UNITED NATIONS ENVIRONMENT PROGRAMME

EAST ASIAN SEAS REGIONAL COORDINATING UNIT

UNEP

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Project Coordinating Unit

NATIONAL REPORT OF VIET NAM

on the

Formulation of a Transboundary Diagnostic Analysis and Preliminary Framework of a Strategic Action Programme for the South China Sea

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Contents

1. INTRODUCTION

Viet Nam has its huge marine territorial water, long coastline and number of islands of big and small sizes. This is favorable for the marine and coastal economic development and at the same time requires great efforts for their management and environment protection. Series of problems and issues related to the environment in general, and the water related one, in particular are the threats and challenges for the country development. Those problems and issues affected the marine and coastal environment, can be classified and referred to the following groups: landbased and seabased pollution including pollution sources, hot spots and high risk areas; the shortage and quality degradation of freshwater resources including the surface and ground waters; the exploitation of freshwater and marine aquatic living resources and the modification of aquatic living habitats.

It is evident that Viet Nam's sea plays an important role in the navigation activities of international and Asian-Pacific Region scales contributing to the formation of the transitional navigation lines between the Indian Ocean and Pacific Ocean through the Malacca and Luzon Straits. Major part of petroleum from the Middle East Region transported to Japan, United States of America and other Asian countries is passed the Viet Nam's sea. Due to the high density of ships passing the area, the negative impacts of oil pollution from shipping activities including oil spill accidents are obvious.

Beside, the recent oil and gas exploration and exploitation development on Vietnamese continental shell is also a potential source of oil pollution in the area.

Viet Nam has many sea ports excluding hundreds of the small ones for fishing boats. The large amount of ships boats fishing in Viet Nam coastal waters are regular sources of shipbased pollution, especially due to the activities of ship and boat washing, the technical shortcomings and careless operation.

At present, nearly a quarter of Viet Nam's population is living in the coastal areas and there is a tendency of high immigration into the areas. There are big cities, 'economic zones', major 'economic corridors', centralized industrial zones and the areas of mining and aquacultural activities located in the coastal zones. The development is expected to be quickly increased in the future. All this creates great pollution sources, hot spots which are the cities, industrial and tourism centers located on the sea coast or the major estuaries receiving of waste of almost all types produced from the inland industrial and population centers in the river watersheds.

Large amount of pollutants from land enters into the coastal and marine environment. The solid waste are mainly the industrial and domestic and a little part from the hospitals. A significant amount of waste water is contributed by major cities and industrial centers such as Hanoi, Viet Tri, Hai Phong and Ho Chi Minh City. The waste enter the coastal water either directly or through the river systems.

The use of pesticides is not controlled properly. The toxicants such as DDT, Lindan, Monitor, Wofatox and Validacin are still being used in agriculture. The pesticides are carried through the ground and surface streams into river systems and entered the coastal waters. Their high contents have been found in some tidal flats and benthic species of the Red River Delta estuaries.

Viet Nam as a tropical country with a dense river network is rather rich in freshwater resources. The water demand in the next couple of years is only about 20-30% of the total amount of surface water and the water quality is still good for all purposes including drinking water supply and water supply for different sectors of the economy. The problems, however are dealt with the unequal

distribution of fresh water in time of a year and space between high mountainous and lowland areas. Moreover, the quality of water decreases significantly in some industrial and population centers due to the weak pollution control and management toward the economic development in the areas. The activities related to the forests exploitation and upstream construction (hydropower stations, reservoirs) also pose some negative impacts such as soil erosion making the water more turbid and increase of salinity intrusion process.

In general, the situation of ground water is similar to the surface one. The different is that due to the development of the economy and the improvement of living standard, the water demand in Viet Nam is ever more rapidly increasing, especially in major cities and industrial centers. The groundwater resources of good quality is unevenly distributed and their exploitation capacity is not consistent with the water demand in those areas. The quality of ground water has been degraded in some places due to its overexploitation, the pollution of surface water sources and the effects from inappropriate activities such as clay soil exploitation for making brick.

For a developing country as Viet Nam, the resources exploitation for economy development is important especially in the coastal areas with highly valuable living and non-living resources. The increase of economy and population at this stage in some way is synonymous with the increase of resources exploitation in both intensity and subjects leading to the increasing pressure on the resource reservation and environment protection. Nowadays, the overfishing is quite severe in the shallow water areas.

Viet Nam's sea is one of the world centers of biodiversity having a great number of marine habitats such as deltas, lagoons, mangrove forests, coral reefs, seagrass beds, estuaries, tidal flats, upwelling areas and coastal islands. The exploitation of living resources includes the activities in fisheries and aquaculture and the exploitation of mangrove forests, coral reefs, seaweeds and seagrasses.

Almost all of the habitats listed above are being exploited and in parallel to the benefits gained from them, the reduction of their reserves and their environment degradation are the actual and serious problems. The root cause of this is the inadequacy in the understanding their nature and value and the economic underdevelopment of the country.

The population of Viet Nam is over 75 mil. with the average population growth rate of 2%. The population of the coastal areas is estimated of about 18 mil. with the growth rate of 2.5%. The economy in the coastal areas is less developed that leads to the overexploitation of resources and habitat degradation by using inappropriate exploitation means.

The unplanned migration to the Mekong Delta has a tendency to be increased resulting in increasing the pressure of forest and mangrove forests damages in the area.

The reclamation of coastal land for agriculture seems to be no longer developed, while that for the aquaculture is still developing causing negative impacts such as propagation of diseases in living aquatic species, reduction of mangrove forest area, environment pollution and coastal erosion and eutrophication which can lead to the red tide phenomenon and toxic algae disaster.

The bloom of small mechanical catching facilities in coastal areas, the low educational level and inadequate law and regulation and enforcement of the environmental protection are threats to coastal water quality and aquatic living habitats.

The forest cover in Viet Nam has been reduced for recent decades. The annual renewable area is about 50 - 100 thousands ha, while the lost one is 110 - 120 thousands ha.

The illegal and untidy exploitation of forests leads to the increase of soil erosion, river water turbidity and floods causing the deposition on navigation channels and turbidness of coastal swimming beaches, the death for corals and disappearance of some valuable aquatic living species in the coastal areas.

The nonliving resources in the marine and coastal areas are diverse including deposited minerals, coal, construction materials, petroleum, fertilizer soil and water. The exploitation is however concentrated on the shore line except for the petroleum. The exploitation of nonliving resources leads to the reduction of aquatic habitat area, degradation of coastal water and ecosystem quality, air and noise pollution, soil quality degradation, coastal erosion, scenic value damages and oil pollution due to the accidents.

Stepping into the period of opening policy, the tourism in Viet Nam is developing with high rate. The number of tourists in 1996 is estimated of in 6 - 7 times larger than that in 1990. About 80% of tourists come to sea beaches.

The tourism of Viet Nam is planed to receive 3.8 mil. of foreigners and 11 mil. of domestic tourists for the year 2000 and 9 mil. and 25 mil respectively for the year 2010. Facing this very fast development of Viet Nam tourism, the infrastructure upgrading and extension on the coast of tourism areas are actual requirements. This can cause more severe consequences for the marine and coastal environment and habitats.

The marine and coastal resources and environment of Viet Nam are affected by natural conditions also. There are about 207 storms and 54 tropical deprecies occurred in the South China Sea during the period 1975-1995), sea level rise and El-Nino phenomenon (the sea level rise of 2.24 mm/year has been recorded Hon Dau, Hai Phong Province is an example of the global sea level rise together with the local tectonic lowering, the temperature of the surface layer water increases while its nutrient content decreases).

The transboundary effects can include the impacts of these natural phenomena, incidents and accidents in the marine transportation and oil exploitation, the hot spots and high risk areas and the river flows of the Red and Mekong rivers networks.

The water related problems and issues described above will be discussed in details in the subsequent sections. The data and information for their assessment are derived from different sources including the annual reports of MOSTE of Viet Nam on the status of environment, the annual reports on the environment status of DoSTE of Provinces, the results of surveys and monitoring activities and the final reports of number of related national and international projects. The data and information cover almost all Viet Nam's cities and industrial and population centers especially those located along the coast. However, it can be seen that there is a lot of information and data gaps of related issues, which have both spatial and temporal characters and many data series are inadequate or having scientific uncertainties. The geographical units used in organizing the data and information are illustrated in the Figure 1 and listed as below:

Cities:

Ha Long, Quang Ninh Province
Hai Phong
Hanoi
Viet Tri
Thanh Hoa
Vinh, Nghe An Province

Hue
Da Nang
Nha Trang
Qui Nhon
Ho Chi Minh
Vung Tau

Bays:

Ha Long and Bai Tu Long, Quang Ninh Province
Da Nang, Da Nang City
Dung Quat, Quang Ngai Province
Qui Nhon, Binh Dinh Province
Vung Ang, Ha Tinh Province
Van Phong, Khanh Hoa Province
Ganh Rai, Ho Chi Minh City

Tourism beaches:

Bai Chay, Quang Ninh Province
Do Son, Hai Phong Province
Sam Son, Thanh Hoa Province
Cua Lo, Nghe An province
Nha Trang, Khanh Hoa Province
Vung Tau, Ba Ria-Vung Tau Province

River mouths (rivers, province):

Ba Lat (Red River, Thai Binh and Nam Dinh Provinces)
Van Uc (Van Uc River, Hai Phong Province)
Thai Binh (Thai Binh River, Thai Binh and Hai Phong Provinces)
Nam Trieu (Bach Dang River, Hai Phong Province)
Hoi (Ca River, Nghe An Province)
Lo (Cam River, Nghe An Province)
Da Nang (Han River, Da Nang City)
Dai (Thu Bon River, Quang Nam Province and Da Nang City)
Dai, Tieu, Dinh An (Mekong River, Tien Giang, Ben Tre, Soc Trang and Tra Vinh Provinces)

Other marine and coastal waters:

Transect of the Tonkin Gulf (North Central Viet Nam)
Spratley Archipelagoes (Khanh Hoa Province)
Con Dao Island (Ba Ria-Vung Tau Province)
Gulf of Thailand

The water related environment is managed by the National Environment Agency (NEA) of the Ministry of Science Technology and Environment which has been found in 1993. Many institutions have been involved to address the problems and issues related to the water. Together with the conventional agencies responsible for the water related problems management, the list of these institutions is presented as follows:

LIST OF INSTITUTION RESPONSIBLE FOR WATER RELATED MATTER

Name	Function
1. National Environment Agency, MOSTE	Environment Management for the whole country
2. *Ministry of agriculture and rural development*	Management of fresh water, structure
- Institute of water resources	(In Hanoi)
- Institute of economic and research on water resources	(In Hanoi)
3. General department of Hydro-Meteorological services	Management research of Hydro-Meteorology
- Institute of Hydro-Meteorology (IHM)	(In Hanoi)
- Center for Marine Hydro-Meteorology	(In Hanoi)
- Branch Institute of Hydrometeorology	(In Ho Chi Minh City)
4. Ministry of fisheries	Management and research
- Institute of Marine Products (IMP)	(In Hai Phong)
- Institute of Fresh water products	(In Hanoi)
5. National Center for Natural Science and Technology	National Research Center
- Institute of Oceanography (IO)	(In Nha Trang)
- Branch Institute of Oceanology (HIO)	(In Hai Phong)
- Branch Institute of Oceanology	(In Hanoi)
- Center for Marine Survey Research and Consultation (CMESRC)	(In Hanoi)
6. Ministry of Transport and Communication Management and research	
- Transport and communication design Company	(In Hanoi)
7. Ministry of heavy industry:	Research
- Institute of Mine and Geology (In Hanoi):	Ground water

8. National Monitoring Network of water and air

- North Region Station: Responsible by the Institute of Civil Engineering (In Hanoi)
- Central Region Station: Responsible by the Center for Environment (In Ho Chi Minh City)
- South Region station: Responsible by the Polytechnics university (In Ho Chi Minh City)
- Baseline Meteorological Station at Cuc Phuong Forest: Responsible by IHM
- Acid Rain Station at Lao Cai
- Gulf of Tonkin Region Station: Responsible by HIO
- Central Coastal water Region Station: Responsible by CMESRC
- South Viet Nam Shelf water Region Station: Responsible by the IO
- Deep Sea water Region Station: Responsible by the NAVY-Viet Nam
- Con Dao Water Region Station: Responsible by IMP

The report is the production of collective works of different institutions and individuals, which are listed below. It has been completely reviewed and revised by the Center for Marine Environment Survey, Research and Consultation (CMESRC) based on the component reports of the experts in different fields such as marine biology, marine habitats and ecosystems, surface fresh water, ground water, aquatic freshwater and marine living resources, marine land-based pollution sources, marine environment legislation, policy and management. The purpose of this report is to provide background data and information and experts understanding and expertise on the environmental problems and issues for the regional transboundary diagnostic assessment conducted by UNEP. There is an advantage in the preparation of the report that almost all data and information on Viet Nam environment has been derived recently together with increasing attention of the Government paid during the last years. The weaknesses are dealt with the limitations in the systematization and synchronism of the collected data. There are also big gaps in some types of data such as marine dumping, shipbased pollution sources, atmospheric inputs into aquatic environment, and those related to the transboundary effect.

LIST OF CONTRIBUTING INSTITUTIONS AND INDIVIDUALS

Institutions:

1. National Environment Agency (NEA), Ministry of Science, Technology and Environment (MOSTE)
2. Center for Marine Survey, Research and Consultation (CMESRC)
3. Branch Institute of Oceanography in Hai Phong (HIO)
4. Institute of Ecology and Biological Resources
5. Institute of Mines and Geology
6. Center for Water and Air Control

Individuals:

	Name	Institution	Function
1.	Dr. Nguyen Ngoc Sinh	NEA	Responsible for the report
2.	Eng. Hua Chien Thang	NEA	Responsible for the report, redaction
3.	Prof. Dr. Pham Van Ninh	CMESRC	Pollution, redaction
4.	Dr. Nguyen Minh Son	CMESRC	Pollution, redaction
5.	Eng. Nguyen Vu Tuong	CMESRC	Pollution
6.	Eng. Le Nhu Nga	CMESRC	Mapping
7.	MSc. Nguyen Hoai	Independent Consultant	Fresh water, redaction
8.	Dr. Nguyen Xuan Duc	Institute of Ecology	Marine Living Resources
9.	Prof. Mai Dinh Yen	National University	Fresh water Living Resources
10.	Dr. Nguyen Dinh Lam	Institute of Mines and Geology	Ground water
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14.	Dr. Nguyen Van Tien	HIO	Modification of aquatic habitats
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2. DETAILED ANALYSIS OF THE POLLUTION PROBLEMS AND ISSUES

2.1 POLLUTION

2.1.1 Sources of pollution

2.1.1.1 Rivers

• The territorial area of Viet Nam (including the coastal islands and the offshore Paracel Islands and Spratley Archipelagoes) is about 330,000 km^2. The average river density for the whole country is 0.6 km/ km^2 and for 3/4 the Viet Nam area is ranged from 1.0 to 1.5km/ km^2.

There are about 2500 rivers of the length more than 10 km each. Due to the rather thin size of Viet Nam almost the Vietnamese rivers are small and moderate composing 90% of the total number of rivers. Among them 90% of rivers have the catchment less than 500 km^2, 66.35% of which (1556 rivers) have their basin less than 100 km^2. The biggest rivers systems such as Hong, Mekong, Ma, Ca have large catchment areas extended to the neighbouring countries. The main direction of the river flow in Viet Nam is NW-SE and forwards to the South China Sea, including the Gulf of Tonkin, excluding the Ky Cung-Bang Giang river systems in the North East part of Viet Nam, which is the upstream part for the related rivers in China.

Along the coast line of over 3200km, every 20 km there exist a river mouth. There are only 9 big river systems with the catchment area of more 10,000 km^2 each. They are, from the north to the south: Hong (Red River), Thai Binh, Ma, Ca, Thu Bon, Ba, Dong Nai and Cuu Long (Mekong). The total basin of these river systems is about 70% the country territory, i.e. about 230,000 km^2. Annually, the Viet Nam's rivers discharge 940 k m^3 of water to the sea. In the Figure 2 the main river systems together with their catchment areas are presented.

Table 1. Water Balance Components

Components	Quantity
Rainfall	640 k m^3
Total river flow	313 k m^3
Underground flow	94 k m^3
Surface flow	219 k m^3
Evaporation	327 k m^3

The table 2 shows the main characteristics of the 9 biggest river systems.

Table 2. Characteristics of the Main River's Systems [Ninh]

River system and Rivers	CA. area (km^2)	River length (km)	Average height of CA. (m)	Average slope of CA. (%)	Average discharge (m^3/s)	Annual water volume (k m^3)
1.Red River system						
1-Thao	51,750	902	647	29.9	796	26.4
2-Da	52,610	1,013	965	36.8	1744	56.4
3-Lo	38,970	469	884	19.7	980	32.2
4-Hong	154,720	1,126			3630	85
2.Thai Binh System						
1-Cau	6,064	288	190	16.0	43.7	4.7
2-Thuong	3,580	164	186	9.4	32.8	1.76
3-Luc Nam	3,066	175	207	16.5	38.6	1.8
4-Thai Binh	15,520	385			318	38
3.Kycung-BacGiang s.						
1-Bang Giang	4,565	108	482	20.1	73.5	2.4
2-Kycung	6,663	243	386	18.1	26.9	0.85
4.Ma system						
1-Ma	28,370	538	762	17.6	326	10.8
2-Chu	7,552	325	790	18.3	135	4.9
5.Ca system						
1-Ngan Sau	3,813	135	362	28.2	124	4.0
2-Hieu	5,330	228	303	13.0	112	3.82
3-Ca	27,224	531	294	18.3	430	13.6
Gianh	4,676	158	360	19.2	60.8	2.0
Quang Tri	2,500	156	301	20.1	104.6	3.3
6.Thu Bon system	10,590	205	552	25.5	444	14.0
Tra Khuc	3,180	135	558	18.5	162	5.1
Ve	1,260	91	170	19.9	44	1.4
7.Ba system	13,814	388	400	10.9	184	5.8
8.DongNai-SaiGon s.						
1-Dong Nai	29,520	586	470	4.6	693	29.7
2-La Nga	4,000	272	468	5.6	83	5.3
3-Be	8,200	344	240	5.3	240	10.3
4-Sai Gon	5,560	256			167	5.2
9.Mekong system						
1-Se San	17,500					12.5
2-Sre Pock	18,280					10.6
3-Cuu Long	795,000	4,200			13.974	550

Viet Nam belongs to the high rainfall countries. The average value is about 2000mm/year, ranging from the lowest rate of 650mm/year at Phan Rang-Phan Ri (Binh Thuan and Ninh Thuan Provinces) to the highest rate of 4000-5000mm/year at Bac Quang (Ha Tuyen Province) and Bana (Quang Ngai province).

In the Table 1, components of the water balance in Vietnamese territory are presented.
The rivers in Viet Nam are the main sources of the marine pollution.

• Sediment transport

The total alluvia discharge of the Viet Nam rivers to the surrounding marine area is 200 - 250 million tons/year. The Red Rivers system has the most important contribution of this alluvial volume - 114 million tons/year. It is the eight river in the world in term of alluvial amount. The average value is ranged from 1000 g/ m^3 in the delta to 1700 g/ m^3 - 3000 g/ m^3 in the upstream area. The maximal alluvial concentration observed:

at Lao Cai Station (Thao River) is 21,000 g/ m^3
at Ta Bu Station (Da River) is 13,000 g/ m^3
at Son Tay Station (Red River) is 6,950 g/ m^3

More than 90% of the alluvial volume is contributed in the rainy season.

The rivers in the Middle Viet Nam have average alluvia value less than the Red Rivers system. However, in the rainy season, the suspended solid is still quite high. For example, the maximal value at station Cua Rao of Song Ca is 15,500 g/ m^3, at station Cam Thuy of Song Ma: 3,900 g/ m^3 and at Thap Buoi of Song Cau: 4,960 g/ m^3.

The biggest river system in Viet Nam- the Mekong system has rather modest alluvial concentration. Even in the flooding season i.e. in August, September, the average concentration is only about 300 g/ m^3 and the maximal value is 700 - 800 g/ m^3 only. But because of its great water discharge, the total alluvial volume is very significant. The Red and Mekong Rivers system compose about 90% the country rivers alluvial discharge. The solid discharge of the rivers in Viet Nam plays determining role in sedimentation in the coastal zone, making the seaward land expansion of high rate at the Thai Binh, Ninh Binh and Ca Mau coasts.

Together with this alluvial amount, there is a significant amount of nutrients for the agriculture. It is equal to 1 ton of fertilizer for 1000 m^3 of alluvial river water.

2.1.1.2 Coastal Provincies and Coastal Population

Table 3. The Coastal provincies and their population of Viet Nam are (statistics in 1996)

City	km^2 area	Population
Quang Ninh	5,938	812,905
Hai Phong	1,503	1,447,523
Thai Binh	1,495	1,632,545
Nam Ha	2,424	2,474,000
Ninh Binh	1,386	800,000
Thanh Hoa	11,138	2,993,239
Nghe An	16,449	2,415,425
Ha Tinh	6,053	1,166,107
Quang Binh	7,983	646,972
Quang Tri	4,592	458,763
Thua Thien Hue	5,009	819,352
Quang Nam-Da Nang	11,989	1,738,088
Quang Ngai	5,856	1,041,966
Binh Dinh	6,076	1,245,142
Phu Yen	5,223	641,792
Khanh Hoa	5,258	817,530
Ninh Thuan	3,530	412,000
Binh Thuan	7,892	824,000
Tien Giang	2,377	1,483,256
Ben Tre	2,225	1,214,329
Tra Vinh	2,363	901,000
Soc Trang	3,139	1,124,000
Kien Giang	6,358	1,197,911
Minh Hai	7,697	155,342
Ba Ria-Vung Tau	1,965	670,243
Tp. Ho Chi Minh	2,029	3,924,435
Total	137,947	32,557,865

The coastal provincies compose 42% of total area and 44% of total population of the whole country.

2.1.1.3 Coastal Cities and their population:

There are some cities located right on the shoreline:

No.	City	Population	year of census
1	Ha Long	255,000	1995
2	Hai Phong	500,000	1997
3	Da Nang	667,200	1997
4	Nha Trang	301,500	1996
5	Quy Nhon	236,200	Jan. 1998
6	Vung Tau	154,505	1995

2.1.1.4 Industrial Pollution from Coastal Installations

In Viet Nam, there are few industrial centers located on the shore line. They are Ha Long, Da Nang, Nha Trang, Quy Nhon and Vung Tau cities. The others are located in the catchments of the rivers and pollutants discharged by them go to the sea through river flows especially in Hai Phong and Ho Chi Minh cities.

- Ha Long: In Ha Long city there are coal industry, oil terminal B12, Cai Lan Port, Ship building factory, electric generation plant and food processing factories. The pollutants are dust, oil, COD, BOD, total N, total P, heavy metals and high temperature waste water.

- Hai Phong: In Hai Phong, there are port, ship building, ship repairing, building material (cement and brick), machinery, chemical and food processing factories. There are 9891 industrial units (big companies, moderate and small factories and enterprises). The pollutants are dust, oil, BOD, COD, total P, total N, heavy metals and Ecoli.

- Nha Trang, Quy Nhon: Industry is small, most of the pollution sources are domestic waste.

- Da Nang: There are some industries such as food processing (48%), textile, leather (12%), machinary production (8%) and 9 port in operation. The pollutants are oil, BOD, COD, Total N, Total P, Ecoli and Heavy metals.

- Vung Tau: There are port, machinery services, oil and gas platforms. The pollutants are oil, heavy metals.

- Offshore industrial installations: In the Figure 3, the area of oil and gas exploitation and exploitation and related activities are shown.

Table 4. The productivity of crude oil is as follows:

Year	Productivity (1000 tons)
1986	40
1987	280
1988	678
1989	1,459
1990	2,500
1993	5,000
1994	7,000
1995	7,700
1996	8,800

Drilling platforms are installed mostly in the South Viet Nam shelf and some of them in the nearshore region of the Gulf of Tonkin and the central water. The oil and gas industry involves two kinds of pollution sources: Permanent pollution and oil spill. Monitoring of water in the area of oil and gas industry in the South Viet Nam has been conducted at 6 stations with the following coordinates:

N°1 - 9°32'N, 107°49'E
N°2 - 9°39'N, 107°55'E
N°3 - 9°45'N, 107°55'E
N°4 - 9°45'N, 108°05'E
N°5 - 9°51'N, 108°00'E
N°6 - 9°51'N, 108°05'E

in two monitoring time periods: June - July and November - December 1996, for the surface water layer. The results show a high concentration of oil as presented in the next table:

Table 5. Average oil concentration (mg/l)

	Station 1	Station 2	Station 3	Station 4	Station 5	Station 6
June - July	0.528	0.556	0.562	0.570	0.592	0.556
Nov.-Dec.	0.498	0.558	0.496	0.576	0.520	0.548

Sources: Monitoring Results, Navy, 1996

The oil amount enters the sea water from the drilling platforms is estimated of 270 tons (1995) and 550 tons (2000) (Trimar, 1995).

From 1990 to 1996, 12 oil spills (from 2-3 m^3 to 15 m^3) have been reported.

2.1.1.5 Discharge from upland and lowland activities

Almost all cities, towns, factories and industrial zones of Viet Nam were built near main rivers of coastal zone (some of them are at the sea coast). Waste water is coming from industrial and population centers and discharges though drainage system to surrounding ponds, lakes, canals and rivers or straight way to coastal waters without treatment. As a result, surface water being polluted flows down and mixes with the sea water causing pollution especially for coastal water body. Recent studies on the establishment of pollution control initiatives for 3 main economic zones in Viet Nam (northern, southern and central) have given some information and data on land based pollution sources in general and sewage sources in particular (Ninh P.V. et all, 1997; Sy P.C. et al., 1997).

Table 6. Waste water sources in the Northern Economic Zone

	Population	Daily amount of waste water(m^3)	Contents
Hai Duong City	146,000	15,000-20,000 (domestic)	BOD (6.75-7.88 tons), COD (10.51-14.89 tons), TTS (24.82-32.12), Oil and grease (1.46-4.38 tons), Total N (0.88-1.75 tons), Amoni (0.35-0.7 tons)
Sao Do town - Pha Lai area,	35,000	1,500-2,500 (industrial)	BOD (3.2%), COD (4.5-8.9%), T (8^0 higher than environs), DO,TTS,Cu,Zn,Pb excess limits
Industrial zone Nhi Tieu,	164,445	5,600 (industrial) 300 (domestic)	COD(90-318mg/l), BOD(3.15-38.5mg/l) Oil and grease (14.8-16mg/l)
Hung Yen Town,	47,000	>200,000 (industrial)	BOD, COD, NO3, toxic substances
Ha Long City,	141,538	7,000 (domestic) 3,000 (industrial)	COD, BOD, organic pollutants, nutrients containing nitrogen of the type NH3
Cam Pha Town,	139,399	3,000 (domestic) 10,000 (industrial)	COD, BOD, NH3, SO4, oil and grease
Uong Bi Town	117,000	1,4000 (power plant); 700,000 (other industries)	Pb, Zn, Cu, S in 7-10 times higher than allowable limits
Hai Phong City,	1,447,523	18,000 (industrial) 50,000(domestic)	almost all types of pollutants
Hanoi City	3,056,146	93,3000(industrial and domestic)	almost all types of pollutants

Source: Ninh P.V. et al., 1997

In the Southern Viet Nam, the major waste water sources are located in Ho Chi Minh, Bien Hoa and Vung Tau cities, which badly pollute their receiving sources such as Dong Nai, Sai Gon and Thi Vai rivers and Vung Tau coastal water. There is insufficiency of drainage systems leading to the receiving sources. The amount of waste water from industrial zones in the southern economic zone is estimated in the following table (Tables 7 and 8):

The discharges of domestic waste water for cities in the economic zone are presented in the Table 8. Discharges of pollutants (kg/day) from domestic waste water are described in the Table 7.

Table 7. Waste water discharge by industrial zones in the Southern Economic Zone (SEZ)

Industrial/ manufacturing zone	Receiving source	Area ($1000m^2$)	Waste water (m^3/day)	TTS (kg/day)	BOD5 (kg/day)	COD (kg/day)
Ho Chi Minh City		**327**	**160**	**2,903.8**	**1,792.0**	**4,172.5**
Tay Bac	Sai Gon River	4	160	35.5	21.9	51.0
Tan Thuan	Sai Gon River	198	7,290	1,758.3	1,085.0	2,526.5
Binh Chieu	Sai Gon River	65	2,600	577.2	356.3	829.4
Sai Gon-Linh Trung	Dong Nai River	60	2,400	532.8	328.8	765.6
Binh Duong Province		**203**	**8,120**	**1,802.6**	**866.8**	**1,727.7**
Song Than 1	Sai Gon River	88	3,520	781.4	482.2	1,122.9
Song Than 2	Sai Gon River	45	1,800	399.6	246.6	574.2
Viet Huong	Sai Gon River	70	2,800	621.6	138.0	30.6
Dong Nai Province		**1,141**	**131,568**	**29,208.0**	**6,484.3**	**1,439.5**
Bien Hoa 1	Dong Nai River	313	88,000	19,536.0	4,337.0	962.8
Bien Hoa 2	Dong Nai River	300	14,000	3,108.0	690.0	153.2
Nhon Trach 1-2	Thi Vai River	103	5,768	1,280.5	284.3	63.1
Go Dau	Thi Vai River	70	3,920	870.2	193.2	42.9
Ho Nai	Dong Nai River	125	7,000	1,554.0	345.0	76.6
Song May	Dong Nai River	198	11,088	2,461.5	546.5	121.3
Vinh Cuu	Dong Nai River	32	1,792	397.8	88.3	19.6
Ba Ria - Vung Tau Province		**150**	**8,400**	**1,864.8**	**414.0**	**91.9**
Phu My	Thi Vai River	150	8,400	1,864.8	414.0	91.9
	Total	***1,821***	***161,168***	***161,168***	***161,168***	***161,168***

Source: Sy P.C. et al., 1997

Table 8. Amount of domestic waste water in (SEZ)

Cities	Province	Receiving source	Population	Waste water discharge (m^3/day)
Ho Chi Minh City		Sai Gon River	4,795,000	479,500
Thu Dau Mot Town	Binh Duong	Sai Gon R.	122,000	12,200
Thuan An Urban Area	Binh Duong	Sai Gon R.	60,236	6,024
Bien Hoa City	Dong Nai	Dong Nai R.	388,315	38,832
Ba Ria Town	Ba Ria-Vung Tau	Coastal water	76,820	7,682
Vung Tau City	Ba Ria-Vung Tau	Coastal water	167,529	16,753
Total:			**5,609,900**	**560,990**

Source: Sy P.C. et al., 1997

The assessment of gross fluxes of heavy metals transported through six major river mouths of Viet Nam has been carried out in the National Project KT.03.07 implementation and can be reviewed in the following (Table 9).

Table 9. The yearly gross fluxes of heavy metals transported by 6 major river systems [Ton/year]

River	Cu	Pb	Cd	Zn	Co	Ni	As	Hg
Thai Binh	3,974.2	154.3	163.9	3,352.0	19.8	11.0	342.5	16.5
Red	2,817	730	118	2,015	254	142	448	11
Han	37	16	na	79	na	na	28	na
Thu Bon	62	16	na	192	na	na	na	na
Dong Nai-Sai Gon	na	102.2	na	77,015	na	na	na	25.55
Mekong	1,825	190	128	1,278	na	na	982	<13

Source: National Project KT.03.07, 1995 (na: not available)

Extrapolation has been made from the results obtained for the studied 6 river networks to the whole country. It is resulted in the Table 10.

Table 10. Gross fluxes for the whole country [ton/year]

Region	Cu	Pb	Cd	Zn	Co	Ni	As	Hg
North	6,791	885	282	5,367	274	253	790	28
Central	293	76	na	676	na	na	44	na
South	11,000	1,102	800	15,696	230	270	1,600	105
Country	18,084	2,063	1,082	21,739	503	523	2,407	134

Table 11. Annual amount of oil and oil products entered to Viet Nam marine water [tons]

Estimated amount (ton) Source	1992	1995	2000
Offshore oil exploitation and exploration	200	270	550
Land-based	4.040	5.300	7.500
Navigation incidents	500	500	1.500
Tanker accidents	2.300	3.500	7.500
Port operation (including discharge from boats and ships in ports)	340	450	600
Total	**7.380**	**10.020**	**17.650**

Source: (NEA, TRIMAR - Sweden, 1995)

The oil pollution sources are mainly from navigation activities, port operation, boat washing and daily operation related to fuel use, commerce and management. It is ought to note that a large amount of oil polluting marine and coastal water is coming from land. The annual amount of oil and oil products entered to Viet Nam marine water is estimated in the table 11.

The assessment in the Project KT.03.07 also gives the estimated gross fluxes of some nutrients discharged to the sea through 6 main rivers as presented in the Table 12.

Table 12. Gross fluxes of some nutrients transported by major rivers (tons/year)

River	NO_3^-	PO_4^{-3}
Thai Binh	10,466.3	9,887.5
Red	14,860	24,602
Han	2,475	36.3
Thu Bon	62	16
Dong Nai -Sai Gon	79,570	10,220
Mekong	27,941	1,470

Source: Ninh P.V. et al. , 1995

It is impossible now to identify the contribution of China and other countries to the load and concentration of contaminants of the Red and Mekong rivers. The state of data does not allow even to know the portion of natural sources and that from human activities.

The amount of solid waste generated in major cities of Viet Nam is significant and a half of it is not collected. The collected waste amount, in general, is carried to temporary dumping sites with no treatment and regard on sanitary regulations. The waste amount, not collected or from the dumping sites can badly affect not only the surrounding environment, but also river streams and coastal water at the end, especially under the impact of run-of during the rainy and flooding seasons.

The synthesis report on environment monitoring and analysis, 1996 of the Center for Urban and Industrial Environment Technologies gives the status of waste management for the 1996 for number of cities (Table 13).

Table 13. Waste management status for the 1996.

No.	City	Estimated waste amount (m^3/day)	Collected waste amount (m^3/day)	xcrement + Sew sludge (ton/day)	Dumping sites
1	Hanoi	3600	2324	23.4 (=18 m^3/day)	Me Tri, An Thanh, Lam Du
2	Hai Phong	922	526	25	Thuong Ly
3	Lao Cai	42	24	na	Cau Sap
4	Hue	229	132	na	Doc Mit
5	Ha Long	310	315	na	Deo Sen-Cai Lan
6	Da Nang	723	350	na	Khanh Son
7	Buon Me Thuo	na	340	na	Buon Kep
8	Vung Tau	na	120	na	Phuoc Co
9	Bien Hoa (Dong Nai)	na	150	na	Tan Trung
10	HCM City	9,568	7,300	na	Go Vap (Binh Chanh), Dong Thanh (Hoc Mon)
11	Can Tho	na	230	na	Chau Thanh
12	Tan An (Lon An)	na	29	na	Loi Binh Nhan
13	My Tho (Tien Giang)	na	370	na	My Tho
14	Rach Gia (Kie Giang)	na	72	na	Nghia Trang
15	Minh Hai	na	680	na	Bac Lieu (Ca Mau)

Source: Center for Urban and Industrial Environment Technologies,1996.

The state of pollution form the land side of Viet Nam is presented in the Figure 5.

2.1.1.6 Ports and Harbors - Maritime transport

At present, there are 60 ports and harbors big and small located in estuaries and at shore line. Among them, 17 are big ones including Cai Lan, Hai Phong, Da Nang, Quy Nhon, Sai Gon, Vung Tau, Thi Vai (they can be seen in the Figures 1 and 3). Following the statistics, the Viet Nam fleet is small and rather old, in average, 16-17 years. There are about:

130 small vessels with the tonnage below 1,000 tons
122 vessels 1,000 - 5,000 tons
120 vessels 1,000-10,000 tons
30 vessels more than 10,000 tons

In the year 2000, this fleet will be risen to 2 millions tons of tonnage. It is estimated that, in tones, the amount of oil discharged into the sea as follows:

Table 14. Oil discharge into the sea (tons)

Reason	1995	2000
Ports activity	450	600
Maritime accident	500	1500
Tanker accident	3500	7500

Sources: TRIMAR, 1995

For the ports maintenance, the drainage work has to be conducted regularly because in general the problem which sedimentation occurs every where. It can be seen that the owning the port network together with the oceanic traffic development (see the Figure 3), Viet Nam is facing more and more the threats of this kind of pollution sources.

2.1.1.7 Sea-bed exploration and exploitation

Apart from the above mining of mineral at shoreline and offshore exploration and exploitation of oil and gas, there is no activity on the sea bed.

2.1.1.8 Marine dumping

At present, the marine dumping is not reported in Viet Nam.

2.1.1.9 Atmospheric inputs to the aquatic environment

In general, the atmospheric input to the aquatic environment is not studied in Viet Nam. Only the dust from coal mining and processing in Quang Ninh is evident. Beside of the coal particles transported by river flows, the coal dust falls to and already covers a large area of the Ha Long Bay and Bai Tu Long Bay, causing a death of coral reefs and degradation of the bays water quality.

2.1.2 Pollution hot spots

The pollution hot spots evidently are the Ha Long Bay, Hai Phong Port, Dang port, Vung Tau, Ganh Rai. They are presented in the Figure 4.

• Ha Long Bay

Ha Long is a new city with different units of industry such as coal mining, mechanical, energy and marine transportation. The industrial sector of Quang Ninh is extremely economically important to the Province, producing 33% of its annual GDP. The dominant industrial facilities are a series of open pit and shaft anthracite coal mines. The estimated productivity of Quang Ninh coal mines (Hon Gai and Uong Bi) is as follows:

Table 15. Coal Productivity of Quang Ninh (Mil. tons)

1996	1998	2000	2005	2010
3.199	3.878	7.291	9.410	9.310

Sources: Coastal and marine Environment Management for Ha Long Bay, EVS, 1996.

Up to now, 200 million tons of coal have been removed from these mines and about 1.6 billion tons of spoil have been produced by the mines over their operation life. The amount of spoil at 2010 will reach 700 million m^3. In addition, washing mined coal produces about 3 million ton of sludge every year.

Another problem connected with the coal mining is dust. Spoil and dust make serious problem for Quang Ninh area. The cumulative results are serve and include:

- Loss of shoreline habitat.
- Nearshore and offshore declines in water quality by surface water contamination.
- Contamination of bottom sediments.
- Damage to important biological resources such as coral reefs, seagrass beds and spawning grounds for fish and other living species.
- Local air quality degradation.
- The creation of large "barren lands" with the absence of reclamation activities of dump sites and deforested watersheds.
- Extreme occupational health hazards from coal dust all most stages of the coal mining operation and
- Decreases in the scenic beauty of the coastal areas.

The industry in Ha Long city discharges 3,100 m^3/day with COD, BOD, NH_3 in to Ha Long and Cai Lan Bays. Cam Pha town discharges about 10,000 m^3/day with BOD, COD, NH_3, SO_4, oil from brewery, choosing coal and exporting coal industries. Uong Bi town discharges about 72,000 m^3/day with Pb, Zn, Cu, SO_4 from the coal mining and electropower generation.

The following table presents the industrial units which are potential to pollute the Ha Long Bay:

Table 16. Industrial units potentially pollute the Ha Long Bay

No.	Name of industrial	Productivity	Waste water
1	Beer Ha Long	5 million lit/year	140 m^3/day, COD, BOD, total N, total P
2	Export of marine products	750 tons/year	95 m^3/day, COD, BOD, total N, total P
3	Oil stock		Oil, oil products
4	Cai Lan port	19 million ton/year	Oil, oil products, organic contaminants
5	Viet Nam-Poland Ship building		COD, BOD, Oil, oil products, heavy metals
6	Hoanh Bo Electricity plant	600-700 MW	Water of high temperature

Oil terminal B12 located in the Cua Luc Mouth, on the side of the navigation channel to the deep sea Cai Lan Port, receiving the ships of 30,000 DWT. In 1996, about 1.8 million tons of oil and oil products is transported through the port and in the future it will be:

Year	2000	2005	2010
Mill/tons	1.8	2.0	3.1

- Hai Phong: Hai Phong is the third biggest city in Viet Nam. The urban population is 564,200. There are 9891 industrial units of all sizes including the big, moderate and small ones. It has a port with the capacity of 3.5 million tons (proposed of 5 million tons in 2000 and 6-7 million tons in 2010 year). The coastal water of Hai Phong receives a significant amount of pollutants:

BOD	3,235	tons/year
COD	4,331	tons/year
TSS	5,036	tons/year

The water is polluted also by oil (0.55 mg/l), Zn (0.080-0.086 mg/l), Cu (0.025-0.064 mg/l) and fecal Coliforms (1500 col/100 ml).

Solid waste generated by the city is about 1,123 m^3/day including 566 m^3/day from in industry, 13 m^3/day from hospitals and 2 m^3/day of hazardous waste. Waste water is about 68,000 - 72,000 m^3/day including 18,000 - 20,000 m^3/day from industry and 1,000 m^3/day from hospitals.

- Da Nang

Da Nang is the second port city in Viet Nam. Its population is 667,200 (1997) (could be 1,000,000 in 2010). There are 767 industrial units operating in the Da nang area with three industrial zones including Da Nang, Hoa Khanh and Lien Chieu. The port system in Da nang consists of nine ports, three among which are oil port. Their capacity is about 3 mil. tons/year and could be 22 mil. tons/year in 2010. The Da Nang Bay receives:

COD:	3,236	tons/year
NO_3-N:	2,475	~
PO_3-P	36.3	~
SiO_2	6,204	~
Fe	1,782	~
Mr	126	~

Cu	37.5	~
Pb	15.9	~
As	27.8	~
Zn	79.5	~
Organic N	4,126	~
Organic P	26.1	~
TSS	194,136	~

The water in the Bay is polluted by oil (1.5 - 3.3 mg/l), NO_3 (0.443mg/l), Hg (0.001-0.003mg/l), Coliform (5-270 $x10^3$), Ecoli (5-140 x 10^3), Zn (0.141mg/l) and Fe(0.314mg/l).

• Ganh Rai-Vung Tau

This region consists of Vung Tau city and Ganh Rai estuary. Vung Tau city is a small peninsula of 172.65 km^2 in area and 154,505 in population. It is the biggest tourism center of Viet Nam with 2,622,000 tourists every year (1995). The tourism season is almost around the year. Apart from tourism activities, Vung Tau is the location for the oil and gas industry service including the machinery sector and port.

Beside the pollution discharged by Vung Tau city, there is also the contaminated river flow of the Sai Gon-Dong Nai River. The water quality of Ganh Rai Bay is definitely controlled by the river discharge. The pollutants amount discharged at Nha Be is as follows:

Table 17. Pollutants amount at Nha Be Station

Pollutant	Amount (tons/day)	Pollutant	Amount (tons/day)
SS	57	BOD	5.6
NO_3-N	218	Pb	0.28
PO_4-P	28	Zn	211
SiO_2	7	Hg	0.07

Table 18. Some pollutants concentrations at Soai Rap River Mouth

SS	155-207	mg/l
DO	5.1-5.7	-
Pb	0.005-0.015	-
Zn	0.005-0.035	-
Ni	0.003-0.005	-
As	0.002-0.005	-
Co	0.001	-
Oil	0.15	-

Table 19. Some pollutants concentrations at Ganh Rai Bay:

BOD	4-11	mg/l
SS	150-260	-
DO	4.5-5.7	-
TN	0.2-0.5	-
TP	0.02-0.05	-
Oil	0.15-0.25	-
Zn	0.02-0.04	-

The coastal area of Vung Tau-Ganh Rai is rich in mangroves, which serves as a fish and shrimp grounds.

2.1.3 Sensitive and high risk areas

In Viet Nam the most sensitive and high risk areas are Ha Long Bay, Hai Phong port, Ganh Rai-Vung Tau, Red River Delta and the Mekong River Delta (Figure 4). The first three areas have been already described in 2.1.2. Hereby, only the last two sensitive and high risk areas are considered.

- Red River Delta (RRD): It is the coastal zone located on the west side of the Gulf of Tonkin from Hai Phong to Ninh Binh. There are two river systems going to the coast of RRD including the Red and Thai Binh ones. The coastal zone together with these river mouths are rich in marine biological resources (mangroves, shrimp and fish grounds, bird stock). The following tables 20 - 23 show the threats from the pollution sources to this high risk area.

Table 20. Gross fluxes of contaminants transported by Red River (tons/year)

Cu	Pb	Cd	Zn	Co	Ni	As	Hg	PO_4^{-3}	NO_3	NH_4	DOT
2817	730	118	2015	254	142	448	12	14860	24602	352	400

Table 21. Contaminant concentration in the coastal zone of Red River (µg/l)

		Cu	**Zn**	**Cd**	**Ni**	**Co**	**Pb**	**Hg**	**As**	**PO^-_4**	**NO^-_3**
Dry season	In river	36.7	35.6	2.8	2.3	5.6	17.0	0.075	9.4	120	307
	At river mouth	37.2	47.6	3.3	2.7	8.2	8.1	0.504	21.3	70	144
	Sea	5.7	22.8	2.9	2.6	7.1	5.5	0.02	20.4	30	90
Flood season	In river	63.0	75.0	4.6	3.4	9.6	10.7	0.24	12.7	448	728
	At river mouth	43.0	55.0	4.2	4.0	9.6	12.5	0.32	7.7	224	121
	Sea	19.2	53.3	4.1	2.3	8.7	8.1	0.25	6.5	77	85

From the above Table, it can be seen that Cu, and Zn mean values excess the allowable limits (Vietnamese standard, 1995)

Table 22. Gross fluxes of contaminants transported by Thai Binh River (tons/year)

Cu	Pb	Cd	Zn	Co	Ni	As	Hg	NO_3	PO_4
3974	154	164	3352	20	111	343	17	10466	9888

Table 23. Contaminant concentration in the coastal zone of Thai Binh River (μg/l)

	Area	**Cu**	**Zn**	**Cd**	**Ni**	**Co**	**Pb**	**Hg**	**As**	**PO^-_4**	**NO^-_3**
River Kinh Thay	In river	84.0	76.0	3.8	1.8	0.5	3.1	0.3	6.9	212.0	220.0
	River mouth	71.0	57.9	3.2	2.1	0.7	2.7	0.4	8.2	490.0	210.0
	Sea	54.6	54.7	2.0	2.0	0.3	2.3	0.4	8.1	98.4	171.0
River Thai Binh	In river	81.0	63.0	3.1	1.9	0.3	3.3	0.4	7.4	221.0	211.0
	River mouth	80.8	56.7	3.1	2.3	0.8	2.7	0.4	6.5	250.3	260.5
	Sea	66.0	40.8	4.3	1.8	0.5	2.2	0.4	5.7	177.5	112.0

- Mekong delta: The Mekong Delta is considered as a coastal zone of the Mekong River Delta from Tien Giang Province to Ho Chi Minh City (Ca Mau Cap). In it, there are biggest areas of mangroves in Viet Nam with shrimps and fish grounds. It is considered as a high risk area.

The severity of issues in the sensitive and high risk areas is ranked as presented in the table 24.

Table 24. High risk areas evaluation

Name	Type	Public health	Drinking water quality	Aquatic life	Recreation	Other beneficial uses	Welfare and economy	Weighted total	Relative importance index	Water treatment	Transboun-dary Aspects	Preliminary Estimated Financial Requirement
Ha Long city	industry, domestic	4	1	5	4	4	3	16,9	90	building	F,B,P,H	28,000,000 ($US)
Hai Phong	port	3	1	3	5	4	5	16,7	89	building	F,B,P,H	40,000,000
Red River estuary		2	2	5	3	4	5	16,4	88		F,B,H	
Mekong River		2	1	5	3	4	5	16,0	86		F,B,H	
Da Nang	port	3	1	4	4	5	5	17,4	93	building	F,B,H	
Vung Tau-Ganh Rai	industry, domestic	5	1	3	4	5	5	18,7	100	building	F,B,H,P,L	

2.1.4 Transboundary effects of pollution

The pollution effects on biosphere in general are as follows:

- The fishery productivity decreases but it seem to be the results of overfishing and prohibited methods of fishing. It is difficult to determine the role of pollution effects. Even the reason of shrimp death at the shrimp ponds of Minh Hai Province is still not clear. It may be caused by eutrophication or some diseases.
- The tourism value is little affected by visible oil pollution on the water surface at Ha Long Bay and Do Son, Sam Son, Quy Nhon and Vung Tau coastal waters.
- The biodiversity in coral reefs are already affected by dust and turbid waters in Ha Long Bay, in Con Dao and some other islands where there is almost no corals nowadays. So these habitats are being strongly affected. For the mangrove forests, the biodiversity is in degradation. There are less and less number of species in these areas.

From the point of view of transboundary effects we can pay attention to the pollution sources at Ha Long City, Hai Phong Port, Red and Thai Binh rivers in the North and Sai Gon - Dong Nai and Mekong rivers and Vung Tau City in the South. Indeed, the circulation caused by monsoons can bring pollution especially oil spills spread to the coast of Hai Nan Island and the coast of Quang Chau Province of China, while the most dangerous sources for Cambodia, Thailand and Malaysia are the pollutants transported by Sai Gon - Dong Nai and Mekong rivers and the Vung Tau City in the South. The figures of the circulation patterns 6 and 7 show the main direction of currents in the South China Sea. It is necessary to note that there exist eddies of a small scale which are not described in the pictures. The sources located in the middle can hardly affect the other countries.

The sources of oil pollution and potential oil spill are the drilling platforms in the Gulf of Tonkin and the Self of the South Viet Nam. The Chinese coastline as well as the coastal waters of Cambodia, Thailand and Malaysia can be affected by these sources.

2.2 FRESHWATER SHORTAGE AND DEGRADATION OF ITS QUALITY

2.2.1 Surface water

2.2.1.1 Sources and status

Viet Nam is a tropical country with large amount of rainfall and huge number of storms. The average rainfall amount is 1960 mm/year with the total amount of water of 650 k m^3 /year. However, there are many differences between the rainfall amount in different areas of the country. Somewhere, this amount is only 800 mm (Nha Ho, Binh Thuan) while it reaches to 4000 - 5000 mm in others (Bac Quang, Ha Giang).

River systems

Three quarter of 331,100 km^2 the total area of Viet Nam are mountains. There is also a very complicated river system with one estuary in each 20 km of the coastal line. It is counted that the number of rivers more than 10 km long is about 2360. Over 90% of these rivers have the length between 10-50 km. The following table (Table 25) shows the area, number and proportion of rivers which have the length of more than 10 km.

Table 25. River classification according to catchment area (F)

$F(km^2)$	<100	100-500	500-1000	1000-3000	3000-5000	5000-8000	8000-15000	15000-20000	20000-30000	Total
Number of river	1556	614	81	55	16	11	3	1	8	2345
Proportion (%)	66,35	26,2	3,45	2,34	0,68	0,47	0,13	0,04	0,34	100

Source: Tran Thanh Xuan

In Viet Nam, the river and streamline systems are divided in to "river systems " and " single river ". River systems with the catchment area of more than 10,000 km^2 are Ky Cung - Bang Giang, Thai Binh, Red, Ma, Thu Bon, Ba, Dong Nai and Mekong. All the main rivers in Viet Nam originate from neighbouring countries, run into South China Sea such as: Mekong, Red river, Ma, Ca. or from Viet Nam and go back to other countries: Ky Cung, Bang Giang, Quang Son-Cao Bang. Hence, it is needed to take into account these international characteristics when using water of those rivers.

Total annual flow

Total average annual water volume discharging in to the sea of all rivers in Viet Nam is about 825 k m^3, in which there are 515 k m^3 generated from neighbouring countries, and 310 k m^3 generated in Viet Nam inner country according to data set of 1961 - 1990. Table 26 shows the total average annual river water volume discharging to the sea.

Domestic water resources are distributed unequally in different areas. The stream module of Ninh Thuan, Binh Thuan's coastline is lower than 5l/s. km^2 while this parameter is more than 100l/s. km^2 in Bac Quang area.

Table 26. Total average annual flow of river systems in Viet Nam

	River systems	**Catchment area (km^2)**			**Total average annual flow volume (km^3)**		
		Outside country	Inside country	Subtotal	Outside country	Inside country	Subtotal
1	Ky Cung-Bang Giang	1980	11200	13180	1.68	1.47	3.15
2	Thai Binh	-	15180	15180	-	10.0	10.00
3	Hong	82300	72700	155000	45.6	83.1	128.7
4	Ma	10800	17600	28400	5.21	13.7	19.0
5	Ca	9470	17730	27200	4.30	19.9	24.2
6	Thu Bon	-	10350	10350	-	17.9	17.9
7	Ba	-	13900	13900	-	9.0	9.00
8	Dong Nai	6700	37400	44100	3.20	31.3	34.5
9	Mekong	724000	71000	795000	455.6	51.4	507.0
10	Other rivers	-	64600	64600	-	66.0	66.0
	Total	835250	331690	166900	515	403.77	820.15

Source : Tran Thanh Xuan

Viet Nam's surface water resources are contributed by main river systems (Table 27) Mekong river has the biggest water amount (62%), the second one is Red River 16 % and the last one is Ba River.

Table 27. Distribution of Viet Nam's surface fresh water resource

River system	Proportion (%)
Ky Cung-Bang Giang	1
Thai Binh	1
Hong	16
Ma	2
Ca	3
Thu Bon	2
Ba	1
Dong Nai	4
Mekong	62
Other rivers	8

The water resources' distribution closely relate with the distribution of rainfall. The areas with larger rainfall amount are the one with the bigger flow and vice versa. The following table (Table 28) shows the counting results of surface water resources in different areas.

Table 28. Distribution of water resources by territory

Region	Area (Km^2)	Total water volume (Km^3)	Average water volume per $1Km^2$ (10^6m^3)
Northern hill and mountain part	104297	151.97	151.97
Red River delta	11455	51.55	51.55
Northern central part	51980	77.88	77.88
Southern central part	100336	105.53	105.53
Southern central delta	45607	51.82	51.82
Tay Nguyen part	55296	53.71	53.71
South-east part	23496	18.58	18.58
South-west part	39876	520.60	520.60

As river water, lake and reservoir water play very important roles in surface water resources conservation in Viet Nam. Lakes and reservoir are to regulate river flow, to increase flow in low flow season, to decrease it in flood season and support to regulate the local climate condition. It is counted that, there are 460 lakes in Viet Nam with the volume of more than 1 million m^3 and the total water amount in them is of 23 billion m^3.

The water flow of rivers in Viet Nam are not distributed evenly in the year. About 60 - 90% are concentrated in 3 - 6 highest flood months, the rest are in low flow season. This character is a big problem in using natural water resources for local communities and for the national socio-economic development.

River streams in coastal zone are quite strongly affected by South China sea's tide. Topographical and hydraulic characteristics and river water discharge control the propagation of tide in to rivers. Tide enter to 180 km upstream in Red river, 36 km in Ma river, 60 km in Ca river and 400 km in Mekong river.

Water quality

Sedimentation in rivers: Soil erosion and washed off sedimentation on the land and in the rivers, channels are the causes of the sediment in the rivers. Sediment flow in Viet Nam's rivers has different seasonal characteristics. The clear season comes in the low flow season and the turbid season is the wet season. Over 90% of the total annual sediment amount is in the flood season. Red river has the largest sediment concentration among rivers in Viet Nam.

Average annual turbidity in Viet Nam's rivers ranges from 100 g/ m^3 to over 500 g/ m^3. The biggest turbidity observed at Lao Cai station (in the Red river) is 21,000 g/ m^3. In Mekong river it is only 700 - 800 g/ m^3.

Viet Nam's rivers transport about 400 - 500 millions tons of suspended sediment to the sea. In this volume, Mekong river contributes 215 million ton, Red river: 115 million ton, Ma river: 5,3 million ton and Ca river: 3,7 million ton.

Sediment in the river is very useful for agriculture. It provides fertilizer, phosphate, Nitrogen, Calcium and others for vegetable and rice. According to the account, the fertility of 1000 m^3 of Red river's water can be equal to 1 ton of excrement.

It is uncomfortable when using Viet Nam's river's water for industrial purpose, especially due to its high turbidity in rainy season. River water should be treated before using.

Chemical components of the river water:

Mineralization: Generally, the mineralization of Vietnamese rivers is low (about 250 mg/l). Red river's mineralization is approximately of 200 mg/l, Mekong - 150 mg/l, the rivers in the south central and east southern areas have the mineralization of 20 - 50 mg/l.

pH Level: Alkalinity of water is at middle and low levels in the rivers of the Northern Viet Nam. The pH in rivers of the Southern Viet Nam such as Dong Nai is lower than 6. Especially in the rivers of Dong Thap Muoi, Long Xuyen and some other areas it goes down to the value lower than 3.0.

Hardness: According to international standard, river water in Viet Nam is soft and even very soft. Hardness of rivers are usually lower than 3 mge/l. The Dong Nai River has the lowest hardness (lower than 0.4 mge/l).

Main ions: All the rivers in Viet Nam are of " Bicarbonate style". However, the ratio between HCO_3^- and anions depends on different river systems. HCO_3^- is nearly 70% of anion in the Red and Mekong rivers. The rate is about 50% in Dong Nai river. In the rivers that have low mineralization, the concentration of Ca is less than the sum of Na and K. The others such as Cl^-, SO_4^{--}, Mg^{++},$Na^+ + K^+$, are very small and do not change much.

Biogens: Most of biogens, which exist in Vietnamese rivers is SiO_2. The concentration of SiO_2 is usually over some main ions such as Cl^-, SO_4^{--}, Na^+, K^+. The concentration of NH_3^-, NO_2^-, NO_3^-, PO_4^{3-} are lower than 3mg/l.

Salinity intrusion problems:

Salinity intrusion is one of the major problems in delta estuary of coastal zone. Water in the coastal delta is affected by salinity water from the sea, especially in low flow season when river streams are weak. The affected area depends on topographical and hydrodynamic conditions, the water amount from upstream and the level of tide.

The salinity effect is strongest in the Mekong River Delta, the second one is in Red River. In the Central and Southern Central of Viet Nam, the salinity affected distance is not too far as a result of steep slope and the presence of a number of dams in each estuary. Table 29 shows the salinity intrusion distance of some rivers in Viet Nam.

Table 29. Salinity intrusion 1 ‰ (g/l) in the river system of Viet Nam

N°	Name of river	Distance of salinity intrusion (Km)
1	Thai Binh	6-7
2	Ninh Co	11
3	Hong	10
4	Tra Ly	8
5	Day	5
6	Ma	<10
7	Ca	32
8	Dong Nai	117
9	Tien, Hau	40 - 60

Surface water pollution

Pollution sources: Most of cities, provokes, factories and industrial zones of Viet Nam have been built near main rivers of coastal zone. Industrial, agricultural and domestic waste waters are discharged directly to rivers, lakes, reservoirs without any treatment. As a result, not only surface water but also the ground water had been polluted.

The industry of Viet Nam is now not very well developing without high centralization. Manufactory without modern technology leads to a lot of waste gas, waste water and solid waste. Most of factories were built from 70s with 1950s technology, had no treatment systems. Table 30 shows some factors which cause pollution in domestic waste water.

Table 30. Total amount of pollutants in domestic waste water of some cities (Tons)

City	BOD_5	COD	SS	TDS	Total N	Total P
Hanoi	16500	36800	20000	36500	3300	400
Hai Phong	7425	16500	9000	16425	1425	180
Nam Dinh	5610	12512	6800	12410	1122	136
Vinh	4950	11040	6000	10950	990	120
Hue	3960	8832	4800	8760	729	96
Da Nang	8745	19504	16000	19345	1749	212
Quy Nhon	3795	8464	4600	8395	759	92
Nha Trang	5115	11408	6200	11315	1023	124
Ho Chi Minh	33000	106720	58000	105850	9570	1160
Can Tho	6600	14720	8000	14600	1320	160

In addition, use of pesticides for agriculture and other purposes is also another pollution source that lead to the degradation of surface water quality. Chemical weapons consequences of the Viet Nam - USA war is one of the factors that leads to water resource's pollution too. However, until today, it has not been fully analyzed and assessed yet.

Surface water resource pollution: In general, all the clean water of Viet Nam is in the river segments far away from cities and industrial zones. Water resource are good enough for supplying and other purposes. Average value of some polluted factors in river systems are shown in the Table 31.

However, surface water in urban areas and industrial zones has been polluted, even in danger.

Hanoi area: The pollution level of To Lich river is at Oligoxaprophit. The BOD amount fluctuates between 10 and 63.5 mg/l. Lu river has been polluted at Alphamezoxaprophit level; the amount of BOD is unstable between 16-27 mg/l. Kim Nguu river is in real danger with very strong pollution level (Polixaprophit) with the measured BOD of 35 - 180 mg/l. This is the most polluted river of Hanoi.

There are 20 lakes with the total area of 592 ha in Hanoi. Lakes, in general, are to store rainfall and waste water. The amount of suspended solid is between 100 - 150 mg/l, BOD from 15 to 45 mg/l, DO is 0.5 - 2 mg/l. BOD and suspended solid of lake water of Hanoi are polluted 5 - 20 times in comparison with Viet Nam Environmental Standard (VES).

Table 31. Average value of some pollution substances in Viet Nam's river water (10^{-3} mg/l)

substances	Red river	Thai Binh river	Mekong	Viet Nam Standard
Cu	36.7	84.00	0.030*	0.1
Zn	35.6	76.00	0.021*	1.0
Cd	2.80	3.80	0.002*	0.01
Ni	2.30	1.80	-	0.1
Pb	17.00	3.10	0.003*	0.05
Hg	0.075	0.30	<0.00002*	0.001
As	9.40	6.90	0.016*	0.05
PO4	0.12	-	0.020*	-
NO3	0.304	-	0.450*	-

Hai Phong area: In general, Hai Phong surface water has been effected by salinity. All the lakes inside as well as outside city are to store rain, storm and waste water. The BOD and suspended solid is 5 - 15 times higher than VES.

Ho Chi Minh city: Untreated industrial waste water and domestic water are directly discharged in to the Dong Nai and Sai Gon rivers. The result of water quality monitoring shows that the DO value is very low (from 0 to 1.2 mg/l), average value of BOD is 120 - 140 mg/l. Heavy metal (Pb, Cr, Hg) is about 20 times higher than the allowable limits.

2.2.1.2 The demand for surface water use

In Viet Nam, water resource is mainly used for agriculture and water supply purposes. Part of it is for other purposes such as tourism and industry.

Demand and status of using water in agriculture:

In agriculture, water is used for irrigation and fish-farming. There are 7.3 million ha of agricultural land including 82% for rice cultivation. Water is supplied for agriculture through 75 irrigation systems, 4000 lakes and reservoirs, 2000 pumping stations. 5.4 million ha has been irrigated until now:

Winter spring rice :	2,320,000 ha
Summer fall rice :	1,340,000 ha
Autumns rice :	1,440,000 ha

It is predicated that the agricultural area which will be irrigated till 2010 will increase from 5.0 million ha (1990) to 6.2 million ha. Consequently, the water demand will be risen on 72%, that means from 215.10^6 m^3 (1990) to 370,530 x 10^6 m^3 (2010).

There are over 213,000 ha of lake surface, which is 7.3 times larger than the area for fish - farming. Water for fish- farming may increase up to 40000 m^3/ha/year. At the moment, only 50% of it is used. The water area for fish - farming in 2010 will increase 3 times in comparison with the demand in 1990. The needed water amount will increase 3.6 times.

Demand and status of common-use water:

Depending on the standard, which indicated that one person need 200-300 l of water per day, the demand for all Vietnamese people is about 8 billion m^3 each year. It is predicated that 20 billion m^3 water would be needed for industry in the year 2000.

The total population of urban areas is 9,918,000 (1993). However, only 70% of them have been supplied with water of the amount of about 50 - 60l/person/day. The total water amount for urban areas is 1,842,460 m^3/day, three quarters of which are from surface water resource. Most of urban areas have been supplied with water but the water lost is about more than 40%. In addition, the water quality is not quite good.

At present, urban people is about 20% of the total population. This number will raise up to 30-35% in 2010. Hence, the demand of water use will increase by about 58% in comparison with the year 2000. The average increasing amount is 234,470 m^3/day.

In Viet Nam, 80% of the population live in rural areas (56 million people). Therefore, the water demand is very high in these areas. Clean water supply in the rural areas is estimated as follows:

Coastal zone:	18%
Delta:	25%
Hilly areas:	28%
Mountainous area:	5%

Fresh water which has been supplied for the rural areas in the late 1993 is 571,800 m^3/day.

The water demand in some places:

Red River catchment:

Water for agricultural use: Nowadays, the area to be irrigated is 961,417 ha. Nevertheless, only 80% of it has been supplied with water (680,727 ha). It has been predicted that by the year 2000, the water demand for agricultural use is about 15.10^9 m^3, equal to 12.3% the total surface water of Red river each year.

Water for common use: By the year 2000, the water demand for common use in the Red river catchment may reach to 878.10^6 m^3 which is about 0.72% the total surface water of the Red river. Water for industrial use in this area is about 1% of the surface water. Red river has such a huge hydro-electric potential. It is assessed that this potential is about 120.10^9 kw/h, which is about 40% of the whole country. Hoa Binh reservoir stores about 9.45×10^9 m^3 of water including 5.87×10^9 m^3 for flood control .

Dong Nai river catchment:

This area has such a very typical climate: long and severe dry-season, steep topographical characteristic, therefore, the demand of water for agricultural use is very high. The total cultivation area which needs to be irrigated is approximately 600,000 ha including 91,000 ha of industrial plants. The demand of water for this purpose is 3.1×10^9 m^3.

Also, the demand of water for electricity supply is really high. The theoretically hydro-electric potential of this area is up to 27.7 billion kw/h. In fact, the exploitable capacity is 8-10 billion kW/h. The table 32 shows the capacity of reservoir and the power of electricity supply of hydro-electric stations of Dong Nai river catchment

Table 32. The capacity of reservoir and the power of electricity

N°	Name of hydropower station	Capacity (10^6 m^3)	Power (MW)
1	Da Nhim	165	160
2	Tri An	2.765	400
3	Thac Mo	1.260	150

Until now, the total demand of using water in this area is 30% the total water amount of Dong Nai river. It is predicted that, this demand will increase up to 40-50% by the year 2000. This figure is over the exploitation limits of this river system.

Mekong river's Delta:

Almost all the water of Mekong Delta is used for irrigation and salinity wash off in agriculture. At present, water is enough for irrigation of 768,000 ha of winter spring rice, 72,000 ha of spring summer rice and 856,000 ha summer fall rice. In April, when the river discharge is smallest of the year, the water used for agriculture is of 20% the river water.

In addition, surface water is also used for living in urban and rural areas in the Mekong Delta (mainly from Tien and Hau rivers). By the year 2010, the demand of using water in this area will be 583,500 m^3/day including 412,000 m^3/day of surface water, which equal to about 1.5% the total amount of surface water.

2.2.1.3 The areas affected by the shortage and quality degradation of surface water:

In general, the natural water resource of Viet Nam is quite rich. The water demand in the next couple of years is only about 20-30% of the total amount of surface water. The water quality is still good and can meet the requirements of all purposes. However, the distribution of water resources is not stable during the year and all over the country: it is overabundant in wet season and underabundant in dry-season. The water quality in some urban and industrial areas decreases dramatically being polluted by the industrial and domestic waste water.

Water is not enough for supplying in some places such as Ninh Thuan, Binh Thuan, Son la, Ha Giang, etc. In some less-rainfall years, in dry season, many places had not have enough water, for example, Tay Nguyen area, Southern Central Part and some coastal area.

The building of lakes for electric generation and water store, however, has some negative impacts such as soil erosion, salinity effects which cause the degradation of water quality in the Red and Mekong rivers.

Most of the urban and industrial area in Viet Nam release waste water directly into lakes and rivers without treatments. It leads to the serious pollution of water resources in Ha Noi, Viet Tri- Lam Thao, Thai Nguyen, Ho Chi Minh city, Bien Hoa, etc. Navigation activities and mineral and oil exploitation also cause the serious pollution of canals and rivers in coastal area.

2.2.1.4 The effects of global climate change:

According to the new research of international meteorologists, the global climatic warming effect occurs because of many reasons among which the human plays a very important role. The global warming leads to the decline of falling-water amount and discharge of rivers in tropical zone.

Some recent researches of Vietnamese scientists have also proved that there are some changes in the country climate such as the average temperature of the air increases by 0.08-0.1^{o}C/10 years and the number of storm raises by 0.5 storm/10 years. Rainfall increases but the rainfall amount of dry season and of the whole year decreases on 0.1 - 0.5%. It leads to the amount of domestic water drooping for 6-20%. Flow in dry season decreases on 10 - 25%. Drought level raises.

According to "climate change and its impacts in Viet Nam " [12]:

- The delta of central part will be the most sensitive area with the climate change. Although water resource does not increase, the flood and drought will be more severe and usual.
- The north part will be more sensitive with drought than flood although the fact that water resources is enough for common use and other proposed.
- East - Northern Viet Nam would be in serious water shortage (annual flow would be decreased and drought increased).
- Southern Viet Nam would be most insensitive with climate change. Although annual discharge is quite stable, the number of floods coming from upper region tends to be reduced and drought might happen more frequently.
- It is predicted that, by the year 2070, droughts will happen more frequently all over the country. Climate change leads to the 3% of the increase of flood discharge, especially 6-8% in the central part. Flood discharge in the Red River will raise by 12 - 15% and the sea level increases about 90 cm. 0.5 million ha will be under water in Red river delta.

In conclusion, there is a fact that water and natural resources in Viet Nam have been affected by global climate change. Although this process is quite slow and lasting for so long time, its impacts are serious. There should be some further research, assessments and effective solution required to develop water resources of Viet Nam in the future.

2.2.1.5 Proposed interventions:

- Promulgating and improving the laws and regulations on surface water use, protection and management
- Developing surface water quality monitoring system, seriously conducting the control, management and treatment of waste water from watersheds.
- Strengthening public awareness on the protection and reservation of fresh water sources and the rational use of domestic water

2.2.2 Ground water

2.2.2.1 Ground water aquifers and current status

Generally speaking, groundwater in Viet Nam occurs in the following main formations:

Ground water in the unconsolidated sediments: Unconsolidated sediments are distributed in two majors plains (the Northern and Southern plains), coastal plains of Central region, the coastal sand dunes and river valleys in mountain regions.

a) In the Bac Bo plain, groundwater exists mainly in two main aquifers

(Pleistocene sand-gravel aquifer and Holocene sand-silt-clay aquifer).

The Holocene aquifer is the uppermost aquifer, with a thickness varying from a few meters to 20 - 30 m. The lithological composition is diversified, consisting of sand, clayey sand, clayey silt alternating with each other both in section and in area. The storage capacity is various, but in general from moderate to poor. The water level is near the surface. at the depth of 1 - 2m. The composition of the groundwater varies greatly, especially in the southern part of the plain. Fresh and saline groundwater are alternated with each other without any clear regulation. In the southern part, saline water areas predominate while in the northern part it is reverse. This aquifer is being tapped for rural water supply with the use of hundreds thousands small diameter drilled wells.

The Pleistocene sand-cobble- gravel aquifer occurs at the depth of 20 - 25 m in the northern part and 40 - 50 m, in some places 60 - 70 m in the southern part. This aquifer is of very good storage capacity. Drilled wells give a yield of hundreds to thousands of m^3/day. The water level is near the surface, in some place the groundwater overflows to the ground surface. In the northern part of the plain the groundwater is fresh. In the southern part the groundwater is mainly saline (t.d.s. > 1 g/1), but there still exist some fresh water lenses such as in Hai Hau (Nam Dinh), An Hai (Hai Phong), Dong Hung, Thai Thuy (Thai Binh). The groundwater in this aquifer usually has high Fe content (5 - 15 mg/1). Currently this aquifer is being tapped for water supply of Hanoi city (about 500,000 m^3/day), Ha Dong, Son Tay towns (27,000 m^3/day). Besides there are hundreds of individual drilled wells, each abstracting 100 - 1,000 m3/day.

b) The groundwater in the unconsolidated sediments of East Southern plain

In general, the groundwater in these sediments here is of good quality. Fresh groundwater predominates, with lower iron content than in the Northern plain. However, in many places the pH value is low (5 - 6.5), not good for water supply. Within the East Southern area there are many well fields such as the ones in Thu Dau Mot, Ba Ria, Tay Ninh, Ben Cat, etc. The total exploitation discharge reaches 40,000 m^3/day. Besides, there are tens thousands of small production wells for rural water supply also extracting groundwater from these sediments.

c) Mekong river delta

Almost all the groundwater in the upper part of consolidated sediments here is saline, cannot be used for drinking and domestic water supply. The fresh water in the area between the Tien and the Hau river occurs at a relatively great depth, usually 300 m, in some places up to 500 m. Whereas in the southern part of the Hau river, especially in Minh Hai area, fresh water is met at much smaller depth, usually at 100 - 120 m, in some places fresh water layers are also met at the depth of 200 m. In Minh Hai area at present there are hundreds of production wells extracting groundwater from these aquifers.

d) Central coastal plains

In general, these plains are narrow and have two aquifers. The lower aquifer is of better storage capacity than the upper one,. However, almost all of the lower aquifer is saline, fresh groundwater is -met only in some places close to the mountains. Therefore large scale groundwater exploitation cannot be carried out in the central coastal plains as in the Northern and East Southern plains. Only medium and small scale groundwater exploitation in these plains in appropriate manner can ensure long term production without salinisation.

e) Groundwater in coastal sand dunes and sand ridges

In Viet Nam coastal sand dunes and sand ridges are very widespread, especially along the coast of central region. In the sand dunes and sand ridges usually exist fresh groundwater lenses above saline water. The sizes of these lenses in general depend on the size of the and dunes and sand ridges. But in general the thickness of the fresh water layer is small. The groundwater is vulnerable to salinisation when inappropriately exploited. However, for the coastal areas where the surface water is usually saline, the groundwater in the sane dunes is a valuable source of water for water supply to the population. For example, in Dong Hoi, at present about 300,000 m^3/day of water is exploited from the Bau Tro lake, which is in fact groundwater in the sand dunes, for domestic water supply to in the town. In Ninh Thuan, a fresh water lake has been discovered on the sand dunes with a volume of over 1,000,000 m^3 (Bau Trang lake). This water source should be tapped for water supply to Phan Thiet town, where the rainfall is the least in Viet Nam and where the rivers are exhausted during the dry season and the groundwater is very scanty and saline.

f) Groundwater in river valleys in mountain areas

In the mountain areas of Viet Nam there are many river valleys which usually are population, administrative, cultural, service centres such as: Muong Thanh, Nghia Lo, Phan Uyen, Cheo Reo, Tuyen Quang, Ha Giang, etc. The valleys usually extend along the rivers forming them. The sediments here consist of two parts: The lower part is of coarse grain and have high storage capacity and the upper part is of fine grains and poor in storage capacity. The groundwater in these valleys usually have hydraulic relationship with the river and is of good quality. The intrinsic groundwater reserve in the river valleys is small. But after a period of exploitation, an induced reserve will appear if the water intake facilities are arranged appropriately and thus the water supply demand of the towns, townships and adjacent population communities can be met.

Ground water in basaltic formation: Basaltic formations are distributed widely in Kontum, Gia Lai, Dac Lac, Lam Dong provinces and scattered in South Central provinces. They form a plateau with uneven height and called in common as the Central Plateau.

The basaltic formations form a complicated hydrodynamic system, as they were formed from many effusive centres at various stages. The highly permeable porous basaltic sequences are alternated with solid unfractured basaltic layers in a complicated manners both in section and in area. Survey data have shown that the ratios of the numbers of springs and wells with low discharge to the ones with high discharge are relatively high. By statistics, of over 200 springs in Tay Nguyen, 65% have low discharge(0.1 l/s), and only 21 % have high discharge (>1 l/s). In some cases, a borehole drilled just beside springs with high discharge gives no water.

The survey results also confirmed that the variation of the groundwater level in the basaltic formations lags behinds that of the rainfall in the area for 2 - 4 month, even 5 - 7 months. This means that in many places only when the rainy season has terminated the groundwater level reaches the

peak, even at the middle of the dry season. This is favourable for the use of the groundwater to serve the irrigation in the Tay Nguyen region. The groundwater in the basalts is of very good quality. The water is fresh and all the components meet the requirements in the use of water for various purposes.

On the basaltic plateau there are sill no concentrated large scale well fields. But small water exploitation works are multiple. The groundwater exploitation facilities include tapping of springs which are very common in Dac Lac, dug wells provided pumps for irrigation, and small drilled wells wide spread in Pleiku town, Buon Me Thuot city or Xuan Loc area.

Ground water in carbonate formations: Within the territory of Viet Nam, the carbonate formations cover about 50,000 km^2 and they have important significance in the economy, defence and other services. They are also a notable environmental element. The carbonate formations themselves ire also an important construction material resource. Associated with them there are many other precious minerals such as iron, aluminium, gemstones, oil, etc. In the limestone area there are many magnificent landscapes attracting tourists and are also the places concealing many secrets of the history and national defence. The limestone areas are also are the habitats of many precious and rare plants and animals. They are also the places with difficulties for the engineering projects, especially the hydroelectric reservoir, mining, road building, etc., projects. The groundwater contained in the carbonate formations is strongly impacted by erogenous factors and human economic activities.

The results of investigations show that, the water bearing properties of the carbonate rocks varies strongly. Next to the springs with discharge of tens, even hundreds l/s are springs with discharge counted in percents of l/s. However, the water bearing characteristics in various areas are not equal.

Quang Ninh karst area: Usually there are springs with discharge 0.1 - 1.0 l/s. The specific capacity of the boreholes varies from 0.01 to 1.26 l/sm. The depth of the karst development is down to 120 m below the surface. In the coastal zone, due to the intrusion of the sea water, the groundwater is saline. Some production wells have been salinised to such extent that the t.d.s. is 3 g/1.

Bac Son karst area: Many springs have discharge up to hundreds l/s. The groundwater is fresh. Groundwater in limestone in some locations is being tapped for water supply to the population. In Lang Son, groundwater is being exploited with a rate of 6,000 m^3/d is for domestic water supply. In Dong Mam, karst groundwater is also being exploited for production and domestic water supply.

Cao Bang - Trung Khanh karst area: Due to high dissection of the relief, most of springs emerging at the bottom of the valleys have small discharge (0.5 l/s).

Son La - Moc Chau karst area: The groundwater has quality meeting the requirements for water supply. The aquifer occurs at the depth of 80 - 120 m. The storage capacity is low, the ratio of water yielding boreholes is low (l/7 in Son La, 1/3 - 1/4 in Moc Chau). In this area there are only individual production wells with capacity of a hundreds of m^3 /day.

Hoa Binh-Ninh Binh karst area: The ratio of water yielding boreholes is higher, 1/2 - 1/3. The aquifer is met at the depth of 50 - 80 m in the southward direction the t.d.s. of the groundwater increases. In this area, besides the well field in Bim Son extracting 20,000 m^3 per day, there are many individual wells, each extracting a few hundred m^3 per day.

Groundwater in other fractured formations (terrigenous, effusive, metamorphic and intrusive formations)

The terrigenous, effusive, metamorphic and intrusive formations are very widespread in Viet Nam. In general these fractured rocks have low water bearing capacity. Only the fractured zones of the tectonic faults, fold axes, the contact zones between rock types have better water bearing capacity. The groundwater in the fractured rocks has good quality, meeting the requirements for water supply of various purposes. In these areas, there are only individual drilled wells, each with capacity of a few hundreds m^3/day.

Table 33. Sustained yield of groundwater in the territory of Viet Nam

Water bearing formations	Sustained yields by regions (m^3/s)					
	North- east	North- west	Northern	North Trung Bo	South Trung Bo	Southern Plain
Unconsolidated	2.25	9.095	88.865	83.17	48.535	158.25
Basalt	-	-	-	13.005	51.300	-
Carbonate	12.55	40.97	-	22.80	-	-
Terrigenous	35.86	27.78	-	120.517	47.530	-
Metamorphic	27.65	86.945	-	69.565	562.84	-
Intrusive	47.128	40.79	-	72.904	108.62	-
Mixed	114.165	47.742	-	85.032	-	-
Total	239.4	214.832	88.865	466.996	312.825	1.58.25

Vietnamese hydrogeologists have calculated the sustained yields by regions and water bearing formations, as presented in table 33. The total sustained yield of the groundwater in the territory of Viet Nam reaches 128,500,000 m^3 /day.

2.2.2.2 Water demand by sector

As in the other countries of the region and the world, groundwater in Viet Nam has outstanding characteristics other than the surface water, which are:

- The groundwater is more stable in quantity and quality;
- The groundwater is less vulnerable to pollution;
- The exploitation of groundwater is simple, not requiring large area as the surface water exploitation.

Therefore, the demand for use of groundwater for water supply to the population and production is ever increasing.

The Vietnamese scientists, on the basis of the economic and population development, have forecast the urban and rural domestic water supply demand to the years 2000 and 2010 in various regions of the country (Tables 34, 35)

By comparison, the water demand to the year 2010 constitutes only 10% of the sustained yield of the territory. However, due to the uneven distribution of the groundwater in the territory and the water demand, in reality the water supply to population and production is still insufficient, especially in the cities, where the large amount of water for centralised water supply is required.

Table 34. Forecast of water demand to the year 2000 and 2010

No	Region	To 2000 (m^3/s)			To 2010 (m^3/s)		
		Urban	Rural	Total	Urban	Rural	Total
1	Northern plain	1004600	633170	1637770	1452860	1252700	2705560
2	Bac Bo midland and mountain region	265600	345160	610760	417100	726550	1143250
3	North Central	204600	411710	616310	372600	739600	1112200
4	South Central	272800	248990	521790	410900	348500	750400
5	Central plateau	77800	130400	208200	108000	333730	441730
6	East Southern	1280600	226740	1507340	1632300	425380	2057380
7	Mekong delta	3606001	520410	881100	470-100	608650	1079350
	Total	3466600	2516580	5983180	4855460	4435110	9290500

Table 35. Water demands for urban areas to the year 2010

No.	Area	Present water supply	Demand			Source
		Source	m^3/day	2000	2010	
1	2	3	4	5	6	7
1	Ha Giang town	Surface w.	4,000	4,700	7,300	Groundw.*
2	Tuyen Quang town		5,700	12,900	16,200	Groundw.*
3	Cao Bang town	Hien river	5,000	7,000	10,600	?
4	Lang Son town	Ground w.	6,000	9,000	12,000	Groundw.*
5	Lai Chau town	Surface w.	3,500	4,000	4,700	Groundw.
6	Dien Bien town			6,600	11,000	Groundw.
7	Yen Bai town	Red river	4,500	12,600	17,500	Groundw.
8	Nghia Lo town		2,000	3,000	5,000	Groundw.
9	Lao Cai town		7,000	7,800	11,000	Groundw.
10	Cam Duong town		3,500	*5,000*	10,000	Groundw.
11	Thai Nguyen city	Cau river	10,000	30,000	43,000	Groundw.*
12	Song Cong town	Cong river	*1,500*	3,300	6,000	Groundw.
13	Son La town		2,200	8,500	11,700	Groundw.
14	Viet Tri city	Lo river	18,000	20,600	30,000	Groundw.*
15	Phu Tho town	Red river	1,000	5,600	8,400	Groundw.*
16	Vinh Yen town		2,000	6,500	10,300	Groundw.*
17	Bac Giang town	Thuong river	*5,000*	13,700	17,600	Groundw.*
18	Bac Ninh town		1,500	8,400	12,500	Groundw.*
19	Ha Long city	G.W + S.W.	20,600	45,000	124,000	Groundw20%
20	Uong Bi town	Surface w.	5,000	12,000	16,000	Surface w.
21	Quang Yen township			3,000	5,000	Surface w.
22	Ha Dong town	Groundw.	16,000	19,000	22,000	Groundw.*
23	Son Tay town		11,000	13,000	*15,000*	Groundw.*
24	Ha Noi city		150,000	700,000	1,000,000	Groundw.*
25	Hai Duong city	Surface w.	20,000	25,000	35,000	Groundw.*
26	Hai Phong city	Surface.	108,000	*115,000*	*150,000*	Surface w.
27	Hung Yen town	Groundw.	10,000	7,000	9,500	Groundw.*
28	Thai Binh town	Tra Ly river	8,500	16,100	26,300	G.W. from Dong Hung
29	Nam Dinh city	Dao river	50,000	60,000	8,000	GW from Hai Hau

30	Phu Ly town	Day river	1,000	5,000	8,000	?
31	Tam Diep town	Groundw.	*500*	6,000	9,000	Groundw.*
32	Ninh Binh town	Day river	1,000	7,500	10,500	GW far away
33	Bim Son town	Groundw.	20,000	25,000	30,000	Groundw.*
34	Sam Son town	Groundw.	400	4,000	10,000	Groundw.*
35	Thanh Hoa city	Surface w.	5,500	24,000	50,000	GW far away
36	Cua Lo town			4,000	10,000	Groundw.*
37	Vinh city	Surface w.	26,000	38,000	50,000	GW far away
38	Hong Linh town			4,800	16,000	Groundw.?
39	Ha Tinh town			6,000	16,000	Groundw.?
40	Dong Hoi town	Sand dune	5,000	12,500	18,500	GW in sand
41	Dong Ha town			17,000	37,000	Groundw.?
42	Hue city	Surface w.		58,500	83,000	GW from far
43	Da Nang city	Surface w.		108,000	158,000	Surface w.
44	Hoi An town			*5,000*	8,000	Groundw.?
45	Tam Ky town			10,000	14,000	Groundw.?
46	Quang Ngai town	Groundw.		20,000	30,000	Groundw.*
47	Quy Nhon town	Groundw.		27,000	39,000	Groundw.?
48	Tuy Hoa town	Groundw.	3,000	14,600	26,000	Groundw.
49	Nha Trang city			*51,000*	70,200	?
50	Thap Cham town			17,000	24,000	?
51	Phan Thiet town			20,000	30,500	
52	Kontum town			10,000	14,000	Groundw.
53	Pleiku town		5,000	14,500	19,500	Groundw.*
54	Buon Ma Thuot city		11,000	20,500	28,000	Groundw.*
55	Da Lat city			24,000	33,300	?
56	Bao Loc town			8,500	13,500	Groundw.*
57	Ho Chi Minh city			1,128,000	1,400,000	30% Groundw.
58	Bien Hoa city			56,000	83,000	?
59	Ba Ria Vung Tau			*50,000*	80,000	50% Groundw.
60	Thu Dau Mot town	Groundw.	8,000	14,000	21,000	Groundw.*
61	Tay Ninh town	Groundw.	7,000	15,500	30,000	Groundw.*
62	Tan An		12,000	14,000	20,000	Groundw.*
63	Sa Dec town			12,500	19,000	Groundw.
64	Cao Lanh town	Groundw.	6,000	16,000	22,000	Groundw.
65	My Tho city	Groundw.	20,000	35,000	50,200	Groundw.
66	Ben Tre town	Groundw.	6,600	*15,000*	26,000	Groundw.
67	Vinh Long town	Groundw.		19,500	32,500	Groundw.
68	Tra Vinh town	Groundw.	8,00	11,700	15,900	Groundw.
69	Can Tho city	Groundw.		93,000	124,000	Groundw.
70	Soc Trang town		10,000	20,700	30,300	Groundw.
71	Long Xuyen town			30,000	42,500	Groundw.
72	Chau Doc town			13,500	20,000	Groundw.
73	Rach Gia town		3,000	28,500	41,000	Groundw.
74	Ha Tien town			8,300	12,700	Groundw.
75	Bac Lieu town	Groundw.	5,000	16,300	22,400	Groundw.
76	Ca Mau town	Groundw.	7,000	23,500	31,600	Groundw.

* The urban areas where water supply can be covered fully by groundwater

2.2.2.3 Areas and quality of groundwater and its impact

Together with the development of the economy, the water demand in Viet Nam is ever more rapidly increasing, whereas the groundwater resources with good quality is unevenly distributed, the groundwater exploitation capacity is not consistent with the water demand. This has caused certain impacts on the economic development of the country.

In the areas, where groundwater is of poor quality (due to the salinity), not meeting the quality requirements.

These areas are relatively widespread in the territory of Viet Nam. They include the coastal areas of the North Central Part and South: the cities of Ha Long, Hai Phong, Hai Duong, Nam Dinh, Thanh Hoa, Vinh, Da Nang, Nha Trang; the towns of Thai Binh, Ninh Binh, Ha Tinh, Ha Nam and most of the towns in the central coastal zone and those in the Mekong delta.

a) For the rural areas

The localities where the groundwater is of poor quality, the people use the fresh water sources available in the area, such as rain water, surface water. Village wells are very common practice in the Northern plain. Boat carrying fresh water for sale are common in the Mekong river delta.

In the past, due to the use of unclean water sources, water borne contagious diseases were very widespread. According to the Ministry of Health, every year the State had to spend tens of billions of VND for medicines to cure disease. Every year the community wasted millions of man-days to tend for the patients due to the use of unclean surface water.

In the recent years, in the rice field, the farmers have been using much chemical fertilisers and insecticides, causing the pollution to the surface water sources in many places. In some localities, industrial factories have been discharging wastes to the rivers. Examples are the Nhue and the Thi Vai river. A few years ago, the wastes discharged by some factories have killed the fish in this river on the reach from Hanoi to Phu Ly. Due to the industrial wastes, many reaches of Thi Vai river have been seriously polluted. The shortage of good quality water has adversely influence the life of the people.

b) For the urban areas

In the areas where the groundwater is of poor quality, surface water is used as the source for domestic water supply. At present, except Hanoi city which uses groundwater as the only source for water supply all the cities are using surface water as the main source, whereas the groundwater constitutes only a small ratio. The use of surface water for water supply has some difficulties and is expensive. In Ha Long, due to the shortage of groundwater, surface water from Dien Vong river has to be used for water supply by building a dam (Da Trang dam) across this river. But due to the waste from coal mining, the Dien Vong river has no more sufficient water, and the water became muddy. Another dam had to be built (Cal Van dam) 5 km from the old dam. This has caused an additional cost of tens billion VND.

The Hai Phong city, as the groundwater there is saline, had to use surface water from Vang Danh river (about 30 km from the city). Also due to the coal mining, the water is no more clean. At present, Hai Phong city is still using surface water sources for water supply and has to use reservoirs with area covering tens thousands of m2 and large water treatment plants.

Some other cities and towns also take surface waters for their water supply: Nam Dinh from Dao river, Hai Duong from Thai Binh river, Thai Binh from Tra Ly river, Thanh Hoa from Le Dynasty canal, Vinh from Lam river. Similarly, other cities and towns also takes surface water from the rivers flowing by them as the water supply sources. At present, due to the human activities, some rivers show indication of pollution. The tides also affect the quality of the water in the rivers.

For area where water is of good quality, but its quantity is in deficiency due to the incompatibility of the resource and demand

This case occurs in many towns and townships in the mountain regions.

2.2.2.4 Causes of groundwater deficiency

When the population growth and the economy is developed, the cultural level of the people increase, the economic structure changes and the water demand also increase intensively.. These are the main causes leading to the deficiency of groundwater both in quantity and quality.

For the rural area

In the past, the rural people did not pay much attention to the quality of the water they used for everyday life. They thought that "any water was clean". Therefore they used any kind of water for water supply (from river, ponds, lake, groundwater). At the end of the 1950s, in the North the campaign " Clean village and fertile rice field", then the campaign "Water well" were launched. Since then the awareness of the rural people has had considerable changes. Since 1982, thanks to the aid of UNICEF, the rural clean water programme was launched, which has changed radically the idea about the groundwater in the water supply. Now every peasant family wishes to have a water well. Therefore the demand of using groundwater has drastically increased. This is one of the basic causes of the groundwater deficiency. in the water supply. According to the calculation of UNICEF, one drilled well equipped with a hand pump would supply water to 15 - 20 peasant households. But actually each of these wells is used only for one family. For example, in the rural area of Hanoi south of the Red river, within one year only (from 1995 to 1996), 6,000 small diameter drilled wells have been added.

For the urban areas

a) Awareness of the clean water producing organisation

In Viet Nam, the specialised clean water producing organisations have not realised the advantages of the groundwater, therefore they still do not make use of the groundwater sources for water supply. Except Hanoi where groundwater is used for water supply, all cities and towns are using surface water as the main source of water supply, with a small percentage of groundwater. This occurs even where the groundwater is of good quality and fairly abundant in quantity. For example, Thai Nguyen city has a fairly large groundwater reserve with satisfactory quality, but the water of the Cau river is still used for the water supply here.

b) The hydrogeological investigations have not met the requirements for water use

In fact, the hydrogeological sector of Viet Nam was born as recently as in 1960. Although the hydrogeological sector has made great success in the groundwater investigation, many cities still use surface water for water supply. This is because the water supply systems there were established long before the groundwater investigations.

c) Rapid growth of the water demand

The water demand has been rapidly increase, whereas the capacity of the clean water producing organisation cannot keep up with the demand. Therefore most of the cities and towns have deficiency in water supply and low water quality. For example, in 1954, Hanoi produced every day 30,000 m^3 of water. In the sixties, the production was increased to 170,000 m^3 per day, in the seventies - over 200,000 m^3 per day, in the eighties - over 300,000 m^3 per day and since the nineties - over 400,000 m^3 per day. In the year 2000 the water demand is expected to be 700,000 m^3 per day and in the year 2010 it will be 1,000,000 m^3 per day. In the mean time, the capacity of the Hanoi Clean Water Business Company still cannot keep up with the demand.

d) Reorganisation of the economy

One of the reasons leading to the groundwater deficiency for water supply to the cities is the reorganisation of the production. According to the plan, many new industrial zones will be established and many new urban areas will arise. For example, Dung Quat port will be built together with the arising of Van Tuong city; the Chan May port together with the Chan May industrial and service area in the near future. Many industrial zones have been built in the areas of Ho Chi Minh city, Hanoi, Hai Phong, Da Nang. Many towns have been converted to cities (Thanh Hoa, Buon Me Thuot, Hai Duong, etc.). Thus there appear new water demand with greater amount and higher quality.

e) Transformation of the economy from bureaucratic-subsidising system to market oriented system is also an important reason

The transformation of the economy from bureaucratic-subsidising system to market oriented system is also an important reason delaying the investigation work, the necessary information cannot provided in time to meet the requirements for the reorganisation of the economy. The same happens to the water supply industry. In the former subsidising system, water used to be given free of charge. Now that the economy was transferred to the coast accounting and market - oriented system, the price of water cannot cover the cost. Therefore the water producing enterprises produce water in a precarious manner. This causes serious deficiency to the cities. In the mean time the water demand is still intensively increased. Private companies grasp this opportunity to drill water wells for their clients. But unfortunately the law for water management has not been adopted, therefore these private well drilling organisations operate with no practice licence, under no control, with no tax paid and no environment protection measures. To date, no statistics has been made of the number of private water well drilling teams operating in each city, each province and the number of wells drilled and abandoned every year. As for advantages, it is possible to say that thanks to the operation of private drilling teams, the problem of water supply in the urban and rural areas in the recent years have been alleviated. But the disadvantages are also great. The State loses every year tens of billions VND, the groundwater quality has been degraded to such an extent which still cannot be fully evaluated.

2.2.2.5 Global impacts on the groundwater in the territory of Viet Nam

The groundwater is recharged by the rain, therefore the global climate changes are having impacts on the groundwater in Viet Nam. Groundwater also is under strong impact of the surface water, therefore the economic activities on the river basins and in the offshore areas also affect the groundwater in the territory.

Global climate changes

The investigations of the climatologists have indicated that over the last hundred years, the number of typhoons in Viet Nam have increased in the recent years (Table 36).

Among the typhoons which have invaded Viet Nam, many large ones have broken the sea dike, making the sea water encroach the coastal zones and rendering groundwater saline.

Table 36. Number of typhoons having invaded Viet Nam over the last 100 years

Periods	North Viet Nam	Thanh Nghe	Binh Tri Thien	South Central	South	Total
1891-1900	13	6	5	10	2	36
1901-1910	18	10	12	11	2	53
1911-1920	10	5	5	10	3	33
1921-1930	9	6	6	6	4	31
1931-1940	14	13	7	13	5	52
1941-1950	14	2	3	8	2	29
1951-1960	17	8	9	8	2	44
1961-1970	14	10	13	12	8	57
1971-1980	17	14	14	13	9	67
1981-1990	19	14	10	17	10	70

The mean temperature and rainfall of the years from 1891 to 1990 in general have no significant changes. But abrupt change of the weather have been more and intensive.

The investigations of the isotope compositions have also indicated that after the signing of the agreements on ceasing nuclear weapon tests, the isotope concentration of the rain water and consequently that of the groundwater has been deceased.

According to the calculation of the scientists, the industrial production throughout the world have caused the green house effect and made the Earth's temperature increase by 2^0C. This leads to the thawing of ice in the North and South poles, and the sea level will rise up. Viet Nam has over 3,000 km of coast line. Many places such as in the Mekong delta the elevation is as low as 1m (M.s.l). These areas will be submerged under the sea. The invasion of the sea water into the groundwater will be much further inland.

Influence of the regional hydrological network

Both major rivers of Viet Nam (the Red river and Mekong river) originates from other countries in the region. The Red river is 1,200 km long, of which only 500 km flows in Viet Nam. This river has created the Northern plain. The activities in the Red river basin in China definitely have their effects on the quality of the groundwater in the Northern plain. The Mekong river, the

lower part of which is called Cuu Long river, flows from China through Mianmar, Thailand, Laos and Cambodia. With its length of over 4,500 km, only 200 km flows in the territory of Viet Nam. This river has created the Nam Bo plain. Thus the economic activities in the Mekong basin in the neighbouring countries would impact the groundwater in the Mekong delta.

Economic activities in the east sea such as oil and gas exploitation would definitely affect the groundwater in the coastal zone and the continental shelf where there are some pockets of fresh groundwater. However, up to present no investigation has been carried out for evaluation of the situation.

2.2.2.6 Recommendations for rational groundwater exploitation

Groundwater is both a natural resource and an element of the environment. Therefore when abstracting the groundwater one must make full use of the resource but not make the environment degraded. For rational exploitation of the groundwater, the following measures can be taken:

- *Preparation of the master plan for the groundwater exploitation*

The master plan for groundwater exploitation should be worked out for the whole country with a scale of 1: 1,000,000. At the same time plans should be prepared for key economic areas and provinces at 1: 100,000 to 1: 50,000 scale. The plans should be worked out by an unified method based on the data ever obtained. In the groundwater exploitation plan, besides the indication of groundwater quantity and quality required, it is necessary to indicate the methods of exploitation, depth of exploitation, the number of the exploitation facilities to withdraw the amount of water suitable with the hydrogeological conditions of the area.

- *Diversification of the water supply facilities*

Dug wells and drilled wells are the most common and widespread exploitation facilities in Viet Nam. The exploitation facilities of this kind are not suitable in the case of thin aquifer and the water demand is great. For this case other methods of groundwater exploitation, such as infiltration galleries, collector wells, can be applied. The facilities of this kind are suitable for groundwater exploitation in the sand dunes and pre-mountain areas.

- *For urban areas*

  + Arrange the well field outside the urban area, may be 30 - 50 km from the centre.
  + It is recommended to arrange pumping stations with capacity of 10,000 - 20,000 m^3/day for the well field to work effectively.

- *For rural areas*

Intensify the centralised groundwater exploitation facilities, providing water supply at village or commune scale rather than individual small diameter drilled wells which are currently widespread.

- *Policies of encouraging investment in the production of clean water should be adopted*

This is to allow domestic and foreign individuals and organisations to invest capital under a preference policy for producing clean water.

- *Establishment of a monitoring to monitor the variation of the ground water*

First of all, this should be concentrated to the most important water bearing formations (those in the unconsolidated, carbonate, basaltic formations), the key economic areas and the cities with large scale groundwater exploitation and utilisation.

- *Finalise the water management law and the subordinate legal documents*

- *Consolidate the management agency, rendering it powerful in the management of the groundwater resources*

- *Intensify the education for improving the awareness of the community about the exploitation and protection of the resources of the territory, to ensure sustainable development*

2.3 EXPLOITATION OF LIVING AQUATIC RESOURCES

2.3.1 Living freshwater resources

2.3.1.1 Status

It is estimated that around $1.4x10^6$ ha of inland fresh waters in Viet Nam including a large network of rivers with at least 2345 rivers of the length greater than 10 Km. The main river of Viet Nam are the Red and Mekong rivers with their lower basins resulting in two vast alluvial plains, which strongly support inland aquaculture. The total surface area of the Red River Delta is $1.9x10^6$ ha and of the Mekong River Delta is 4×10^6 ha.

Due to its geomorphologic pattern, high rainfall and dense network of rivers, Viet Nam has very rich and diverse biodiversity in inland water bodies. The lotic waters are rivers, streams, waterfalls, estuaries and the lentic waters are ponds, lakes, dams, rice fields,... The inland wetlands are distributed everywhere.

Freshwater biodiversity of Viet Nam

The freshwater bodies of Viet Nam are very rich and diverse in flora and fauna. There are 1402 microalgae in freshwater in the whole country, 324 invertebrate animals only in the North, the same number of invertebrate animals in the South. For the freshwater fish, there are 48 families, 217 genus and 471 species. Beside, there are more than 30 freshwater macrophytes, many batrachians, water turtles, snakes and some water mammals.

The freshwater biodiversity was divided into 11 freshwater biogeographical units. Every type of water bodies has its own community. It can enumerate pond and lake community, river, stream, wetland, estuary, irrigation channel and underground cave. The freshwater biodiversity of Viet Nam is rich and diverse because it develops in the good natural tropical conditions and different ecosystems.

One specific pattern of ecology of freshwater fish fauna here is that there are many migratory species. Many fish species are living in estuaries, deltaic water bodies, but they immigrate to the upper and middle courses of rivers for spawning (some species of Cyprinidae and Clupeidae).

Although the freshwater biodiversity index is high, the commercial species are not many:

Freshwater fish: about 50 species
Invertebrate animals:
- Crab: 1 species
- Shrimp: some species
- Water snails: some species
- Clams: some species
- Frogs: some species
- Reptiles : Water turtles, Trionyx and water snakes

Many phytoplanktons and macrophytes were exploited for animal husbandry.

Viet Nam is a country with traditional aquaculture. The culture fish species are carp and other phytophagous, Chinese carp species such as Silver Carp, Mud Carp and Grass Carp. With the financial and technical aids of the Government, the aquaculture develops well. Many exotic fish species are developed well in Viet Nam conditions. There are 24 culture fish species now in Viet Nam.

According to the report of the Ministry of Fisheries, the production of aquaculture of Viet Nam is illustrated in the Table 37 and for different provinces in the Table 38.

Table 37. Aquaculture Production in Viet Nam

1981	180,380	(tonnes)
1982	188,901	-
1983	204,530	-
1984	223,279	-
1985	230,400	-
1986	242,866	-
1987	251,000	-
1988	253,791	-
1989	283,327	-
1990	306,750	-
1991	335,910	-
1992	349,630	-
1993	372,845	-
1994	333,022	-

Source: Vo Van Trac, Pham Thuoc, 1995

Aquaculture production includes all inland fisheries (culture and capture) and coastal aquaculture.

Up to now the estimation of exploitation of freshwater living resources is very different, depending on the methods of calculation. Based on the data for different water bodies, it is estimated in the Table 39 for different socioeconomic regions and different types of water bodies. The South Viet Nam is ranked as the first region which has the best catching capacity.

Table 38. Production and Surface area of Inland Aquaculture of Viet Nam

Province/City	Area (ha)	Production (tons)	Province/City	Area (ha)	Production (tons)
Hanoi city	7000	7,500	Quang Ngai	3,700	1,500
Ho Chi Minh city	13,500	14,000	Binh Dinh	3,500	1,800
Hai Phong city	8,500	3,500	Phu Yen	2,300	1,200
Ha Tuyen	2,000	1,200	Khanh Hoa	4,000	2,000
Cao Bang	1,000	500	Thuan Hai	2,100	600
Lang Son	1,000	300	Gia Lai Kontum	2,100	700
Lai Chau	1,028	400	Dac Lac	5,300	1,200
Hoang Lien Son	21,000	2,000	Lam Dong	1,900	1,100
Bac Thai	5,000	3,000	Song Be	10,500	700
Son La	1,000	400	Tay Ninh	20,000	3,200
Vinh Phu	10,000	7,000	Dong Nai	29,000	3,500
Ha Bac	6,700	5,000	Long An	13,000	15,000
Quang Ninh	8,500	1,500	Dong Thap	10,000	24,800
Ha Son Binh	27,000	13,500	An Giang	14,000	33,000
Hai Hung	9,000	9,000	Tien Giang	8,000	8,000
Thai Binh	7,500	5,200	Ben Tre	27,042	24,000
Ha Nam Ninh	18,000	7,100	Cuu Long	31,600	40,500
Thanh Hoa	8,800	4,300	Hau Giang	33,000	30,000
Nghe Tinh	13,800	5,100	Minh Hai	107,000	36,000
Quang Binh	3,500	1,800	Kien Giang	5,500	4,000
Quang Tri	1,600	1,000	Vung Tau-Con Dao	1,300	400
Thua Thien Hue	4,000	1,410	Military		3,000
Quang Nam-Da Nang	5,730	1,500	Farm		3,500

Total: Production: 335.910 tones
Area: 520.000 ha

Table 39. The Estimated amount of captured fresh water fishes in different types of water bodies and socio-economical regions in Viet Nam Average annual in the years 80 (tones)

	Ponds/ cages(1)	Lakes Reservoirs	Ricefields	Rivers	Total
North	120,000	5,000	5,000	6,000	136,000
South	90,000	4,000	30,000	20,000	144,000
Center	5,000	3,000	900	3,000	11,900
High lands	5,000	1,000	100	500	6,600
Total	220,000	13,000	36,000	29,500	298,500

(1) From Aquaculture

Table 40. The weight of some fish species captured in the Mekong delta in 1977 and 1992 (Source: Mekong Delta Master Plan, 1993)

Fish species	Captured fish weight (g/individual)	
	1977	1992
1. Labiobarbus sp.	50-100	15-25
2. Cirrhinus microlepis	100-300	50-100
3. Cyclocheilichthys enoplos	500-1,500	100-200
4. Leptobarbus hoeveni	400-1,200	100-200
5. Morulius chrysophekadion	100-300	50-200
6. Ophiocephalidae	300-800	40-120
7. Osteochilus melanopleura	200-500	30-200
8. Ophiocephalus micropeltes	3,000-5,000	1,000-1,500
9. Plotosidae	1,000-3,000	1,000-1,250
10. Boesemania microlepis	2000-5000	100-150
11. Puntius gonionotus	300-800	40-500

In Viet Nam, there are about 20 thousands of professional fishermen and many times of the above number of non-professional. The professional part of fishermen catches a half of the above catching amount.

2.3.1.2 Endangered species

- In the Red Book of Viet Nam, it has been registered for 40 fish species and 23 invertebrate animals which are rare and endangered. During the last 50 years, there were the following species which were extinct in Viet Nam water bodies:

- Japan eel (*Anguilla japonnica*)
- Grass carp of the Red river (*Ctenopharyngodon idellus*)
- Scleropages in the La Nga river (*Scleropages formosanus*)
- Lethocerus in the Red river delta (*Lethocerus indicus*)
- Brackish water crocodyle in the Mekong river delta (*Crocodylus porosus*)
- Orcella brevirostris, a mammal specie living in the Mekong river delta (*Orcella brevirostris*)

- Another fact is that, there are many fishing villages have been moved from rivers to lands for the jobs other than fishing. Examples are fishing villages of Thac Bo, Phu Tho, Viet Tri, Ha Noi and Hung Yen.

2.3.1.3 Economic losses

It is difficult to estimate the reduction of fresh water (see the Table 37). However we can do it for particular areas:

- By calculation, the production of exploitation of living resources of the Red River in 1964 was 1,200 tons, but in 1990, it was only 500 tons.
- The catching amount of the Chau Giang River in the year of 1978 was 200 tons, and in 1982: 50 tons.
- The catching amount of the Chau Truc lake is continuously decreased: in the year of 1966 it was 650 tons, in 1976: 101 tons and in 1995: only 70 tons.
- The catching amount of the Thac Ba Dam Reservoir in 1980 was 300 tons and in 1990: only 100 tons.
- For the Ba Be Lake, it was 36 tons in 1960 12 tons in 1967 and around 10 tons at present.
- The production of fresh water fish in the Mekong Delta was 85,000 tons in 1970 with the average exploitation rate of 135 Kg/ha in main rivers, 4.4 Kg/ha in paddy areas and 65.6 Kg/ha in inundated water areas (K. F. Lagler, 1976, University of Michigan). In 1990, however, the NEDECO company estimated that production was only 66,000 tons. Fishermen in the Tien and Hau rivers estimated that production becomes lower every year and at present it may be only a half of what it was 15 year ago (1955 in comparison with 1970).
- The production of Clupanodon - a migratory fish species from estuaries to the middle course of the Red river is continuously decreased: In 1962 it was 550 tons, in 1963: 450 tons, in 1964: 336 tons, in 1965: 161 tons, in 1966: 68 tons, in 1967: 56 tons and in 1995: only some tons.
- The production of Hilsa - another migratory fish species from estuaries to the lower course of the Da river for spawning also decreases: in 1964 it was 54 tons, in 1970: 47 tons, in 1971: 60 tons, in 1972: 44 tons and in 1995: some tons.

2.3.1.4 Major problems/issues

It is confirmed that the fish catching capacity decreases quickly. The facts are as follows:

- The degradation in freshwater living resources exploitation is firstly for fish species that are living in the rivers, streams, rice fields and swamps. It is caused by using chemical fertilizers and pesticide
- The fish group which decreases are firstly migratory, big size and good tasting fish species (see the Table 40, for example).

- Another fact that demonstrates the degradation of resources is the size of the captured fish, that becomes smaller and smaller.

2.3.1.5 Input of global change: No data available

2.3.1.6 Proposed interventions

There are on going and planned activities for stopping the degradation of freshwater living resources:

- Promulgation and enforcement of laws and regulations on the management of resources.

Except the Law of Environment approved by President of the country in December 1993, since 1964 there has been promulgated 8 legislative documents of national level. The most important is Decree of the President on the Protection and Development of aquatic resources approved on April 25th, 1989, which comprises 29 articles. The Primer Minister has signed a Decision in June 2nd, 1990 and the Minister of Fisheries - the Guidelines in August 30th, 1990 for applying this Decree to the practice.

These documents, however need to be revised to adapt present status and requirements on the Resources and Environment. For example, the allowable limits for some chemical matters in water and the size of some fish species permitted for catching must be changed. These legislative documents were promulgated in time of socialism command line economy and now must be rewritten for free market economy with socialism orientation.

The most weakness in the freshwater living resources management in Viet Nam may be the legislation enforcement. There are so much violations of regulations, but not treated. An example is fishing by electric pulse and using dynamites.

Viet Nam has also approved some International Conventions (RAMSAR, CITES, Biodiversity Conservation,...). However, their implementation is very limited.

- Institutional arrangements for the management of the living aquatic resources.

Up to now, there are the Departments of Conservation of Aquatic Resources within the Ministry of Fisheries and of 26 coastal provinces having closed relation with the aquatic resources. However, there is no institution responsible for the management of freshwater living resources of the country. It is very difficult to control the resources exploitation.

- Educational and training activities on the conservation of natural resources.

There are many workshops and training courses, organized by different institutions and universities. Public media are also be introduced with the conservation of nature. There are many projects sponsored by international organization in address the mentioned problems.

- Involvement of different socio-economic sectors in the activities on the conservation of natural resources, for example, reduction in the use of pesticides, herbicides,... in agriculture, reduction and elimination of waste discharges into natural water bodies in industrial sectors.

- Technical and financial assistance for the migration of fishermen at the coast to mainland, training them with new professions and development projects on their livelihood.

- Recovery of endangered fish species in natural water bodies, for example the grass carp, silver carp in the Red river.

2.3.2 Living marine resources:

2.3.2.1 Status

a. Marine fish

Composition of species: Until now, 2058 species of marine fish belonging to 717 genera 198 families and 32 orders were found in the Viet Nam sea. Among them, there are 110 species, which have economical value and the highest catching yield. The composition of marine fish and economical species, which was recorded may be inadequate and they are only typical for coastal zone. Many species of fish at the deep sea have not been studied.

The main economical species of the Vietnamese sea are the following: The Lamniformes order (Shark fish) includes Carcharius spp., Scoliodon spp., Shark sphyrna (Sphyrna mokarran) and Ring-tailed-ray (Dasya tisuamak); the Herring family (Clupeidae): Zeun scads (Dussumieria hassaltii), Long herring (Elisha elongata), Boac sardinella (Sardinella jussieu), round herring (S. aurita) and Sardine (S. sirm); The fingered family (Polynemidae): Polynemus plebejus, P. setarius, Eleteronema tetradactylum; The sea basses family: Groupers (Epinephalus spp), Jarbua grunt (Therapon theraps), Therapon jarpus, Pergy (Priacanthus tayenus), P. macracanthus, Decapterus maruadsi, nacrele scad (D. lajang), meuson (Serions sp.),batfish (Formio niger), snapper (Lutianus sanguineus), L. russelli, L. vitta, mullet (Upeneus moluccensis), Japannese macrel (Scomber japonicus).

Distribution: The resource of marine fish can be divided into 2 groups: pelagic and demersal fishes. The fish flocks tend to be distributed near the bottom. According to Bui Dinh Chung (1994), if the water column is divided in five equal parts, the fish distribution is 3% on surface, 13,6% at upper layer, 15,3% in the middle, 18% near the bottom and 50% at the bottom.

Migration: Most of species of economical fishes in the Viet Nam sea are the local fishes. There are few species, which are migrant from nearshore to offshore or inversely in order to find out suitable places for feeding up or reproduction when environmental conditions changed.

In Viet Nam, there is no research on migratory fishes. The study on fish resources, however, shows qualitatively that the dorshe, flying fish, tuna are the migratory ones. There is a migratory phenomenon from the North to the South in accordance with the seasonal change of sea water temperature.

Only few ocean pelagic fishes such as Scomber, Auxis, Exocoetidae are migrant farther along shore following the south direction when temperature of water in the North increases.

Reserve and exploitable capacity of marine fish: The results of the study on the assessment of the reserve and exploitable capacity of marine fish of Viet Nam is presented in table 41. This table shows that fish reserve of Viet Nam sea is estimated of 2,770,000 tons, while the exploitable capacity is 1,109,000 tons. The southeast area of Viet Nam sea has the highest reserve and exploitable capacity (44.1% of the total). In the southwest area, it is 18.3%, in the Central Part: 20.3%, in the Gulf of Tonkin: 16.9% and at pelagic knolls: 0.4%.

Table 41. Reserve and exploitable capacity of fish of Viet Nam sea

Area	Kind of fish	Reserve		Exploitable capacity		%
		Tons	%	Tons	%	
Gulf of Tonkin (the west half)	P. fish	390,000	83.3	156,000	83	
	D. fish	48,409	16.7	31,364	17	16.9
	Total	438,409	100	187,364	100	
Central Part of Viet Nam sea	P. fish	500,000	89	200,000	89	
	D. fish	61,641	11	24,658	11	20.3
	Total	561,646	100	224,658	100	
South-eastern area of Viet Nam sea	P. fish	524,000	42.9	209,600	42.9	
	D. fish	698,307	57.1	279,323	57.1	44.1
	Total	1,222,307	100	488,923	100	
South-western area of Viet Nam sea	P. fish	316,000	62	126,000	62.0	
	D. fish	190,679	38	76,272	38.0	18.3
	Total	506,679	100	202,272	100	
Pelagic knolls	P. fish	10,000	100	2,500	100	0.4
Total	P. fish	1,740,000	63	697,100	62.8	
	D. fish	1,029,041	37	411,617	37.2	100
	Total	2,769,041	100	1,108,717	100	

Source: Bui Dinh Chung, 1994
Notes : *Pelagic fishes = P. fish ; Demersal fishes = D. fishes*

The annual fishery productivity is as follows:

Year	1991	1992	1993	1994	1995	1996	2000
Productivity	955,940	972,250	1,053,467	1,158,449	1,209,727	1,260,000	1,471,600

Source: Environment Status, Report 1997

The above table shows that since 1993, the annual fishery productivity is near or over the exploitable capacity.

b. Marine shrimp

Composition of species: Until now, it was found out 101 species of marine shrimps, belonging to 34 genus, 11 families. Among them, the Penaeidae family has the highest number of genus with 75 species. Almost 50% of the total number of species are economical species.

Distribution: According to depth, marine shrimps can be divided into 3 groups: shallow, wide distribution and deep sea groups

c. Cuttlefish and squid :

Composition of species: Up to now there has found out 26 cuttlefish species and 25 squid species. Common species, which are distributed over all Viet Nam sea and have economical value are: Kisslip cuttlefish (Sepia lycidas), Broadclub cuttlefish (Sepia latimanus), Pharaonid cuttlefish (Sepia pharaonis), China squid (Loligo chinensis), Beka squid (Loligo beka), Swordtip squid (Loligo edulis), Bigfin reep squid (Sepioteuthis lessoniana), etc.

Distribution: In the north part of Viet Nam sea, there are 3 squid grounds including Cat Ba, Hon Me and Bach long Vi. In the south part, there are 2 grounds in dry season (Phan Rang - Phan Thiet and the west and east of Ca Mau water) and a large area from Phan Thiet to Ca Mau and the northwest coast of Phu Quoc Island, which tends to move farther seaward.

Reserve and exploitable capacity: The total reserve of cuttlefish is 64,140 tons and exploitable capacity is 25,650 tons (Table 42).

Table 42. Reserve and exploitable capacity of cuttlefish of Viet Nam sea (tons)

Area	Reserve E. capacity	<50m	50 - 100m	100 -200m	>200m	Total
Gulf of Tonkin	Reserve	1,498	394.9	-	-	1,892.9
	E. capacity	599.2	158.0	-	-	757.2
	%	79.14	20.86	-	-	100%
Central part	Reserve	3,900.4	3,835.7	4,504.6	1,300.5	13,341.2
	E. capacity	1,560.2	1,534.3	1,801.8	520.2	5,416.5
	%	28.8	28.3	33.3	9.6	100%
South-eastern part	Reserve	24,933.3	10,755.9	7,404.1	5,612.5	48,705.8
	E. capacity	9,973.3	4,302.4	2,961.6	2,245.0	19,482.3
	%	51.19	22.08	15.21	11.52	100%
Total	Reserve	30,331.7	14,986.5	11,908.7	6,913.0	64,140.0
	E. capacity	12,132.7	5,994.6	4,763.5	2,765.2	25,656.0
	%	47.29	23.37	18.57	10.78	100%

The southern area of Viet Nam sea has the highest reserve and exploitable capacity (up to 47,705.8 tons). In the Gulf of Tonkin, it is only 1,892.8 tons. The reserve of cuttlefish in the deep water layer (below 50m) is 47,29% of the total one. The reserve of squid over all Viet Nam sea is 59,112.8 tons and the exploitable capacity is 25,645.1 tons (Table 43).

The southern area of Viet Nam sea have the highest squid reserve- 41,577.1 tons, which is equal to 70,33% of the total one. In the Gulf of Tonkin it is 11,768.7 tons (19,91%), in the central area of Viet Nam sea: 5,767 tons (9,76%). At deep sea part (below 50m), the reserve of squid is 30,881.5 tons (52,24% of the total).

Table 43. Reserve and exploitable capacity of squid of Viet Nam sea (tons)

Area	Reserve E. capacity	<50m	50 - 100m	100 -200m	>200m
Gulf of Tonkin	Reserve	9.244,3	2.524,4	-	-
	E. capacity	3.697,7	1.009,8	-	-
	%	78,55	21,45	-	-
Central part	Reserve	317,8	434,5	2.033,1	2.981,6
	E. capacity	127,1	173,8	813,2	1.192,6
	%	5,51	7,53	35,26	51,70
South-eastern part	reserve	21.319,4	12.831,5	2.559,4	4.866,8
	E. capacity	8.527,8	5.132,6	1.023,8	1.946,7
	%	51,28	30,86	6,16	11,70
Total	Reserve	30.881,5	15.790,5	4.592,5	7.848,3
	E. capacity	12.352,6	6.316,2	1.837,0	3.139,3
	%	52,24	26,71	7,77	13,28

d. Coastal Invertebrate

In coastal water area from the depth lower than 10m to the tidal flats, there are diverse biological resources. Many economical species are considered as special marine products belonging to the Mollusk, Crustacean, Echinodermatian and Anellidaen groups such as Granosa Ark, Black lip, Pacific tree oyster, Asia moon scalop, meretrix venus. Almost all of these species are usually gathered with high density, that is easy for their catching. For long time, these special products have been exploited and brought important income to the coastal communities. Nowadays, they are used mainly for export.

Composition of species and distribution: There are 60 grounds of special species located along the coast from Quang Ninh to Ha Tinh Provinces (Table 44).

+ Coastal water of the central Viet Nam sea: According to results of surveys during time 1992 - 1994 of project KT.03.08, from Hai Van to Phan Thiet, there are 56 economical species of invertebrate among which 25 species are considered as special species . Distribution and reserve of special species in the coastal water of the central Viet Nam sea is presented in table 45.

+ Coastal water of the south Viet Nam sea: The results of surveys of the project KT.03.08 during time period of 1992 - 1995 show that in the coastal water from Can Gio to Hon Chong (Kien Giang province) there is only one main special species, Meretrix lyrata, high in density and large in amount.

Table 44. Distribution and reserve of special species in the coastal waters of the North Viet Nam (Project KT.03.08)

No.	Name of species	Grounds	Reserve (ton)
1	Sipunculus nusdus	Quang Ninh - Hai Phong	1.800
2	Phascolosoma similis	Quang Ninh - Hai Phong	1.045
3	Avalone- Haliotis spp.	Co To, Bach Long Vi, Hon Me, Hon La, Con Co, North of Hai Van	20-30 (before 1975)
4	Babylon-Babylonia sp.	Thanh Hoa- Thua Thien-Hue, Co To, Cat Ba, Thua Thien-Hue	3.000 Thousands tons (before 1975)
5	Oyster -Pteria spp	Quang Ninh-Thua Thien Hue	
6	Venus -Meretrix pp..	Quang Ninh to Nghe An, Lang Co	26.014
7	Red venus-Cyclina sinensis	Mong Cai - Cat Hai	2.000 T
8	Black venus- Dosinia laminata	Quang Ninh to Thua Thien Hue	4.300
9	Grasosa ark- Anadara granosa	Quang Ninh to Thua Thien Hue	2.200
10	Ark-A. subcrrenata-Aloidis laevis	Hai Phong to Thanh Hoa	150.000
11	Limpet- Emerella corrugata	Quang Ninh, Hai Phong, Ha Tinh	1.000-1.500
12	Corbicula subsulcata	Tam Giang Lagoon (Thua Thien-Hue)	11.000
13	River oyster- Ostrea rivularis	Quang Ninh, Hai Phong, Thanh Hoa	11.920
14	Mactra - Mactra quadrangulari	Ha Nam Ninh	

Table 45. Distribution and reserve of special species from coast of central Viet Nam sea

No.	Name of species	Distribution	reserve (ton)
1	Cephea conifera -medusa	Da Nang - Vung Tau	230 - 230
2	Haliotis spp.-Abalone	Da Nang - Ninh Thuan	50 - 100
3	Turbo marmoratus-Turban	Da Nang - Khanh Hoa	0,4 - 0,5
4	Trochus niloticus- Top	Da Nang - Khanh Hoa	50 - 100
5	Melo melo -	Da Nang - Binh Thuan	100 - 150
6	Babylonia areolata-Babylo	Binh Thuan	1.000- 1.500
7	Anadara granosa- Ark	Da Nang - Vung Tau	20 - 25
8	A. antiquata - Ark	Binh Thuan, Phu Yen, Da Nang Da Nang - Binh Thuan	20.000-25.000
9	Mytilus viridis - mussel	Da Nang - Binh Thuan	100 - 120
10	Modiolus philippinus	Da Nang - Binh Thuan	3.500 - 4.000
11	Pteria penguin - Oyster	Da Nang - Vung Tau	10 - 20
12	Pinctada maxima -	Binh Thuan	8 - 15
13	Chlamis nobilis	Da Nang - Vung Tau	15.000 - 20.000
14	Amusium pleuronectes	Da Nang - Binh Thuan	400 - 500
15	Arca navicularis - Ark	Da Nang - Khanh Hoa	500 - 1.000
16	Tachypleus tridentatus	Da Nang - Binh Thuan	6.500 -7.000
17	Actynopyga echinites	Da Nang - Binh Thuan	20 - 30
18	A. mauritiana	Da Nang - Binh Thuan	20 - 30
19	Halodeima atra	Da Nang - Binh Thuan	40 - 50
20	Holothuria scabra	Da Nang - Binh Thuan	40 - 50
21	Microthele nobilis	Da Nang - Binh Thuan	10 - 20
22	Thelenota ananas	Da Nang - Vung Tau	20 - 30
23	Diadema setosum	Da Nang - Vung Tau	250 - 350
24	Tripneustes gratille		150 - 200

In recent years, at some localities such as Go Cong, Ben Tre, Can Gio, due to the better management, the yield of special products increases by 400 to 500 times. The total yield of the whole Viet Nam in 1993 was 55,000 - 61,000 tons. Productivity of the aquaculture of the species was 30 -40 tons/ha. Except Meretix , there are some other special species such as: subcrenata Ark , granosa Ark, antiquata Ark, Dendronereis, ect.

e. Coral reef

Viet Nam is in the tropical area of the West Pacific and is very abundant in corals. However, data on corals in Viet Nam sea are very limited except those on the Scleractinian corals.

Composition of species: Up to now, it has been found out 617 species, belonging to 43 families, 157 genera. Among them the Scleractinian corals has 350 species (56.7%). Families belonging to the Scleractinian corals which have the most abundant species are: Acropodidae (83 species), Poritidae (3 species). Some genus, which are large in number of species are: Monipora (31 species), Acropora (47 species), Porites (19 species). The status of coral composition is presented in the Table 46.

Distribution: Geographical position and natural conditions of Viet Nam sea in general are favorable for corals growing, especially the hermatypic corals group. Except estuaries, which have low salt degree and mud, corals are mostly distributed in steep shelf, near islands, especially at Truong Sa and Hoang Sa Archipelagoes in Central East Sea. There are 4 main areas as follows:

+ Paracel Islands and Spratley Archipelagoes
+ Central of Viet Nam sea and Southeastern islands (Cu Lao Cham, Ly Son, Khanh Hoa - Ninh Thuan, Phu Quy and Con Dao islands)
+ Northwestern coast of Gulf of Tonkin (Bach Long Vi, Co To, Cat Ba, Nam Chau and Con Co Islands and Bai Tu Long Bay)
+ Southwestern sea (Tho Chu, Nam Du, An Thoi, Phu Quoc islands)

Distribution of corals is shown in the Figure 4.

Table 46. Coral composition in Viet Nam

No.	Order	Number of families	Number of genera	Number of species
1	Alcyonacea	5	24	130
2	Coenothecalia	1	1	1
3	Stolonifera	1	1	2
4	Telestacea	1	1	4
5	Gorgonacea	7	30	73
6	Pennatalacea	7	8	31
7	Actiniaria	2	2	2
8	Scleractinia	16	79	350
9	Zoanthidea	2	3	12
10	Aritipathidea	4	6	10
11	Ceriantharia	1	2	2
	Total: 11 Orders	47	157	617

Source: Environment Status, Report 1997

Status of exploitation and use: There is not enough data to determine the area of coral reefs of Viet Nam. According to Sorokin (1990) the area of coral reefs in the world is about 600,000 km^2, in which 150,000 km^2 (25%) is in South East Asia. If suppose that Viet Nam has 10% of the coral reef area of the region, it would be 1,500,000 ha.

Except offshore islands, coral reefs in Viet Nam are distributed near the coastal population centers, the socio-economic activities in which have great impacts on the reefs ecosystems. The survey results during last 15 years show that the area of coral reefs has been reduced in 15-20%, mainly at coastal waters of the Middle part of Viet Nam from Da Nang to Binh Thuan province (KT.03.11 "Special Programme on South China Sea"). Coal dust has caused the death to large areas of corals in the Ha Long and Bai Tu Long bays (Quang Ninh Province). Together with the coral reef area reduction the number of species is also reduced. For example, while the coverage of coral reefs in Bai Tien area (Nha Trang) is 30% (1984), there was 60 species and as it reduced to 1% (1988) the number of species became 30 (KT.03.11). Other living organisms are also reduced in number significantly.

Corals are traditional object to exploit for commercial purpose at tourism sites. Due to the limitation of knowledge and understanding on the value of corals in marine ecosystems, they are untidily exploited at almost all places in the Viet Nam sea where they exist. Dead corals are also exploited for building materials (lime and cement production). The measures on their protection and management are unsuccessfully implemented.

g. Marine algae

Composition of species: Up to now, it has been identified 653 species of marine algae in the coastal zone of Viet Nam. 90 species have economical value (equal to 19% in total species). Among them, there are one species of Cyanophyta phylum, 11 species of Chlorophyta phylum, 27 species of Pheophyta phylum and 51 species of Rhodophyta phylum.

There are two groups of the highest economic value including Sargassum and Gracilaria. Sargassum group consists of 49 species, 5 varieties and Gracilarian group: 19 species and one variety.

Distribution: Marine alga resources mainly distribute at coastal zone and change with seasons.

Sargassum usually starts growing in the end of autumn and beginning of winter (November, December) and grows fast in March, April in the North and in April, May in the South of Viet Nam. Sargassum, in general, dies in summer except at narrow area with suitable ecological conditions, where it can exist in summer and has high biomass. This is summer algae which has sparse distribution low productivity.

Gracilarian distributes on tidal flats, in brackish lagoons and salty fields. In lagoon, Gracilarian has in many times higher density and biomass than on tidal flats. In the North of Viet Nam, Gracilarian in brackish lagoons grows fast in April and May. From July, most of algae die due to rainfall which leads to low salinity. In the South of Viet Nam, the Tam Giang - Cau Hai lagoon, belonging to Thua Thien - Hue province has large amount of Gracilarian

Status of exploitation: In Viet Nam, the exploitation of algae is focused mainly on two groups: Sargassum and Gracilarian. During the period of 1986 - 1992, the annual exploitable amount of fresh algae is 6,000 - 7,000 tons 90 - 95% of which was Gracilaria verrucosa. For Sargassum, although the natural reserve is high, the annual exploitable level is only 3 - 5%.

Table 47. Reserve of Sargassum on coast of Viet Nam

Area	Reserve (Tons)
Quang Ninh	12,200
Hai Phong	270
Thanh Hoa	100
Nghe An - Ha Tinh	370
Quang Binh	480
Vinh Linh	80
Quang Nam - Da Nang	2,000
Nghia Binh	4.300
Phu Khanh - Binh Thuan	1.500
Total	35,000 tons

Table 48. Reserve of Gracilarian on coast of Viet Nam

Area	Reserve (Tons)
Quang Ninh	2.000
Hai Phong	1.800
Thai Binh	400
Nam Dinh - Ninh Binh	440
Thanh Hoa	560
Nghe An - Ha Tinh	300
Quang Binh - Thua Thien Hue	2.000
Quang Nam - Da Nang	250
Nghia Binh	800
Phu Khanh	600
Ninh Thuan - Binh Thuan	150
Total	9.300 tons

h. Mangrove forest

Composition of species: Up to now, 95 species of mangroves have been identified, belonging to two groups:

+ First group: The real mangrove species, which include 35 species belonging to 26 genus, 16 families

+ Second group: The species acceding to mangrove forest, which are usually met in secondary forests, cultivated forests, deposited flats and along river banks. This group includes 40 species belonging to 37 genus, 27 families.

Distribution: Mangrove forest in Viet Nam are distributed in coastal estuaries and partly in lagoons and bays. The statistics for the whole country show that it is mainly distributed in the east and west of the South of Viet Nam. Mangrove in the North of Viet Nam is shorter with the average height of 1-5 m, has less value for timber. Its major contribution is providing nutrients and serving as eco-environment for marine living organisms. It is distributed mainly in coastal estuaries from Mong Cai to Ha Long. Another area is in the estuarine area of Red River Delta. In the Middle part of Viet Nam from Lach Truong (Thanh Hoa province) to Vung Tau, mangrove grows at deltaic river mouths, lagoons and partly in coastal bays. Like in the North, mangrove here is short (1-6 m) and has less value in timber production. In the East and West of the South of Viet Nam, mangrove is found from Vung Tau to Ha Tien. It is distributed mainly in two river mouths of Dong Nai and Mekong rivers. The mangrove here has average height of about 10-20 m and is valuable for timber production, environment protection, nutrient provision and ecological balance.

Thus, there are 4 main distribution areas of mangrove forests in Viet Nam:

+ At the coast of the North Viet Nam from Mong Cai (Quang Ninh province) to Do Son (Hai Phong city). The mangrove forests here grow very well being protected by many islands wind and wave. The main species are: Rhyzophora macronata, Eruguinea gymnorrhyza and Avicenia. They are in average 1.5 - 1.7 m high.

+ At the coast of the North Viet Nam from Do Son (Hai Phong province) to Lach Truong (Ma River mouth -Thanh Hoa province): Although there are large tidal flats, which are rich in alluvium but the mangrove forests here are less developed due to effects of wind, typhoon and wave. Only mangrove forests in estuaries such as Acanthus, Sonneratia caseolaris, Kandelia candel, Aegiceras can grow well.

+ At the coast of the Central Viet Nam from Lach Truong to Vung Tau: The tidal flats here are very narrow due to the high slop of bathymetry and poorness of coastal water in suspended matters. Mangrove grows in narrow bands outside the river mouths including Rhyzophora, Aegiceras, Eruguiera, ...

+ At the coast of the South Viet Nam from Vung Tau to Ha Tien: There are many wide tidal flats, rich in alluvium in the estuarine areas of Dong Nai and Cuu Long rivers. The mangrove forests grow very well in the areas not being affected much by wind and wave, especially at the Ca Mau coast, where Rhyzophora, Nippa fruticans, Avicenia and Eruguinea exist.

i. Seagrasse:

14 species of seagrass has been found in Viet Nam. Among the countries in the region, this number is only less than in Philippines (16 species), higher than in Malaysia (13), Indonesia (12), Thailand (12), Singapore (7) and Cambodia (4).

The seagrasses suitable for the sea water of the salinity higher than 25‰ are the following species: Thalassia hemprichii, Thalassodendron, Ciliatum, Holophita decipiens, Cymodocea rotundata, C. serrulata, Halodule uni. The group in water of salinity less than 25‰ includes Halophia beccarii, Ruppia maratima. The group suitable for large change of salinity (from 5 to 30‰) includes Halophia ovalis, Zostera faponica, Helodule pinifolia. The seagrass of more salted water grows in bays or island areas while the one of less salted water: in the tidal flats of estuaries and lagoons. The growing season of seagrass in the North of Viet Nam is the winter-spring (from November to June of the following year) while in the Middle Part, from March to October. Farther to the sea, seagrass grows for round year, but more intensively in rainy season when the sea water becomes less salted and nutrient amount in water increased.

2.3.2.2 Endangered species

Among the species identified in Viet Nam sea, there are 37 rare species or those of extinction, which have been recorded in Red Book of Viet Nam, including: 6 species in V level (Vulnerable), 24 species in R level (Rare), 2 species in E level (Endangered), 2 species in T level (Threatened) and 2 species in K (insufficiently)

Among the species recorded in the Red Book of Viet Nam there are:

- 5 species of shrimp
- 3 species of cuttlefish and squid including 2 species in E level and 1 species in V level
- 36 species of invertebrates including: 5 species of Echinodermatian with 2 in E level and 3 species in V level; 5 species of Arthropod with 4 in V level and one in T level; 26 species of Mollusk with 8 in E level, 6 in V level, one in T level and 14 rare species.
- 6 coral species with 5 in V level and one rare species.
- 19 alga species, including 7 species are in V level; 2 species are in T level; 3 species are in K level and 7 rare species.

Marine fauna and flora species recorded in the Red Book of Viet Nam are presented in the following table:

Table 49. List of marine fauna and flora in the Red Book of Viet Nam

No	Name	Dangerous level
	Fauna Fish	
1	Amphioxus belcheri	V
2	Stegostoma fasciatum	R
3	Rhincodon typus	R
4	Alopias pelagicus	K
5	Cephaloscyllium umbratile	R
6	Etmopterus lucifer	R
7	Pristis cuspidatus	R
8	Pristis microdon	R
9	Rhina ancylostoma	T
10	Narcine tonkinensis	R
11	Chimaera phantasma	K
12	Elops saurus	R
13	Megalops cyprinoides	R
14	Albula vulpes	R
15	Nematolosa nasus	E
16	Anodontostoma chacunda	E
17	Ateleopus japonicus	R
18	Solenostomus paradoxus	R
19	Trachyrhamphus serratus	R
20	Syngnathus acus	R
21	Solenognathus hardwickii	R
22	Hippocampus histrix	V
23	Hippocampus kuda	V
24	Hippocampus japonicus	K
25	Hippocampus trimaculatus	V
26	Hippocampus kelloggi	V
27	Velifer hypselopterus	R
28	Zeus japonicus	R
29	Zeus cypho	R
30	Schindlerria praematura	R
31	Bostrichthys sinensis	V
32	Satyrichthys rieffeli	R
33	Psilocephalus barbatus	R
34	Oxymonocanthus longirostris	R
35	Masturus lanceolatus	T
36	Mola mola	R
37	Antennarius melas	R
	Invertebrates	
	Corals	
38	Corallium japonicus	T
39	Corallium konojci	T
40	Isis hipputis	R
41	Pocillopora damicornis	T
42	Pocillopora verrucosa	T
43	Acropora florida	T

	Echinodermata	
44	Heterocantrotus mammillatus	V
45	Actinopyga echinites	V
46	Actinopyga mauritiana	V
47	Microthele nobilis	E
48	Thelenota ananas	E
	Arthropoda	
49	Panulirus homatus	V
50	Panulirus longipes	V
51	Panulius ornatus	V
52	Panulirus versicolor	V
53	Tachypreus tridentatus	T
	Mollusca	
54	Haliotis asinina	V
55	Haliotis ovina	V
56	Trochus niloticus	E
57	Trochus pyramis	E
58	Turbo marmoratus	E
59	Chelycypraea testudinaria	T
60	Cypraea argus	R
61	Cypraea histrio	R
62	Cypraea mappa	R
63	Cypraea spadicea	R
64	Cypraea turdus	R
65	Mauritia scurra	R
66	Blasicrura chinensis	R
67	Ovula costellata	R
68	Calpurnus lacteus	R
69	Calpurnus verrucosus	R
70	Lambis crocata	R
71	Strombus luhuanus	V
72	Cymatium lotorium	R
73	Charonia tritonis	V
74	Epitonium scalare	R
75	Mytilus viridis	V
76	Pinctada margarritifera	V
77	Tridacna gigas	R
78	Anomalocardia squamosa	E
79	Gafrarium tumidum	E
80	Nautilus pompilius	E
81	Loligo chinensis	E
82	Sepioteuthis lessoniana	V
83	Sepia phasaonis	E
	Flora	
	Algae	
84	Caulerpa racemosa	V
85	Caulerpa repens	V
86	Caloglossa leprieurii	K