CHAPTER 2

PART II CURRENT SITUATION OF THE HA LONG BAY AREA

CHAPTER 2 NATURAL CONDITIONS

2.1 Topography

The study area covers Ha Long bay, and its hinterland, namely Ha Long city, Cam Pha town, Hoanh Bo district, the eastern part of Yen Hung district, and the eastern part of Cat Ba island. The bay is situated directly south of Ha Long city and is renowned for its hundreds of scenic limestone islands which offer great tourism potential. The limestone islands stretch along the coastline to the Chinese border. Cam Pha has its own bay called Bai Tu Long which is also included in the study area and is one of tourists' destinations. Mining activities are carried out in the hills which stretch parallel with the coast from Ha Long city to Cam Pha town. In fact, this area is at present the most important coal mining area in Vietnam.

Although flat coastal lands are limited in the study area as a whole, there are some flat lands around the Bai Chay estuary. The northern portion of the study area is mountainous and has limited opportunities for development. The coastal zone is relatively narrow which has led to extensive coastal land reclamation.

Ha Long city was formed in April 1994 by merging the two towns of Bai Chay and Hong Gai which are geographically separated by the Cua Luc strait. The areas in the city are very different in character. The south coast line of Bai Chay is the center of tourism industry where major hotels, mini hotels, seaside recreational areas, and beaches are situated. On the other hand, the north coast of Bai Chay being shut out from the tourist area by a ridge of hills is now being developed as a deep seaport and an industrial area.

Hong Gai is a bustling commercial center and a port terminal for exporting coal which has been excavated in the hinterland. The activities of open pit mining will be reduced gradually in the next 10 years.

Cam Pha town is regarded as the national center of coal mining activities. Coal mines spread to the north and the south faces Bai Tu Long bay. The topography includes mountainous areas with height of 40-200 m, hills with height of 20 to 40

m, plains and mangrove forests. The hills to the north of the town are covered with coal tailings dumped from the mines and have formed a unsightly landscape.

Hoanh Bo district is located along the north of Bai Chay bay, and consists mainly of farming land in the south and limestone hills and mountainous area in the north. The mangrove field is at present stretching along the coastline of Bai Chay bay, and its area is gradually invaded by land reclamation and construction of dike systems. Cat Ba island lies southwest of Ha Long bay. The eastern part of the island which belongs to the study area is mostly limestone karst hills. The eastern part of Yen Hung district is mostly a wetland in river estuaries where mangroves are growing.

2.2 Land Use

2.2.1 Existing Land Use

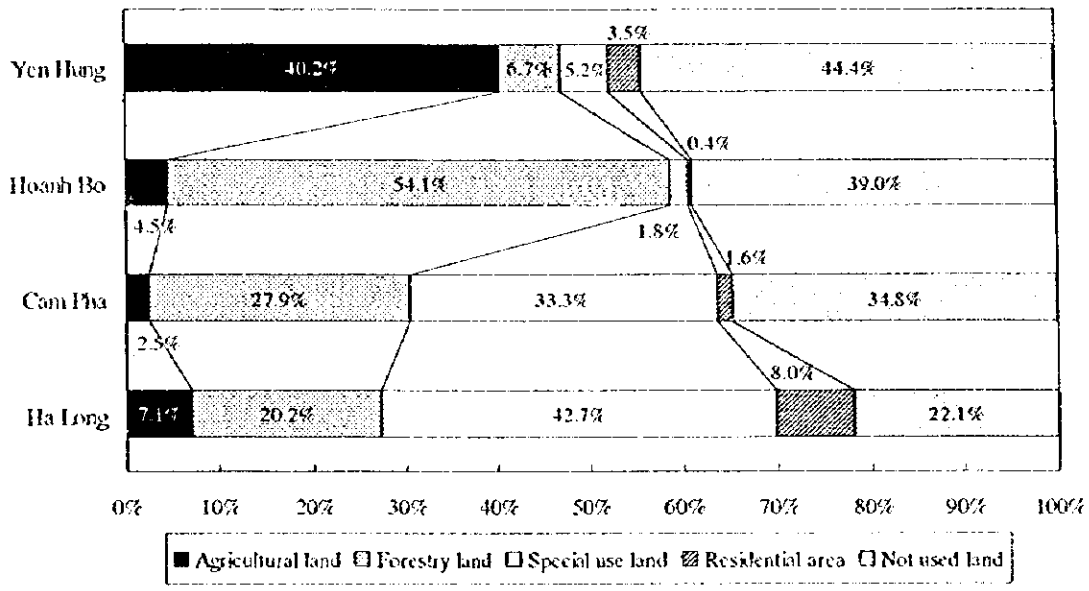
A relatively small portion of land is used for agriculture, i.e. about 2-7% except Yen Hung district, most of which is not included in the study area. The agricultural land is mostly used for annual crops such as rice, and very little is used for perennial crops, i.e. cash crops such as fruit (ADB, Coastal and Marine Environmental Management for Ha Long Bay, 1995). The special use land which is for building, transport, irrigation, and mineral exploitation has a substantial share of the land use in Cam Pha (33%) and Ha Long (43%). Most of special land in Cam Pha is coal mining area (ADB, *ibid.*) In the case of Ha Long, the land seems to be used not only for coal mining, but also urban facilities. The forestry and the not used lands account for over 90% in Hoanh Bo district. Accordingly, it implies the district is least developed in the study area.

Existing Land Use Pattern in the Study Area in 1996

Category (Unit: ha)	Ha Long	Cam Pha	Hoanh Bo	Yen Hung	Total	Quang Ninh
Agricultural land	870	1,197	4,123	12,784	18,974	55,492
Farming land	276	703	2,233	5,971	9,183	32,851
Paddy field	150	434	2,050	5,701	8,335	28,154
Forestry land	2,482	13,560	49,327	2,114	67,483	196,958
Special use land	5,242	16,174	1,678	1,656	24,750	35,683
Residential area	981	760	408	1,118	3,267	7,244
Not used land	2,711	16,932	35,573	14,094	69,310	298,480
Total land area	12,286	48,623	91,109	31,766	183,784	593,857
Category (Unit: %)	Ha Long	Cam Pha	Hoanh Bo	Yen Hung	Total	Quang Ninh
Agricultural land	7.1	2.5	4.5	40.2	10.3	9.3
Forestry land	20.2	27.9	54.1	6.7	36.7	33.2
Special use land	42.7	33.3	1.8	5.2	13.5	6.0
Residential area	8.0	1.6	0.4	3.5	1.8	1.2
Not used land	22.1	34.8	39.1	44.4	37.7	50.3
Total land area	100.0	100.0	100.0	100.0	100.0	100.0

Note: 1) Special use land is for transportation, irrigation, mineral exploitation, etc.
2) The sum of farming land and paddy land is not equal to agricultural land.
3) Forestry land includes only the natural forest. Besides, the reforestation area is 40,000 ha and the other secondary forest land is 151,873 ha. The total land for forest is 387,873 ha. (63% of the provincial land)

Source: Statistical Year Book of Quang Ninh Province, 1996



Source: Statistical Year Book of Quang Ninh Province, 1996

Existing Land Use Pattern in the Study Area in 1996

2.2.2 Result of Satellite Image Analysis

(1) Land Use Change by Macro Analysis

In the macro analysis of the land including the study area, a whole land use map was made using "LANDSAT TM" data of 1988, 1992, and 1997. The analyzed area of 5,600 km^2 in total was classified into five main land types, as shown in the next table.

Classified Area in 1988, 1992, and 1997

Classification	1988		1992		1997	
	Area (km^2)	Ratio (%)	Area (km^2)	Ratio (%)	Area (km^2)	Ratio (%)
Forest	1,985	35	1,871	33	1,784	32
Farm & Grass	253	5	297	5	328	6
Urban	377	7	415	7	437	8
Mine	193	3	225	4	259	5
Water Body	2,792	49	2,792	49	2,658	49
Total	5,600	100	5,600	100	5,600	100

Note: Water body includes seawater area.

The macro analysis shows that forests have been exploited for agriculture, urbanization, and mining activities. The forest land has decreased by about 10% from 1988 to 1997. Also, the water-body area has been decreased recently due to reclamation.

Comparing 1989, 1992, and 1996 maps, the following land use changes in the study area are noted:

i) In the southern part of the National Highway No. 18, especially around the coal mining sites of Hong Gai district, the land use pattern has significantly changed.

ii) In the surrounding area of Bai Chay bay, there has been a large change in land use. The following changes are significant: expansion of coal mining area, and reclamation of tidal flat, and mangrove forest area within Bai Chay bay and along Ha Long bay.

The next table shows changes of principal categories such as mangrove forest, tidal land and coal mining sites in 1989, 1992, and 1996.

Changes of Mangrove Swamps, Tidal Flats, and Coal Mining Areas

(Unit: ha)

Land Category	1989	1992	1996	1996 / 1989
Mangrove Swamps	2,987	4,080	3,483	1.2
Tidal Flats	7,648	5,573	3,583	0.5
Coal Mining	3,256	4,084	5,418	1.7

Between 1989 and 1996, the coal mining area increased continuously. On the other hand, the tidal land decreased by 50 %. The mangrove forest increased in 1992, but then decreased in 1996. The figure of 1989 for mangrove forest was, however, supposedly underestimated, because its satellite data was during the high tide period. These recent land use changes imply that environmental impacts on the natural ecosystem in the study area are gradually becoming bigger than before.

(2) Results of Detailed Analysis

Focusing on the river basins flowing into Ha Long bay which was investigated in the macro analysis, land use maps of 1:100,000 scale were drawn on the basis of multiple "SPOT" data between 1986 and 1996. Figure 2.2.1 shows the latest land use map and the table below presents the land use of the study area in 1996.

Land Use of the Study Area in 1996

No.	Land Use Category	Area (ha)	%
1	Natural Forest	14,400	13.9
2	Secondary Forest	37,100	35.9
3	Trees on Limestone	4,400	4.3
4	Scrub Land	16,600	16.0
5	Grass Land	7,000	6.7
6	Bare Land	800	0.8
7	Agricultural Land	6,200	6.0
8	Coal Mining	5,400	5.2
9	Residential Area	3,800	3.7
10	Water Body	7,600	7.4
Total		103,300	100.0

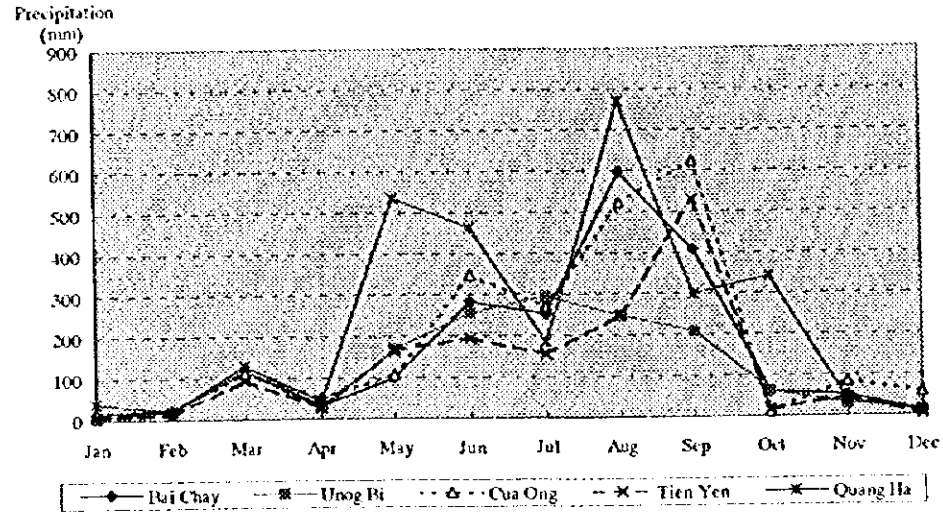
Note: The seawater area including tidal flats and mangrove swamps, and islands are excluded.

The whole area covered by the detailed analysis is 1,033 km^2. The first major category is forest (natural forest, secondary forest, and trees on limestone) occupying 54 % of the total land area. Coal mining and residential area respectively account for 5 % and 4 % of the whole. Their shares are rather small for their possible large impacts on the environment. Surface water area of 7,600 ha accounts for 7 % of the total land area.

2.3 Climate

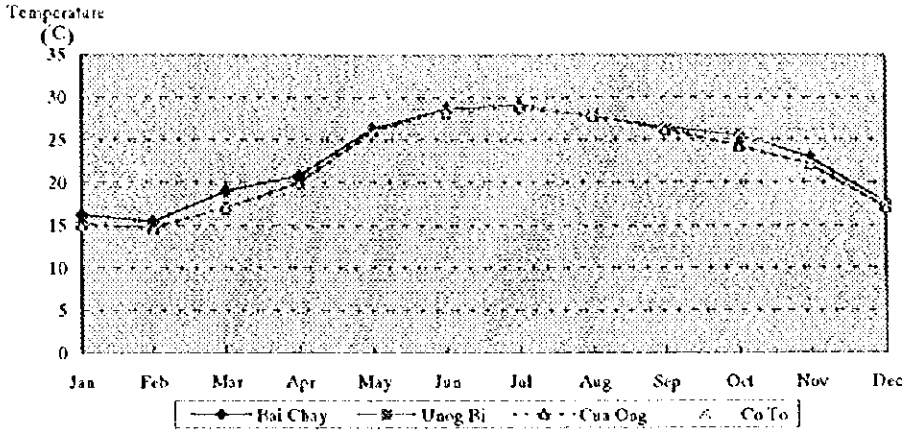
The climate of the study area is dominated by a relatively dry north-east "winter" monsoon (October/November to March/April) and the wetter "summer" monsoon (May/June to September/October). Information on precipitation, temperature, relative humidity, and sunshine is shown in the following figures. The annual rainfall is about 1,800-2,000 mm. The temperature of the study area ranges from 25-29°C for May to October, and 15-23°C for the other months. The monthly average humidity is relatively steady and ranges from 75-90%. Low winter temperatures and rainfall limit some types of agricultural production. Typhoons and associated storm surges can cause significant flooding and damage, especially to coastal areas.

Highly intensive rainfalls can occur in some areas, leading to high erosion rates in logged watersheds and to high pollution loading runoff events, especially during the start of the wet season, when dry canals and river beds are flushed.



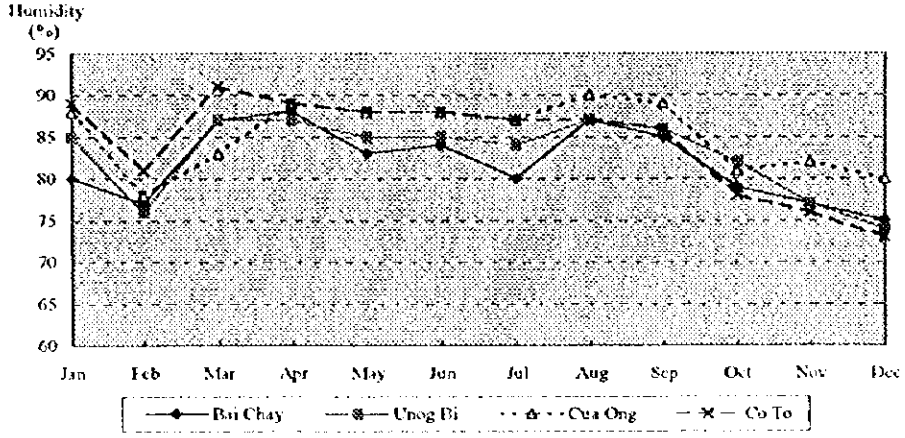
Source: Statistical Year Book of Quang Ninh Province, 1996

Monthly Average Rainfall in the Study Area and the Vicinity in 1996



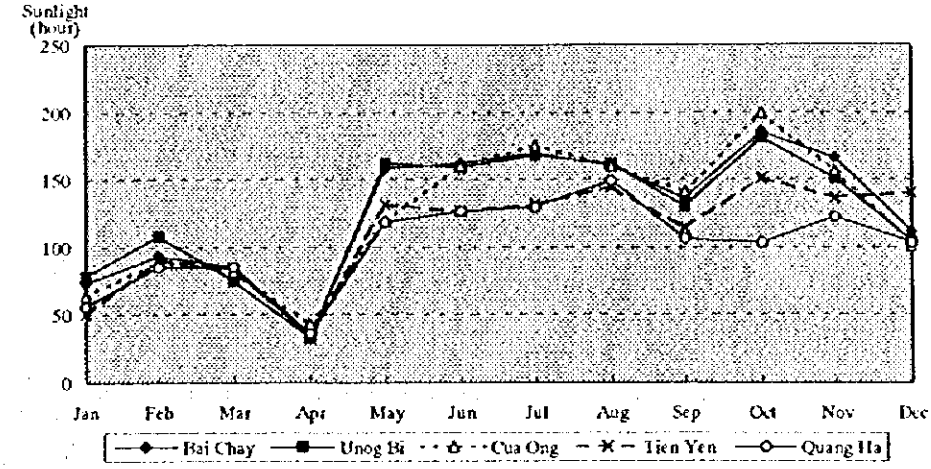
Source: Statistical Year Book of Quang Ninh Province, 1996

Monthly Average Temperature in the Study Area and the Vicinity in 1996



Source: Statistical Year Book of Quang Ninh Province, 1996

Monthly Average Humidity in the Study Area and the Vicinity in 1996



Source: Statistical Year Book of Quang Ninh Province, 1996

Monthly Average Hours of Sunlight in the Study Area and the Vicinity in 1996

2.4 Geology and Soil

Ha Long bay is surrounded by limestone islands and rocky hills spread along the coast. The seabed is covered with 1.5-2.0 m deep fine grain sediments. The coast is characterized by tidal flats and hills of terrigenous rocks aged the early Mesozoic. The tidal flats, most of which are covered mangroves, are engraved by a system of digitate shaped tidal creeks and channels. In addition, some rocky benches and beaches are found on the Bai Chay and Tuan Chau coasts.

The seabed and tidal flats are mostly covered with three major sediments: sands (0.1-1.0 mm in diameter), coarse silt (0.05-0.1 mm) and politic (0.01-0.05 mm) sediments. Beaches in Bai Chay, the low tide flats in Bai Chay bay and in northern Tuan Chau island are covered with terrigenous sands. Shelly sands are seen on small beaches of limestone islands in the southern Ha Long bay, on the bank surrounding coral reefs, and on Cua Van inlet bed.

Coarse silts are found in most of the areas in Bai Chay bay and from Cai Dam-Tuan Chau through the northern Cat Ba-Cua Van-Dau Be to the border of Bai Tu Long bay. Politic mud widely covers an area of Ha Long bay and Lan Ha bay (southeast of Cat Ba island). The tidal flats with mangroves in the east coast of Bai Chay bay is also covered with this sediment.

There are ten soil groups in northern Vietnam and seven of them have been used for agriculture. These are marine sandy soils, saline soils, sulfate acid soils, alluvial soils, water-logged soils, degraded soils, and yellowish-red soils. In Quang Ninh province, there are three types of the soils which are found problematic for agriculture: saline soils, sulfate acid soils, and degraded soils.

Saline soils stretch along the coast of Hai Phong, Hai Hung, Nam Ha, Ninh Bin, Thai Binh, and Quang Ninh provinces. The area of saline soils has been decreased substantially due to development of irrigation and drainage systems. Estimated 44,000 ha sulfate acid soils are in Hai Phong, Quang Ninh, and Thai Binh provinces. A good management is necessary for these soils to support one rice crop plus two subsidiary crops or two rice crops plus one subsidiary crop.

2.5 Rivers and Surface Runoff

2.5.1 Rivers

Total catchment area of the bays is 105,000 ha exclusive of emergence; i.e. between highest high water and lowest low water levels. The catchment is mainly characterized by 100-300 m high steep hills of weathered limestone running from east to west as well as the rivers. There are five large rivers in the catchment namely the Mip, Troi, Man, Dien Vong, and Mong Duong rivers (hereinafter referred to as the Main Rivers). The Dien Vong river drains the eastern basin of Bai Chay bay. The Troi and Man rivers form the other major drainage in the west and north of Bai Chay bay, respectively. The Mip and Mong Duong rivers are located at the eastern and western boundaries of the catchment. The largest river running to the bays is the Dien Vong river with basin of 256 km^2. The tidal influence distance to these rivers is limited about less than 10 km from the coast.

There are also several small rivers and streams with inconsequential flows in the coastal line from Bai Chay to Cua Ong. Most of them are located on the lowlands between the steep hills which gradient varies from 12 to 20% and the bay consist of alluvial and marine sediments with 4 to 5 m above sea level. Thus, rivers are short in length and with steep gradient and rainfall in this basin of small rivers locating coastal line quickly runs into streams/rivers discharging to the bays. Flood is rare in the rivers, occurring only for short time in the early part of the rainy season.

2.5.2 Discharge

(1) Gauging Stations

There were two hydrological gauging stations in the catchment of the bays. They were the Bang Ca station of the Mip (Yen Lap) river and Duong Huy station of a tributary of the Dien Vong river. However, these stations were suspended in 1970 at Duong Huy station and 1973 at Bang Ca station. According to the observation records from 1961 to 1970 collected by the Hydro-meteorological Service of Vietnam, maximum of 189 $x10^6 m^3$ is discharged per year from these two rivers.

(2) Surface Runoff

Total surface water runoff is extrapolated using empiric relationship between basin area and effective rainfall which is calculated by multiplying amount of precipitation and discharge ratio. Discharge ratio is set based on land uses and evapo-transpiration (Technical Guideline for River Works, Ministry of Construction of Japan, 1997). The estimated surface runoff is about 980 million m^3/year ($30m^3/s$) in total catchment area. The surface runoff from the Main Rivers is estimated about $806 \times 10^6 m^3$/year, which accounts for 82% of the total. The hydrology and water quality in the bays are strongly influenced by the rivers' discharge, so that differences of density between fresh and salt waters make a stratification in the bays. The formula used is as follows ;

Effective Rainfall (ER) = (R-ET)*f

where, R : amount of rainfall (mm)

ET : amount of evapo-transpiration (mm)

f : runoff coefficient, namely urban area is 0.8-0.9, agricultural field is 0.6-0.7, forest area is 0.7.

Source: Technical Guideline for River Works, Ministry of Construction of Japan, 1997

(3) Monthly Discharge of the Main Rivers

Assuming that the surface runoff is proportional to effective rainfall, the monthly average discharge values of the Main Rivers during the summer season from June to August accounts for 60% of the annual discharge.

2.5.3 Sediment Runoff

The hilly areas of the catchment, which were once forested, have been cleared of most of their forest cover. The removal of forest cover has lead to soil erosion and it is likely to increase sediment loads being carried into the bays. The deforestation caused by coal mining, intensive agriculture, and other human activities such as exploitation for limestone or cement, construction of houses in the hill slopes has increased soil erosion. Land reclamation activities bring about sediment runoff during the rainy days.

Assuming the concentration of suspended solids (SS) in the waters flowing into the bays is 2,000 mg/ℓ on rainy days and 20 mg/ℓ on dry days, the amount of sediment runoff as SS is estimated at 150 tons/day.

2.6 Vegetation and Forest Resources

Vietnam has a wide range of natural vegetation types, which in some cases have been almost degraded by human activities. Original vegetation types in Vietnam comprise "mangrove forests", "malaleuca forests", "fresh-water swamp forests", "monsoon forests", "lowland evergreen/semi-evergreen broadleaf forests", "hill evergreen/semi-evergreen broadleaf forests", "forest on limestone", "mountain evergreen and mixed coniferous forests", and "sub-alpine vegetation". The distribution map of the original vegetation shows that the land area in the study area originally belongs to "semi-evergreen hill forest" and Cat Ba island belongs to "forest on limestone" (Government of the Socialist Republic of Vietnam and the Global Environment Facility Project VIE/91/G31,1994).

In this study, the Field Survey has been made to obtain the information about species composition, vegetation formation, and distribution in the study area. According to the survey, 1,027 species belong to 171 families, 6 phylum were recorded in the study area. Most of them belong to *Magnoliophyta* with 43 families, 951 species. Others have a much less number. They are *Polypodiophyta* with 18 families, 58 species, *Pinophyta* with 6 families, 11 species, *Lycopodiophyta* with 2 families, 5 species and *Psilotophyta* and *Equisetophyta* with 1 family, 1 species in each. The result of the species study on distribution areas showed that the mainland community consists of 475 species and the Cat Ba island community consists of 749 species. Many species on the Cat Ba island are distributed on this island only. The vegetation map that has been made on the basis of the Field Survey is shown in Figure 2.6.1. Among the species recorded in the study area, 19 species were listed in the Vietnam Red Data Book (1996) which are under threat of disappearing and must be protected. Endangered plants in the study area are as follows:

Annamocarya sinensis (walnut)
Ardisia silvestris (spearflower)
Chukrasia tabularis (bread tree)
Cibotium barometz (scytianlamb)

Cinnamomum partheroxylon (camphor tree)	*Cunninghamia lanceolata (China fir)*
Cycas balansae (bread palm)	*Madhuca pasquierri (chewing gum tree)*
Morinda offcinalis (madder)	*Murraya tetramera (jasmine orange)*
Nageia fenyi (broadleaf pine)	*Psilotum nudum (whisk plant)*
Sasa japonica (arrow bamboo)	*Smilax glabra (catbrier)*
Smilax petelotii (catbrier)	*Stemona saxorum (lily)*
Strophanthus divaricatus (oleander)	*Strychnos cathayensis (strychnine tree)*
Thysanotus chinensi (asphodel)	

According to the data of the Department of Agriculture and Rural Development (DARD) in QNPC, Quang Ninh province has a total land area of 593,800 ha and 66% of them is composed of forest area in 1996 (DARD, 1998). In the forest area, 186,949 ha is covered by forests and 203,934 ha is bare land as shown in below. The forest vegetation in Quang Ninh province accounts for 31.5% in 1996.

DARD, which is in charge of forest management, has classified natural forests into three grades of forests, namely "rich forests", "intermediate forests", and "poor forests". The characteristics of each forests are as follows.

Rich forests: forests which remain almost intact and they are often 3 layer structured. The high layer is dominant with trees of over 40 cm in diameter. The mid layer includes trees of 16-35 cm in diameter. The under layer includes regenerated trees. On the whole, this type of forest is rich in reserves and has dense canopy. Their canopy is 0.8 and above. The diameter of trees in these forests is more than 17 cm. Their wood volume ranges from 110 to 210 m^3/ha.

Intermediate forests: forest that have been cut many times with structures of 2 to 3 layers. They are the main target for cutting in recent years and their canopy structure is uneven and discontinuous. Their canopy is 0.4-0.7. The diameter of trees ranges from 13 to 22 cm or average 17 cm, and the wood volume ranges from 61 to 110 m^3/ha or average 80 m^3/ha.

Poor forests: forests that have been exhausted with canopies destroyed in wide areas. They are often 2-layered with some big trees of large diameter, short height, low density and poor quality remaining in the high layer. Their lower layer include regenerated trees or bushes. Some are invaded by small bamboo trees. Their

canopy is 0.2 to 0.3, and the wood volume ranges from 20 to 60 m^3/ha or average 45 m^3/ha.

DARD has managed forests according to the standard of the wood volume that is set for each grade of forests. The "rich forest" is set to keep the wood volume of more than 100 m^3 per ha.

DARD has the plan to raise the forest vegetation with a goal of up to 40% increase by the year 2000. To achieve the target forest vegetation, two measures are needed. One is to reduce deforestation mainly caused by collecting for firewood and coal mining, and the other is to promote reforestation. QNPC has enforced coal mining factories to buy wood from other provinces, and as a result the cutting volume of wood has reduced from 100,000 m^3 in 1970 to 10,000 m^3 in 1997. As for reforestation, DARD has carried out many projects, namely Project 264, 327, PAM and so on. Owing to these projects, 5,500-5,800 ha of bare land has been reforested per year from 1996 to 1998, and 6,500 ha of reforestation is planned in 1999.

Forest Land Ratio in Quang Ninh Province in 1996

Forest Land	Ratio (%)
(1) Forests	31.5
a) Natural Forest	23.0
- Rich Forests	0.2
- Intermediate Forests	4.8
- Poor Forests	4.8
- Others	13.2
b) Planted Forests	8.5
(2) Bare Land	34.3
Total Area	65.8

Source: Department of Agriculture and Rural Development of Quang Ninh Province, 1998

2.7 Mineral Resources

There are extensive mineral resources in the study area, but they are primarily limited to coal and stuffs for building materials such as limestone, clay and kaolin. Metals are not found in significant quantities.

Coal is undoubtedly the most important mineral in the study area. In Quang Ninh province coal deposit has been found in a 10km wide faulted trench zone stretching east west for 150 km. Coal occurs in sediments that are up to 4,500m

thick, containing some 61 seams with an aggregate coal thickness of up to 150m. Coal types in Quang Ninh province include anthracite, semi-anthracite, bituminous, and others. In Cam Pha town there are six major mines, 3 are underground (Thong Nhat, Mong Duong, and Khe Cham) and 3 are open pit mines (Deo Nai, Coc Sau, and Cao Son). In Ha Long city, the major open pit mines are in Ha Tu and Nui Beo. Also, two underground mines are located in Ha Lam and Tan Lap.

Coal reserves and existing operating coal mines provide an energy source to drive industrialization and urbanization in the study area. On the other hand, there are serious environmental problems associated with mining, processing, and transporting coal.

Non-metallic minerals such as limestone, clay, silica, sand and gravel used for construction materials are prevalent. Of these limestone seems to be commercially the most important in the study area. Nearly all of them are at present used locally, primarily in the cement industry and secondarily in the brick and tile industries.

2.8 Tourism Resources

Quang Ninh province has a lot of tourism potential which has been strengthened further by the designation of Ha Long bay to the World Natural Heritage area in 1994. Ha Long bay is considered as one of the areas with the highest tourism potentials in the country. Its spectacular karst seascape is recognized throughout the world. In addition, Ha Long bay is also known as "Gui Lin of marine" which is worldwide well known for its karst limestone mountains in China. Ha Long bay is also culturally and historically important, as it contains a lot of archeological sites of national significance.

In the study area, Cat Ba park is the only national park which has the highest biodiversity of any coastal and marine site in the northern Vietnam, with a number of plants and animal species that not found anywhere in the world. Besides, Quang Ninh province has a lot of scenic beaches along the 250 km coastline such as Bai Chay, Tra Co, Minh Chau, Quan Lan, Vinh Trung, and Vinh Thuc.

However, due to the insufficient infrastructure of the country and of Quang Ninh province, the present tourism activities are still limited only to short stay activities, such as bay cruises for international and local tourists and bathing on the beaches for the local. The key tasks for successful tourism promotion are to attain well-organized tourism management and environmental protection as well as the related infrastructure development. The relatively low sunshine hours in Ha Long bay is a disadvantage for a beach resort, however.

Deforestation has limited the opportunities for eco-tourism in the study area. However, mountainous areas, in particular the road corridor of 18B from Hoanh Bo to Mong Duong may offer significant potential for mountain-oriented tourism development for the future.

2.9 Water Resources and Water Use

(1) Reservoirs and Ponds in the Catchment

Water resources in the catchment area of the bays are rivers and reservoirs. The biggest dam is the Yen Lap dam with a total storage volume of 130×10^6 m^3 (effective storage of 115×10^6 m^3) from which water is utilized for domestic and industrial water supply of 3,000 m^3/day, and for irrigation purposes of 70×10^6 m^3/year in Yen Hung district.

The largest river is the Dien Vong river whose water is being used as a raw water source of domestic and industrial water supply for Hong Gai, Ha Tu, Cam Binh, Cam Son, and Cua Ong quarters. The water is taken by the Da Bac dam with capacity of 15,000 m^3/day, but the dam's capacity has been decreasing by soil erosion and sediment runoff in the catchment area.

The water of the Troi river is used mainly for domestic and industrial water as well as irrigation in Dong Dang, Bai Chay, and Gieng Day quarters. The water supply in Bai Chay quarter comes from the Dong Ho dam located in the tributary of the Troi river with capacity of 20,000 m^3/day. In addition, there are many small ponds and lakes like An Bien, Roc Ca, and small streams. Existing and proposed dam and reservoir are shown in Figure 2.9.1.

(2) Water Uses in the Bays

The water of the bays is used for various purposes such as transportation by ships and ferry boats including floating ports, bathing, and other recreational uses.

Transportation is one of the main activities on the sea. There are 9 main ports in the study area which can be categorized into three types; namely coal ports, oil ports, and general ports. Besides, many small ports or harbors are located on the coastal line, which are mainly used by local residents. A passenger car-ferry is operated in the Cua Luc strait, while there are two berths located on the Bai Chay and Hong Gai sides. In addition, there are ferry services between Hong Gai and small islands as well as Hai Phong.

Recreational uses are also other main activities on the sea. Lots of people enjoy bathing or boating on the sea. According to the Ha Long Bay Management Board (HLMB), there are about 1,500 tourist boats in this area. Most tour boats sail from Bai Chay new tour boat harbor and go around world heritage site.

Some water area is being used as a place for residence. According to QNPC, there are about 3,000 inhabitants living on the sea, mainly near Hong Gai quarter (close to Hong Gai market) and Cam Bin quarter. They are usually living in a small boat, but some people built relatively large house floating on the sea.

2.10 Landscape

2.10.1 Characteristics of Landscape

There are various landscapes owing to the varied topography and vegetation in the study area. These can be classified into four types based on the topography, vegetation, and land use as shown below.

(1) Rural Landscape

Mountain landscape is most widely seen in the mainland area of the study area because a large part of the land area is composed of mountains. Other landscapes in the land area are composed of Farm landscape at the foot of mountains and the River landscape along the Mong Duong, Dien Vong, and Troi rivers.

(2) Urban Landscape

Urban landscape can be seen in the city areas such as Hong Gai, Bai Chay, Cam Pha, and Cua Ong.

(3) Seashore Landscape/Seascape

Seashore landscape in the study area comprises various landscapes/seascapes such as tidal flats without vegetation, mangrove swamps where mangrove grows densely in tidal flats and rocky coast.

(4) Marine Landscape/Seascape

Marine landscape/seascape in the study area is composed of numerous limestone islands in Ha Long bay and its valuable landscape has been conserved as the World Natural Heritage Site of UNESCO. Cat Ba island located next to the World Heritage area in Ha Long bay is also famous for its rich forest and diverse fauna and flora and has been designated as a National Park in order to preserve its values.

(5) Value of Landscape

The values of landscape depend on perceptive impressions of human being for environment including lithosphere, hydrosphere, atmosphere, and biosphere. Therefore, the values of landscape may change depending on personal preference and viewpoints. However, in general the values can be evaluated objectively by the quality of landscape elements and may be classified into several landscape grades such as Landscape of global value, Landscape of national value and Landscape of provincial value according to the quality of landscape elements. The main landscapes of the study area are listed as follows according to the landscape values.

a) Landscape of global value : Ha Long bay area (World Natural Heritage)
b) Landscape of national value : Cat Ba national park, other protected area
c) Landscape of provincial value : Landscape of natural resources

2.10.2 World Heritage Area

(1) Characteristics of Landscape in Ha Long Bay World Heritage Area

In Ha Long bay there are a lot of limestone islands that have district shapes. The combination of peculiar shapes of islands, natural color of the rocky surface, vegetation on the islands and water color around islands forms a scenic beauty.

The landscape of the Ha Long Bay World Heritage area (World Heritage area) can be appreciated from the seashore of the mainland and from boats on the sea. The landscape from mainland is a photographic scene from fixed viewpoints and the landscape from boats is the sequence scenes from a moving viewpoint in the sea. Typical landscapes from the mainland and the sea are shown in Figure 2.10.1 and 2.10.2.

The value of landscape can be evaluated from various aspects, but the main aspects are:

a) Diversity : this value depends on the variety of landscape elements.
b) Naturalness : this value depends on the proportion of land covered by natural landscape elements.
c) Beauty : this value depends on aesthetic impression given from the landscape.
d) Prominence : this value depends on the prominent landscape elements.
e) Peculiarity : this value depends on unusual landscape elements.
f) Visibility : this value depends on openness of view and the grand scale of landscape elements.

Each value item depends on the landscape elements. The important landscape elements that produce the high value of the World Heritage area are listed as follows:

a) Shape and surface of islands
b) Color and clearness of seawater
c) View of natural resources
d) Natural scenery

By studying the present condition of landscape elements of the World Heritage area, typical landscapes viewed from the mainland and the sea are evaluated respectively. Among the landscape from mainland, the characteristic of landscape from the seashore in Bai Chay is the distant view of various islands in the World Heritage area. In contrast, the landscape from Hong Gai is the close-range view of islands in the buffer area. Main element of landscape from mainland is the shape of islands which is in common between these two viewpoints. That produces the value of landscape, the characteristics of which are mainly diversity, peculiarity, and visibility.

In contrast to the landscapes from the mainland, the characteristics of landscape from viewpoints on the sea is the close-up view of islands surrounded by the yellowish-green sea. Main elements of the landscape from the sea are the natural surface texture and shape of islands, color and clearness of seawater and natural scenery without any disturbance from artificial landscape elements. They produce the high value of landscape, characteristics of which are the diversity, naturalness, beauty, and peculiarity.

The condition of landscape elements except the shape of islands and combination of islands can be affected by human activities and the change of natural environment. Most of landscape elements have been found to be maintained in good condition at present according to the field reconnaissance in this study, but several activities and conditions that may degrade the value of landscape were observed as follows and are shown in Figure 2.10.3. According to the questionnaire survey for tourists in this study, the floating garbage was pointed out as the first reason when they feel dissatisfied about the landscape of the World Heritage area:

a) Landslide, oil slick, floating garbage : this injures the beauty of landscape
b) Anchored and sailing transport ship : this degrades the naturalness of landscape

(2) Tourism Spots

The tourism spots popular among tourists in the World Heritage area are shown in Figure 2.10.4 based on the guide map issued by HLMB. Main tourism spots are

the Dau Go island and its surrounding waters, the waters from the Chan Voi island to Van Boi island, Bo Hon island and its surrounding waters, Dau Be island, and Dao Van Gio island. Main tourism spots are located in the western area of the World Heritage area.

2.10.3 Other Valuable Landscape

The landscapes of the Cat Ba national park and reserves such as the Bai Chay Forest and Don Song Ky Tung Forest that have been designated as a protected area by the Government are listed as the landscape of national value.

Natural resources and natural environment held in good conditions can form valuable landscape. In the study area, the landscapes around the natural resources such as riversides of the Mong Duon, Dien Vong, and Troi rivers, mangrove swamps of Bai Chay bay, Yen Hung, Quang Hanh, tidal flats along Cam Pha, Hung Thang, and Bai Chay bay are listed as the landscapes of provincial value in the study area. The typical landscapes of provincial value are shown in Figure 2.10.5.

2.11 Cultural Assets and World Heritage

Quang Ninh province has a lot of historic and cultural sites at Yen Tu (home of Vietnamese Buddhism), Long Tien (temple), Bai Tho (ruins of old town), Tra Co (ruins of archaic building), Bach Dang (a battlefield in the Middle Ages), and Cua Ong (temple). These sites are situated in the study area besides Yen Tu and Tra Co. mentioned above.

Ha Long bay including Cat Ba island holds over 1,900 islands and islets forming a spectacular seascape of limestone pillars. Because of their precipitous nature, most of the islands have been uninhabited and unaffected by human activities. The exceptional esthetic values of this site are complimented by its great biological interest. Accordingly, UNESCO designated Ha Long bay as the World Natural Heritage in December, 1994.

In addition, recent surveys of the Cat Ba national park have counted 745 plant species, five of which are rare and endangered. A lot of these plants are used for

traditional medicines. Furthermore, the park provides a habitat for 155 vertebrate species. The park's population of the white-headed languor is the only remaining population of the species in the world according to "the Study of Coastal and Marine Environmental Management for Ha Long Bay", 1995, financed by ADB.