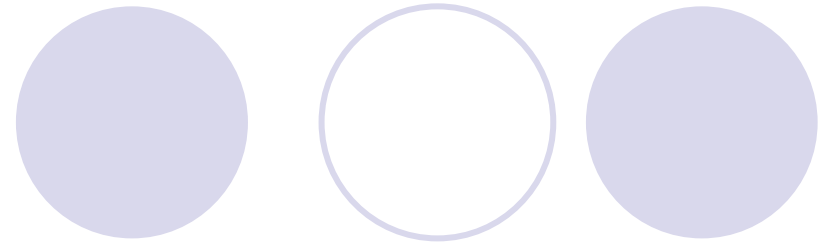
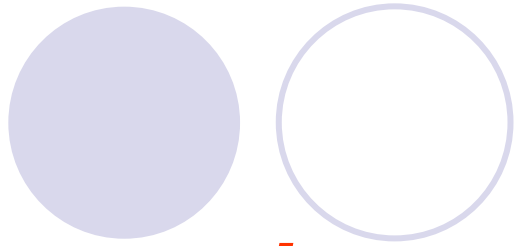


Geological and Hydrological Conditions of Hanoi City – An Overview from Urban Planning Point of View

Dr. Do Minh Duc
M.Sc. Tran Thi Luu

Hanoi University of Science



Main content

1. Background
2. Geology
3. Hydrogeology
4. Conflicts between development and the Environment
5. Proposals



I. BACKGROUND

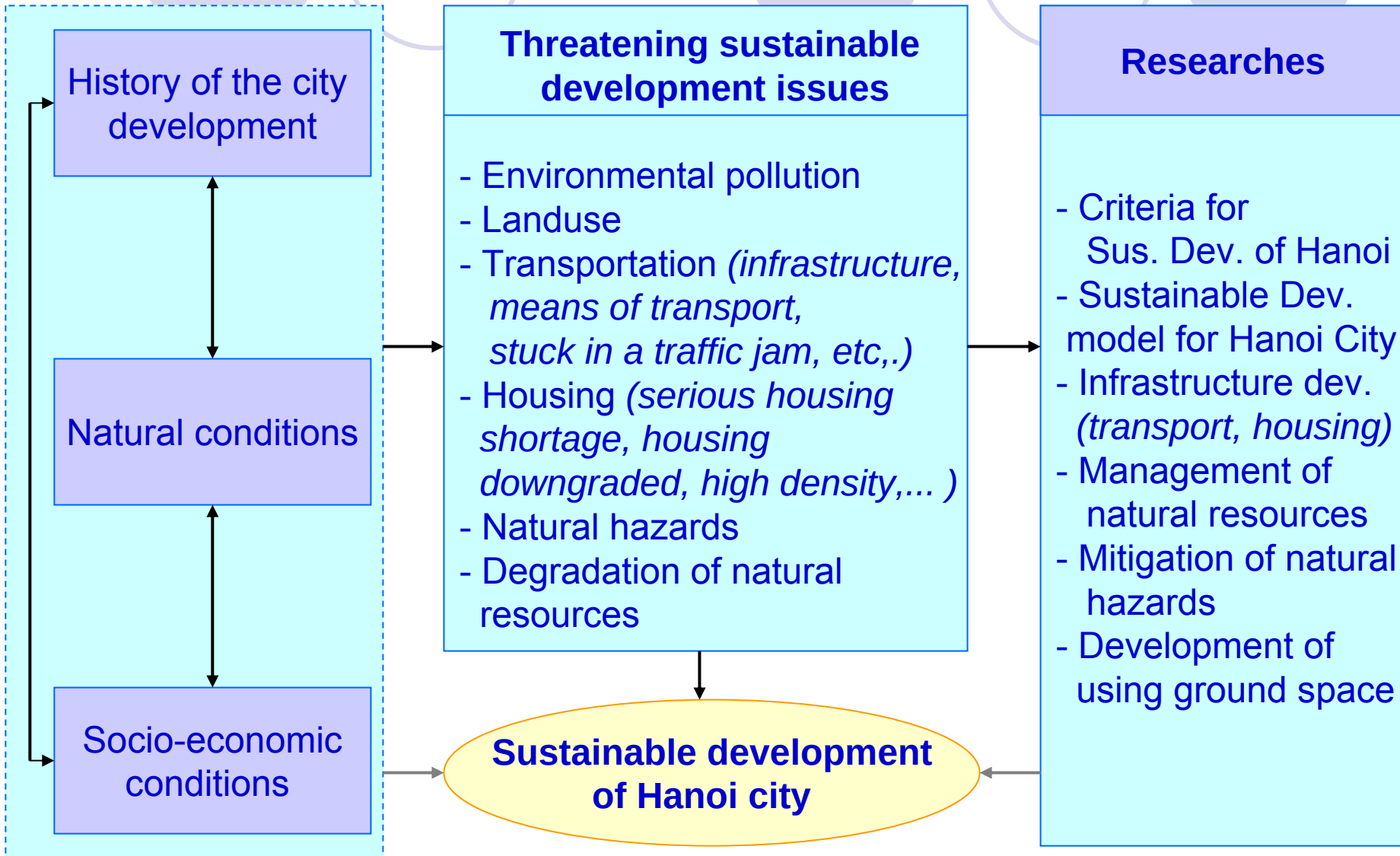
CRITERIA OF A SUSTAINABLE URBAN AREA

A sustainable city is a city which meets the following basic criteria:

-  A part of a larger sustainable area
-  Being highly competitive
-  Having good management
-  Having healthy settlement areas
-  Having health financial situation

(The World Bank, 2000)

Integrated Approach



METHODOLOGY

Factors

- **Topography**
 - Slope (degrees)
 - Elevation (m)
- **Geodynamics**
 - Uplifting/Subsidence
 - Distance to fault(m)
- **Engineering Geology**
 - Surficial Geology
- **Groundwater**
 - Depth to groundwater level (m)
 - Corrosive potential of groundwater
 - Distance to intensive groundwater extraction area
- **Geological hazards**
 - Earthquake (M)
 - Distance to river bank erosion (m)
 - Distance to river dike segment (m)
- **Man-induced hazards (full or partial)**
 - Land subsidence
 - Inundation (depth under water level –m)

INTRODUCTION OF HANOI AREA

From 1 August 2008:

Area of Hanoi Capital including of Hanoi capital, Ha Tay Province, Me Linh District (Vinh Phuc Province) and 4 communes as Yen Trung, Yen Binh, Dong Tien, Dong Xuan (Luong Son District, Vinh Phuc Province)

Located in coordinate of:

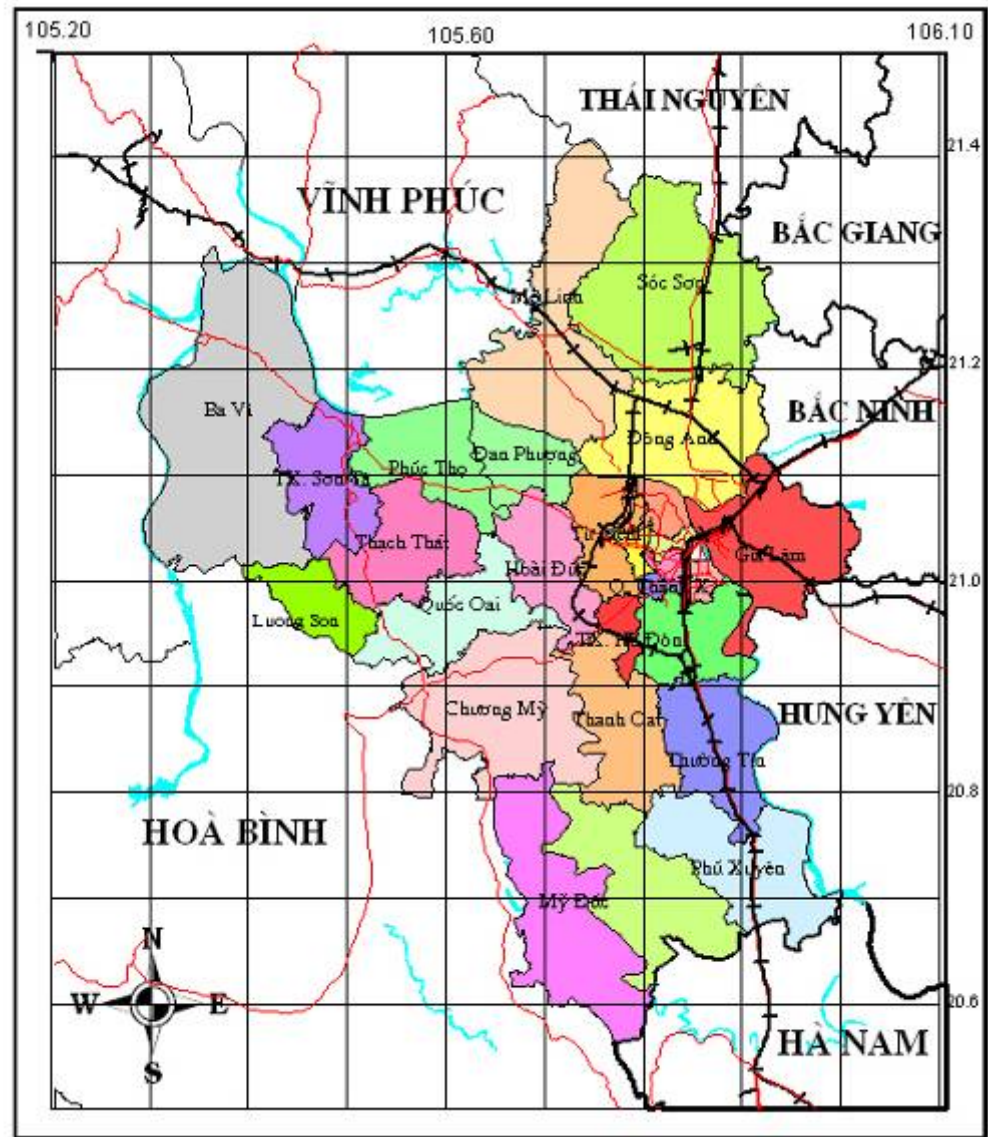
20°33' - 21°25'

105°17' - 106°02'

Area: about 3.300km²

Population: 6.232.940 (pers.)

Number of District: 27



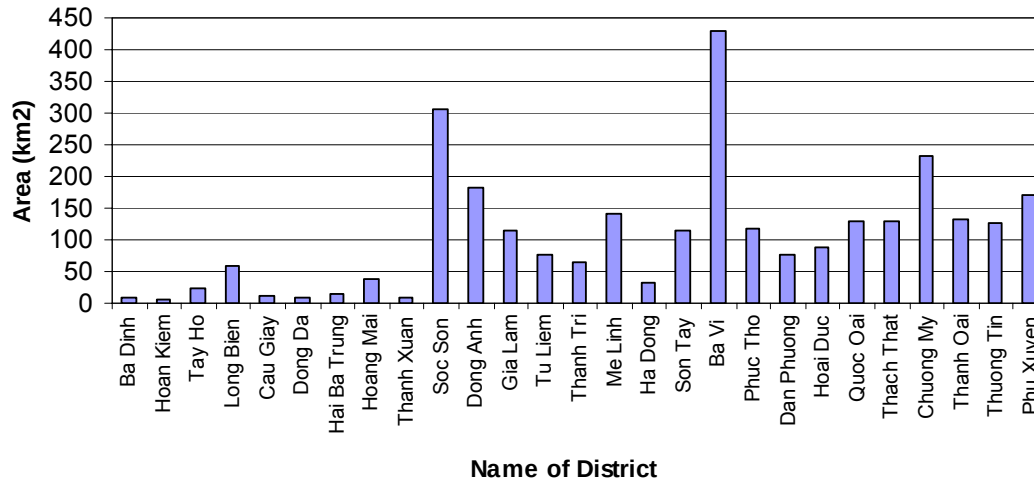
The map of Hanoi area

INTRODUCTION OF HANOI AREA

No.	Area	Area of land (km2)	Average Population	Density (pers./km2)	No.	Area	Area of land (km2)	Average Population	Density (pers./km2)
1	Ba Dinh	9.3	226200	24323	15	Me Linh	140.9	180529	1281
2	Hoan Kiem	5.3	178300	33705	16	Ha Dong	32.9	136426	4148
3	Tay Ho	24	105400	4392	17	Son Tay	113.5	118505	1044
4	Long Bien	59,5	176800	2970	18	Ba Vi	428	257500	602
5	Cau Giay	12	162500	13497	19	Phuc Tho	117.1	156308	1335
6	Dong Da	10	366250	13497	20	Dan Phuong	76.6	133600	1744
7	Hai Ba Trung	14.7	306100	30307	21	Hoai Duc	88.3	183256	2075
8	Hoang Mai	39.5	216751	5486	22	Quoc Oai	129.5	149109	1151
9	Thanh Xuan	9.1	190800	20944	23	Thach That	128.1	151845	1185
10	Soc Son	306.5	260320	849	24	Chuong My	232.9	274960	1181
11	Dong Anh	182.3	280600	1539	25	Thanh Oai	132.2	184962	1399
12	Gia Lam	114.8	206300	1797	26	Thuong Tin	127.7	202450	1585
13	Tu Liem	75.3	247800	3290	27	Phu Xuyen	171.1	184916	1081
14	Thanh Tri	63.3	158650	2508					

INTRODUCTION OF HANOI AREA

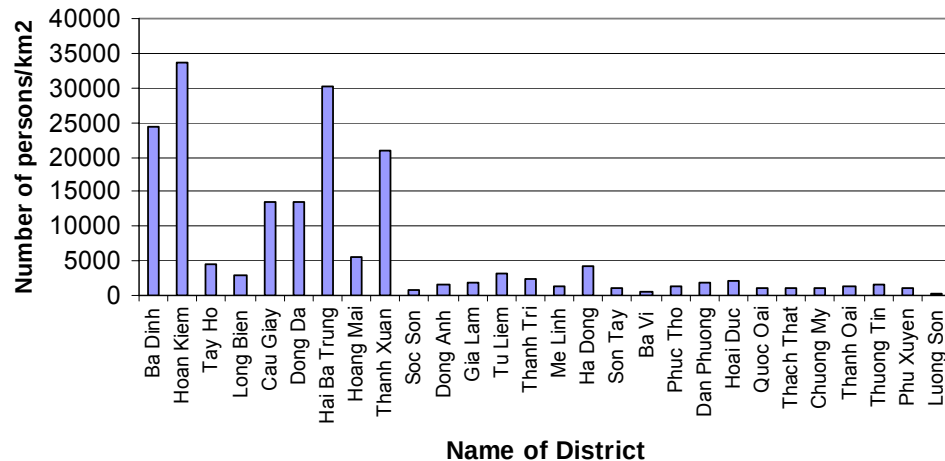
Area of land of Districts



The area of land in Districts of Hanoi city

The distributed population

Population Density in District

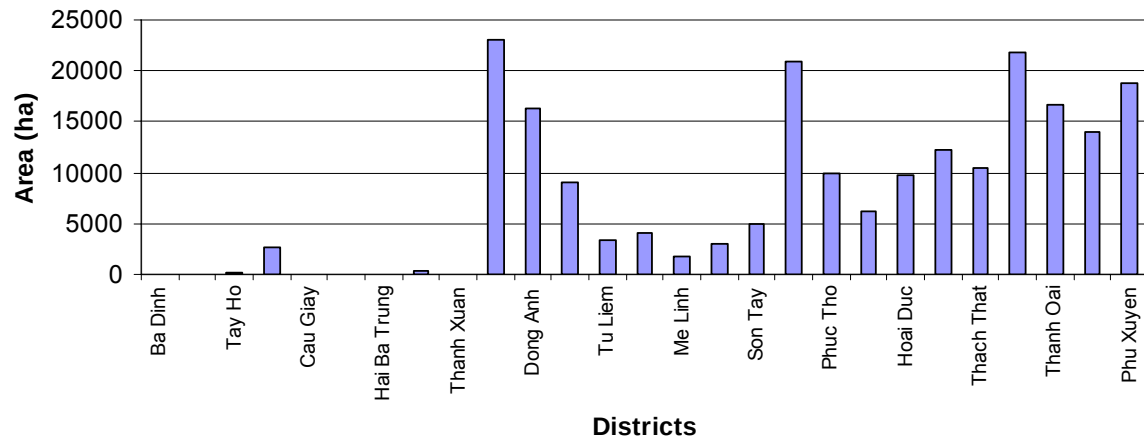


ECONOMIC CONDITION

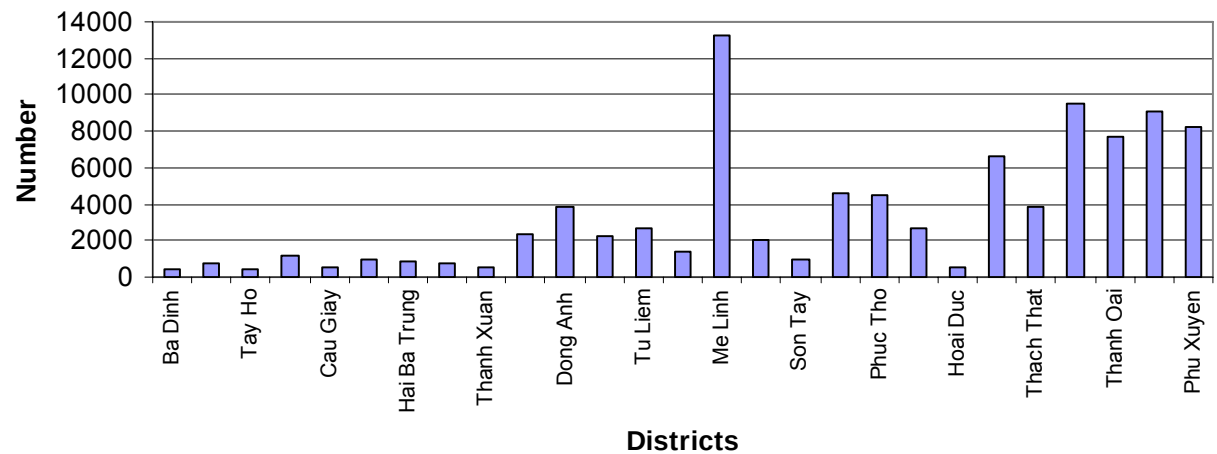
No.	Area	Planted area of agriculture	Number of establishment	No.	Area	Planted area of agriculture	Number of establishment
1	Ba Dinh		480	15	Me Linh	1780	13285
2	Hoan Kiem		720	16	Ha Dong	3101	2036
3	Tay Ho	229	397	17	Son Tay	4879	947
4	Long Bien	2576	1127	18	Ba Vi	20913	4599
5	Cau Giay		531	19	Phuc Tho	9933	4541
6	Dong Da		945	20	Dan Phuong	6252	2627
7	Hai Ba Trung		812	21	Hoai Duc	9836	533
8	Hoang Mai	333	701	22	Quoc Oai	12154	6627
9	Thanh Xuan		543	23	Thach That	10480	3800
10	Soc Son	23115	2400	24	Chuong My	21841	9558
11	Dong Anh	16357	3799	25	Thanh Oai	16601	7668
12	Gia Lam	9097	2213	26	Thuong Tin	14093	9043
13	Tu Liem	3327	2639	27	Phu Xuyen	18760	8221
14	Thanh Tri	4023	1394				

ECONOMIC CONDITION

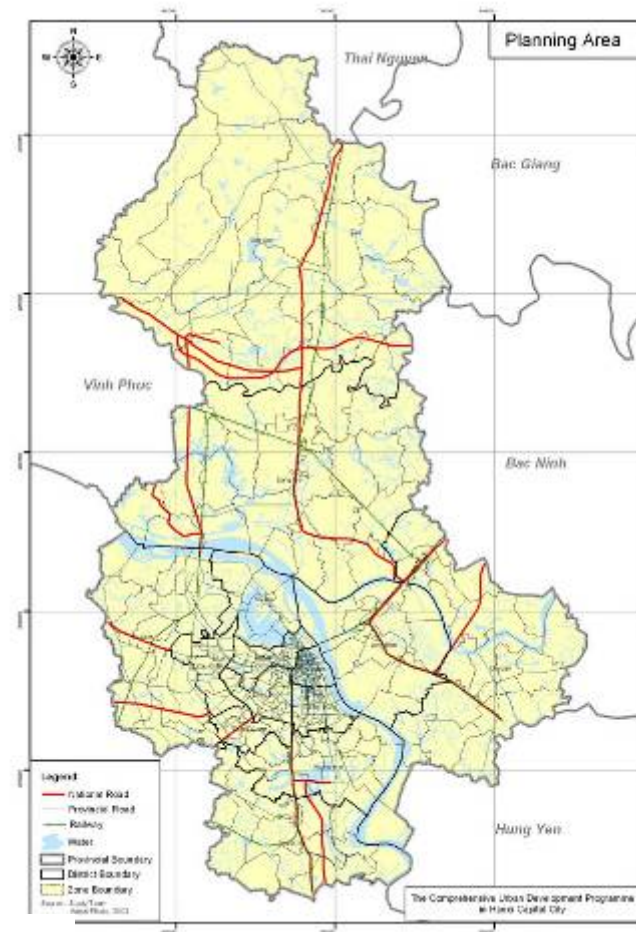
Area of Agriculture



Number of establishments



Study Area



Hanoi City

Area : 920.97 (km²)

Population : 3,082,800 (2004)

Structure of Urban Land

- Population density = Level of Concentration on Development
- Population growth rate = Level of Development Pressure

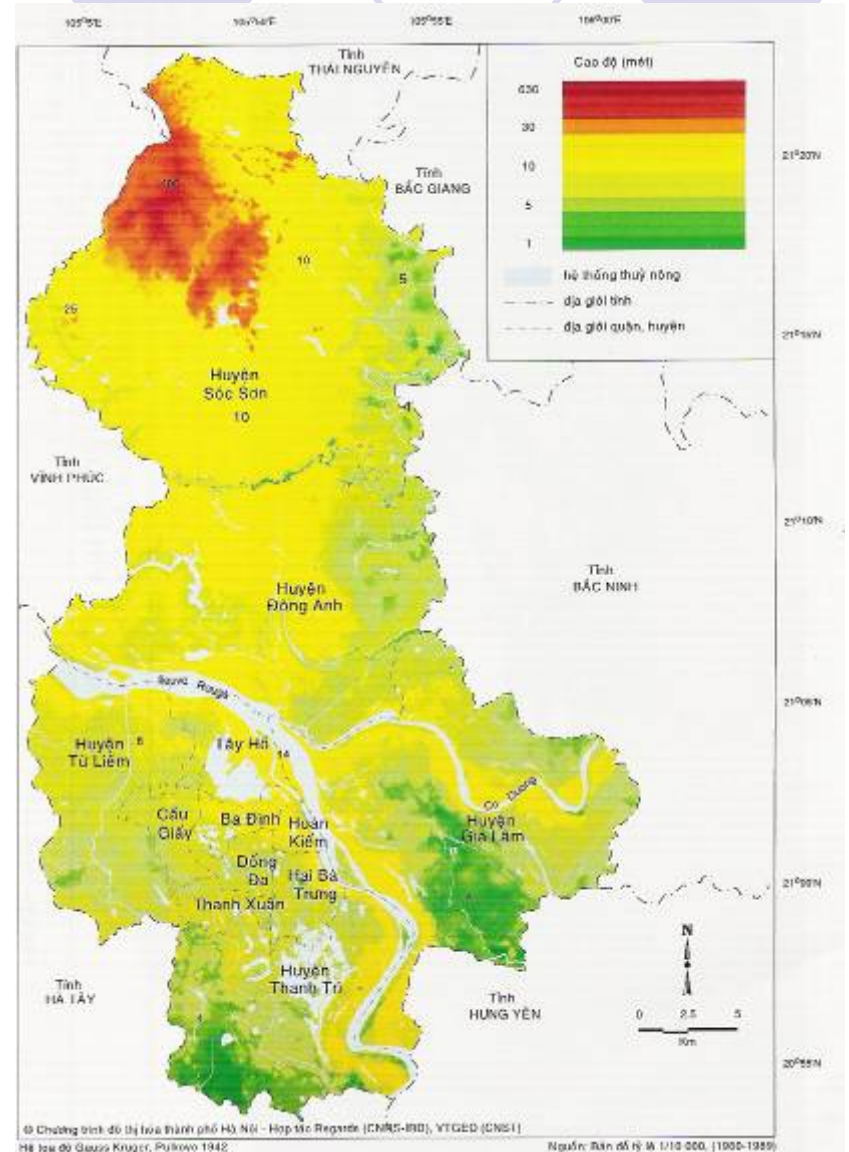
Type of Urban Land

Type	Area (km²)	Population				Pop Density (2003) : perso n/ha	Pop. Growth Rate %/yr
		1999		2003			
		'000	%	'000	%		
Urban Core	34.5	963	36.0	1,053	35.0	305	2.3
Urban Fringe	141.9	673	25.2	827	27.5	57	5.3
Sub urban	140.5	342	12.8	392	13.0	28	3.4
Rural	604.1	695	26.0	735	24.5	12	1.4
Hanoi Capital	921.0	2,675	100.0	3,008	100.0	33	3.0



TOPOGRAPHY

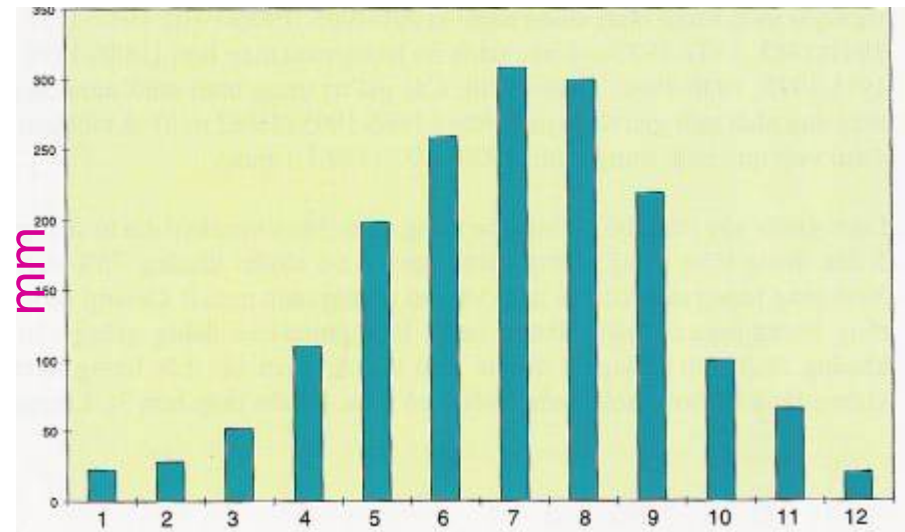
- Most of the area of Hanoi has the average elevation of 5-20m above sea level. The rest covering only the northern and northwestern parts of Soc Son district is mountainous with elevation of 20 - 400m, maximum 462m (the Chan Chim mountain peak).
- The topography of Hanoi lowers from north to south and from west to east. This is reflected clearly through the flow direction of the main river flowing across Hanoi.



Climate

- The climate of Hanoi bears the humid tropical monsoon characteristics, with hot and wet summer and cold and dry winter. The annual mean relative humidity is 84% and the rainfall is 1676mm
- The summer lasts from May to September, characterized by high temperature and rainfall with dominantly southeast wind direction. During this period, the highest average temperature occurs in July (28.90C) and the highest average rainfall occurs in august/july (318mm)

Average rainfall from 1986-1997



Month

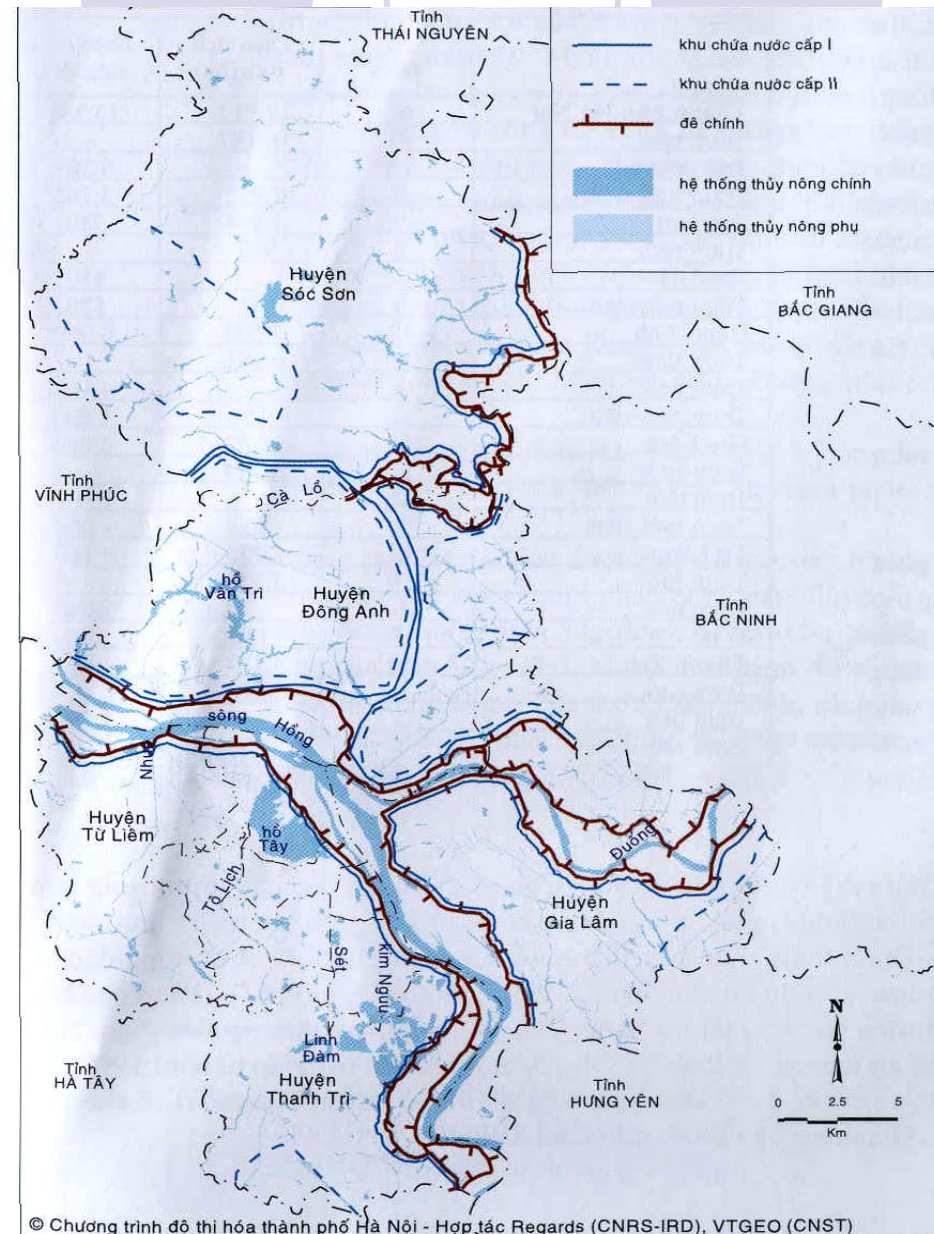
Hydrology

- River: 157km in total length

- Big rivers: (drainage and irrigation rivers): Hong, Duong, Nhue & others (a branch of Hong river), water quality is rather good.

- 4 small rivers (drainage river):

- To Lich, Kim Nguu, Lu and Set rivers are the main drainage for waste water of the city.
- Total length: 38.8 km



Hydrologic characteristics

	Rivers	Lakes
Number	10	111 (24 lakes -inner city)
Area or length	157.7 km	2180 ha
	Total length of 36.8 km for 4 main drainage axes : Tolich, Kim Nguu, Set, Lu	The largest West Lake (516 ha), then Linh Dam Lake (52.2 ha).

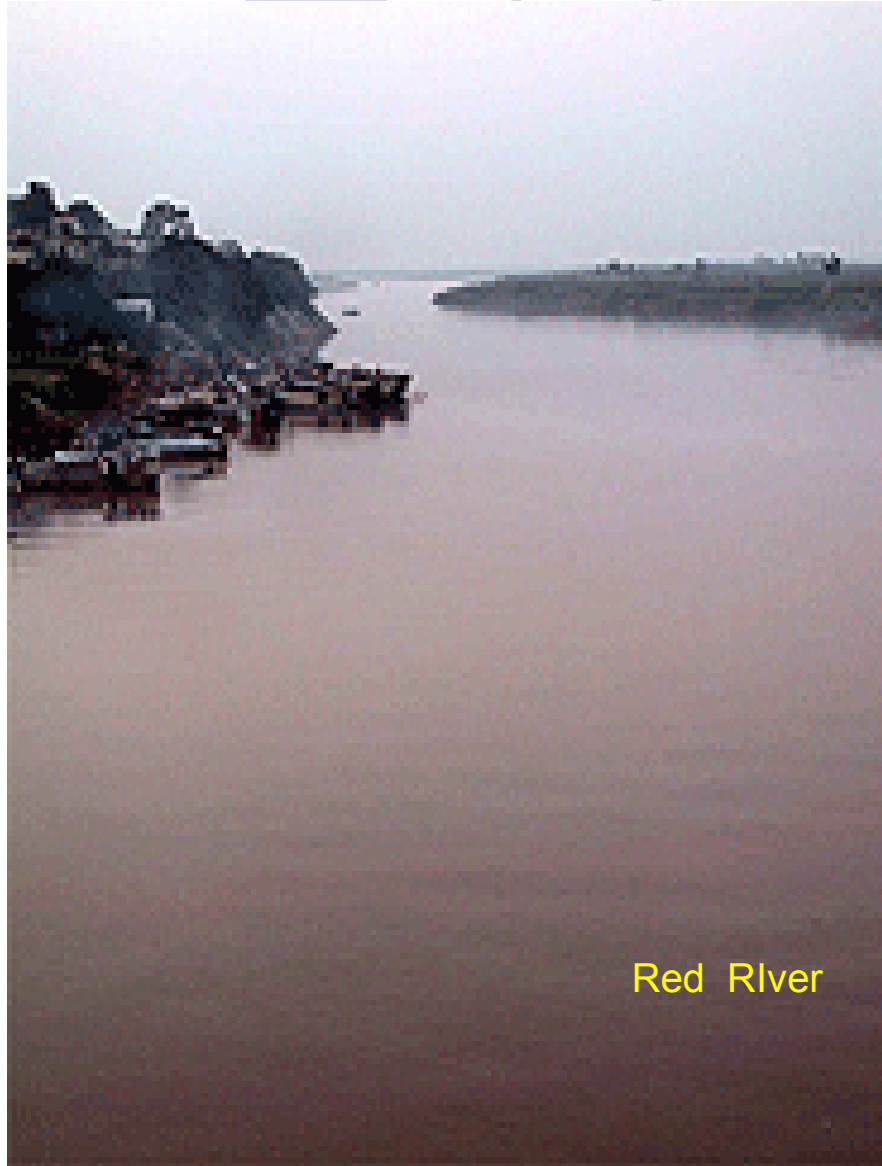


Hoan Kiem Lake



West Lake

PICTURE OF SOME RIVERS



Red River



To Lich River



SET River

Hydrology

The functions of rivers

No.	Rivers	Main function
1	To Lich	Holding waste waters
2	KimNguu	
3	Set	
4	Lu	
5	Red	Water supply, drainage
6	Ca Lo	
7	Cong	
8	Cau	
9	Duong	
10	Nhue	

Hydrology

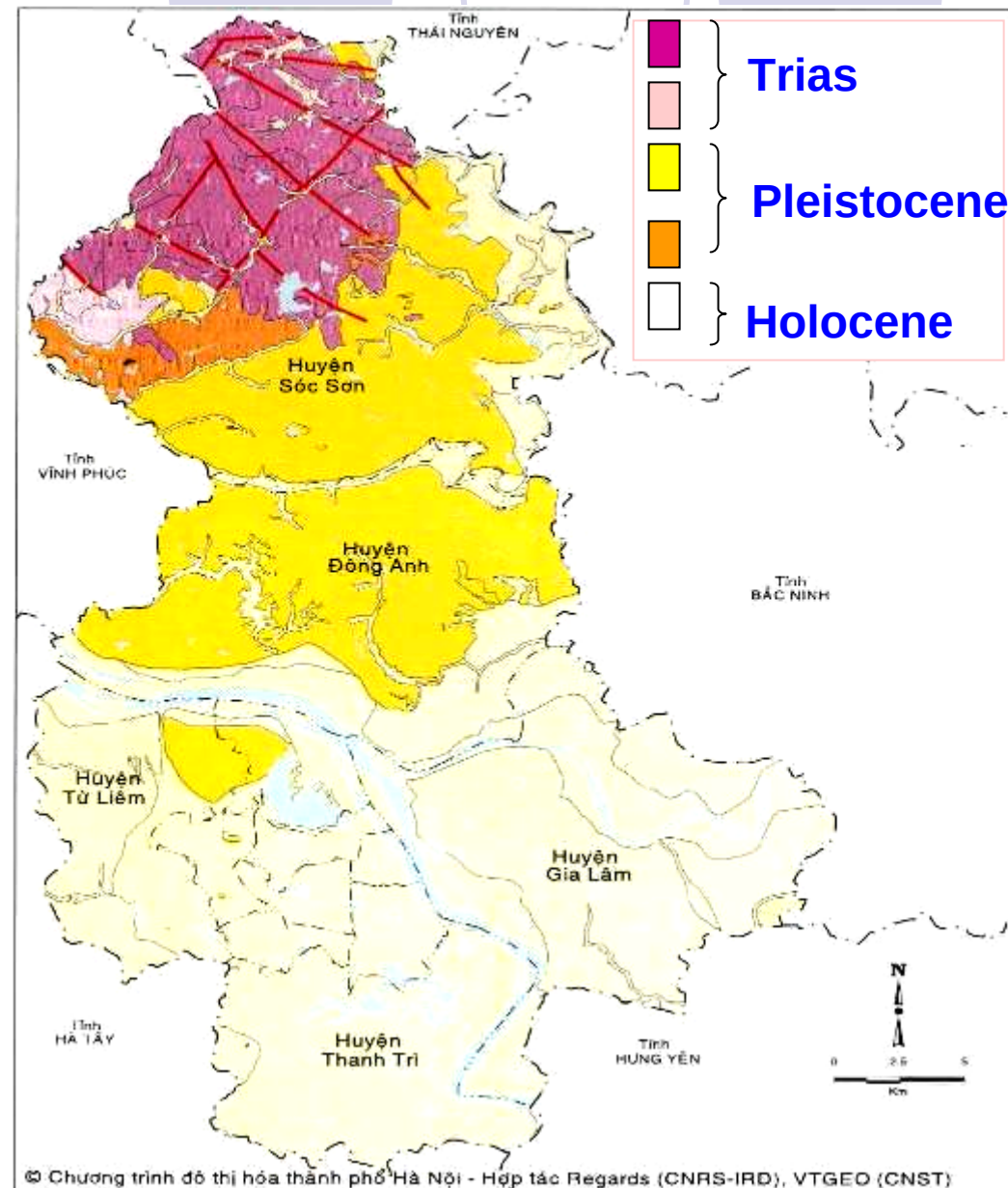
The functions of some lakes

No.	Lakes	Main function
1	West Lake	Tourism, entertainment, climate regulation, pisciculture
2	Truc Bach	Tourism, entertainment
3	Thu Le	
4	Bay Mau	
5	Van Chuong	Holding waste waters
6	Giang Vo	
8	Thanh Nhan	
7	Ba Mau	Holding rain and waste waters

2. Geological condition of Hanoi City

During the Quaternary period (1.6 Ma to present), most of the land of Hanoi has been created through transgressions and regressions of the sea in 5 depositional cycles

- **Cycle 1:** From 1.6 to 0.7Ma, the Lechi formation, early Pleistocene ($Q_1^{1\text{ Ic}}$).
- **Cycle 2:** From mid - late Pleistocen, the Hanoi formation ($Q_1^{2-3\text{ hn}}$)
- **Cycle 3:** From late Pleistocen, Vinhphuc formation ($Q_1^3\text{ vp}$)
- **Cycle 4:** From late Pleistocen to early Holocen, Haihung formation ($Q_2^{1-2\text{ hh}}$)
- **Cycle 5:** From late Holocen to present, Thaibinh formation ($Q_2^2\text{ tb}$)



Engineering geological Conditions

Hanoi background was divided into 4 groups, basing on its characteristics, distributed depths, thick and geohydrography conditions

1. *Group I - Very good for constructions:*

- Distributed all Dong Anh and Tu Liem dist,
 - Quite flat, good drainage
 - Compositions: clay, clay with sand, sand with clay
- Pleistocene age with high mechanical and physical indexes.
- Groundwater: < 5m.

2. *Group II - Good for constructions:*

- ✓ Distributed inner city, along To Lich, Hong, Duong river, most of Gia Lam dist.
- ✓ Quite flat or be local cut in somewhere.
- ✓ Compositions: clay, clay with sand, sand with clay Holocene age
- ✓ Good or medium mechanical and physical indexes
- ✓ Groundwater: 2 - 5m

Engineering geological Conditions

Hanoi background was divided into 4 groups, basing on its characteristics, distributed depths, thick and geohydrography conditions

3. *Group III - Medium*

- ✓ Distributed all Thanh Tri and a part of Gia Lam dist (near Hong river) and some areas in Dong Anh, Tu Liem dist.
- ✓ Quite bad topography, hollow surface.
- ✓ Compositions: Mud and organic soils
- ✓ Bad mechanical, physical indexes and drainage
- ✓ Ground water may erode concrete

4. *Group VI - Bad for constructions*

- Distributed between Hong and Duong river dykes.
- Always flooding in rain season.
- Very bad mechanical, physical indexes,
- Never good for constructions.

Engineering geological Conditions

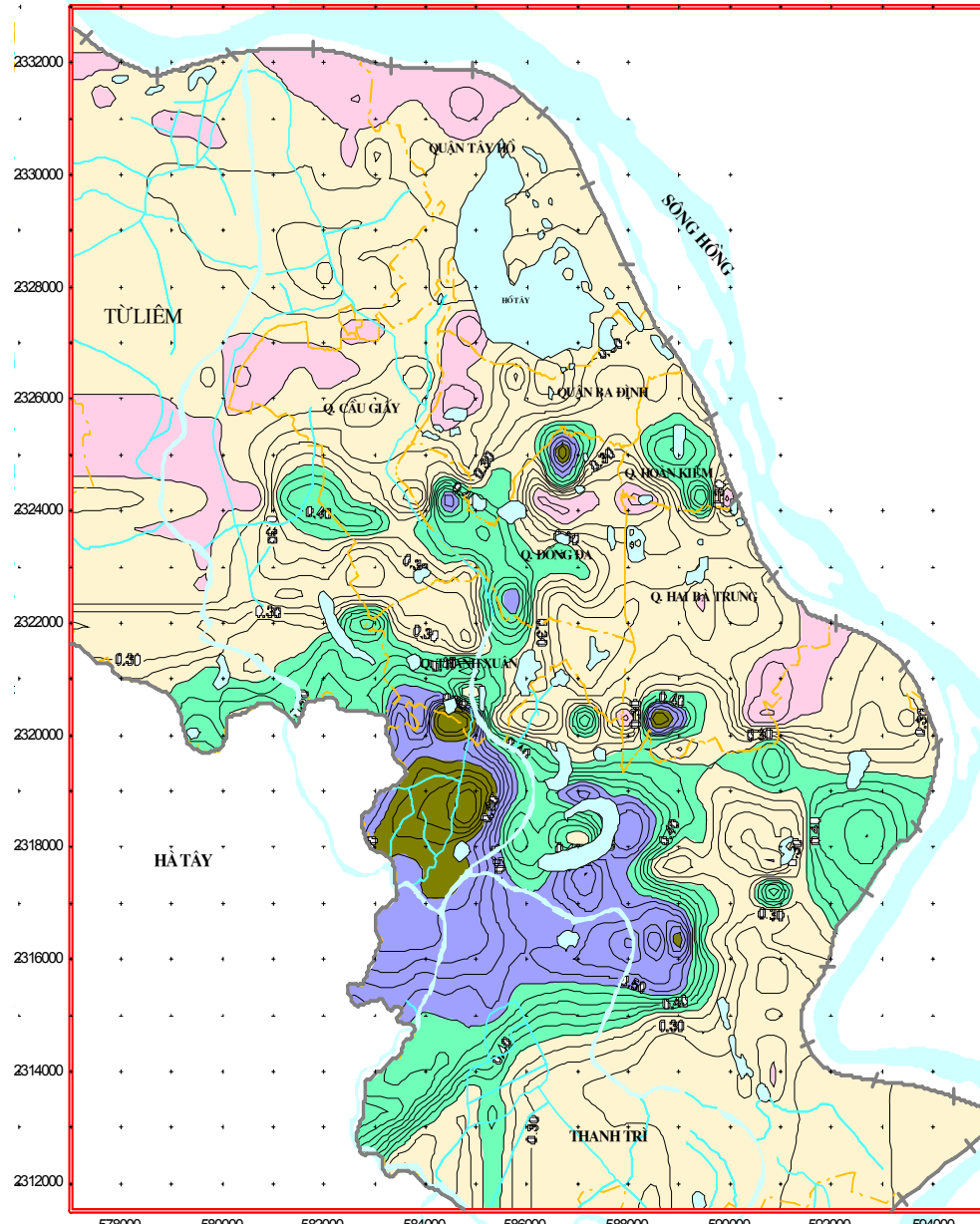
Hanoi background are divided into 4 zones, based on its characteristics, distributed depths, thicks and geohydrography conditions

1. **Zone I - Very favorable for construction**
2. **Zone II - Favorable for construction**
3. **Zone III - Less favorable for construction**
4. **Zone VI - Not favorable construction**



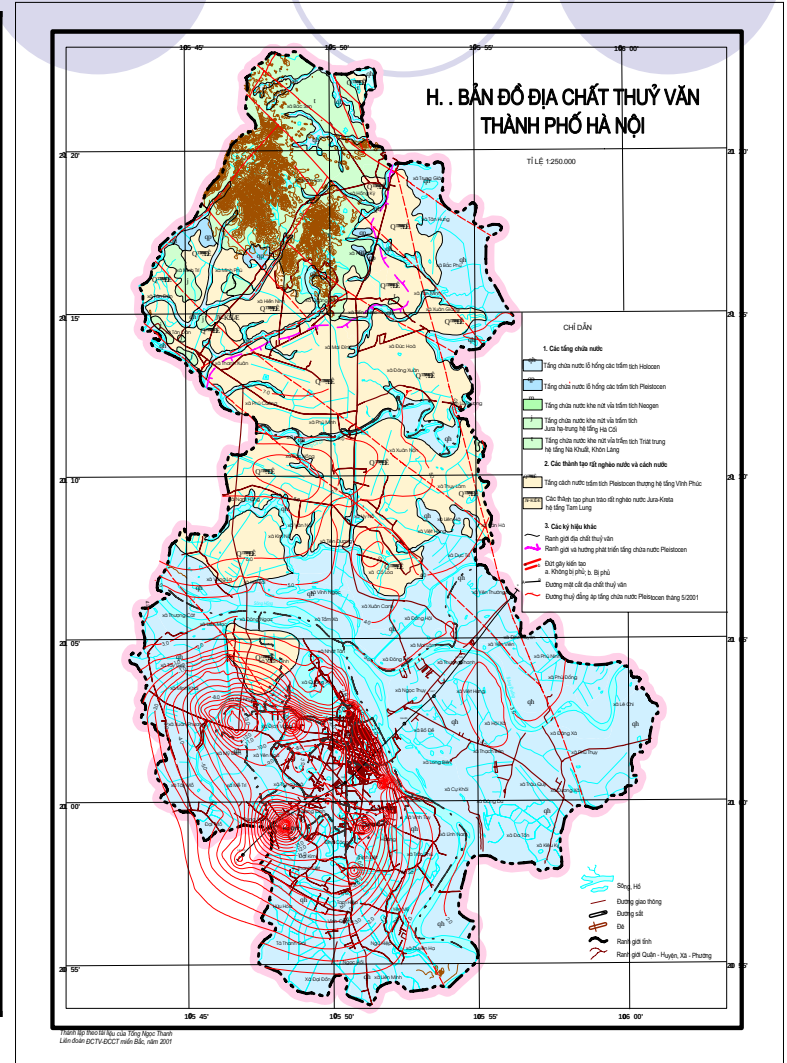
Engineering geological Conditions

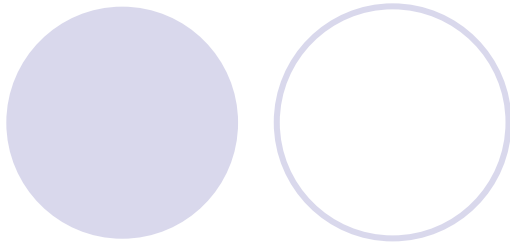
**Geotechnical
condition zoning map
in the southwest of
Hanoi**



3. Hydrogeological condition

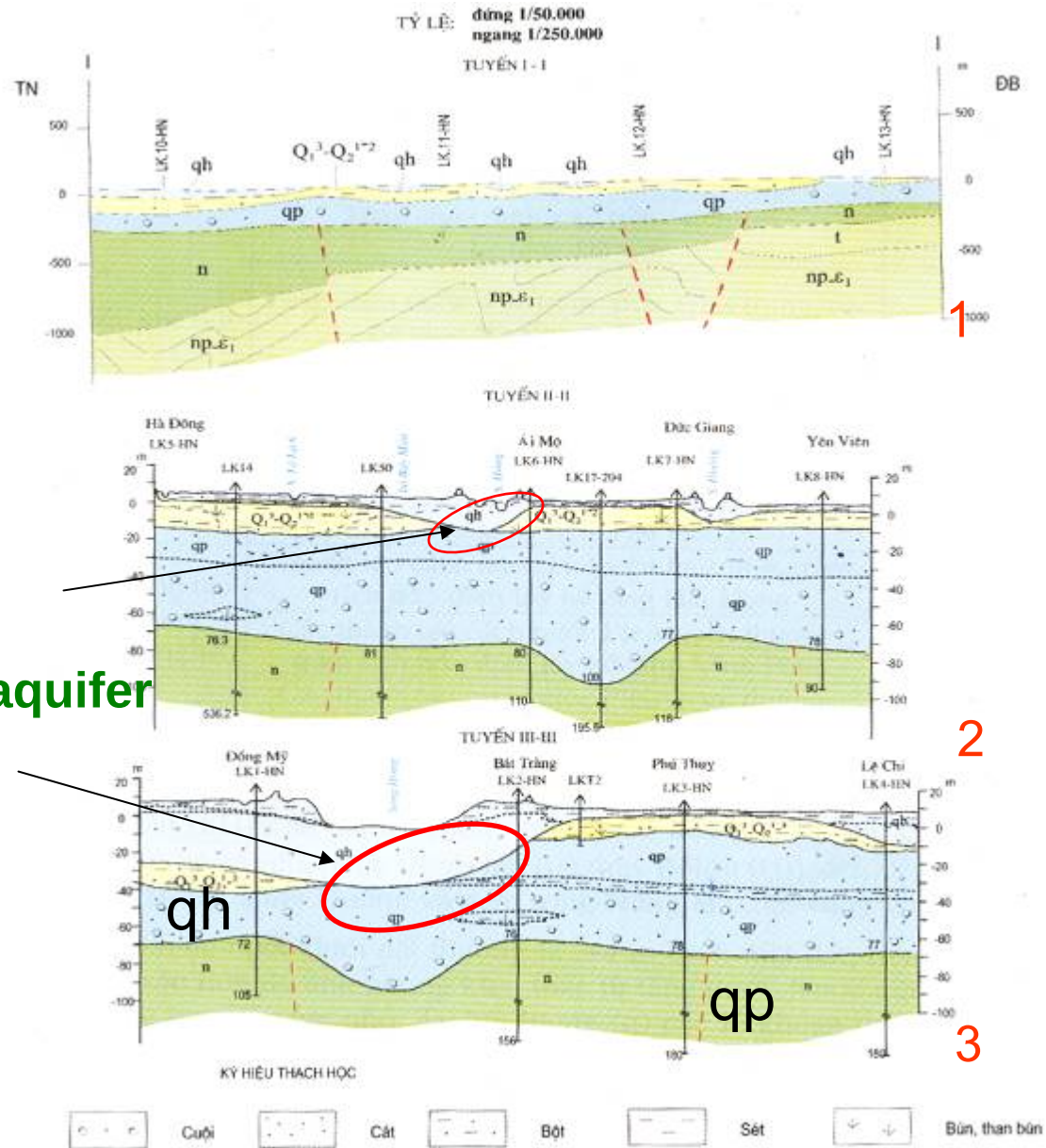
	qh aquifer	qp aquifer
Location	from the Red and Duong Rivers southward	from the south of the Soc Son District southward
Total area (Km ²)	530	>700
Composition of sediment	weakly permeable silty clay, silty sand	Sand, sand mixed with grit and gravel
	Sand, sand mixed with grit and gravel	Gravel mixed with grit and sand
The depth of the groundwater level (m)	3-4	2-35
Supplying significance	poor	very rich





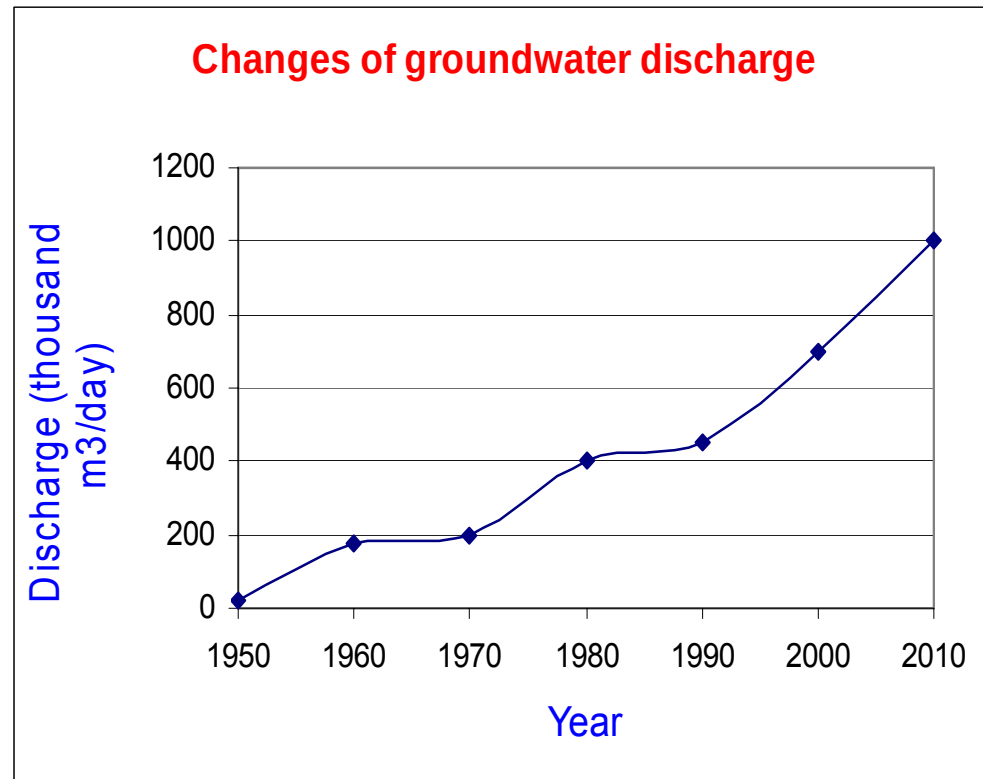
Hydrogeological cross section

Windows between qh and qp aquifer



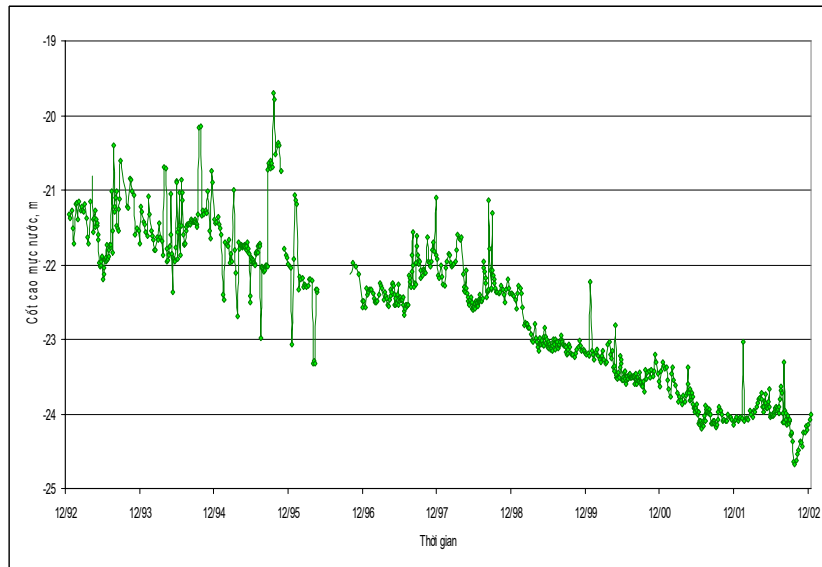
Groundwater exploitation

- Began to exploit groundwater for serving the living demand since 1909.
- Up to present time, the quantity of drill wells and exploiting capacity continually increase



Change of groundwater level due to exploitation

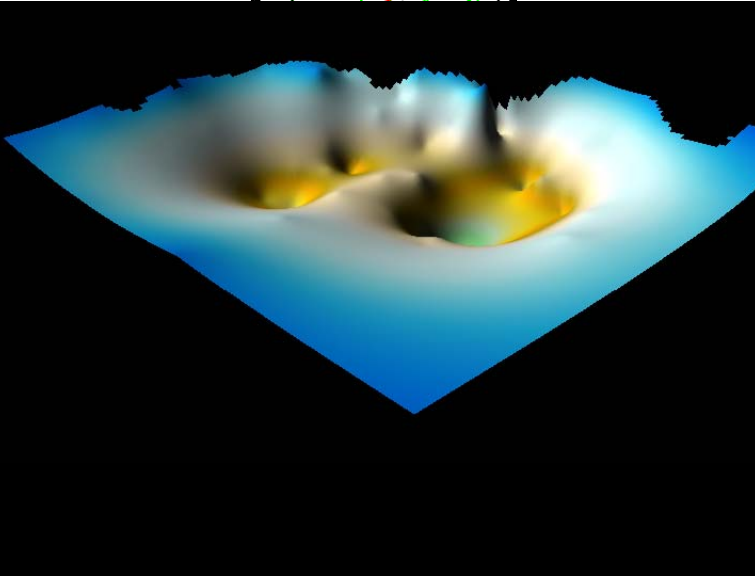
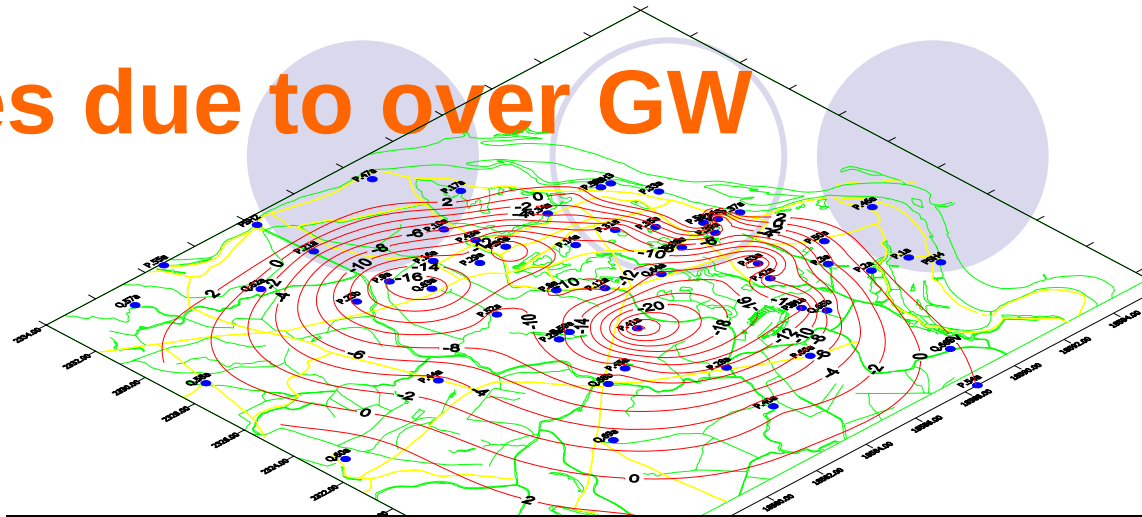
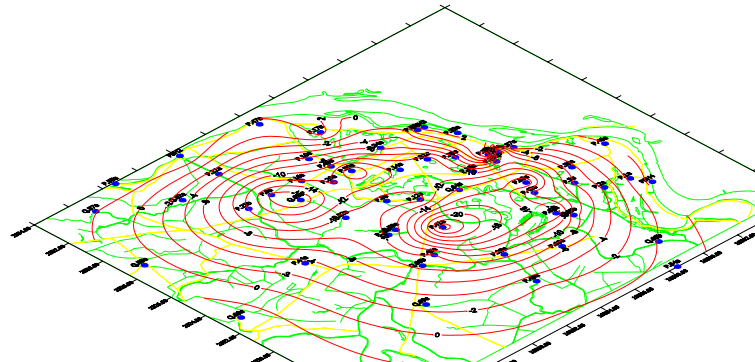
Ngoc Ha



Ha Dinh

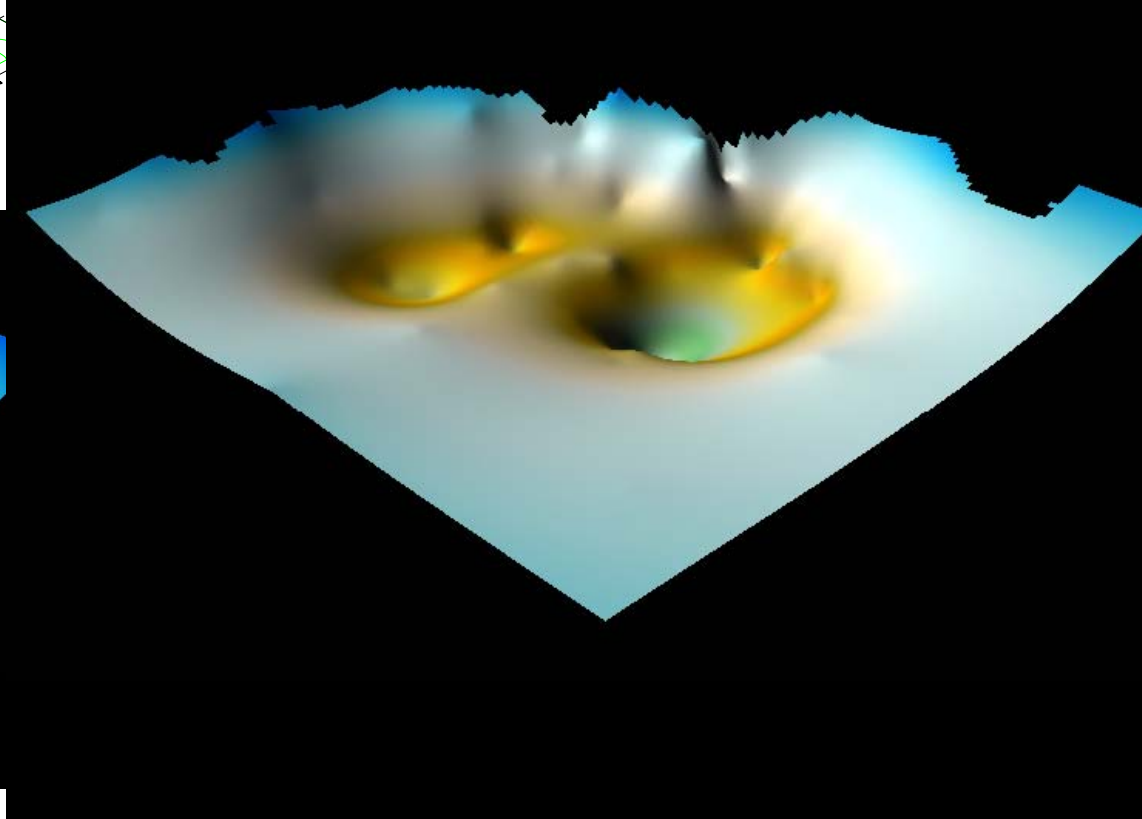


Depression cones due to over GW exploitation



Diện tích phễu <14m : 29.01 Km²

Đường thủy đẳng áp



Diện tích phễu <14m : 29.71 Km²

Đường thủy đẳng áp

Land subsidence due to over GW exploitation

Subsident rate

1. Thanh Cong, Ba Dinh area: 4.5cm/year
2. Ha Dinh: 3cm/year
3. Pháp Vân, Hạ Đình, Tương Mai, Văn Điển, Mai Dịch: 2cm/year



**Land subsidence in Thanh Cong area
The first floor is now only 1.5m in height**

4. Conflicts between development and the Environment

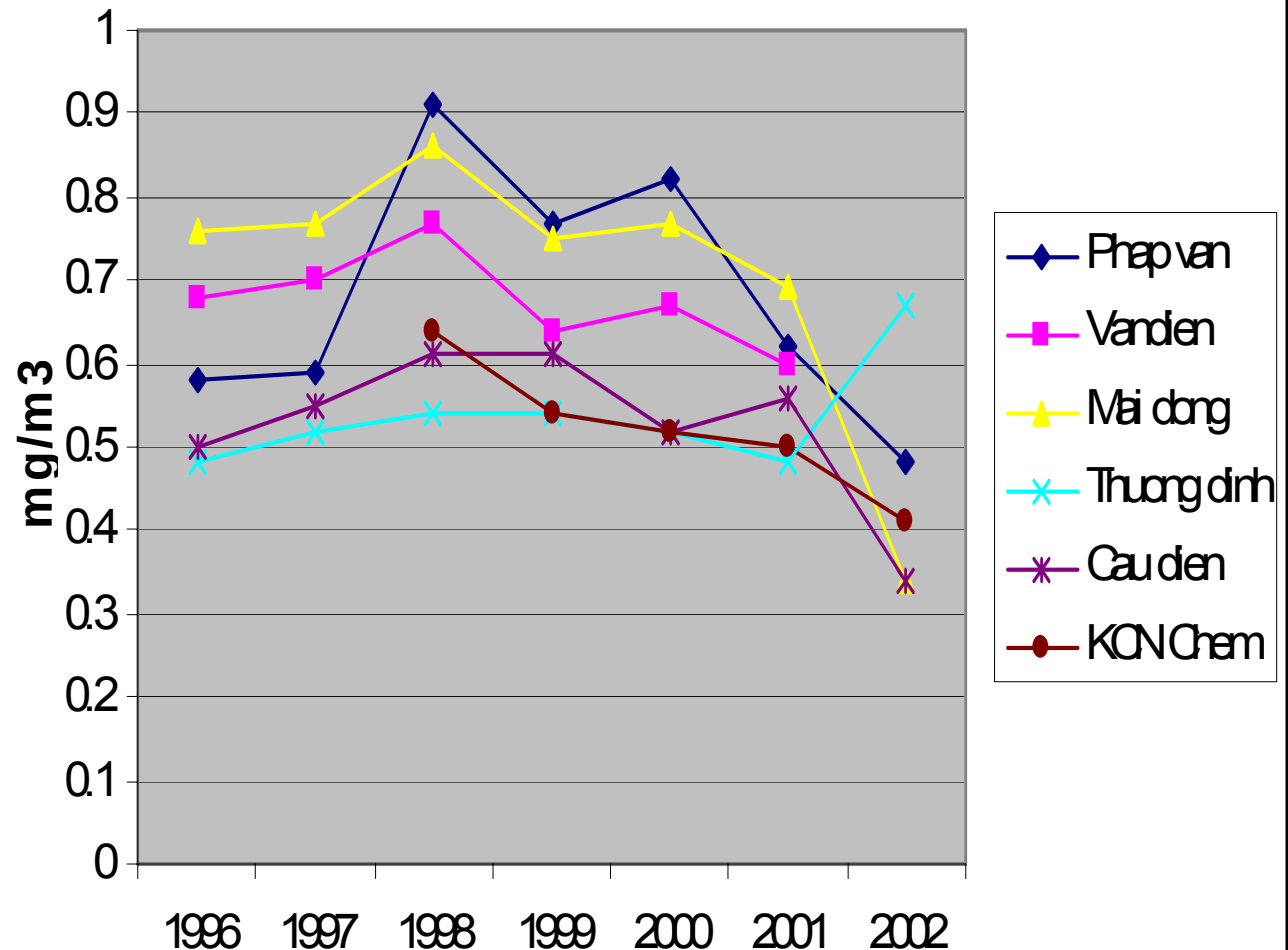
- ✓ Quality of Air, Water and Land
- ✓ Disaster Vulnerability
- ✓ Social and Cultural changes



Air Environment

- Concentration of dust: over the allowance 2.5-4.5 times, most of industrial zones tend to decrease,
- Inner city manifests to pollute of SO_2 , NO_x , ...
- By 2010, air pollution caused by industry decrease in inner city
- By 2020, most of parts of streets polluted

Concentration of dust in some industrial zones of Hanoi



Air Environment

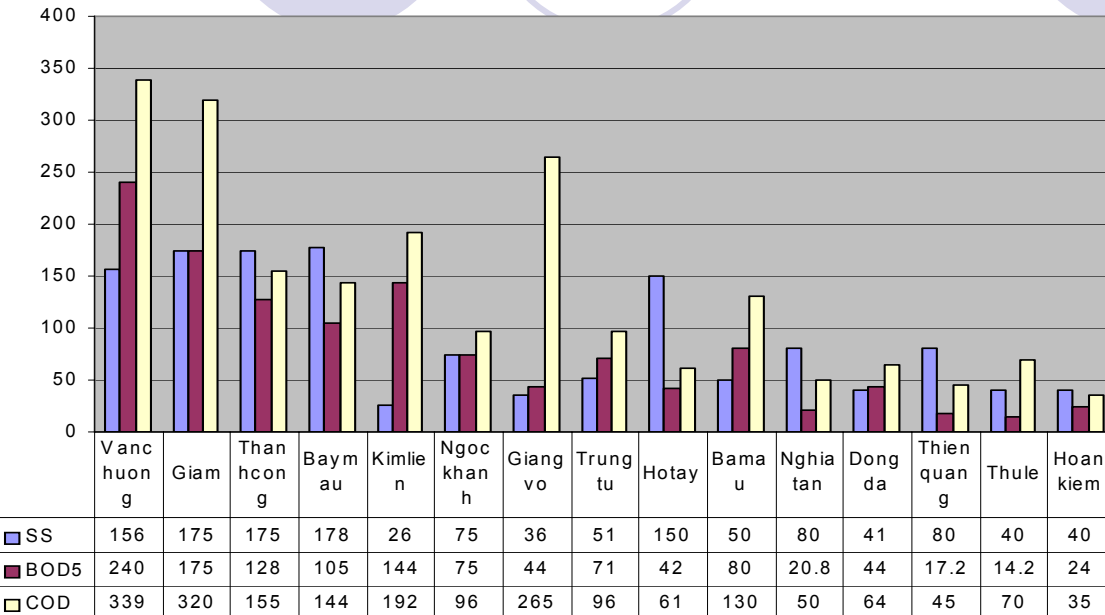
- **Noise**

- Industry: Intending to decrease.
- Transportation: increasing slowly

<i>Location \ Year</i>	1996	1997	1998	1999	2000	2001	2002
IP Thuongdinh (dBA)	70-75	70-75	70-75	70-75	70-75	70-75	61.13
IP Caudien (dBA)	65-70	65-70	65-70	65-70	65-70	65-70	62.02
IP Vandien (dBA)	70-75	70-75	70-75	70-75	70-75	70-75	
IP Maidong (dBA)	70-75	70-75	70-75	70-75	70-75	70-75	62-75
IP hapvan (dBA)	70-75	70-75	70-75	70-75	70-75	70-75	64.4
Nga Tu So (dBA)		82.03	82.07	81.8	80.5		
Nga TuVong (dBA)	83.62	83.62	81.95		77.12		

Current status of noise pollution at some places in Hanoi

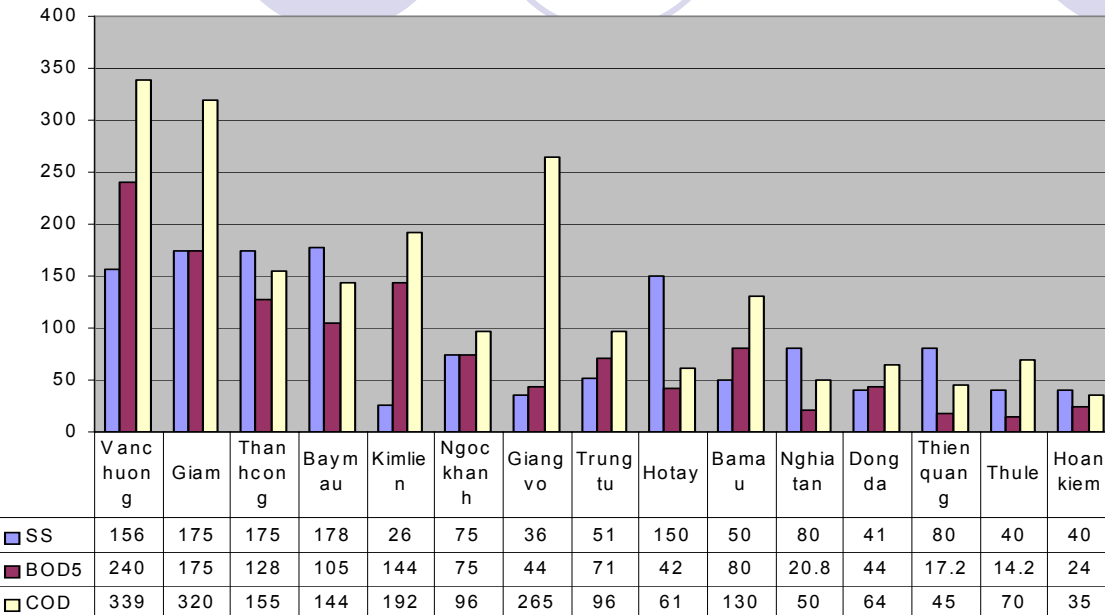
Lake pollution



pH															
DO															
coli form	some hundreds times greater than the permitted standard														
NH4															



Lake pollution



pH															
DO															
coli form	some hundreds times greater than the permitted standard														
NH4															



Lakes

8-25%

No.	Lake names	Area (ha)		Depth (m)	Water level (m)
		Before	Present		
1	West Lake	561.96	516	2.0-4.0	6.20
2	Truc Bach	26	19	1.5-2.0	6.2
3	Thu Le	12	9.9	2.0-3.0	5
4	Giang Vo	4.5	6	3.0-4.0	5.25
5	Van Chuong	6	5.2	2.0-3.0	5.2
6	Bay Mau	19.64	18	2.0-2.5	5.1
7	Ba Mau	6.32	4.5	1.2-3.0	5.1
8	Hoan Kiem	16	12	1.5-2.0	6.8

RIVER POLLUTION

- - Red river
- - Duong river

Pollution of solide matters
Pollution coef: 3 - 8 times

- To Lich
- Kim Nguu
- Set
- Lu

Seriously polluted by
organic mixtures DO=2-3 times pollution coefficient

BOD ₅	COD	NH ₄ ⁻	Microor-ganisms
1.5-4 (times)	1.5-5 (times)	12.5-27 (times)	2-13000 (times)

- Cau
- Ca Lo

pH
DO
BOD₅
NH₄⁺
PO₄³⁻
Metals

Lower than
the standards
of water environment

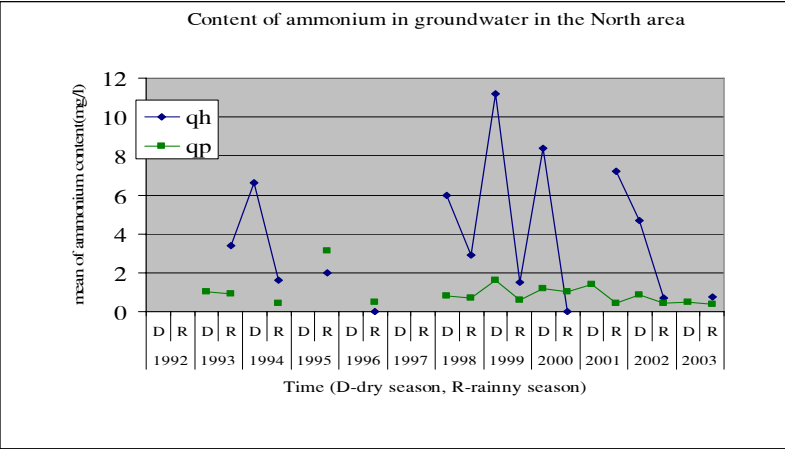
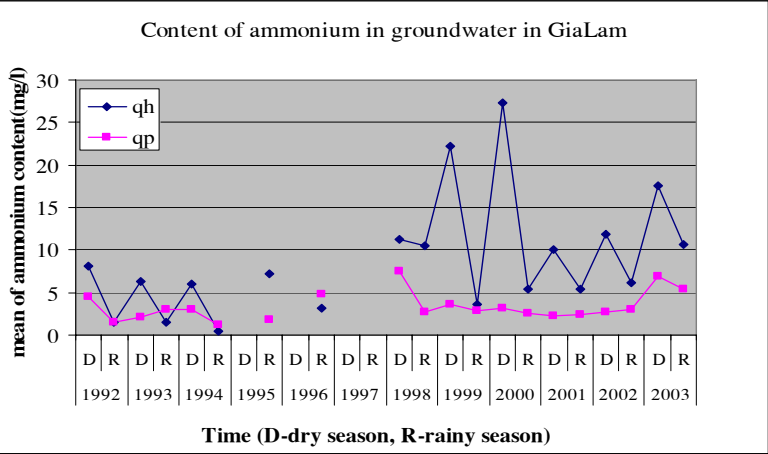
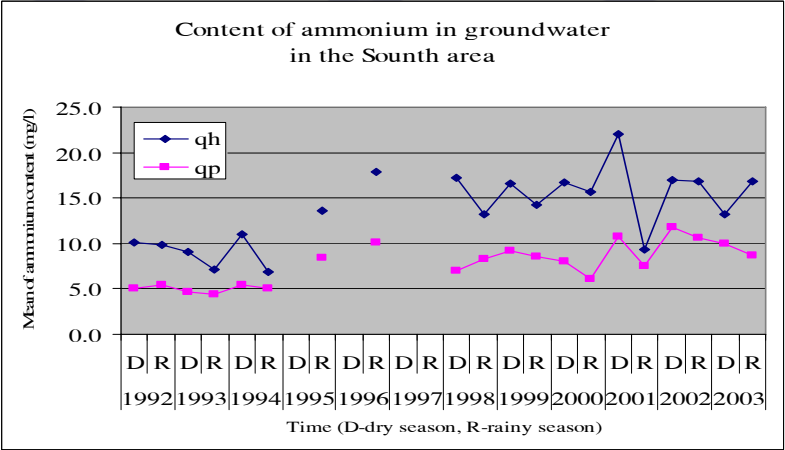
Pollution level

Ca Lo, Red, Duong, Cau, Nhue,
Kim Nguu, To Lich and Lu Rivers

GROUNDWATER POLLUTION

Ammonium

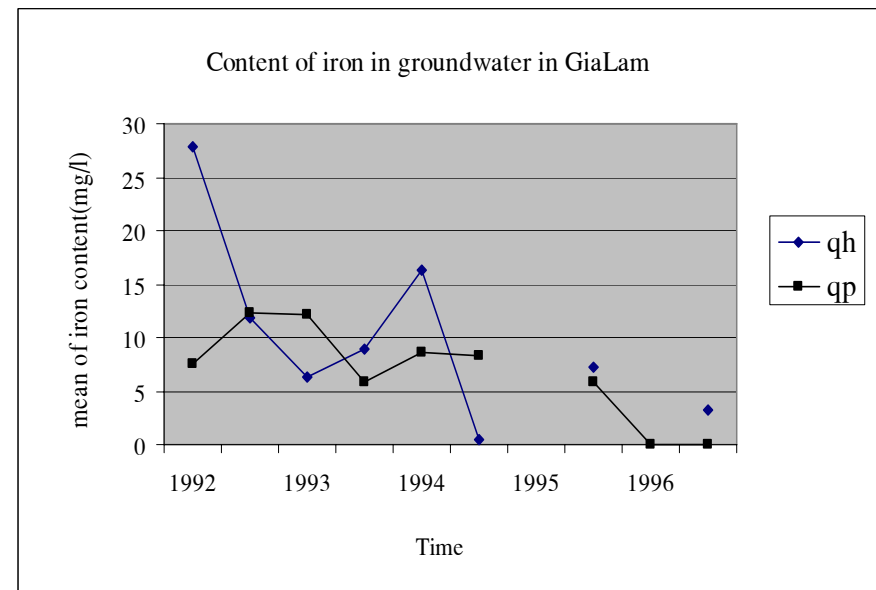
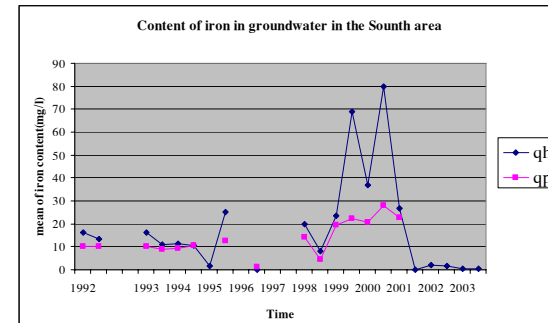
- Found in all parts of the city: southen, northen and GiaLam.
-



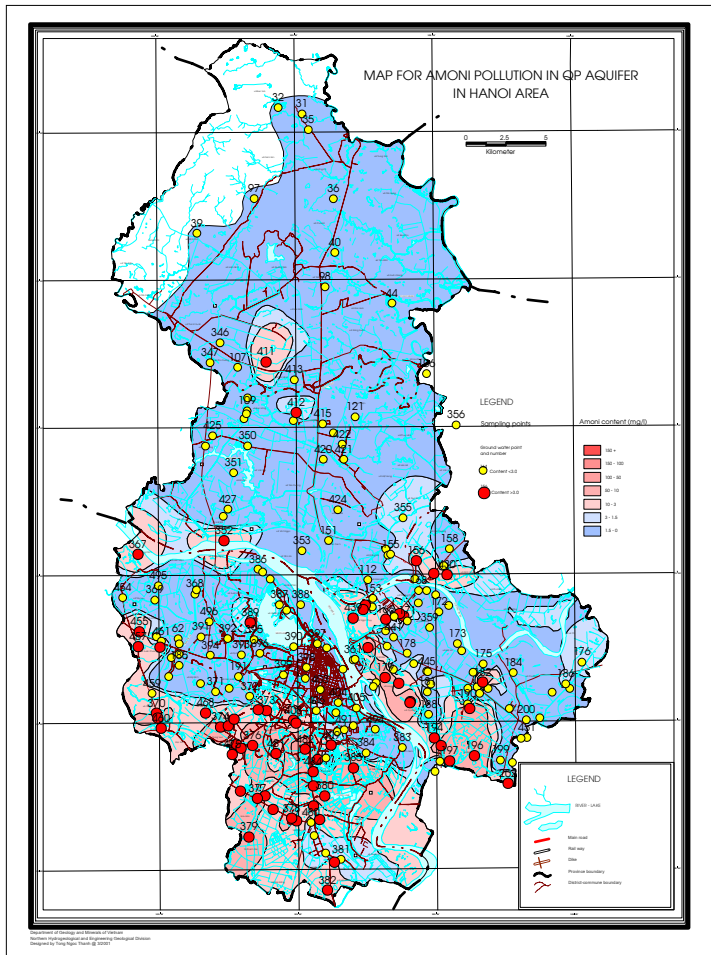
GROUNDWATER POLLUTION

Iron

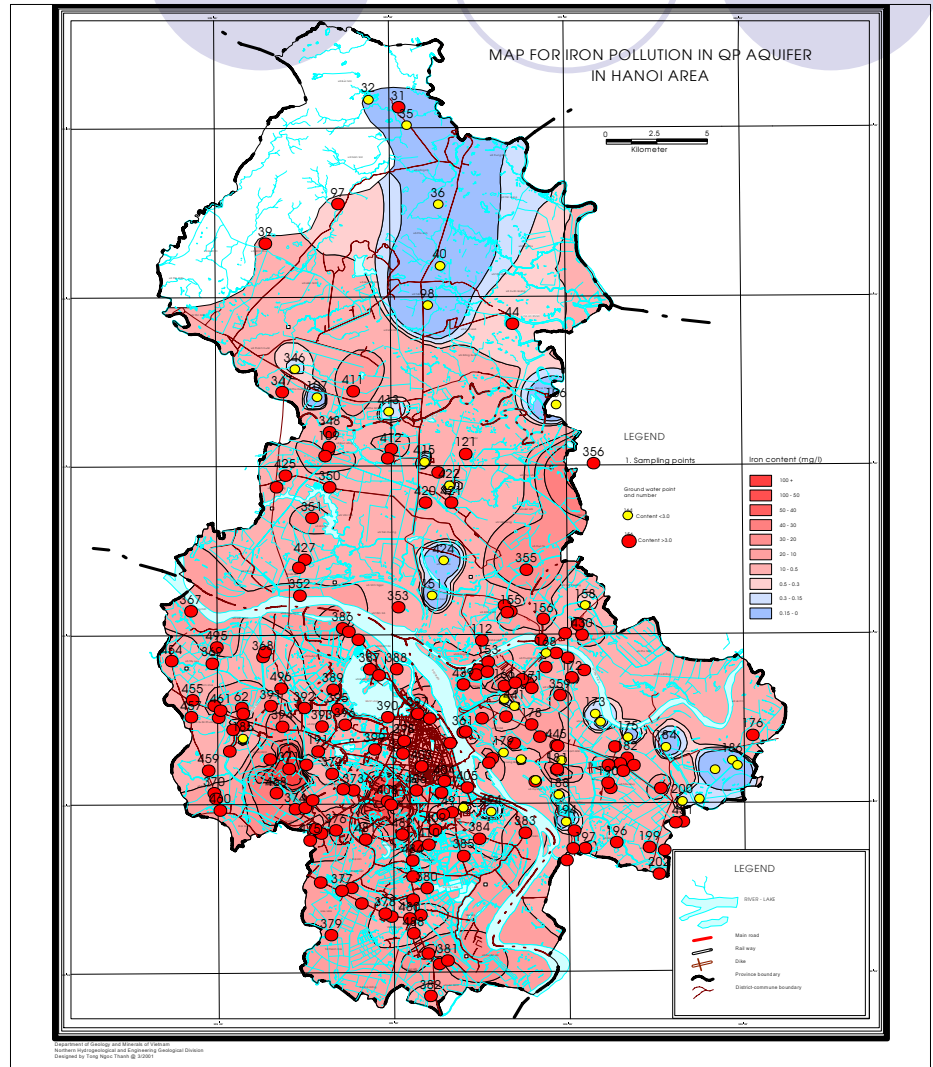
- Both aquifers and all parts of Hanoi city contain high iron.
- The southern part of the city is the most serious groundwater pollution by iron and then Gia Lam and the last is the north area.



Maps of iron and ammonium pollution of Groundwater

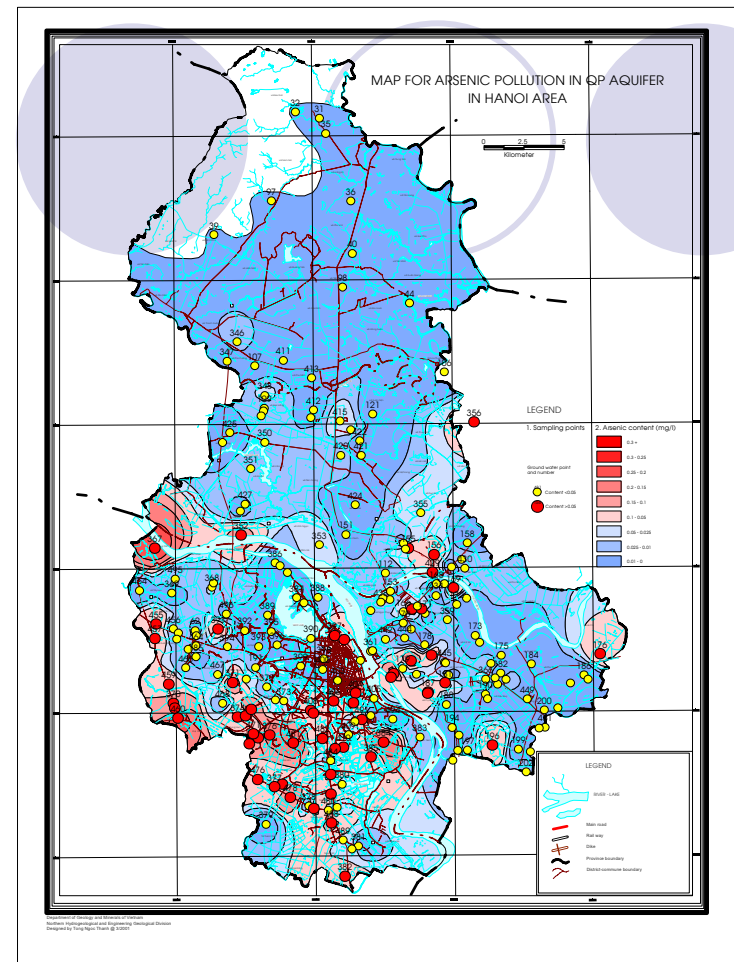
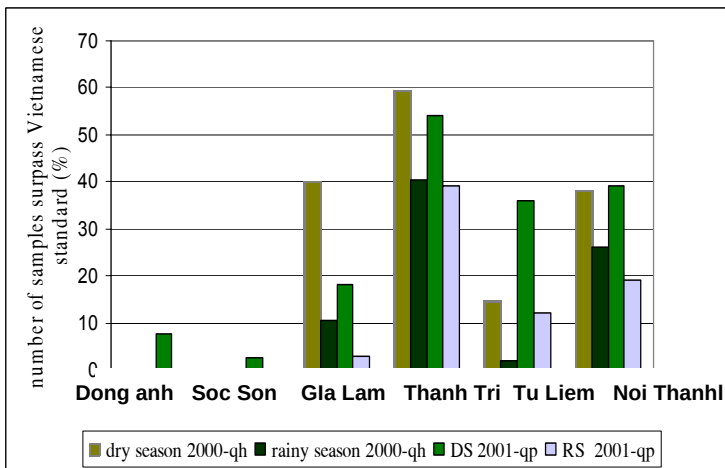
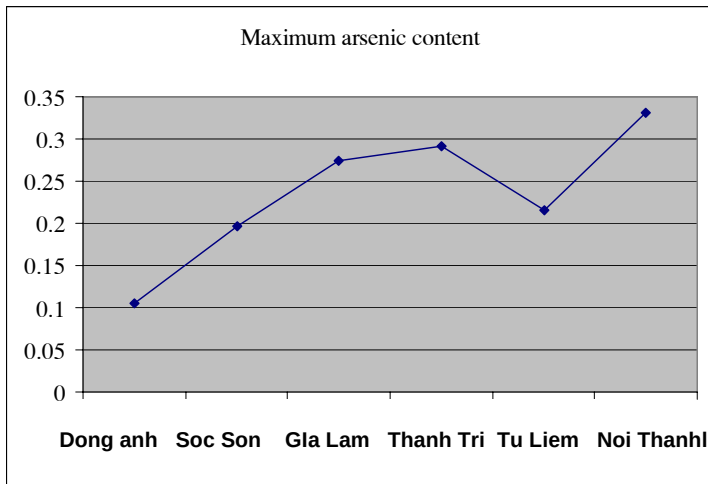


Ammonium

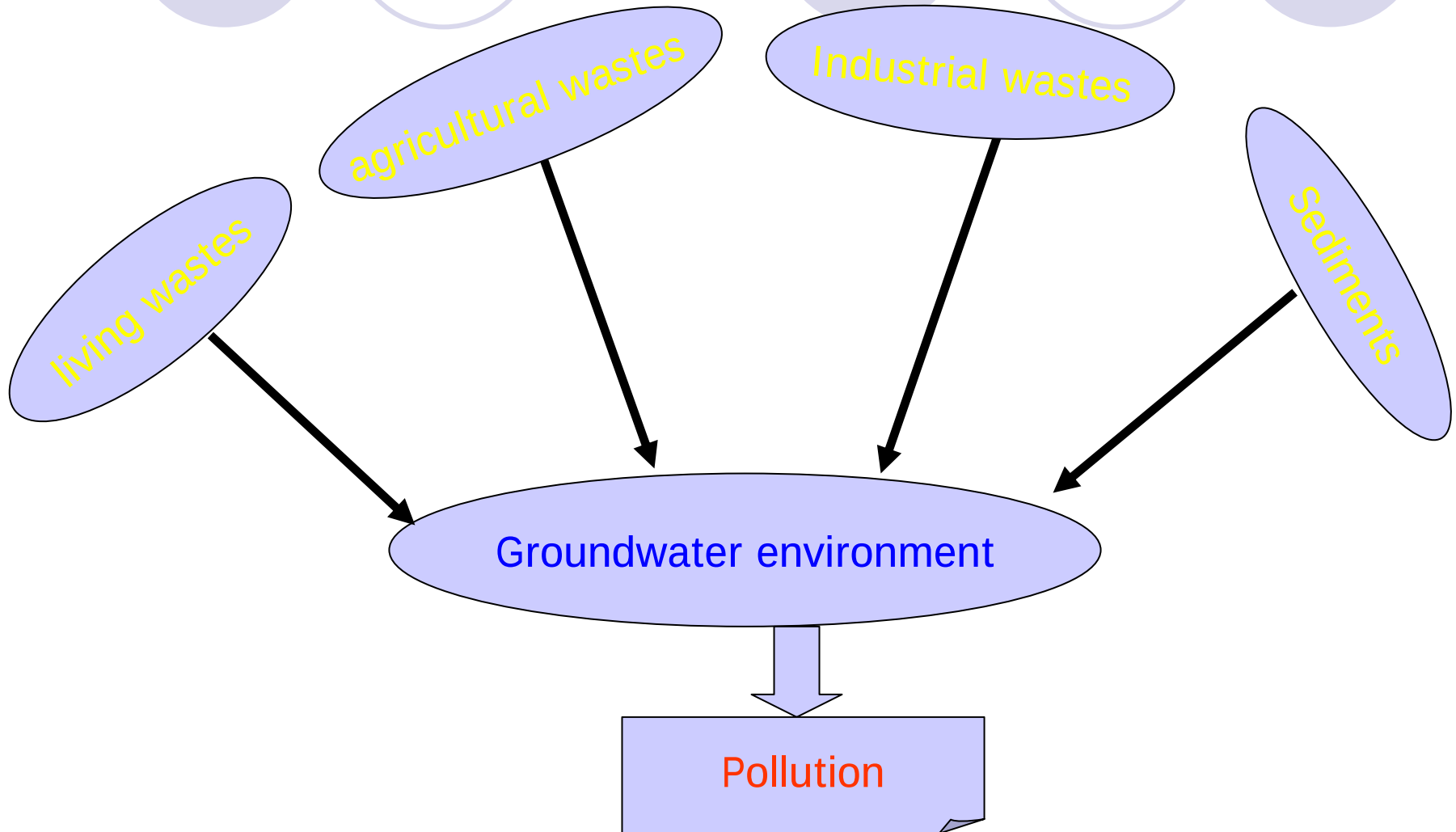


IRON

Arsenic pollution in Groundwater



The source of groundwater pollution



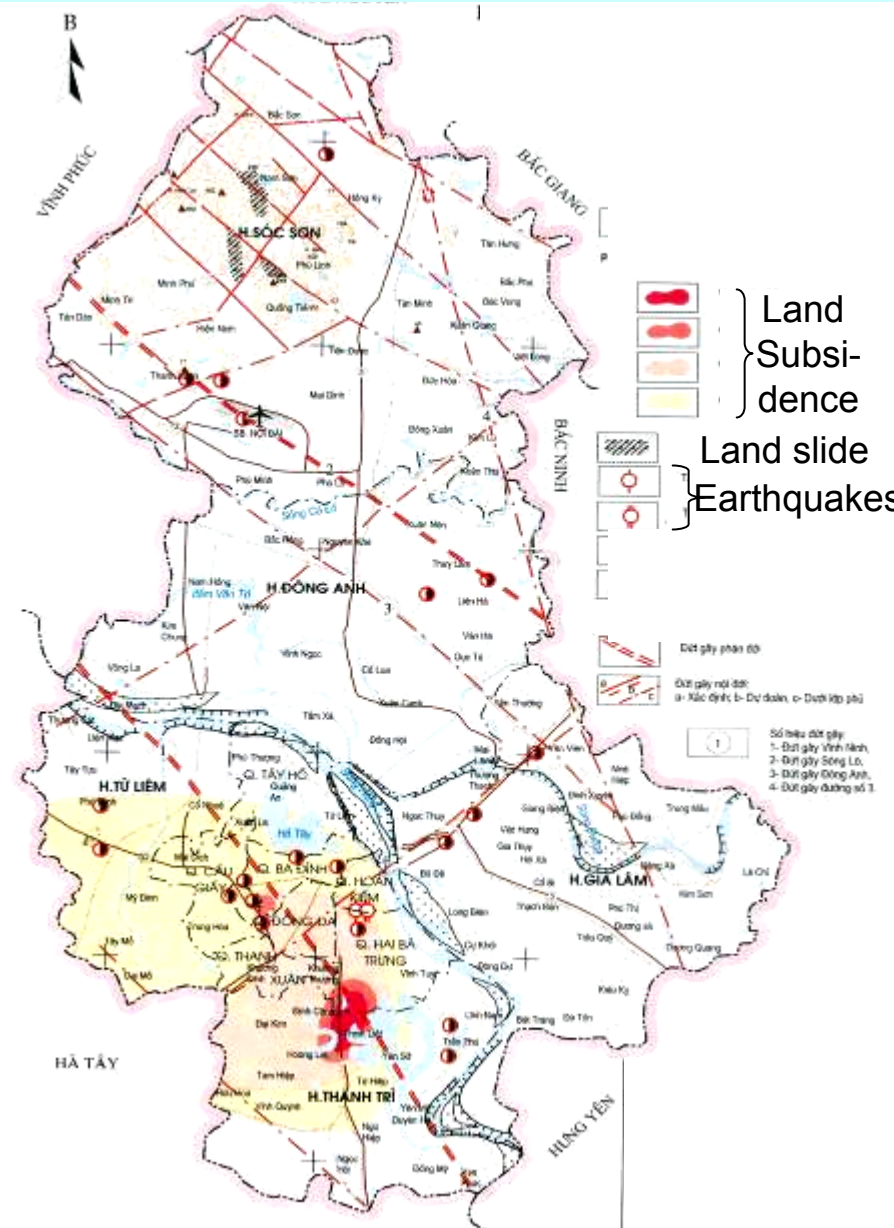
Natural hazards

Short-term hazards

- Storm
- Flood
- Inundation

Long-term hazards

- River bank erosion
- Sedimentation
- Land subsidence
- Earthquake



Natural hazards

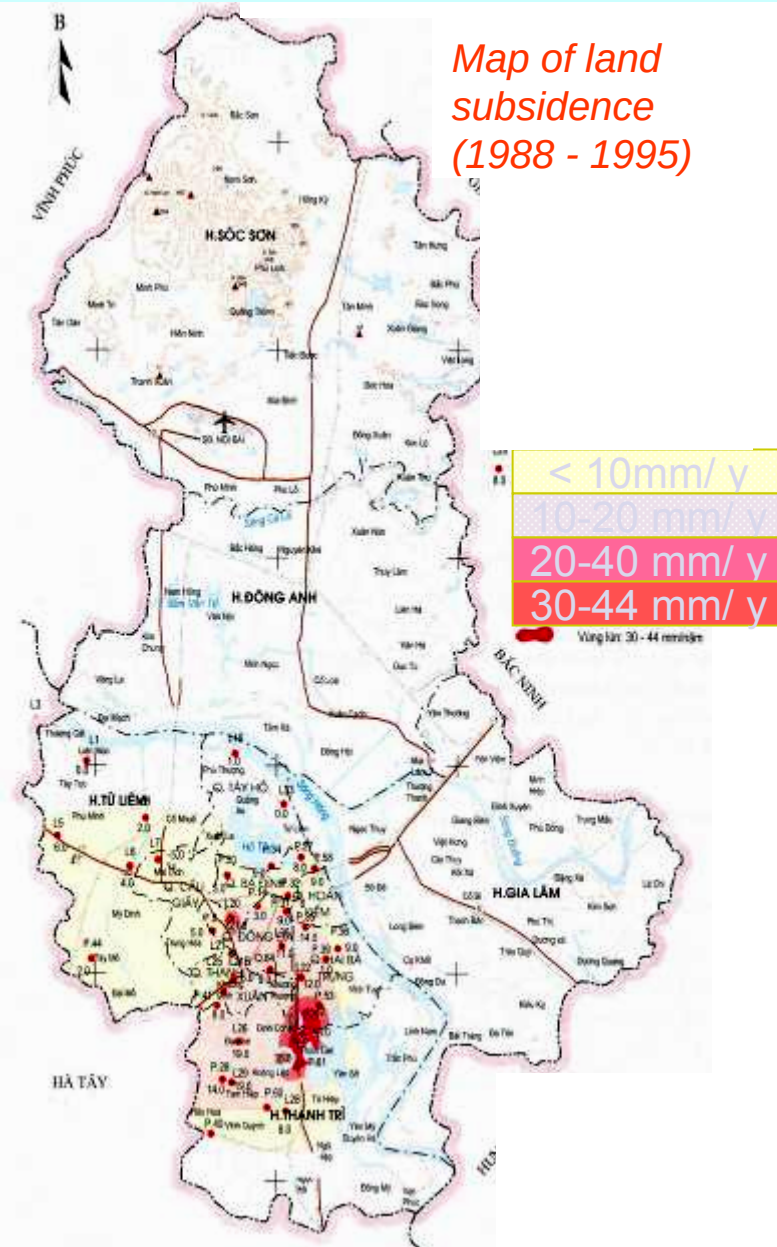
River bank erosion



Natural hazards

Land subsidence

- ✓ The most intensive subsidence in Hanoi by 1999 : 35 - 40 mm/year
- ✓ In most of the remaining area, the 20mm – 25mm/year
- ✓ In the Northern part: 10mm/year,
- ✓ The area along the Red river is not subsided.



Natural hazards

Earthquakes

There are over 130 earthquakes from 1277 to present:

- ✍ 3 reached the magnitude of 5.1 in Richter scale (*in 1277, 1278, 1285*)
- ✍ 1 reached the magnitude of 5.3 in Vinhphuc province in 1958 (*about 60 km from Hanoi*)
- ✍ 1 with magnitude of 5.6 in Bacgiang in 1961 (*about 60 km from Hanoi*)
- ✍ Hanoi city lies in the zone with possible earthquake of 7 to 8 M degree



Grade 7 (MSK-64)

Grade 8 (MSK-64)

5. BASIC STRATEGIES

1. Respecting the features of water-city as the identity of Hanoi wide area, building up new Hanoi as ecocity, based on Day River- and lakes-centered planning.
2. Focusing the potential of handicraft villages scattered in the suburbs of Hanoi wide area
3. Maintaining and utilizing the symbol of Hanoi's tradition and vitality; proposal-oriented to help 36 streets district to become a world cultural heritage ratified by the UNESCO

5. BASIC STRATEGIES

4. Maintaining :

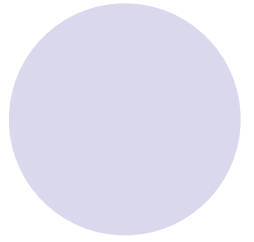
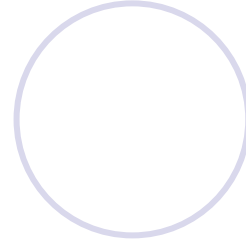
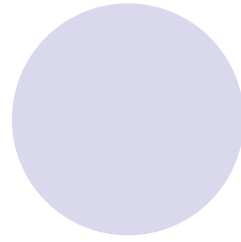
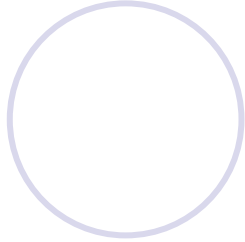
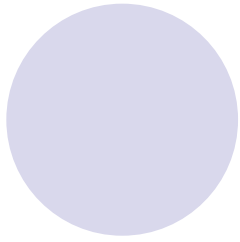
The existing urban area of HN as the historical capital (HC)

And establishing:

An administrative capital about 25-30 km west of the HC (Hoa Lac-Bavi Area).

5. Towards a Better & More Sustainable Living Environment

6. Encouraging international and inter-disciplinary approaches to the city



Thank you for your attention