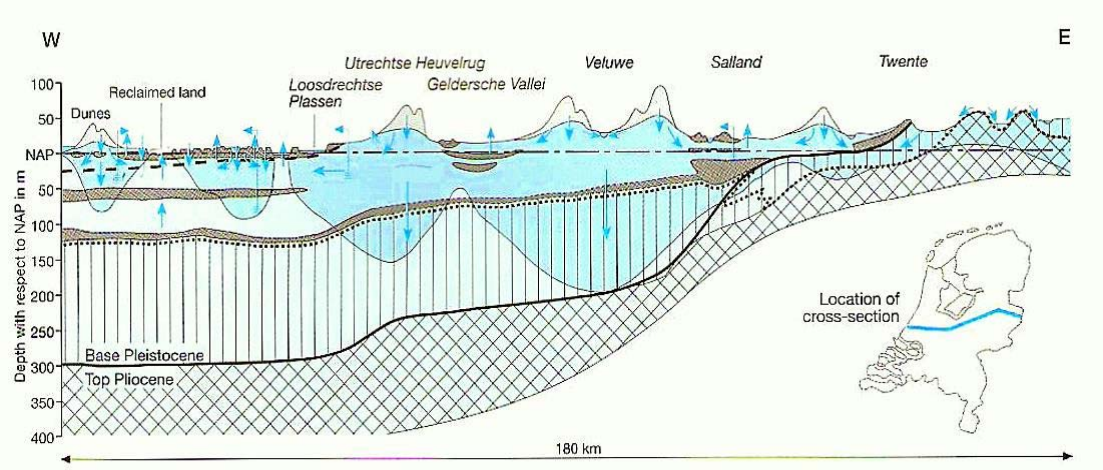
Groundwater problems and solutions in provinces of Zuid-Holland (The Netherlands) and Hebei (China)

A comparison in order to improve the cooperation between the two provinces



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Bachelor Thesis in Land and Water Management

2010

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Summary

Since the friendly cooperation between Zuid-Holland and Hebei started in 1993, the science and technology cooperation had been carried out in many fields. Considering my various backgrounds and my personal interest, I looked for the differences in the current urban groundwater management between Province of Zuid-Holland and Hebei and the ways to improve the exchange of expertise and cooperation. During my research, I used interview, literature study and practical study to get the answers for my research questions. I gave general overviews of the groundwater situation in two provinces and the effects of climate change to take readers into my research. Moreover, I gave the history and the development of the water policies. In the same chapter, the different policies and organizations of water authorities were also given as a foundation of the further research and let both provinces aware the political differences. In addition, the classification of general groundwater problems was given and groundwater problems itself and groundwater management problems were analyzed. Following the problems analysis, the best practices of the two provinces as well as the possibilities to apply their solutions and experience during dealing with the groundwater problems were given. The conclusion of my research is two provinces still got a lot of potentials for the cooperation. But the processing of the cooperation could be faster.

Acknowledgement

This thesis would not have been possible unless Mr. Hans van den Dool offered me the opportunity to do an internship for my final part of study in Van Hall Larenstein. He gave precious comments on my thesis and a lot of support for my internship. I owe my deepest gratitude to Mrs. T. Molegraaf that she offered me this opportunity to do my research in the Water Bureau in the Province of Zuid-Holland. She helped me a lot during my working in the PZH and with the useful research materials as well as the comments on my thesis. She also gave me a rare chance to join the mission in March. It is a pleasure to thank Mr. J.G. Meijles, for his tutorial on my research and valuable comments on Chapter 2, 3, 4 and 5. I am grateful to Mr. Xu Zhenci and Mr. Eric Oosterhof for their valuable comments and discussions throughout the interviews and for their open-minded attitude towards my research done. The Water Bureau in the Province of Zuid-Holland is a very pleasant place to work, with friendly and enthusiastic colleagues. There were always possibilities for vivid discussion and, also important, there was always someone helping me out in case of practical and technical problems.

Chenyang Zhao

June 1st, 2010

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Abbreviations

PZH	Province of Zuid-Holland
HP	Hebei Province
NAP	*Normaal Amsterdams Peil*: Amsterdam Ordnance Datum
KNMI	*Koninklijk Nederlands Meteorologisch Instituut*: Royal Dutch Meteorological Institute
NITG-TNO	*Nederlands Instituut voor Toegepaste Geowetenschappen TNO*: Netherlands Institute of Aplied Geoscience TNO- National Geological Survey
N	Nitrogen
Fe-Mn	Ferrimanganic
F	Fluorine
NPRC	National Provisional Ruling Council
DRC	Development and Reform Commissions
EWFD	European Water Framework Directive
PMG	*Provinciale Meetnetten Grondwaterkwaliteit*: procincial groundwater quality monitoring networks
LMG	*Landelijk Meetnet Grondwaterkwaliteit*: national groundwater quality monitoring network

1. Introduction

As the final part of my study in the Van Hall Larenstein University of Applied Science, this thesis offered me the possibility to express my knowledge gained throughout my four years college education. Therefore, I expressed my work and research ability in the Water and Environment Department in Province Zuid-Holland by formulating a thesis problem and providing the recommendations.

The central objective of this thesis is to contribute to the cooperation of integrating groundwater management by a better understanding of groundwater problems between Province Zuid-Holland in the Netherlands and Hebei in China. In particular I aim to compare the different elements that influence the groundwater management and different reference levels to define the problems. The aim of the current chapter is to bring you into my research and show the background information about the stage of cooperation project in general (Section 1.1), Problems analysis of the groundwater (Section 1.2) and the Methodology of my research (Section 1.3). Finally, an outline of the thesis as the last section of the introduction will provide a guidance for reading.

1.1 Background of the cooperation

Since the friendly cooperation between Zuid-Holland and Hebei started in 1993, the science and technology cooperation had been carried out in many fields. Two province governors signed a three-year memorandum of understanding about cooperation projects in September 2006 and started 3 water cooperation objects. In June 2009, both provinces were hoping to continue the cooperation about water resources development and management and the related scientific and technological cooperation. In the following two months, the memorandum of understanding has been formal signed in 25th October 2009 by the Water Resources Department of Hebei Province and the Water& Environmental Protection Bureau in Zuid-Holland. In March 2010, the water department in Hebei Province visited the Zuid-Holland. During the meeting of future cooperation, the two departments discussed to set up a pilot project on groundwater monitoring and management in Hebei. PZH will use the pilot area as an example (to do the operation, get the sample). The provinces will offer governmental input on permits, policy and management. At the end of 2011, they will organize one big International Conference in Hebei.1

[1] Refer to the Reference list in the back.

1.2 Problem analysis

In many urban areas there are cases in which local aquifers are not able to meet the quantity and quality of water needs of the growing population. In other cases the factors which induce unaware water policy makers to discourage groundwater use are the result of poor management, lack of protection and other interests [Emilio Custodio, 1997]. The groundwater problems exist for a long time in the two provinces, but the actions to manage these problems are slow, even with a lot of energy and staffs working on it. Since the provinces can find more opportunities for solving the problems through the cooperation between the two provinces.

Now we formulate the main research question and five sub research questions which express the research structure.

Main Research Question

To narrow down the research and the main research question was formulated:

> ***What are differences in the current urban groundwater management between Province of Zuid-Holland and Hebei and How to improve the exchange of expertise and cooperation?***

To create a manageable research design, the following research questions will be used to structure the research:

1. How is the Groundwater situation in Zuid-Holland and Hebei Province?
2. What are the differences policies between two provinces for groundwater management?
3. What problems are related to current urban Groundwater management?
4. What lessons can be learned from both sides?
5. How to improve to the cooperation?

1.3 Methodology

As the research objective generally formulated in Chapter 1, this research ***aims to give recommendations to promote the cooperation of groundwater management and monitoring between Province of Zuid-Holland and Hebei***. In the previous section, I have introduced the background and problems of the cooperation. I aim to highlight these issues by illuminating both the technical and theoretical perspective. These

research objectives ask for exploratory and qualitative research methodology. Furthermore, the main focus is on lessons can be learned from both sides.

Research Strategy

The research strategy is set up in three parts: pre-research, theoretical analysis and aggregate analysis.

- Pre-research

The pre-research was done by discussion with internal and external tutors and literature study on Internet. This helped me to analyze the information I had in order to clarify the research subject and define the research broad. This includes the first-hand experience in March during the Hebei delegation visited Province of Zuid-Holland.

- Theoretical analysis

The theoretical part of the thesis refers to research questions 1 and 2. It will start with literatures review of the history of cooperation and general groundwater situation in two provinces. Then, the different groundwater problems and the organizations and policies will be discussed with PZH and HP experts and learned by reading pervious projects reports, which can help to give a foundation of the further research.

- Aggregate analysis

The aggregate analysis is part of the study comprises interviews to the PZH and HP experts about the research questions 3 and 5. It includes the questionnaire, telephone interviews, email communication, face to face interviews and also the field visiting.

Methods

To answer these research questions, a combination of technical analysis and theoretical research methods is used, including interviews and literature study.

- Interviews:

During the face to face interviews with experts in PZH, telephone interviews to governmental officers in HP (see questionnaires in Appendix 1), I got more specific information and more professional ideas and suggestions. Data and information processing was very important in this methodology. To make the information reliable, interviewees are all chosen inside of the water department.

A well-designed questionnaire was used to gather information on both the lessons want to be learned from both sides as well as information on specific components of the groundwater problems (see Appendix 2).

- Literature Study:

I collected information from three sources:

The internet about groundwater situations and problems and water management policy in Hebei. Documents given by Ms. Molegraaf about water legislation in the Netherlands and by Mr. Meijles about European Water Framework Directive and Guidance on Risk Assessment for Groundwater. In addition, I studied the reports of former stages cooperation and reports on former visits.

- Practice study:

I also joined the mission of Hebei delegation that visited the PZH in March as a first-hand experience of the cooperation and be a one day translator for the Water Department of Hebei Province during the visit in Dunea Drinking Water Company.

1.4 Guidance for reading

In the first part, I give an introduction of this research and a background of the cooperation. Then I define the problems and I mention in this report and demonstrate the methods used to carry out the research. In Chapter two I give an overview of groundwater situation by facts and figures. In Chapter three I compare the groundwater policies and organizations in both provinces. In Chapter four I illustrated the general groundwater problems and selected two problems of both provinces for future analysis. According to the previous research, I gave the lessons can be learned from both sides to contribute to the value of my research. At the end of the thesis, recommendations, conclusion and appendixes will be given.

2. Outline of groundwater situations

2.1 Introduction

This chapter addresses ***the Groundwater situation in Zuid-Holland and Hebei Province?*** Groundwater situations are described to give a general overview for the two provinces. Section 2.2 and 2.3 give introduction of PZH and HP, including geography and factors and figures related to groundwater. In Section 2.4, groundwater system and its characteristics of both sides are given. In the end of this chapter, a comparison of the different situations is given.

2.2 Province of Zuid-Holland

2.2.1 Geography

Province of Zuid-Holland is in western Netherlands, bordering the North Sea and adjoining the provinces of Noord-Holland (north), Utrecht and Gelderland (east), and Noord-Brabant and Zeeland (south) (See Figure 2.1). Drained by the ramifications of the Lek, Waal, and Maas (Meuse) rivers, Zuid-Holland includes the islands and former islands of Dordrecht, IJsselmonde, Hoeksche Waard, Voorne-Putten, and Goeree-Overflakkee. It formed part of the historical county and province of Holland, which was divided officially in 1840 into the provinces of Noord-Holland and Zuid-Holland. Zuid-Holland (South-Holland) is a bustling, multifaceted province. It is home to 3.5 million people, who inhabit an area of around 2,900 km^2. This makes it

Figure 2.1 The position of PZH in the Netherlands [2]

the most densely populated of the twelve Dutch provinces, with 1,220 inhabitants per km^2.

Zuid-Holland is protected from the sea by a long line of coastal dunes. The coastal strip of beaches and dunes is used predominantly for recreational, resort, and residential purposes. Most of the land area behind the dunes consists of polder landscape lying well below sea level. At present the lowest point in PZH is a polder near Rotterdam, which is about seven meters below sea level. On the lee side of the dunes are situated the old towns of Leiden, Delft, and The Hague, the last the capital of the province and the seat of government of the country.[3]

2.2.2 Soils and Land use

The three major zones in the Netherlands, characterized by their top soil (Figure 2.2) are:

- elevated sandy areas;
- areas of the most recent coastal accretions, largely covered by clayey soils;
- a relatively low transition zone with peaty soils.

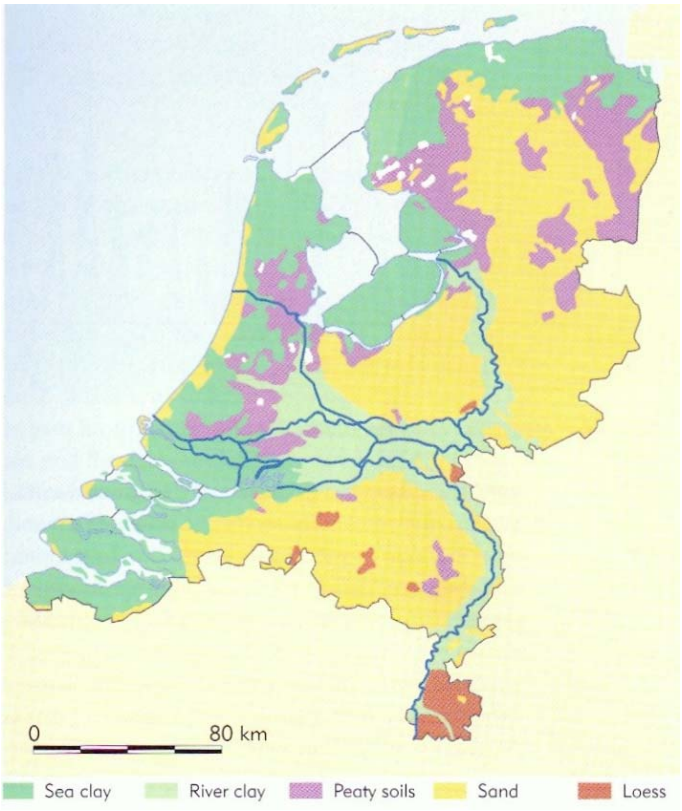


Figure 2.2 The major soil types of the Netherlands [4]

The sandy alluvial soil of the coast (geest) is mostly devoted to horticulture, notably flowering bulbs in the Bulbland north of Leiden, vegetables and flowers in the Rijnsburg area to the northwest, and fruit and vegetables (especially tomatoes, cucumbers, and lettuce) in the Westland south of The Hague(See Chapter 5). Farther inland is a region of peat and fertile alluvial clay; agriculture is carried on in the reclaimed lakes (polders) and dairy farming on the older soils, with cheese making in the eastern districts. Arable farming predominates on the marine clay soils of the delta island.[5]

By far the most important part of the province economically is the port and industrial area of Rotterdam, which extends along the New Meuse (Nieuwe Maas) River and connects to its out port, Europoort, via the New Waterway.

2.2.3 Facts and figures related to groundwater in PZH

In this paragraph, some facts and figures that related to groundwater in PZH are showed.

Over the most of the Netherlands the first several hundred meters of the subsurface comprises recent unconsolidated sedimentary deposits of gravel, sand, silt, peat and clay. As can be seen from Figure 2.3, the water table is relatively close to ground level. Figure 2.4 shows the depth to the water table in relation to NAP.

The climate of the Netherlands is temperature maritime. The mean monthly temperature varies between 2 ℃ in January and 17 ℃ in July.

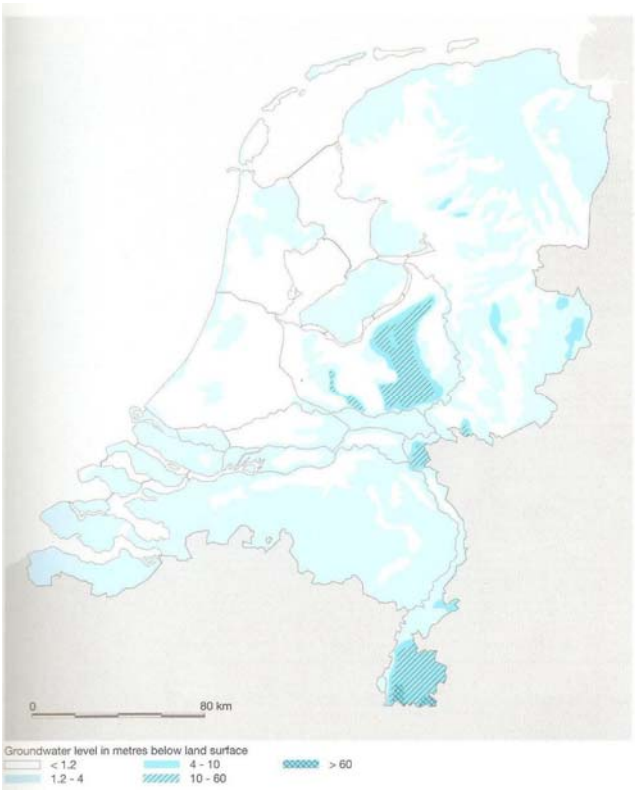


Figure 2.3 Depth to water table in relation to land surface, based on the mean lowest groundwater level [6]

The mean annual precipitation is 792 mm which, given the country's area, is equivalent to a volume of 29.6 billion m^3 water. Precipitation falls for about 7% of the time, mostly as rain (only 3% falls as snow). The main meteorological station of the KNMI is in De Bilt, in the centre of the Netherlands; the mean annual precipitation here is 8282 mm.

The mean annual precipitation for the entire country of 792 mm, which is equivalent to a volume of 29.6 billion m^3 exceeds the mean annual evaporation of 550 mm, which

is equivalent to about 20.5 billion m^3. For this reason, there is an annual precipitation excess in the Netherlands of, on average, 242 mm, which is equivalent to about 9

billion m^3. This precipitation excess fluctuates greatly which depicts the annual potential precipitation excess at De Bilt in the period 1930-1999.

A drought index has been developed for the agricultural sector in the Netherlands; it is a percentage indicating how frequently a drought of the magnitude in question occurs. The lower the percentage for the degree of drought is, the more severe is that drought. Thus a 10% dry year is a year with a precipitation deficit that occurs only once in ten years. Sometimes the term 'degree of drought' is used; a 20%degree of drought is the same as a 10% dry year.

Figure 2.4 Depth to water table on 9 February 1996 in relation to NAP[6]

Figure 2.5 is a simplified west-east cross-section indicating the main elements and processes that characterize the hydrogeology of most the Netherlands. In the west, the uppermost Holocene confining layer is overlain by dunes-Eastwards; this confining layer consists of clay and peat, underlain by an aquifer. The first aquifer consists of sands from the Sterksel, Urk and Kreftenheye Formations, the aquifer consists of clays from the Kedichem Formation, and the second aquifer consists of sands belonging to the Harderwijk Formation.[6]

<u>The groundwater Abstraction from the dunes</u>

The abstraction of fresh groundwater from the Dutch coastal dunes is a special case. It has grows rapidly since its start in 1853. Much of the water currently abstracted from the dunes is river water (mostly from Meuse and Rhine) that is allowed to percolate through the dunes. This process, which exploits the purifying action of infiltration through the dunes, was started on a large scale in 1956.

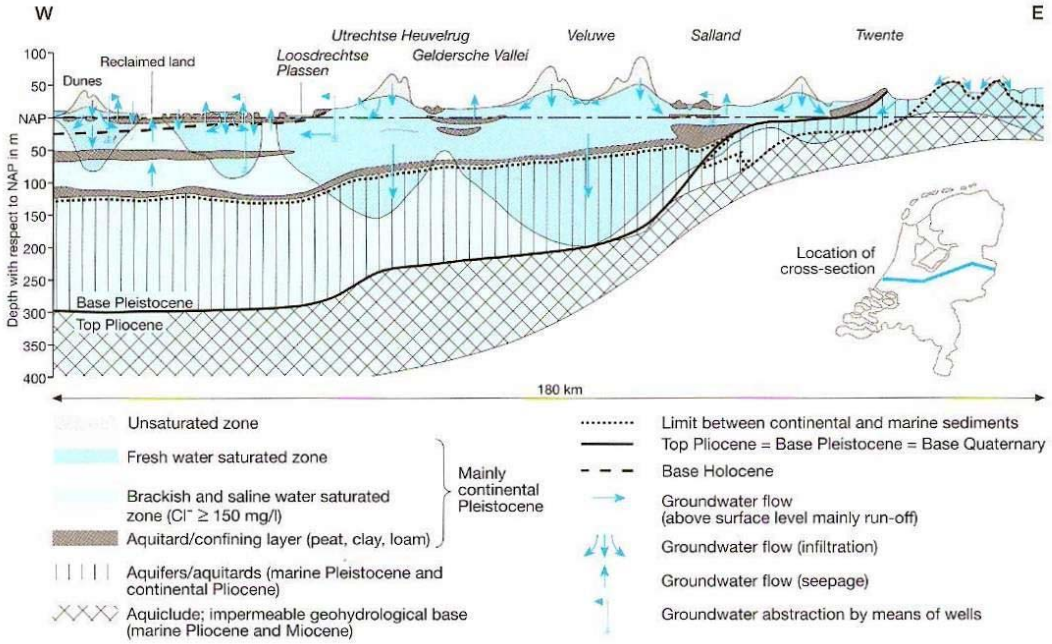


Figure 2.5 Hydrogeological cross-section through the Netherlands [6]

Figure 2.6 shows the trends in groundwater exploration in the dunes.

The river water to be filtered used to be conveyed to the dunes in purpose-built infiltration canals, but these days it is also introduces deep in to the dunes via drilled infiltration wells. The groundwater is abstracted some distance away from these wells. This more recent practice has less impact on the environment.

As well as abstracting infiltrated river water in the coastal dunes, some water companies have, since 1995, been applying a natural pre-purifying treatment to polluted river water. The method makes use of the purifying action of the sediment adjacent to the river bank and was developed to reduce the high costs of conventional methods for purifying river water.

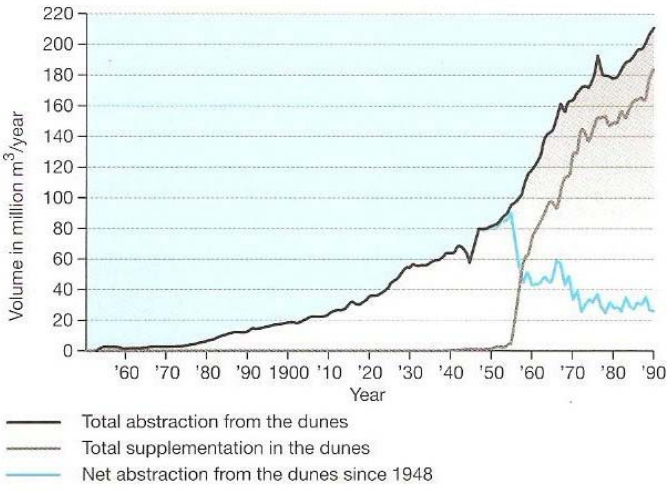


Figure 2.6 Groundwater abstraction and supplementation in the dunes, 1850-1990 in mln m³ per year [6]

In 1998 approximately 65% of supplied by groundwater; the remainder was obtained from surface water- primarily

from the Meuse and Rhine. This surface water is treated by the water companies, either to provide water of a quality fit for drinking, or to yield water unfit for human consumption that can be used in industry.[6]

Groundwater monitoring networks and information system in the Netherlands

Given the great variation in the properties of the underground, a dense network of monitoring points is requires to obtain the necessary groundwater data in the Netherlands. Not surprisingly, there has been an extensive network for many years, to satisfy the need for detailed information in this densely populated country.

The classification of the groundwater networks could be according to the administrator of the network, as has been done in Table 2.1.

Type of monitoring network	Administered by	Estimated number of monitoring points
Strategic water management	State and/or province	5 000 *
Operational water management	Municipalities	2 000 **
	Water boards	3 000 **
	Nature conservation	12 000
Water users	Water companies	4 500
	Industry	500 **
Research in relation to management	NITG-TNO and RIVM	4 000
Research	Universities	200
	and	
	research institutes	200
Total		31 400

* 4000 points measuring volume and 1000 points measuring quality

** Insofar as reported to NITG-TNO

Source: van Bracht, 1994

Table 2.1 Types of groundwater monitoring networks in the Netherlands (situation in 1994)

The provinces have supplementary monitoring points. These networks are known as provincial groundwater quality monitoring networks (PMG). Figure 2.7 shows the first national analysis, conducted in 1991 and using 252 monitoring points selected from the LMG and 173 selected from the PMG.[6]

Taxes and Groundwater consumption in the Netherlands

In 1995 the government introduced an environmental tax on groundwater abstraction. In 1996, private abstractions having a capacity of less than 10 m^3 per hour were exempted from tax. This benefits smaller agricultural enterprises and other private individuals. The groundwater tax is one of the main reasons for the burgeoning of small-scale installations for groundwater abstraction to supply agricultural enterprises and households since 1995. This trend has counteracted the expected environmental

benefit of the tax. In addition to the groundwater tax there are also provincial levies on groundwater. These are 1 to 2 cents per m^3.

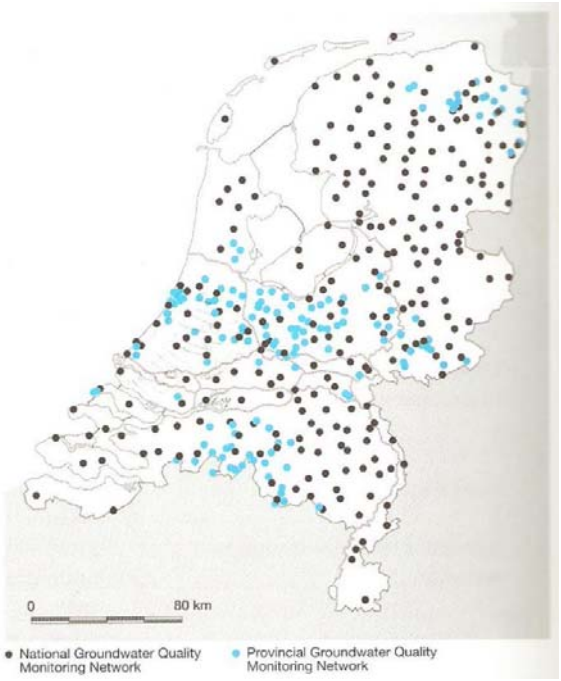


Figure 2.7 Monitoring points in the National Groundwater quality Monitoring Network and the Provincial Groundwater Monitoring Networks in 1991[6]

On the basis of the preceding sections it is possible to draw up an overview of the total use of groundwater in the Netherlands (Table 2.2). The table shows the use in an average year during the period 1988-1992, ignoring the water demand of the natural vegetation, the water removed by hydraulic measures (to maintain standard levels and during afwatering and ontwatering) and the surface water used as cooling water in power plants.[6]

Table 2.2 Total Dutch water consumption in an average year during the period 1988-1992. Assuming a population of c. 15 million. Volumes in mln m^3 per year (excluding groundwater demand of natural vegetation, water removed by hydraulic measures and cooling water in power plants) [6]

Use	Groundwater	Surface water	Total
Domestic (up to 300 m^3 per year per connection, mains supply)	470	240	710
Industrial (over 300 m^3 per year per connection, mains supply)	300	155	455
Industrial (primarily cooling water) from company wells	340	3 545	3 885
Other (e.g. fire services, leaks (mains supply))	45	25	70
Agricultural sector (sprinkle irrigation) and private wells	300	100	400
Civil engineering (well points) and consumption for **soil and groundwater remediation**	100		100
Total	1 555	4 065	5 620

Source: Dufour, 1998

2.2.4 Effects of Climate Change

Concern about the impact of dewatering on boggy and damp habitas in nature conservation areas in the Netherlands, coupled with prediction of sea-level rise and the threat of the Meuse and Rhine overflowing, as happened in 1993/1994 and 1994/1995, spawned debate about the possibility of a significant climate change. Table 2.3 shows the 30-year means for a number of meteorological variables, from which it can be seen that the 'normal' 1961-1990 is appreciably wetter than the 'normal' 1931-1960. The period from 1988 to 1994 was even wetter. The summers in that period were, on average, drier- which means that there was an increase in winter precipitation. It can also be seen that the mean annual temperature in the period 1988-1994 was 1℃ higher than normal.[6]

Figures 2.8 and 2.9 show marked changes in precipitation and temperature patterns over much longer periods.

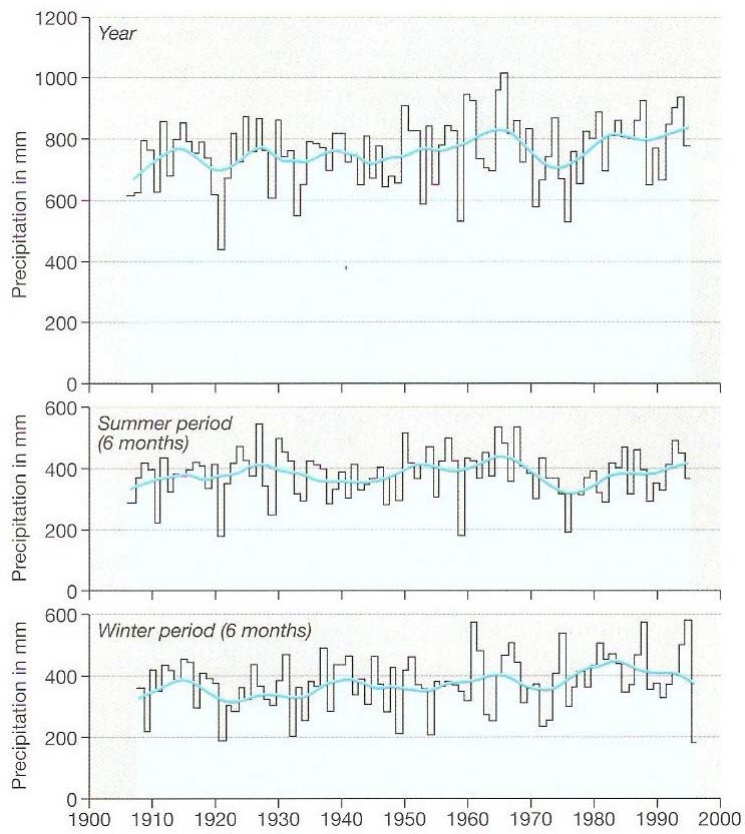


Figure 2.8 Precipitation pattern 1907-1995/96 obtained by averaging 13 selected sations[6]

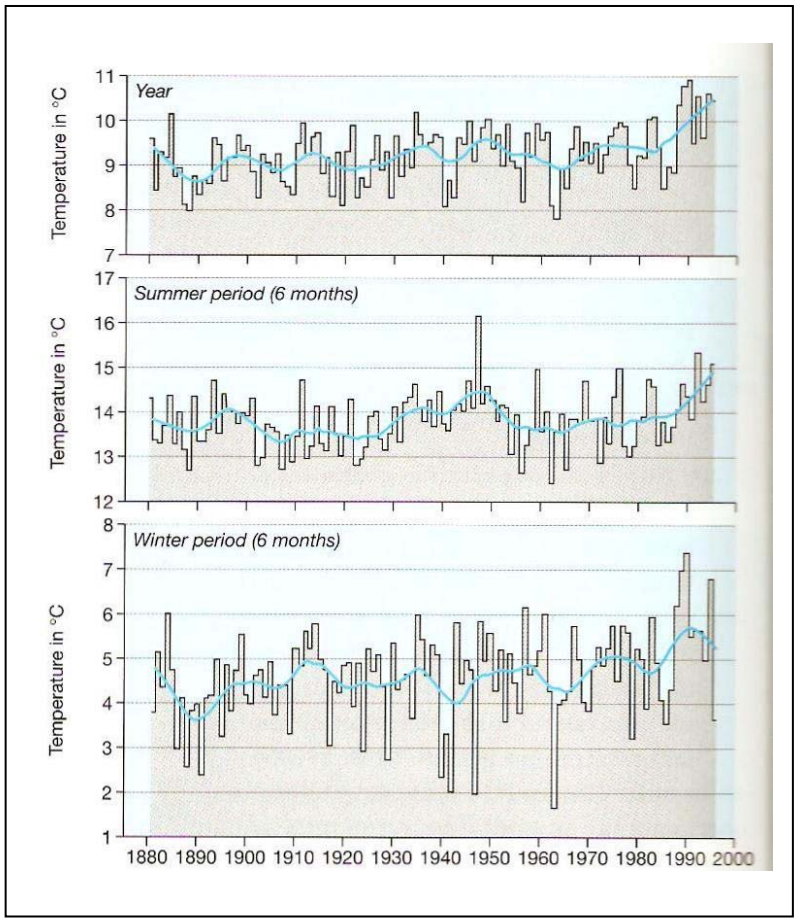


Figure 2.9 Temperature at De Bilt 1880-1995/6 [6]

Table 2.3 Means for 4 meteorological variables at De Bilt [6]

Table 3 Means for 4 meteorological variables at De Bilt

Period	Precipitation (mm per year)	Duration of precipitation (hours per year)	Mean annual temperature in °C	Sunshine (hours per year)
1931-1960	766	543	9.3	1572
1961-1990	803	604	9.4	1477
1988-1994	818	677	10.3	1533
1992	956	731	10.5	1604
1993	928	835	9.6	1494
1994	1036	863	10.6	1548

Source: Feddes, 1995

The KNMI's long-term predictions for the mean annual temperature in the Netherlands are a mean annual increase relative to 1990 of 0.5-1℃ in 2050 and of 1-4℃ in 2100. This will be accompanied by the winter precipitation in the Netherlands and the total rainfall in the Meuse catchment increasing relative to 1990- by 6% by 2050 and by 12% by 2100. Summer precipitation is also expected to increase- by 1% by 2050 and by 2% 2100 (both relative to 1990 figures). Summer

rainfall events will be shorter and more localized. This means that there will be more local downpours.

The predicted decline in the areas covered by snow and by permanent glaciers in the Alps is expected to reduce the discharge of melt water into the Rhine. The contribution from rainfall will therefore become more important, leading to larger fluctuations in flow rate further downstream. Further upstream, the summer water levels of the Rhine will be lower than they used to be.

The ministry of Transport, Public Works, and Water Management estimates that the predicted rise in sea level in the period 1998-2050 will be a minimum of 10 cm and a maximum of 30cm. In the same period the subsidence in the lowest-lying polders is expected to be a minimum of 10 cm and a maximum of 45 cm. The sea-level rise accompanied by soil subsidence has enormous implications for the depth of the boundary between fresh and brackish/saline groundwater in the west and north of the Netherlands.[6]

2.3 Province Hebei

2.3.1 Geography

Hebei is home to 69,890,000 people (2009), who inhabit an area of around 187,700 km^2, so the density is 372/km^2. Most of central and southern Hebei lies within the North China Plain. The western part of Hebei rises into the Taihang Mountains (Taihang Shan), while the Yan Mountains (Yan Shan) run through northern Hebei, beyond which lie the grasslands of Inner Mongolia (See Figure2.10). The Great Wall of China cuts through northern Hebei from east to west as well, briefly entering the border of Beijing Municipality, and terminates at the seacoast of Shanhaiguan in northeastern Hebei. The highest peak is Mount Xiaowutai in northwestern Hebei, with an altitude of 2882 m.

Hebei borders Bohai Sea on the east. The Hai He watershed covers most of the province's central and southern parts, and the Luan He watershed covers the northeast. Not counting the numerous reservoirs to be found in Hebei's hills and mountains, the largest lake in Hebei is Baiyangdian, located mostly in Anxin County.[7]

Figure 2.10 The Map and position of Hebei Province in China [8]

2.3.2 Soils and land use

There are several soil types in Hebei and 7 types that are widely and largely distributed which are Cinnamonic soil, Moisture soil, Brunisolic soil, Chestnut soil, Aeolian sandy soil, Meadow soil and Grey forest soil. The Cinnamonic soil is the widely distributed soil account for 34.64% of the total area which mainly in sides of Beijing-Guangzhou Railway on Taihang piedmont, Northern of Tong Country in the southern of Yan Mountain piedmont to Tang Shan and hills, piedmont plain and upper-middle of alluvial fan which the attitude is lower than 700-1000 meters. The areas are momentous for the grain and cotton production and dried and green fruit plantation bases. There are some other types of soil that the amount are very few such as Saltierra, Chernozem soil, Paddy soil, Swamp soil, Subalpine meadow soil and etc. [9]

The water areas account the total area of the Hebei Province for 3.82% with 720,650hectare.[10] The coastal line is 487 km and the total area of the coastal zone is 9,000km^2. It has natural conditions to develop offshore oil, marine chemical industry, maritime transportation and marine tourism and etc. Qinghuangdao is an well-known ice-free port in the northern China. There are Yellow River, Hai River and Luan River flowing in through Heibei Province which has advantage to develop offing cultivation.

2.3.3 Facts and figures related to groundwater

Hebei has a continental monsoon climate, with temperatures of -16 to -3 °C in January and 20 - 27 °C in July, and with annual precipitation of 531.7 mm, occurring mostly in summer, account for 60~70% precipitation and runoff are in June to August which the characters are drought in spring and flood in autumn. The annual water resources decreased 37% in the 5 years period of 2001-2005. The not well-distributed of water resource and the contradiction of supply and demand is more serious.

Table 2.4 shows the different annual average precipitation in Hebei

Year	Precipitation (mm)
1956-1959	611.5
1960-1969	553
1970-1979	547.7
1980-1989	478.5
1990-2000	515.7

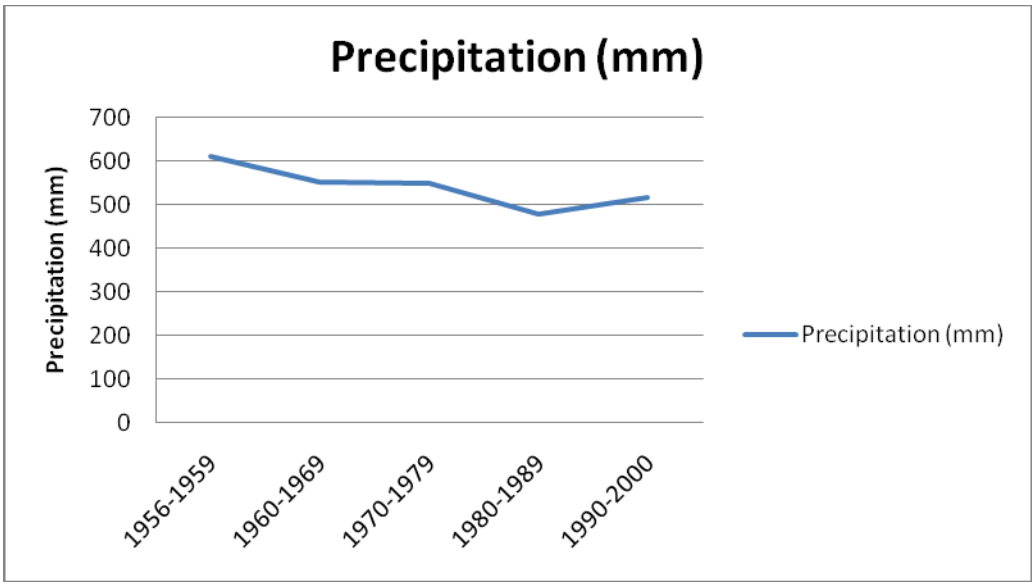


Figure 2.11 shows the interannual variations changed a lot in 45 years in Hebei

The total average amount of freshwater resources over the period of 45 years is 20.47 billion m^3 in Hebei. The amount of surface water in this period is 12 billion $m^{3.}$ The groundwater whith a salinity content of equal or less than 2g/L in the same period is 12.257 billion m^3. .

Figure 2.12 shows the different water resources that supply Hebei province in the last 45 few years. The total available 45 years amount of water supply is 15.18 billion m^3. This amount is mainly delevired with surfacewater and freatic fresh water (see fig. 2.12).

We can see the total available amount of water supply is 15.18 billion m3 in 2000 in Hebei. Figure 2.13 shows the different water requirement from different users and the total water requirement in 2000 is 21.57 billion m^3in Hebei. And the ratio of water deficiency is 29.6% in 2000 in Hebei.[11]

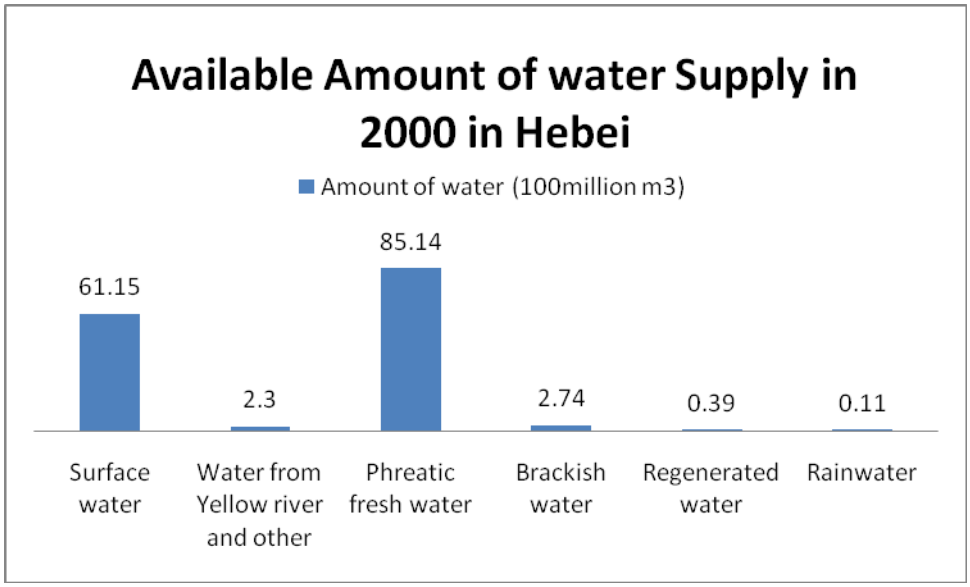


Figure 2.12 The amount of differen water resources different resources supply in Hebei in 2000

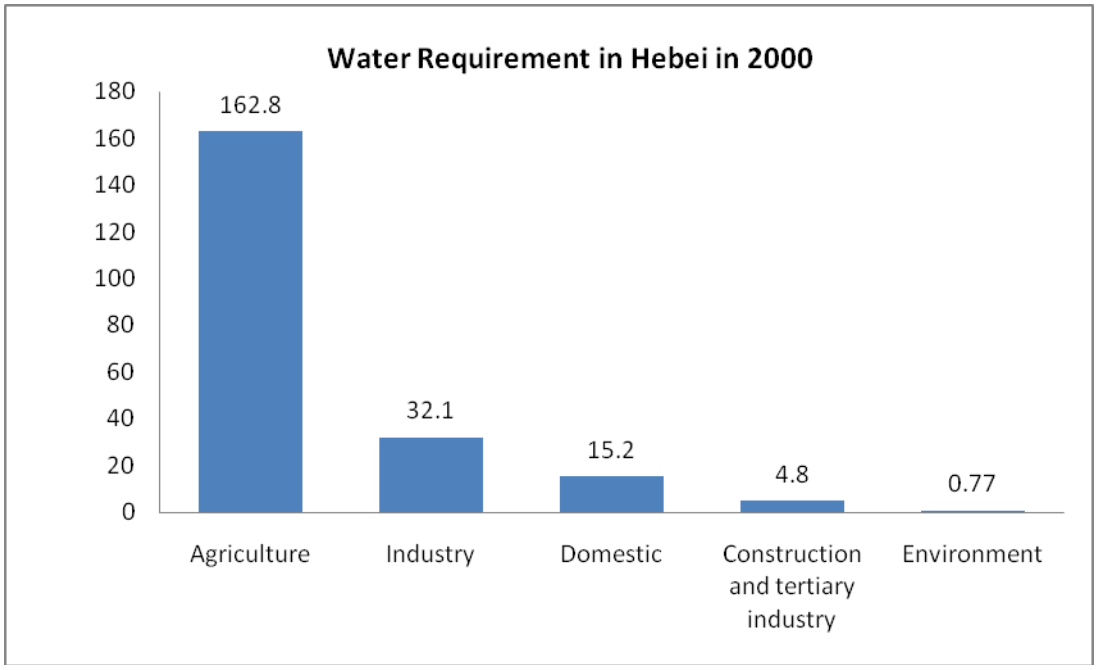


Figure 2.13 The Water Requirement from different users in Hebei in 2000

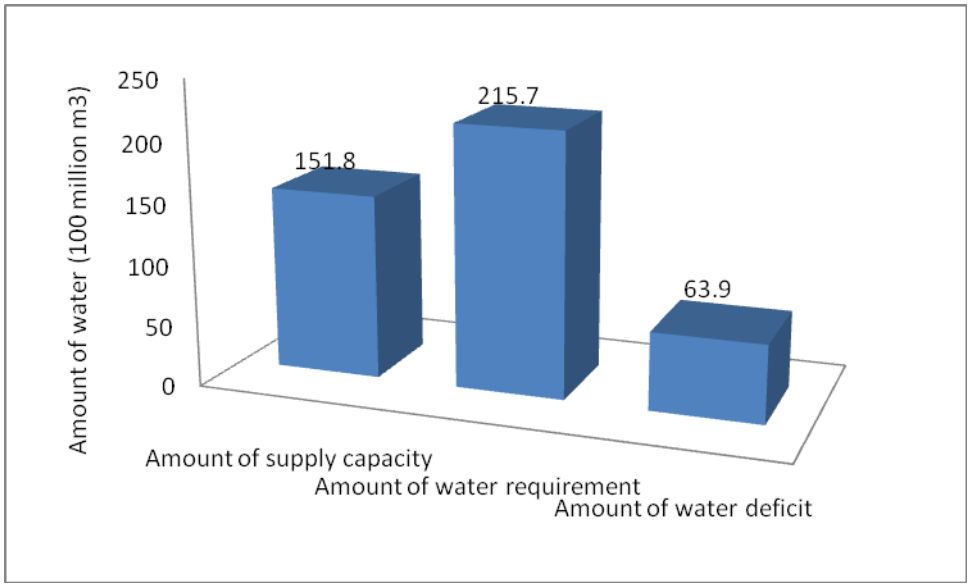


Figure 2.14 analyse the supply and demand of the water resource in Hebei.

2.3.4 Effects of Climate Change on groundwater

Hebei is the fourth major grain producing area in China and one of the most sensitive places influenced by global climate change. The effects are wide range, heavy and suffer great losses.

According to statistic data from 42 meteorological stations in Hebei (See Table 2.5), the average temperature increased as follows:

Table 2.5 The increased range of temperature at 42 meteorological stations in Hebei[12]

Time Period	Increased range of temperature
50s-60s	0.1－0.6℃
60s-70s	0.1－0.7℃
70s-80s	0.1－0.6℃
80s-90s	0.2－1.2℃

From 50s to 90s in the 20th century, the local annual average temperature increased 0.2－1.2℃ and the province increased 1.0℃.

The average temperature in the province rose dramatically in the 80s because the growth of winter temperature and of the lowest temperature (the temperature at night). The temperature in summer and highest temperature (daytime temperature) changed

little. The high temperature and drought always occurred at the same time in Hebei made the shortage of the water resources.[12]

The total amount of surface water and groundwater decreased significantly in this whole period. The total effect from climate change is austere. The relation of precipitation and amount of water resource is showed in Figure 2.15.

The basic reason of diminishing available water resources related to climatic factors in Hebei is the decrease of precipitation and climate warming. This combined effect is caused by:

- The significant fluctuation of the precipitation in specific areas
- The extreme weather increased, inundation and drought situation is more severe in the last 50 years according to earlier periods;
- Mountain glaciers shrink away continuously and water environment turns for the worse;
- Sea water level raises speed up and aggravate disaster in the marine environment.

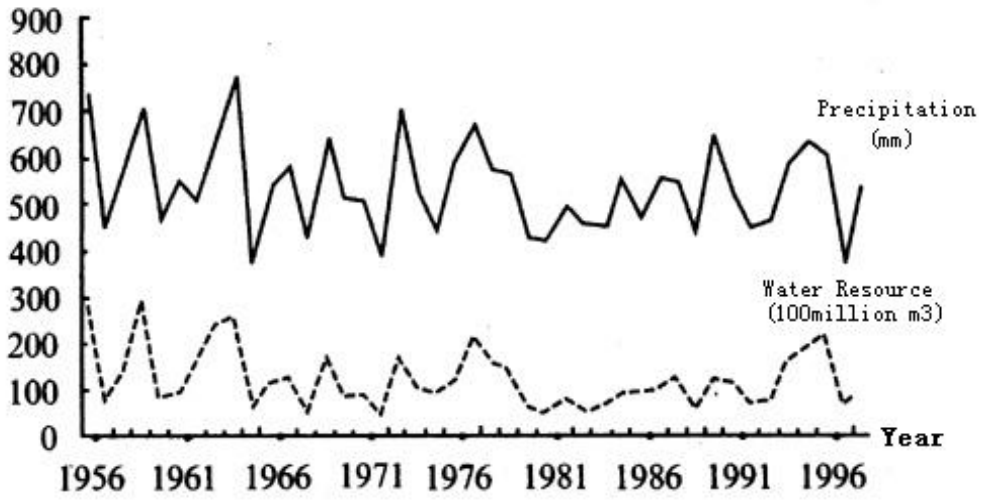


Figure 2.15 Variation of annual precipitation and amount of surface water resources in Hebei[12]

2.3.5 The management phase of climate change in Hebei

A milestone of Chinese climate change policy is her institution building stretching down from the national level (designed originally for coping with international pressure) to the provincial level. On June 30, 2008, the Provincial Programmes for

Climate Change Mitigation & Adaptation in China was launched by the NPRC Climate Change Coordination Office and provincial Development and Reform Commissions,--including Hebei, Inner Mongolia, Liaoning, Ningxia, Qinghai, Shanxi, Tibet and 20 other provinces, municipalities and autonomous regions.

The programme is set up to help build provincial climate change offices, draft each province's climate mitigation and adaptation strategy in accordance with the national climate change programme and build capacities to cope with climate change challenges. This programme should help greatly to implement climate change policy at the local level.[13]

The increasingly systematic and complex institutional arrangements and formulation of related documents clearly show the Chinese government's growing focus on climate change issues. In March 2008, *The Implementation Plans for the Climate Change in Hebei* was published which is the first general policy document to deal with the climate change.

According to *the Implementation Plans,* two goals were set up which were:

- To control the emission of green house gas and
- To improve the ability to adapt the climate change until 2010.

The plans also included a goal to slash energy consumption per unit of 10,000 GDP by 20 percent and discharges of carbon dioxide (CO2) by 127million tons between 2008 and 2010.

The major fields to slow down the emission of green house gas of the Plans were:

- The production and transformation of the energy;
- Improvement of energy efficiency and conservation,
- Improvement of agriculture, forestry and waste materials from cities.

The major fields to adapt the climate change were: agriculture, forestry and other natural ecosystems, water resource, littoral zone and coastal areas.[14]

2.4 Conclusions

As from previous sections, the topography of the two provinces is totally different. Zuid-Holland is a completely water made river delta, but Hebei has plain, mountains, plateau, hills and basin. Therefore, the groundwater systems in two provinces are totally different. While comparing the climate, there is less rain in summer with but a lot of rain in the rest seasons of the Zuid-Holland. However, Hebei has plenty of rain in summer together with high evaporation as a result of less infiltration to the groundwater. In addition, the available fresh groundwater situations are different which lead to dissimilar groundwater managerial focus. As a result of this, there are lots of potentials for understanding the situations from both sides that they can learn more through the cooperation.

3. Policies and organizations in both provinces

3.1 Introduction

In Chapter 3, because of the different geographical positions of two provinces, so the different groundwater situation was introduced. In this Chapter, I give the different policies and organizations. As the political system is very complicated, so I only give some general views in this chapter.

3.2 In the province of Zuid-Holland

All the countries in the European Union should follow the European policy. So I first introduce the European water Framework Directive which is the directive for all the water policies in the countries.

3.2.1 European water policy

To avoid unequal completion in the fight against water pollution, the European Union was obliged to issue Directives. The coherent, river basin oriented Water Framework Directive came into force in December 2000. EU-member states are now making efforts to implement the regulations by 2027.

The directives classified into source-oriented is the most important instrument which is the Directive on Pollution Caused by Dangerous Substances Discharged into the Aquatic Environment of the Community, known under number 76/464. It contained regulations for groundwater. These regulations ceased to apply as the Groundwater Directive came into force in 1980. This Directive aims to protect the groundwater against discharges and pollution by substances on the black and grey lists.[4]

3.2.2 Water administration and its background in the Netherlands

The Netherlands is a decentralized unitary state with three main hierarchical administrative levels of water management: national, provincial and regional level. At each level there are bodies with specific responsibilities: legislative and executive. A multitude of different departments or agencies on national level is responsible for the various sectors of public policy, each deriving its authority from legislation. The

province of Zuid-Holland is responsible for groundwater policy in Holland. Water boards on regional level are responsible for surface water policy.

In 13th century, the local communities began to elect representatives to the regional meetings where the common water management affairs were discussed. In the 19th century provincial water authorities were established and charged with the supervision of the water boards and water-related issues of the municipalities. In the 20th century the level of participation has been increased to include house owners, tenant farmers and residents because these categories were interested in flood protection and regional management too. Since the water boards take care of the water quality of surface water based on the 'polluter pays' principle, representatives of households, industries and companies participate in the administrative and executive bodies of the water boards.

3.3.3 Institutional structure of different levels

There are three levels for the institutional structure of the Netherlands, National level, Provincial Level and Regional and local level. In the national level, The Ministry of Transport, Public Works and Water Management is responsible for flood protection and water management. The directorate 'Rijkswaterstaat' of this ministry, which has been in existence since 1978, supervises the implementation of water policy by the provinces and water boards. The Ministry of Housing, Spatial Planning and The Environment is responsible for general environmental policy: setting of water quality standards and emission standards for surface water as well as for groundwater; law concerning soil and groundwater protection, drinking water and sewerage.

The organization and tasks of the 12 provinces are ruled by the Province Act. With the exception of the state managed infrastructure, the twelve provinces define and supervise the responsibilities and activities related to flood protection and water management. The provinces can formulate politics of their own but must adhere to the directives issued by the national Government. The provincial orders prevail over orders of municipalities and water boards. The provinces have created the Interprovincial Platform, in which organization common views and statements of the provinces are formulated.

There are Water boards, Municipalities and Drinking water companies in the Regional and local level. There are 37 water boards. The water boards organization comprises: the General Assembly, the Executive and the Chief Executive. The provincial authorities define and supervise the tasks of the water boards under approval of the

national Government. The water boards are responsible for flood protection, and management of quantity and quality of surface water in their territory.

The tasks and organization of the 489 municipalities are governed by the Municipal Act. Municipal organization comprises: the Municipal Council and the Municipal Executive. The water management task at municipal level is limited to the management of sewerage systems performed by the local public works department. Drinking water supply is taken care of by 17 drinking water supply companies. The province is responsible for the control of the quantity and the quality of the groundwater for drinking water. Although they have a privatized structure, the shares are owned by public authorities (provinces and municipalities).

3.2.4 Water legislation in the Netherlands

There is widely variety of water legislation. Apart from the fundamental directives in the Constitution, the water laws can be divided into five categories. The first one deals with the water management organizations, the second with aspects of (integrated water) policy, and the third with the management of the water-related infrastructure. The fourth, specific category is drinking water, and the fifth category pays attention to acts relating to other relevant water issues.

The Water Management Act (1989) defines the planning structure for water management by the Government agencies at different levels and gives rules for the quantitative management of surface waters. The planning structure of this act is of major importance because it presents and integration of national and provincial plans based on the Pollution of Surface Waters Act, the Groundwater Act and the Water Management Act itself. It also includes statutory cross-references with spatial planning and environmental planning.

The Groundwater Act was published in 1981. It contains general rules and regulations for the abstraction of groundwater and/or the infiltration of water. The Act further obliges of the provinces to set up a management plan for the groundwater, also referred to as a groundwater plan. The provincial governments are the implementers through the services they provide and are responsible for the instruments provided by the act. These are abstraction permissions; abstraction registration; duty to report; and levies. All abstractions of more than 10 m^3/ hour require permission. No volume flow measurement is made in the case of a mandatory obligation to report, and neither is there an obligation to pay the provincial tax. However, in cases of an obligation to register or to obtain a license, volume flow is measures and provincial tax is payable. The registration also serves to provide the province with an insight into the total

number of abstractions. This act concerns groundwater quantity only, although qualitative aspects are incorporated where the recharge of aquifers is concerned. Other quality aspects are dealt with in the Soil Protection Act.

Table3.1 shows the report, register and obtain licenses for the abstraction and injection of groundwater in Province of Zuid-Holland in 1994.

There are now several Acts concerning groundwater protection:

- The Environmental Management Act,
- The Pollution of Surface Waters Act,
- The Soil Protection Act,
- The Fertilizers Act and
- The memorandum on the use of animal fertilizers.

Table 3.1 Obligations imposed by the provinces to report, register and obtain licenses for the abstraction and injection of groundwater in 1994. The farms or companies are not required to measure volumes or rates.

Province	**Report**	**Registration**	**License**
	With a *pump capacity exceeding*	**With a *pump capacity exceeding***	**With a *pump capacity or an abstraction exceeding***
Zuid-Holland	1 m^3/hour	No	12 000 m^3/year
After: Misset Milieuboekje, 1994.			

In provincial level the province of South-Holland has to make every four year a Water plan for their province. The first plan is made in 2009. In this plan the province has made clear her priorities in the field of:

- Water security against sea-level rise and inundations at the two main rivers
- (Rhine and Meuse);water quality, as well as for surface waters as for groundwater;

- Division of sweet surface water through the province to the different functions of water use (agriculture, shipping transport, drinking water; cooling water for industry);
- Conservation of sweet groundwater sources for drinking water and protection of ecosystems in natural reserve areas.

The plan is made with the participation of other water-authorities, as the National Water board, regional water boards, municipalities, drinking water organizations and organizations of farmers and nature conservation.

Together with the plan the province mad an Executive Program for the period from 2010 – 2014 and a Monitoring plan to monitor the development of the execution of the plan yearly.[6]

3.3 In Hebei Province

In this section, firstly, a national water policy in China is introduced. Then I give a brief introduction of the Water Department of Hebei. It is the only institute to manage the groundwater.

3.3.1 National water policy

In the national level, all the institutions in China follow the *Water Law in the People's Republic of China*. The Water Department of Hebei is responsible for the groundwater management and the Hydrology and Water Resources Survey Bureau of Hebei is responsible for the groundwater monitoring. The Administration of Geology and Mineral Resources of Hebei has institutions monitoring. (Mr. Xu Zhenci)

3.3.2 Organization inside of Department of Water Resources of Hebei Province

There are ten agencies inside of Department of Water Resources of Hebei Province and the following four departments are relevant to manage the water.

- Water Administration Department
- Water Resource Department (Water Saving Office of Hebei)
- Division of Water and Soil Conservation

- Rural Water Conservancy Agency

3.3.3 Main functions of the Water Department of Hebei

There are 15 main functions of the Water Department of Hebei. I summarize some items that are related to the groundwater management and monitoring, plans for the working and permission for the water licensing and etc:

- Making initial drafts principles and policies, development strategy, medium-term and long-term plans and annual plans for water resources of the whole province. Organize and draw up related legislations and regulations and supervise the implementation.
- Centralization of management of water resource including atmospheric water, surface water and groundwater.
- Organize the long-term planning of water supply and demand, water allocation proposal and supervise the implementation.
- Organize the master plan related to national economy, urban planning and the proof of water resources and flooding protection in major construction projects.
- Organize and implement the regulations for water licensing and regulations for water resources fees. Publish the announcement for the water resources of province and direct the hydrology work of the province.
- Draw up the regulations for water saving, make plan for saving on water, making standard and organize, direct and supervise the water saving work in Hebei.
- Making water resources protection plans according to national laws.

There are also some regulations for groundwater quantity, such as *the Plan for the Groundwater Exploitation and Utilization and Exploitation Control of Hebei*. And for the groundwater quality, there are *Quality Standards for the Groundwater Environment* (GB3833-2002) and *Quality Standards for the Groundwater* (GB/T14848-93). *Directive for Climate Change Adaptation of Hebei* is a regulation for the climate change.

4. Main problems on groundwater

4.1 Introduction

In this Chapter, I first introduce the groundwater problems in general (section 4.2). Secondly, the groundwater management in the two provinces (section 4.3) and the groundwater quality pollution (section 4.4) will be introduced.

4.2 In general

This is a classification of groundwater problems which is a result of the discussion with Mr. Meijles. I put the list here because it can give an overview of the groundwater problems to readers and make it easier to understand. In the following paper, I selected two typical problems from both sides to analyze and make comparison of them. Moreover, some solutions or actions that two provinces did carry out, will appear to show the development of the technology in recent years.

Ⅰ. Problems of groundwater itself:

I made difference between the groundwater quality and quantities to distinguish the problems more clearly and logically.

A. About fresh groundwater quantities

- Drought, caused by yearly diminishing rainfall and lack of sufficient infiltration
- Fresh Groundwater depletion, caused by (yearly) more abstraction than refilling (by rain)

B. About groundwater quality

- Sea water intrusion (through salty water);
- Groundwater pollution (caused by human activity)

Ⅱ. Problems of groundwater management

A. About fresh groundwater quantities

- Too little or no attention on the groundwater quantity by lack of awareness of the importance of sufficient groundwater;
- Too little or no attention on the groundwater management by lack of awareness of the importance of sufficient groundwater management;
- Lack of data of recent and/or historic groundwater levels;
- Lack of data of recent and/or historic groundwater quality data;
- Outdated monitoring facilities for groundwater levels;
- More pronounced groundwater management pollution;
- Residents unaware of the groundwater problems

B. About groundwater quality

- Lack of recent and/or historic groundwater quality data;
- Lack of knowledge of groundwater quality problems;
- Lack of awareness of importance of managing groundwater problems

In the next section I consider groundwater quantity problems and groundwater quality problems together with management problems, because these problems are problems by lack of management.

4.3 Groundwater problems and groundwater management problems

Groundwater quantity problems in the province of South Holland

In the province of South Holland problems ther are problems on groundwater quantity. By lowering water levels for drainage purposes to increase agricultural production, groundwater levels in natural conservation areas also were lowered. So the natural value of the plants in these areas diminished and some of these plants didn't survive because of drying these areas. Since 2000 the province has an policy to combat the further drying of these areas. One of the measures is to try to reconstruct historic

groundwater levels. Therefore information about historic groundwater levels is required. Trying to rise groundwater levels, monitoring is needed to control the velocity of rise of the level in time. (Mr. J.G. Meijles)

Groundwater quantity management problems inside of Water Bureau in PZH

The Water Bureau of the province does not have an agreement for determining historic reference levels for monitoring the groundwater levels (a level is always related to quantity) in nature reserve areas, which are forced by the Water Framework Directive of the EU. To know if the levels are good or not good, it is relevant to have a - historic - level, to be able to compare the recent levels with. The lack of monitoring and the absence of reference levels are not considered as a big problem in the provincial organization. Solving this problem is not a priority in South Holland.

Groundwater quantity management problems in Hebei

In general, the problems of groundwater quantity are more serious than the quality problems. Many of the management problems are related to the groundwater problems itself. The problems and solutions related to poor groundwater management from Hebei are:

- Groundwater depletion

  ➔ To strengthen the monitoring, define the area of over abstraction, restrict the exploitation and close the private wells.

- Problems of water resources tax levy

- Decentralization of the management (too many divisions)

  ➔ Reform the management organizations, strengthen centralization of management, definite the competent authority is the Water Department of Hebei and integrate the water resource fees.

- And lack of optimized dispatching and water wastage and etc.

  ➔ Strengthen the water management planning, draw up the annual planning for water. Reinforce the measurement for the water and unified install the water meter. Enhance the publicity of the water saving, increases water prices. Reward the water saving and punish the water wastage and etc.

The groundwater depletion in Hebei

From 1976, the amount of average annual groundwater over exploitation is 4 billion m^3 and the total amount of over abstraction in 30 years is more than 120 billion m^3 which can equal to 200 times pondage of the biggest fresh water lake called Baiyangdian in North China. Hebei is one of the most water-deficient areas in China with only 331 m^3 for water resources ownership per capita and one seventh of the national average, and less than one third of 1000 m^3 of the international standard. The annual water consumption of the whole province is 23 billion m^3 but the water supply capacity is only 17 billion m^3. The rest part of the supplement can only depend on the groundwater over exploitation.

The persistently groundwater over abstraction already caused environmental problems in Hebei. Recently, the phreatic water level is already 15 meters below the ground surface and the deep phreatic water is lower than 40 meters than the historic data. The groundwater level decreased caused the land subsidence and sea water intrusion and etc. Among others, the land surface in Cangzhou has already declined more than 2 meters. Because of sea water encroachment in Qinhuangdao, the groundwater cannot meet the drinking water standard. At present, the area of phreatic water is more than 150 million km2 and the deep phreatic water exceeded to 40 thousand km^2.

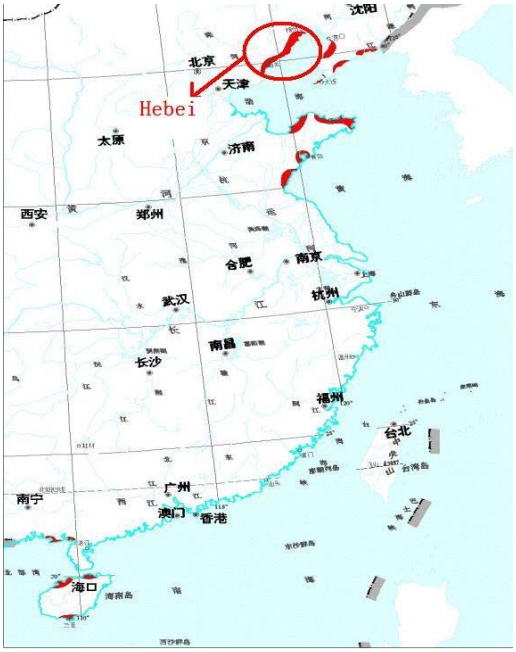


Figure 4.1 Sea water intrusion areas in China

The red circle in the figure 4.1 shows the sea-water intrusion areas in Hebei.

Land subsidence, ground fissure and surface collapse

There are 10 subsiding centers in Hebei Plain include Cangzhou, Baoding and Hengshui. It is influenced by groundwater level decreased, the thick of underground cohesive soil and mechanical property. The distribution range is almost the same with the drawdown cone of groundwater.

Since last 80s, the frequency of the ground fissure has increased obviously in Hebei plain. The surface collapse is always accompanied with the ground fissure. It includes

karst collapse and soil horizon collapse. The karst collapse is mainly distributed near urban district of Tangshan, Xushui country in Baoding. The soil horizon collapse is distributed in front of pediment Plain of Taihang Mountain. The surface collapse is because over explosion of groundwater, heavy rains, saline groundwater infiltration and water lost in soil and etc. [15]

4.4 Groundwater quality pollution

In this century the explosion in socio-economic and technical developments has led to a serious assault on the quality of soil and groundwater. Today, all over the world, a variety of problems is encountered: physical, chemical and biological degradation of soils, overdrawn aquifers, salt-water intrusion and groundwater contamination.

Many activities hold a potential threat for soil and groundwater pollution. At first, these were seemingly only local pollution, caused by point sources such as waste disposals, and accidental spills of chemicals, and were of minor importance for the state of the subsurface environment at regional or national scales.

Another serious impact on soil and groundwater results from the intensification of agriculture. The use of fertilizers, pesticides, sewage sludge and animal waste produces a substantial and widespread deterioration of soil and groundwater quality. Several groundwater pumping stations in agricultural areas are threatened by high levels of nitrate, heavy metals and organic micro pollutants. It is expected that in the near future a quarter of the extracted groundwater will be in need of extra treatment. Atmospheric deposition (e.g. acid, heavy metals and organic micro pollutants) caused by industry, traffic and agriculture is another diffuse threat to the quality of soil and groundwater. In this case, two provinces stand in the same position on the groundwater pollution and they also took a lot of actions to deal with the problems. [4]

Groundwater pollution in PZH

As we know, the Rotterdam city in Zuid-Holland is a well-known with its port and industries. The place where the industries stand, the pollution problems appeared. It is a so-called local pollution. Local pollution includes leakage from storage tanks and pollution arising from the dumping of waste. Examples of local pollution in the PZH include the polluted groundwater under sites where harmful chemicals are stored, or under industrial areas. The pollution of the groundwater from the port and industries came from economic boom century and the groundwater was serious polluted. And the range of the pollution were fully occupied the aquifer. The province is controlling

the pollution because they do not want it spread to other non-polluted areas. How the problem is solved depends primarily on decision making, on the technical options and on the funds available.

Soil pollution

The Soil Protection Act in the Netherlands forbids bringing in chemicals to the soil. Only with permission of the province people or organizations are allowed to bring in chemicals into the soil and so into the groundwater, during a maximum period of four years, but only when they get permission of the province.

Therefore they have to prove beforehand, that the chemicals they bring into the soil don't pollute the groundwater. Furthermore, they have to monitor the chemicals in the water with which the chemicals are brought into the soil regularly and send the results to the province to control them.

Diffuse pollution

Diffuse pollution of soil and groundwater in South Holland is mainly caused by using animal and industrial fertilizers and pesticides by the farmers. This chemicals run tot the groundwater whit the rainwater falling during the season, mainly in the raining period in autumn and winter, when there is a more water falling than subtracted by the plants. The province is monitoring the fertilizer-chemicals and pesticides in groundwater in the province on 50 sites spread over the province on 4 different depths in the groundwater at 5, 10, 15 and 25 m below the soil surface level.

The province is monitoring the quality of the groundwater every four year. This period is taken because the quality of groundwater in Zuid-Holland has proven not to change considerably in time.

In 2007 in some places some pesticides were monitored above the reference level of 0, 1 microgram/liter, which is the reference level of the EU for the quality of groundwater because of drinking water purposes. So the province is now investigating in which way the pollution of these pesticides is coming into the groundwater. [6]

<u>Groundwater pollution in Hebei</u>

Groundwater quality pollution and deterioration in Hebei Plain

The groundwater pollution in Hebei plain is mainly distributed near cities and canals which made the industrial waste water is the main pollution source. The serious

pollutants are Nitrogen (N) and Ferrimanganic (Fe-Mn) then come to Fluorine (F), salinity, total hardness in water and etc. In macroscopic views, the trend of groundwater pollution areas and main pollutants are increasing. Because the government did some regulatory measures recent years, the pollution speed slow down in some parts of the cities. However, along with the development of township enterprises, the trend of the pollution is aggravating and it is hard to monitor and control as the pollutants are much dispersed.

The salinity and total hardness of the groundwater is raised because of groundwater exploration. It is obvious high concentrated that the aquifers of groundwater in the depth of lower than 100 meters wells. The high fluorine, high and low iodine content water is distributed in groundwater in Hebei plain. As the groundwater level decreased significantly, made the content and area of Fluorine ions are increased.

The groundwater exploitation in phreatic and deep phreatic water in sea water area leads the rise of water-head, incursion of saline groundwater to fresh groundwater. The intermixing of the two kinds of groundwater made the groundwater quality deterioration, the contents of saline and main irons increase, the areas of salt groundwater increased and the areas of fresh groundwater decreased. [15]

5. Lessons can be learned from both sides

In this Chapter, I give the best practice to dealing with the groundwater problems in PZH and HP (section 5.1 and 5.2), respectively. Secondly, based on the previous sections, I will discuss the alternative way that two provinces could learn from each other in the future.

5.1 Best practice in Province of Zuid-Holland

5.1.1 Looking for opportunities to use brackish water for horticulture

In the Westland of the Province Zuid-Holland, the glass-house-centre of Holland, near to the sea, brackish groundwater is used by 10 percent of the horticulture-farmers for irrigating their crops. The saltwater is pumped out from the first aquifer, than is distilled by contrary-osmosis and 50% of the so sweetened water is used for irrigating the plants in the glasshouses. The other 50% of concentrated salty water is discharged to a deeper aquifer, so it does not pollute the first aquifer with salty water. This technique is only used for horticulture because some horticulture crops need so much water, for which other sources, such as surface water or rainwater, are not sufficient. Over more these horticulture crops create more profits than other agriculture crops, so the farmers can pay the investment in the contrary-moose-equipment.

But according to the European Water Framework Directive, it is since 2006 no longer allowed bringing the salty water, with some dangerous heavy metals, into the ground. So water-users need to find other sources of water or other solutions to keep using this technique of making fresh groundwater as a source for their irrigation.

The government of the Province of Zuid-Holland gave the horticulturalists 6 year to look for alternative techniques for sufficient water supply for their crops. The government is meanwhile also looking for some exceptions to deal with the policy of totally forbidden the use of salt groundwater.

Superficial water from the river Rhine is generally used for the rest part of agriculture to irrigate the inland agricultural area. Canals and ditches are used for delivery the water to different parts of Holland. Because of the big amount of water needed for some horticultural crops to grow in the glasshouses, this way of delivering does not give sufficient water for these crops in the Westland. The province is now, together with the organization of the horticulturalists, the water board and drinking water

companies looking for alternative ways to supply this region of sufficient sweet water. In all cases the horticulturalists will have to pay more money for their future water supply. (Mr. J.G.Meijles)

5.2 Best practice and future plans in Hebei Province

5.2.1 Meanings of the Project South-to-North water diversion to Hebei

Hebei can achieve a lot of benefits through the project South-to-North water diversion. In this section, a brief introduction of this project and the meanings to Hebei will be given.

The first phase of the middle route of this project will distribute 3.47 billion m^3 amount of water to Hebei. The scope of the water delivery include the plain in south of Beijing and Tianjin with an area 62.1 thousand km^2. The objective consists of Handan, Xingtai, Shi Jiazhuang, Baoding, Hengshui, Langfang and Cangzhou and 92 countries. The construction mission for Hebei is so called 'Two vertical, Six horizontal and Ten reservoirs'. 'Two vertical' means general main canal in the middle and east route. 'Six horizontal' is six large-scale water delivery engineering reservoirs. Four plain regulate and store reservoirs and six compensation regulation reservoirs in western mountain areas.

The meanings to Hebei are:

- To guarantee there is enough water to supply for developing the coastal economy society.
- To ensure the water demand for developing the cities and towns
- To ease and repair the geological environmental disaster caused by significant of groundwater level drop, increase the area of wetlands and improve the ecological environment.
- To indirect raise the agricultural water supply and improve the irrigation conditions for agricultural industry
- To improve the drinking water quality
- To promote the water saving, pollution control, water conservation and water environment

5.2.2 Best practice in Hebei

Recently, Hebei has already accomplished the scientific research project of survey and assessment of soil water resources. They have figured out the distribution, reserve and change discipline of the soil water resources and technical measures for enhance the efficiency to develop and utilize this resource. For instance, a scientific demonstration project has already completed in Cangzhou. To increase the irrigation amount when irrigate the winter wheat in winter. The crops can use the water stored in deep subsoil in spring which can reach the goal to save the water and high yield in the same time.

There are also some successful examples for changing the groundwater situations. In Hengshui, they strengthened the efforts to develop and utilize the brackish water to reduce the exploitation of the groundwater and control the drop of groundwater level. In Cangzhou, they controlled the groundwater development, closed up wells from water users; use the water from the Yellow River and united delivery of water. In Shijiazhuang, they made use of ancient channels to recharge the groundwater and control the drop of groundwater level. (Mr. Xu Zhenci)

5.3 Lessons to be learned from both sides

5.3.1 Same actions

From the previous chapter, we know both provinces are using artificial recharge to solve the groundwater depletion. Especially in PZH, they use natural ways to recharge surface water to groundwater and the transportation from surface water to groundwater is underground, without losing water due to evaporation. This is called: subsurface infiltration.

According to Chapter 3, two provinces both have short and long term plan for the groundwater management and they put the plan in the laws. Inside of the organizations from both provinces, there are several parties involved in the groundwater management. However, the water legislation in the PZH is more concentrate on the delta area while the the topographical features of Hebei are more complicated.

PZH and HP use the technology to desalt saline/brackish groundwater to irrigate the plants. Hebei’s purpose is to reduce the fresh groundwater explosion; however, the

fresh groundwater is not available in the Westland. Even though, it cost a lot for the technology using, but the profits of the business in the Westland can cover the cost.

5.3.2 Lessons Hebei Province can learn from Zuid-Holland

Questionnaires and interviews showed that Hebei wants to learn:

- The system of the government management in Zuid-Holland.
- Determine reference-standard levels and standard periods for groundwater quality monitoring
- Design of simple groundwater modeling, to make visible groundwater streaming and relations between groundwater and surface water

In my point of view, it is important for Hebei to consider the environment during the management of groundwater; otherwise Hebei has to solve the problems of damage the environment after some years. (Mr. Xu Zhenci)

5.3.3 Lessons Province of Zuid-Holland can learn from Hebei

According to the questionnaires and interviews, Zuid-Holland may learn:

- The regional assessment of water resources
- The plan for exploitation and utilization in medium and long-term
- Plan for water saving
- Drought counter-measures from Hebei's experience to deal with future unknowns

6. Discussions, Conclusions and Recommendations

According to previous chapters, the situations between Province of Zuid-Holland and Hebei Province are very different. Therefore, there are plenty of knowledge can be learned and borrowed from each other. In this Chapter, some discussions from both provinces, the conclusion of my research and recommendation for the cooperation will be given.

6.1 Discussion

Apply the project South-to-North water diversion in PZH

One of the aims of the project is to supply enough water to intake areas. However, considering the groundwater quantity problems in Zuid-Holland is not serious but the quality problems, it is not necessary to apply the project in Zuid-Holland.

Is it feasible to use the saline groundwater to irrigate the high profits crops in Hebei?

Firstly, Hebei should develop the high profits crops/plants if they want to use saline groundwater to irrigate. Because the cost is very high if the technology is used. Secondly, the plan of using groundwater to irrigate should be better to save water because the water wasting is another reason for groundwater depletion.

Use the subsoil to store the groundwater in PZH

As former research said, Cangzhou in Hebei use subsoil to store water in winter then crops can use the stored water in spring. This method is aim on solving the quantity problems in Hebei. However, it is a good way when dealing with the groundwater quantity problems. Probably, this can be used in the future when Zuid-Holland meet the quantity problems.

6.2 Conclusion

The biggest difference of the current groundwater management between Province of Zuid-Holland and Hebei is：

Hebei Province more focus on the quantity management but it also has quality problems. Province of Zuid-Holland meets the quality problems and the fresh groundwater quantity problems. Nevertheless, the management to save water is a permanent topic for both provinces. At last, the density of monitoring the groundwater

is totally different. The density of monitoring the groundwater in Hebei province is less than PZH.

The exchange of knowledge is still need to be improved. Both provinces are lack of information communication. This can be improved through: the Publication and website. The media need to update frequently to let both sides understand the actions and changes in the current situation.

Hebei needs to close the private wells which can system manage the groundwater depletion. And they can learn from pilot project to learn how the Netherlands manage the groundwater abstraction to make its water taxes system more perfect. Hebei needs to investigate the private point pollute the groundwater and solve the point source pollution. Hebei should aware of the highest evaporation and precipitation is in summer. So it is better to store the rain water in the rest of the year to stop losing water.

The Pilot on groundwater monitoring and management in Hebei:

- Hebei is still looking for the pilot because it is hard to find a place that has a groundwater observation well per km^2. An ideal one is to find a large area geohydrologic unit that has dense observation wells and has long historical data.
- The provinces of Zuid-Holland will offer governmental input on permits, policy and management in this pilot. But they should aware of the regulations and policies in Hebei before making plan.

Groundwater monitoring systems are well developed in the Netherlands. The provincial Academy of Water Resources has information how it is organized in the Netherlands. According to Hebei, the Netherlands has a much better system, and they are eager to learn more through the pilot project.

According to my research, the two provinces still got a lot of potentials for the cooperation. But the processing of the cooperation could be faster.

6.3 Recommendations

In the following section, I give some recommendations about the monitoring the groundwater quantity and groundwater flow, the important of the reference level and how to define the reference level.

Monitoring groundwater quantity and groundwater flow?

To know how the groundwater flows and how the quantity of the groundwater is developing, monitoring of the groundwater level and monitoring of the flow direction of groundwater is needed.

Monitoring groundwater levels is the only way to get reliable information about the direction of developing the quantity of groundwater, besides knowledge of the direction of the groundwater stream. When the groundwater level in a certain point decreases, then - in general - the total quantity of groundwater is diminishing and when it rises, than in general the quantity is increasing. So regularly measuring of the level of groundwater is a simple, but very useful tool, to get knowledge about the total quantity of (sweet) groundwater that is available for different purposes.

The importance of Reference Level

To solve the groundwater problems, it is important to identify the problems first. In order to define the problems of groundwater, a reference level is needed to compare different situations. Without the reference level, it is hardly to identify the problems and keep the groundwater meet the standard. It may contain levels of groundwater quantity and quality.

How to define the reference level?

Firstly, it is needed to find historic data in the certain points. The data can be found by means of local water departments and monitoring stations. And the valid data related to the groundwater are always based on monitoring sites. Secondly, we need analyze and make a comparison to all the data in a certain timeframe to carry out the reference level. A reference level is so called “natural reference level” because people use the actual historic data as a reference to analyze the problems. It is important to give a reference level before defining the problems and to update the reference level frequently.

Reference

1. Pan Zenghui., Hebei Province-Zuid-Holland Province Water Cooperation project in the Second Stage, Hebei, 2009
2. http://en.wikipedia.org/wiki/South_Holland (2010.05)
3. http://www.newworldencyclopedia.org/entry/Holland#Geography (2010.05)
4. Pieter Huisman, Water in the Netherlands, managing checks and balances, NHV-special 6, Delft, 2006
5. http://www.britannica.com/EBchecked/topic/658303/Zuid-Holland (2010.05)
6. Dufour, F.C., Groundwater in the Netherlands-Facts and figures, Netherlands institute of Applied Geoscience TNO-National Geological Survey, Delft/Utrecht, the Netherlands
7. http://en.wikipedia.org/wiki/Hebei (2010.05)
8. http://images.rednet.cn/articleimage/2009/08/07/1613057727.jpg (2010.05)
9. http://www.he.xinhuanet.com/zhengwu/2006-07/03/content_7414857.htm (Land Resources, 2006)
10. Hebei Province., Overall Plan of Land Utilization., (1997-2010)
11. Xu Zhenci., Presentation on Current SituationWater Resource in Hebei (2008)
12. Guo Yingchun, Zhang Guanglu, Ruan Xin and Zhao Yubin., The effects of Climate Change to Water Resources and Desertification in Hebei., Survey on Geography and Territory. (2001.05)
13. Bo Wang, Understanding China's Climate Change Policy
14. http://www.ccchina.gov.cn/cn/NewsInfo.asp?NewsId=11423 (2010.05)
15. Liao Xianfeng., The Groundwater Environment Problems and Solutions in Hebei Plain
16. Molegraaf, T.G., Report on the Visit of the Hebei Water Resources Department to the Zuid-Holland Water Department, The Hague, 2010

17. Common Implementation Strategy for the Water Framework Directive (2000/60/EC), Guidance on Groundwater Statues and Trend Assessment, European Communities, 2009

18. Guidance on Risk Assessment for Groundwater

19. John Chilton et al. (eds) Groundwater in the Urban Environment, Volume 1: Problems, Processes and Management, British Geological Survey, Wallingford, UK, 1997

20. John Chilton et al. (eds) Groundwater in the Urban Environment, Volume 21: Selected City Profiles, British Geological Survey, Wallingford, UK, 1999

21. IOB-EVALUATIONS., NO.284., Institutionak Development., Netherlands support to the water sector., 1988-1998., Policy and Operations Evaluation Department., March 2000

22. http://www.cma.gov.cn/qhbh/newsbobao/200912/t20091221_54402.html (2010.05)

23. http://www.66wen.com/06gx/shuili/shuiwen/20071120/53329_4.html (2010.05)

24. http://www.hwcc.gov.cn/pub/hwcc/ztxx/xgzt/hbpd/hblt/200109/t20010911_19113.html (2010.05)

25. http://www.ccchina.gov.cn/cn/NewsInfo.asp?NewsId=17341 (2010.05)

Appendix

Appendix 1 Figures about the groundwater situation

Figure 2.3 Depth to water table in relation to land surface, based on the mean lowest groundwater level [6]

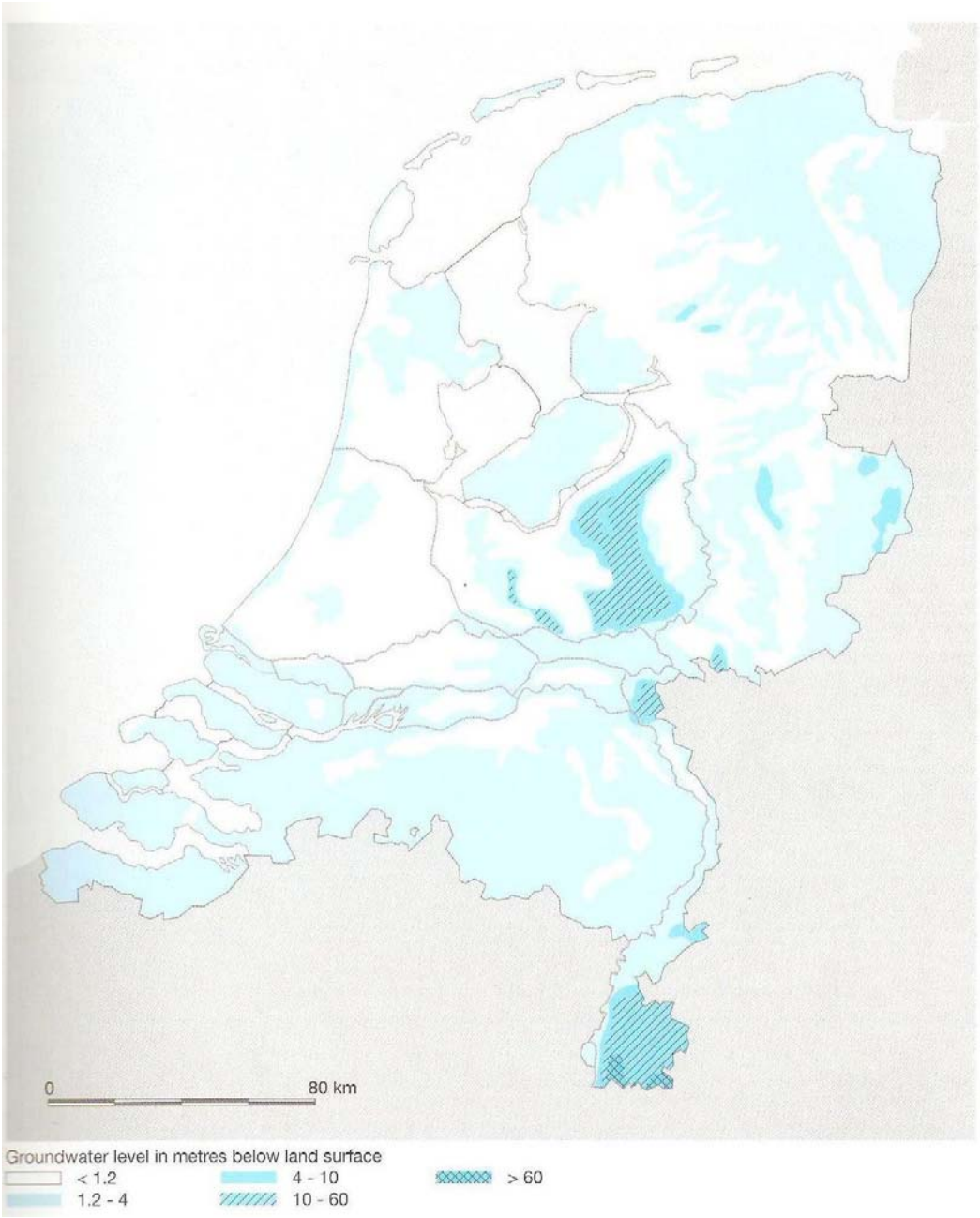


Figure 2.4 Depth to water table on 9 February 1996 in relation to NAP[6]

Figure 2.5 Hydrogeological cross-section through the Netherlands [6]

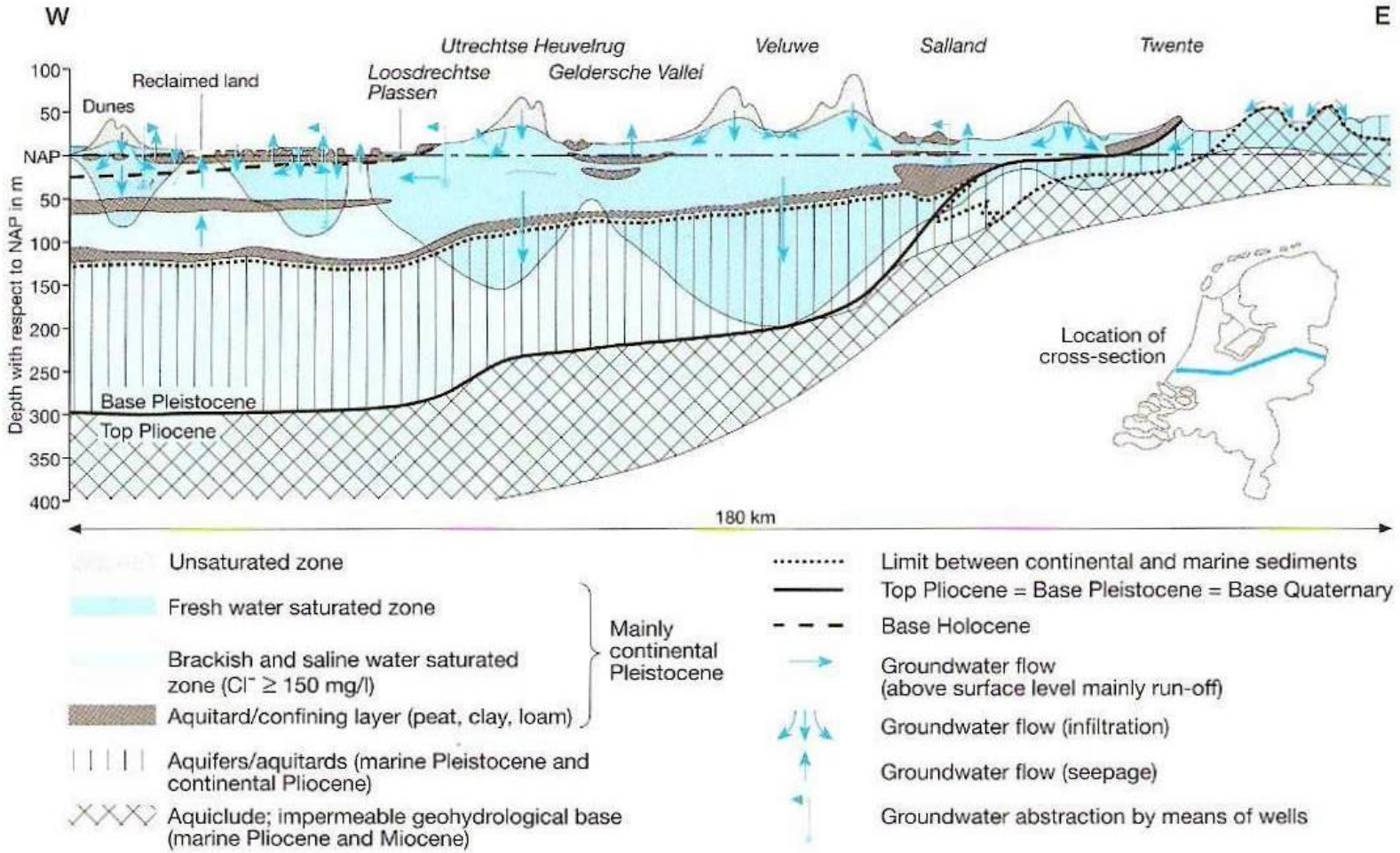
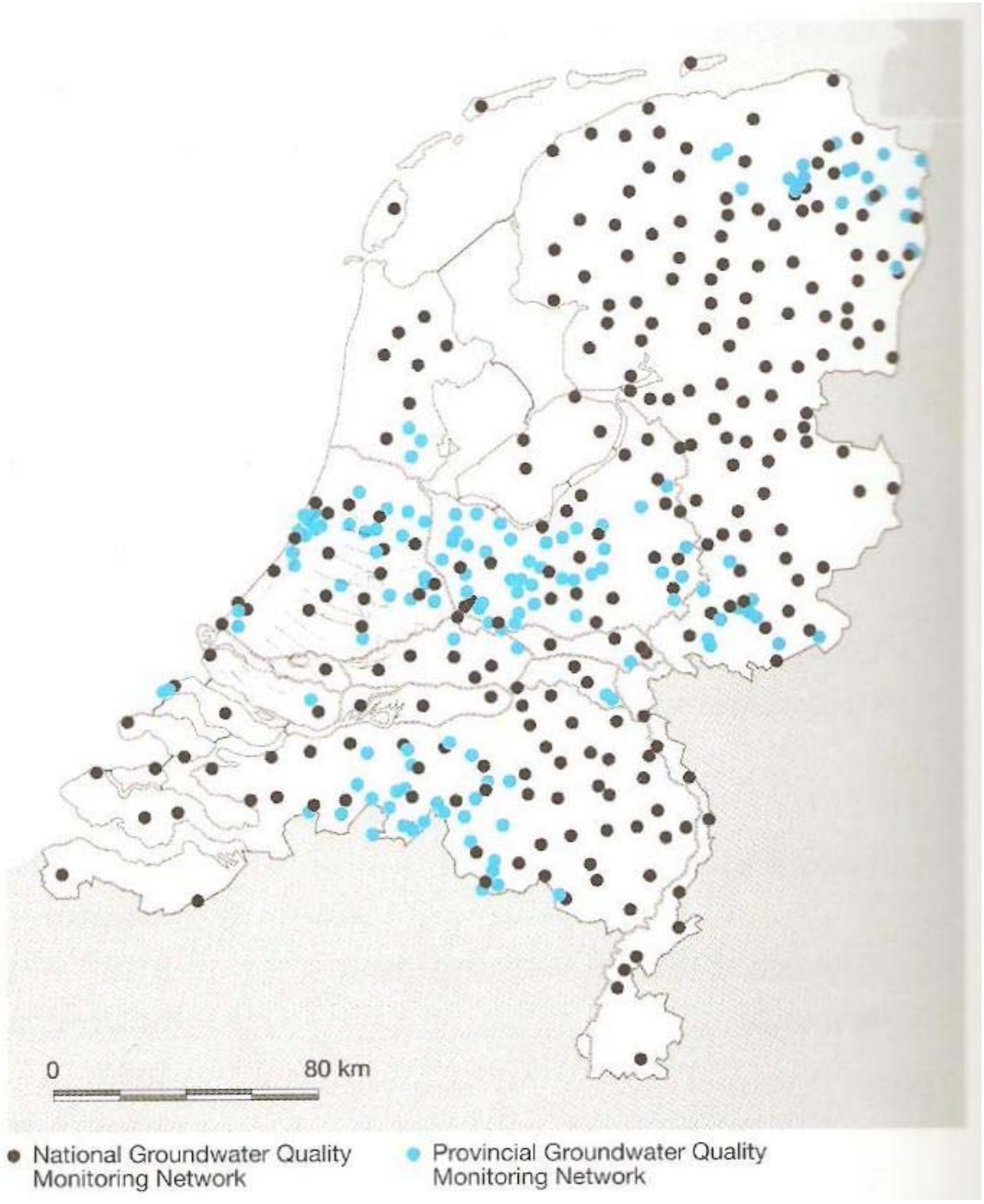


Figure 2.7 Monitoring points in the National Groundwater quality Monitoring Network and the Provincial Groundwater Monitoring Networks in 1991[6]



Appendix 2 Report on the Visit of the Hebei Water Resources Department to the Zuid-Holland Water Department

Report on

the Visit of the Hebei Water Resources Department to

the Zuid-Holland Water Department

10th march – 13th march 2010

Mrs. Van Someren, Mrs. Molegraaf, Mrs. Derks, Mr. Xu, Mr. Li, Mr. Brandsma, Mrs. Dwarshuis van de Beek, Mr. Zhang, Mr. Roest, Mr. Vroon, Mr. Liu, Mr. Zhao, Mrs. Hui

Version 16-04-2010

Mrs. Tirza Molegraaf

Report on the visit of the Hebei Water Resources Department to the Zuid-Holland Water Department 10th march – 13th march 2010.

This is the businesslike report on the visit of Hebei Water Resources Department to Zuid-Holland Water Department. The heartily reception and the dinners offered by the province of Zuid-Holland, which were also very important in the better understanding of each other, will however not be forgotten. The Water delegation had common meetings as well as joint excursions. Some activities were organized separately.

The water delegation of Hebei province was formed by:

Mr. Zhang He	Peoples Government of Hebei province	Vice governor
Mr. Li Qinglin	Department of Water Resources	Director
Mr. Liu Zhiguang	Langfang city	Vice Mayor
Mr. Xu Zhenci	Hebei Research Institute of Water Resources	Director
Mr. Zhao Limin	Hebei Design and Research Institute of Water Resources	Director

The delegation members of Zuid-Holland province and the contact persons of organizations involved in the visit are listed at the end of this report.

All presentations given during those two days are also included as an appendix to this report. They will also be issued on the common website.

Part 1: Thursday March 11

Visit to the 'New Waterway' and the Maeslantkering

Mrs. Marcela Laguzzi, *head watersafety and control bureau, Province of Zuid-Holland*.

A film about the Storm Surge Barrier was showed, where after a tour on the operation, construction

and maintenance of the Barrier was given by the officers of the information centre.

If a water level of 3.00 meters above NAP is anticipated for Rotterdam the Storm Surge Barrier in the New Waterway has to be closed. In these circumstances the Storm Surge Barrier computer - the Command and Support System (Dutch acronym BOS) instructs the Control System (BES) to shut the barrier. The BES implements the BOS's commands.

In the event of a storm tide, the docks are filled with water, so that the hollow gates start to float and can be turned into the New Waterway. Once the gates meet, the cavities are filled with water and the gates sink to the bottom, thus sealing off the 360 metre-wide opening. After the high water has passed the gates are pumped out and the structure begins to float again. Once it is certain that the next high water will not be another abnormally high one, the two gates are returned to their docks.

When the New Waterway is sealed off it is no longer possible for shipping to pass. The storm-surge barrier will only be closed in extremely bad weather – in probability once every ten years. A test closure will probably be conducted once a year in order to check the equipment. This will be done when there is little shipping. With the rise in sea levels the storm-surge barrier will need to close more frequently in 50 years time, namely once every five years.

More information on the Maeslantkering in English can be found on the website: http://www.keringhuis.nl/engels/home_flash.html

Presentation ‘Deltaprogram Rijnmond-Drechtsteden’ (annex 1)

Mr. Evert van de Meide, *senior policy advisor on water safety, Province of Zuid-Holland*.

He explained the transformation that is going on in thinking about the way safety can be provided. There are three goals to meet in the decision: long term water safety, sustainable freshwater supply and vital spatial planning.

Three scenarios are being researched:

1. Staying open
2. Completely closing of the New Waterway
3. Lockable-open

Challenges which will be met are: guarantee of fresh water supply, building new dikes, water quality regulations, harbour connection and economic development, saltation and nature conservation.

In 2014 the initial concept decision will be made on the basis of the scenarios.

Interesting discussion follows about: How is the government coping with the population? Who decides which solution will be chosen? Will the ones who are at a disadvantage be compensated? Is there a policy for stakeholders? But also who is responsible for the project and therefore for the costs?

Watersafety and ecocities; Dordrecht

Mr. Gijs van de Boomen, *director and landscape architect, KuiperCompangnons*.

Vice Mayor Liu welcomes KuiperCompagnons to Langfang City.

Mrs. Tiffany Tsui, *teamleader sustainable development services, DHV.*

One of the largest Dutch engineering consultancy firms active in China, DHV, has successfully launched several projects with local governments in Hebei province including Cangzhou, Caofeidian Eco City and Tanghai and collaborates with Dutch knowledge institutions and companies, such as Wageningen University, KOW and Nautilus. The projects cover the areas of regional water management, metropolitan agriculture, ecological technologies and eco city developments. Provincial level support and coordination are needed for coherent regional strategy and knowledge sharing.

Mrs. Ellen Kelder, *teamleader water, municipality of Dordrecht*.

Mrs. Kelder explained shortly the interesting situation of the city of Dordrecht. The most busy and economic important street of Dordrecht, the 'Voorstraat' where we also had our presentation, is also a primary barrage. The city is hereby split in two: one site is not protected by this dam, the other site is. The old buildings in the unprotected part of the city are being adjusted to climate change and rising water levels.

Presentation Port of Rotterdam (annex 2)

Mr. Nico van Limborgh, *senior projectmanager, Port of Rotterdam*.

The port of Rotterdam is one of the main ports of the world. The reasons are: location, deep sea port, hinterland connections and tradition of continuous improvement and innovation. It has grown from a small port in the city in 1950 to a big container port now.

The company 'Port of Rotterdam' is a corporatized public Company (Municipality Rotterdam 66,7 % and State of Netherlands shareholders 33,3 %). The roles the company performs are:

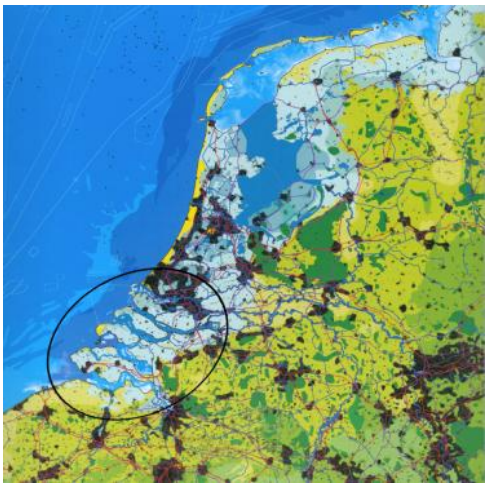
- Monitoring economic developments
- Initiate and execute long term (port) planning
- Provide adequate infrastructure (Financing and commissioning quay wall, jetties, dredging works)
- Co-ordination of shipping
- Facilitating Dataflow
- Ensure efficient, good transport
- Balancing interests of all public and private stakeholders, with port development as objective

Discussion: Vice governor Zhang was inspired by the management style of the Port of Rotterdam. Further on he was interested in the import and export data of the Port of Rotterdam.

Presentation 'South-West Delta' (annex 3)

Mr. Luc Absil, *policy advisor watermanagement, Province of Zuid-Holland*.

In the 16th century the Delta of the Netherlands was unprotected and consisted mainly of diverted islands. In 1953 the Delta has suffered a great flooding; hundreds of people were killed and thousands were homeless. From 1958 to 1986 we build the Delta works: shorter shorelines, compartments and more safety was the result. The economy of the hinterland flourished: agriculture, horticulture and tourism could develop. Fresh water increased the profit because bulbs and fruit could be grown. Also transport routes could become more efficient. But the negative site was diminished water quality and ecological deterioration. Now we are looking for a balance in safety, profit and ecology. A Steering group, with chair Vice-governor Dwarshuis, looks for possibilities to change the Delta in a safe, ecologically sustainable but attractive and innovative Delta. Climate change asks for different and flexible solutions.



Discussion:

New insights about the balance between safety, profit and ecology.

Part 2: Friday March 12

Visit City of the Sun, Heerhugowaard

Delegation: Mr. Zhang and Mr. Liu

Vice Governor Zhang He and Vice Mayor Liu Zhiguang visited the "city of the sun" in Heerhugowaard. Mr. de Boer, Vice Mayor from Heerhugowaard and Mr. van den Boomen and Ms. Xiaoying Liu from Kuiper welcomed the delegation and gave them a tour through Heerhugowaard. The "city of the

Heerhugowaard: Mr. Liu, Mr. de Boer, Mr. Zhang, Mr. van den Boomen

sun” is a part of Heerhugowaard that strives for emission neutrality and is designed by KuiperCompagnons. Mr. Zhang and Mr. Liu were very interested in the sustainable but also the social aspects of the city.

KuiperCompagnons is working on an eco-project for Langfang City and therefore it was very good for them to meet with Mr. Liu, Vice Mayor of Langfang. KuiperCompagnons is also making plans for projects in Tanshang Shijiazhuang and Tangzhou. They hope that Mr. Zhang, Vice Governor of Hebei can help them with the progress on these projects.

Visit Dunea, drinking water company, Meijendel (annex 4)

Delegation: Mr. Li Qinglin, Mr. Xu Zhenci and Mr. Zhao Limin

Mr. Guurt Kok, *director department control and management, Dunea*.

Mrs. Mirja Baneke, *consultant drinking water supply, department strategy and development, Dunea*.

A short film was shown on the production process of drinking water in the dunes. Afterwards Mrs. Mirja Baneke gave a presentation on artificial recharge and groundwater abstraction in dune area. The overexploitation of fresh groundwater from the dunes is solved by infiltration of surface water, recharged from outside the dune area. The goal is to be able to increase the abstraction rate of groundwater without losing the advantages of groundwater.

Discussion:

1. Plan to build a reservoir for storing the groundwater in Hebei. The water is stored in the soil. They pump the water from the soil when it is needed. (Mr. Li Qinglin)
2. The different aquifers in Hebei are managed by the government which is different from Zuid-Holland. (Mr. Li Qinglin)
3. The amount of evaporation is more than precipitation in Hebei province which is one of reasons leading the depletion of groundwater in Hebei. (Mr. Zhao Limin)

Meeting future cooperation

Attendance: Mr. Li Qinglin, Mr. Xu Zhenci, Mr. Zhao Limin, Mr. Jacques Vroon, Mr. Jan Roest, Mrs. Tirza Molegraaf, Mrs. Renee Derks, Mrs. Zhao Chenyang

Chair: **Mr. Jacques Vroon**, *Director Water and Green Department, province of Zuid-Holland*.

During the meeting several topics are discussed:

1. International conference;
2. Pilot on groundwatermonitoring and management
3. Knowledge program
4. Climate Change
5. Publication and website

International conference

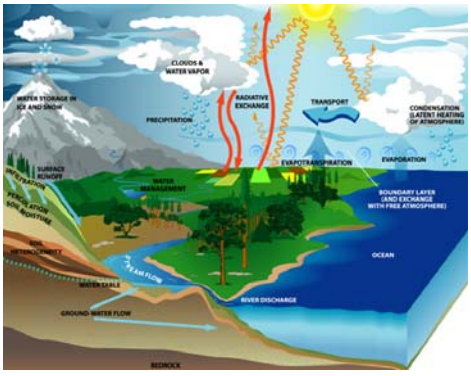
Agreement:

Organization of one big International Conference at the end of 2011. The best location is Hebei. Involvement of other themes will be decided on in a later stage.

Concerns: Results concerning the other cooperation themes. The province of Zuid-Holland stresses that integration of the Environmental department should be a goal. The International Conference should present concrete results. Involvement of at least the Water department, research centres and Universities in the water field is necessary.

Pilot on goundwatermonitoring and management

The Netherlands have a lot of experience in this field. Hebei would like to share knowledge in the field of groundwater technology and management. They would like to exchange experiences and problems in the field.



Agreement:

We start up a pilot. Find the pilot area in Hebei, use the pilot area as an example (to do the operation, get the sample). The provinces offer governmental input on permits, policy and management. Companies offer input on modelling, management, data collection etc.

Knowledge program

To make the pilot effective a knowledge program will be started. The program will include:

Training and learning on

- Groundwater Management
    - Regulations (approval of permit for the intake of groundwater, how it is processed)
    - Network (organization, groundwater management system)
- Groundwater Technology (monitoring and operation system, import instruments and modeling system)
    - Instruments: Monitoring the groundwater, Data analysis and transfer system, Groundwater recharge engineering
    - Research the change of groundwater (Quality, quantity and etc.)
    - Learn the development cases for groundwater exploration

Agreement:

Set up a knowledge program in combination with the pilot. Possibilities for internships on both sides will be included. More people for training one time in Zuid-Holland, e.g. practical staff for a long duration but management for a short duration. The training can be combined with a workvisit.

Climate Change

Climate change is an important subject concerning the cooperation. The Netherlands struggle with floods and Hebei struggles with droughts. But also drought is a problem in the Netherlands like floods in Hebei.

Agreement:

In 2011 the focus will be on knowledge exchange about thechnology and government to government policies in relation to climate change. Concrete topics are flood prevention system under the climate change situation, drought resiliance and sea storm in the coastal line. But also taggling questions as ‘what is the influence of global climate change on water management (measures and infrastructure)’ and ‘what is the policy point of view on global climate change’.

Publication and website

Both sides want to continue to strengthen the communication (websites, brochures and etc).

Agreements:

To improve the platform of communication we will show the cooperation project through the websites and publications. This website will be updated or changed. Both parties will provide effort to make this succesfull.

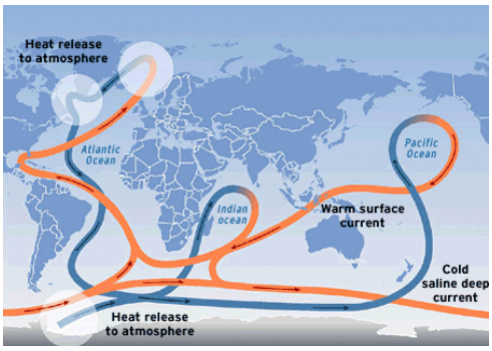
A pubication about the cooperation program and its results will be issued in English. Zuid-Holland provides finacial and technical support.

<u>Seminar on groundwatermonitoring and management</u>

In the session 3 presentations were held.

Chair: **Mr. Wiebe Brandsma**, *Director Co-development Program Zuid-Holland, province of Zuid-Holland*.

Mr. Alexander Bakker, *PhD Time series analysis and manipulation in tailored climate change scenarios, Royal Netherlands Meteorological Institute (KNMI)*. (annex 5)

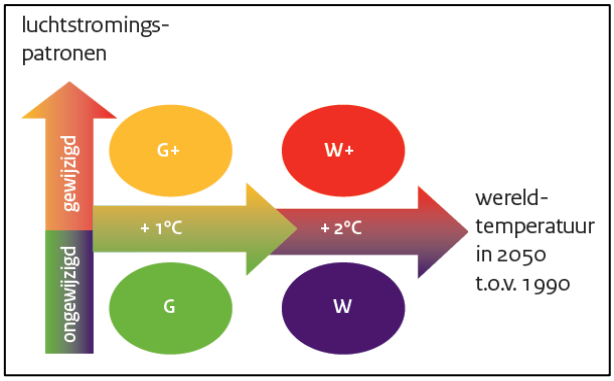


The KNMI is the national institute for weather, climate and seismology. It disseminates weather information to the general public and all kind of sectors. The weather department is, amongst others, responsible for extreme weather warnings. For the climate department the scenarios belong to the key products.

The Climate services division functions as a portal to professional users of climate information. We provide knowledge about past, current and future climate. Our division is amongst others responsible for future climate scenarios.

Different types of scenarios

- Generic set: for use by broad range of disciplines
- " tailored" scenarios: e.g. more extreme scenario for Delta commission (coastal protection)



Originally, the scenarios especially focused on water management

issues. But, the user needs heavily diverge.

For example communities asked for information to adapt sewage constructions to climate change. For adapting these systems to more intense rainfall in the future, they need 5-60 minutes rainfall extremes. They don't need these data for the coming 10 or 20 years, no those constructions will lay there for the coming 40 - 80 years, so they need a time horizon of 2050-2100.

The Dutch Delta Committee, a committee consulting the National Government, I believe also famous abroad because of there scenario of 1,30 meters sea level rise in the Netherlands in 2100 (85 KNMI, excluding soil subsidence). They need to look even further ahead then in the above example. For coastal protection constructions they look at a time horizon up to 200 years ahead of yearly sea level rise.

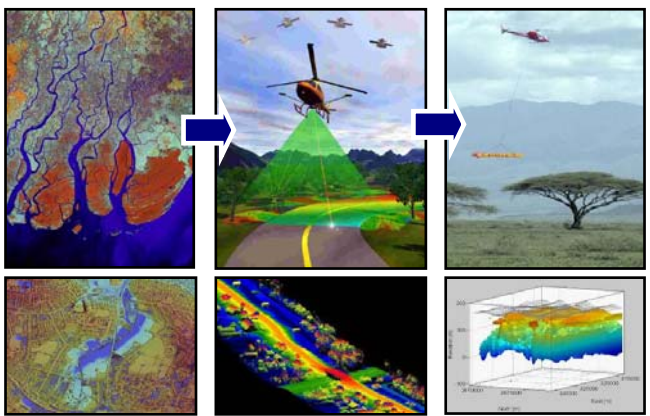
Water managers and a lot of other users need time series for their impact assessments. Therefore, methods are developed to generate time series matching the future scenarios.

One method is to use historical time series and "transform" them into time series matching the scenarios for a certain time horizon. The scenarios are useful for professional impact assessments, but also for answering important cultural questions.

Mr. Job Nijman, *Director, Fugro Water Services (annex 6)*

It is important to notice that interferences in the water cycle will influence the surrounding ground or surface water quantity or quality. Many solutions can only be found once we understand the local and in case of large impacts the regional hydrological system. Buildings can act as groundwater barriers and might cause local groundwater rise. Pollution can be transported miles away from the source through groundwater aquifers.

The water cycle refers to the process whereby water is circulated through the billion spheres.



In the hydrological cycle two fundamentally different elements can be distinguished; 'blue' and 'green' water. Out of the total

annual amount of 110,000 cubic kilometres (km3) of precipitation on the land surface, about 40,000 km3 (37%) is converted into surface runoff and aquifer recharge (blue water). Blue water is used for drinking and domestic purposes, industry and hydro power (altogether 0.1%) and irrigated agriculture (0.9%). Although the share of irrigated agriculture in the total hydrological cycle is marginal, it is the most important user of blue water, leading in an increasing number of places worldwide to severe shortages and competition of water.

An estimated total annual amount of 70,000 km3 (63%) of precipitation is stored in the soil and later returns to the atmosphere trough evaporation and plant transpiration (green water). Rainfed and irrigated agriculture both uses green water.

What is needed?: Data for Understanding the system

- better understanding of the system and effects
- integrated approach
- better predictions and mathematical models
- automated engineering
- Real-time monitoring and early warning systems

Non invasive techniques: *Mostly less accurate than destructive techniques, main advantage is the ability to cover large surface and subsurface areas*

Invasive techniques:*Very accurate & detailed information but expensive for large areas*

Examples from China, Greece, America, Australia and Germany were given (annex 6).

Mr. Mattijs Hehenkamp, *Advisor watermanagement, Grontmij*.

Mr. Marcel van Uitert, *Senior Projectmanager/Advisor, Arcadis*. (annex 7)

A short introduction on policy making in Zuid-Holland is given by Mr Van Uitert.

A sustainable system depends on three sets of policy choices: Spatial planning, Watermanagement and autonomous developments of the system.

Mr. Hehenkamp showed us an example of sustainable groundwatermanagement in Turkey. Three different parts has to be taken into account. Juridical implications, Institutional decisions and technical plans.

The technical part is elaborated further:

- Groundwater quantity and groundwater quality;
- Ecological and protected areas;
- Pressures and impacts in the project area;
- Objectives and goals with respect to directives;
- Proposal for monitoring in the project area;
- Risk assessment: future developments in the area (till 2015);
- Program of measures (longlist) including economical analysis.

Part 3: Meeting Mrs. Lenie Dwarshuis and Mr. Zhang He

Mr. Zhang is very impressed by the routine of the Water Department of the province of Zuid-Holland. He mentioned that we can achieve a lot with limited human resources and means. The flexibility was very good. He was also impressed by the transport system of the Netherlands.

The program was in many ways as expected. The delegation learned much about the high level of watermanagement. They enjoyed their visits to the Measlant barrier and Dordrecht. They wil give integrated watermanagement more attention: safety, profit and environment.

Besides this he was inpressed by the management of the port of Rotterdam. The construction of the port from little to world port is impressive.

Also ‘the city of the sun’ Heerhugowaard was enlightning. Very integrated approach with high technology but practical applications.

Mrs. Dwarshuis is pleased to hear those compliments. She hopes that cooperation between the port of Rotterdam and the ports in Hebei could be lifted to a higher level.

Also important companies like DHV and KuiperCompagnons have intrests in Hebei and support to their mission in watermanagement and ecocities are stressed.

She accentuates the World Expo in Shanghai and in particular the Dutch Water Week from 4 to 11 June 2010. She invites Mr. Zhang to be the co-host of day five: Delta developments.

The next one and a half year the cooperation will be strenghtened. At the end of this year the province of Zuid-Holland will evaluate the cooperation. The concrete results on business and governmental level will be evaluated. Hopefully enough results can be achieved and highlighted to continue the cooperation in the years after 2011.

Part 4: Final conclusions

Mr Zhang He and Mrs. Dwarshuis

- Mr Zhang He will attent the Holland Water Week. He will be present, with a Hebei Waterdelegation, in Shanghai on June 11 as a co-host. Mrs Dwarshuis will be the host of this day.
- Both Mr. Zhang He and Mrs. Dwarshuis will give sufficient political and finacial support to the cooperation between the Water Departments of both provinces.
- Both Mr. Zhang He and Mrs Dwarshuis expect concrete results at the end of the cooperation in 2011.

Mr. Li Qinglin and Mr. Jacques Vroon

- Organization of one big International Conference at the end of 2011. The best location is Hebei. Involvement of other themes will be decided on in a later stage.
- We start up a pilot. Find the pilot area in Hebei, use the pilot area as an example (to do the operation, get the sample). The provinces offer governmental input on permits, policy and management. Companies offer input on modelling, management, data collection etc.
- Set up a knowledge program in combination with the pilot. Possibilities for internships on both sides will be included. More people for training one time in Zuid-Holland, e.g. practical staff for a long duration but management for a short duration. The training can be combined with a workvisit.
- In 2011 the focus will be on knowledge exchange about thechnology and government to government policies in relation to climate change. Concrete topics are flood prevention system under the climate change situation, drought resiliance and sea storm in the coastal line. But also taggling questions as ‘what is the influence of global climate change on water management (measures and infrastructure)’ and ‘what is the policy point of view on global climate change.
- To improve the platform of communication we will show the cooperation project through the websites and publications. This website will be updated or changed. Both parties will provide effort to make this succesfull.
- A pubication about the cooperation program and its results will be issued in English. Zuid-Holland provides finacial and technical support.

Rotterdam: Mr. Liu, Mr. Zhao, Mrs. Derks, Mr. Zhang, Mrs. Molegraaf, Mr. Li, Mr. Xu

Dunea: Mrs. Derks, Mr. Kok, Mr. de Haan, Mr. van Uitert, Mrs. Molegraaf, Mr. Li, Mr. Hehenkamp, Mrs. Baneke, Mr. Zhao, Mr. Xu

Contact person and organizer of the visit:

Mrs. Renée Derks, Junior Project Manager, Co-Development Program: r.derks@science-alliance.nl, +31620103412

Mrs. Hui Jiang, Project Assistant, Co-Development Program

Province of Zuid-Holland:

Mrs Lenie Dwarshuis	van de Beek, Vice-Governor of Zuid-Holland in charge of International Affairs and Water Management
Mr. Huub Goumans	Director Environment
Mr. Wiebe Brandsma	Director of China Programs: wjm.brandsma@pzh.nl, +31618309837
Mrs. Tirza Molegraaf	Projectmanager Watercooperation Hebei, t.molegraaf@pzh.nl, +31646098384
Mrs. Marianne de Nooij	Senior Policy advisor Europe/International Affairs, m.de.nooij@pzh.nl
Mr. Jaques Vroon	Director Water and Green Department, jh.vroon@pzh.nl
Mr. Jan Roest	Head Watermanagement (ad interim), ji.roest@pzh.nl
Mw. Marcela Laguzzi	Head Watersafety, m.laguzzi@pzh.nl
Mr. Evert v/d Meide	Senior policy advisor Watersafety, lj.vander.meide@pzh.nl
Mr. Steven Visser	Projectmanager South West Delta, sj.visser@pzh.nl
Mr. Luc Absil	Policy advisor Watermanagement, llm.absil@pzh.nl
Mrs. Zhao Chenyang	Assistant Watermanagement

Interpreters

Mrs. Nan Su (Charlotte)

Dr. Shuhua van Someren-Wang

Contact person companies:

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KNMI:	Mr. Alexander Bakker, Alexander.Bakker@knmi.nl
Grontmij:	Mr. Mattijs Hehenkamp (Advisor Watermanagement), mattijs.hehenkamp@grontmij.nl
Dunea:	Mrs. Mirja Baneke (Consultant), m.baneke@dunea.nl

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Appendix 3 Plan of Approach

Groundwater problems and solutions in provinces of Zuid-Holland (The Netherlands) and Hebei (China)

A comparison in order to improve the cooperation between the two provinces

Thesis Plan of Approach

Supervisor in Larenstein: Mr. Hans van den Dool

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Supervisor in Zuid-Holland Province: Ms. ir. Tirza Molegraaf

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Zhao Chenyang

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February, 2010

1. INTRODUCTION

Since the friendly cooperation of the first stage between South-Holland province and Hebei province has been successfully completed and the second stage is just started, more information and communication about the evolving projects are needed. In the second stage, the cooperation will mainly focus on: the bilateral governmental water development and management project, Groundwater Monitoring and Management, Flood control and etc in the scenario of climate change in Hebei.

Considering my various backgrounds and my personal interest, I have decided to undertake this internship to do some research on groundwater management. Apart from this, I will give support to my external supervisor as much as I can. Moreover, I can experience more on the monitoring phase of groundwater to enrich my knowledge and experience in terms of practical field research.

Problem Definition

There are lots of water related problems in both South-Holland and Hebei province. Those problems include as:

- Groundwater depletion
- Outdated groundwater monitoring facilities
- Drought
- Sea Water intrusion
- Groundwater pollution

Research Objective

The research objective is to improve the cooperation project between South-Holland and Hebei Province as far as groundwater management is concerned.

Main Research Question

What are differences in the current urban groundwater management between South-Holland and Hebei provinces? How can the exchange of expertise and cooperation be improved?

Research Questions

This assignment will focus on groundwater management which leads to following research questions:

6. How is the Groundwater situation in South-Holland and Hebei Province?
7. What are the differences policies between two provinces for groundwater management?
8. What problems are related to current urban Groundwater management?
9. What lessons can be learned from both sides?
10. How to improve to the cooperation?

2. METHODOLOGY

Research Strategy

The research strategy is set up in three parts: pre-research, theoretical analysis and aggregate analysis.

- Pre-research

The pre-research was done by discussion with internal and external tutors and literature study on Internet. This helped me to analyze the information I had in order to clarify the research subject and define the research broad. This includes the first-hand experience in March during the Hebei delegation visited Province of Zuid-Holland.

- Theoretical analysis

The theoretical part of the thesis refers to research questions 1 and 2. It will start with literatures review of the history of cooperation and general groundwater situation in two provinces. Then, the different groundwater problems and the organizations and policies will be discussed with PZH and HP experts and learned by reading pervious projects reports, which can help to give a foundation of the further research.

- Aggregate analysis

The aggregate analysis is part of the study comprises interviews to the PZH and HP experts about the research questions 3 and 5. It includes the questionnaire, telephone interviews, email communication, face to face interviews and also the field visiting.

Methods

To answer these research questions, a combination of technical analysis and theoretical research methods is used, including interviews and literature study.

1. Literature study

- The information which is available in the Internet in terms of circumstances of both sides in this project.

http://www.holland-hebei.net/

http://www.zuid-holland.nl/index.htm

http://www.hebwb.gov.cn/Nederlands/index.jsp

- Groundwater Management - The Search for Practical Approaches
- Satoshi Takizawa Ph.D. “Groundwater Management in Asian Cities: Technology and Policy for Sustainability”

- The internet WUR-library
- Documents which are given by Ms. Molegraaf and colleagues from Province

- T. Track, D. Mueller and W. Gevaerts “Guidance on Risk Assessment for Groundwater” (27 September 2009)
- Common Implementation Strategy for the Water Framework Directive (2000/60/EC) Guidance on Groundwater Status and Trend Assessment

- Molegraaf, T.G., Report on the Visit of the Hebei Water Resources Department to the Zuid-Holland Water Department, The Hague, 2010

2. Interview

I will interview core stakeholders for gathering their points of view to support the research.

3. Consultation and Discussion

Some consultation and discussion are needed with Ms. Molegraaf and Mr. van den Dool to get inspiration for the research and check the reliability of information.

The sub-questions will be answered by the following methods.

1. How is the Groundwater situation in South-Holland and Hebei Province?
   - Websites and literature study
2. What are the differences policies between two provinces for groundwater management?
   - Literature study and interview/ e-mail
3. What problems are related to current urban Groundwater management?
   - Literature and interview
4. What lessons can be learned from both sides?
   - Interview, analysis and science literatures
5. How to improve to the cooperation?
   - Analysis and integrate the previous research

3. RESULTS

1. Assignments from supervisor

During the working in the Province South-Holland, assignments will be given from supervisor

2. Thesis report

The thesis report will contain a maximum of 40 pages, excluding annexes. The main questions and sub questions will be answered. There will also be a colloquium which will take about 30 minutes. This includes a PPT of 25 slides.

The table of content:

- Introduction
- Methodology of the research
- Chapter 1. Outline of groundwater situations
- Chapter 2. Different policies
- Chapter 3. Related Problems for groundwater management
- Chapter 4. Lessons can be learned from both sides
- Conclusion
- Recommendations
- Reference
- Annexes

4. PLACE OF WORK

I will work in The Hague two days a week. During these working days, my external supervisor Ms. Tirza will coach me and I will work on the task given by her. I will also join the mission of Hebei delegation to do the translation jobs and to be an assistant for both of two provinces. This way I also can pick up information that is useful for my thesis research.

I will spend one day a week working at Van Hall Larenstein. The work will consist of consultation and communication with my internal supervisor for this internship and give remarks for this new opportunity in South-Holland province. The rest of the time I will work at home.

5. TIME SCHEDULE

Week	Monday	Tuesday	Wednesday	Thursday	Friday
1 (March 1st- March 5th)	Draft Plan of Approach	Meeting for plan of work in The Hague Sign agreement	Literature study Preparation for mission next week		
2 (March 8th- March 12th)	Preparation for mission Improve the Draft Plan of Approach from feedback			Mission Hebei delegation	
3 (March 15th- March 19th)	Summary of the mission Desk Study	Get feedback of the Plan of Approach	Working in The Velp		Finish the Plan of Approach
4 (March 22th- March 26th)	Info. searching and exchange Conference in The Hague (9.30-11.00)	Working in the Hague	Desk research and pre research on the questions		Working on the Plan of Approach and hand in
5 (March 29th- April 2nd)			Preparation for thesis Literature research		
6 (April 5th- April 9th)	Begin to write thesis	Working out a structure of thesis		Write the Introduction and Methodology of the thesis	
7 (April 12th-	Working on the first research question			Finish the Chapter 1	

April 16th)				
8 (April 19th- April 23th)	Do the research on the second research question		Formulate the questions of Interview	Prepare for the interview
9 (April 26th- April 30th)	Background study and Interview		Working Finish the Chapter 2	Holiday
10 (May 3rd- May 7th)	Do the research on the third research question		Holiday	Finish the Chapter 3
11 (May 10th- May 14th)	Do the research on the fourth research question		Holiday	Finish the Chapter 4
12 (May 17th- May 21th)	Finish the preface, conclusion, recommendation and Appendixes of the thesis		Working on the layout of the thesis	Finish the draft final thesis
13 (May 24th- May 28th)	Holiday	Get feedback from Internal and External supervisor		
14 (May 31st- June 4th)	Improve the final thesis		Hand in the Final Thesis	

Appendix 4 Interview questionnaires

1. What are the organizations that are responsible for the groundwater management and monitoring?
2. What are the groundwater problems caused by lack of management in Hebei? Any solutions?
3. What are the positives effects of the climate change in Hebei?
4. Are there any best practices that solved the groundwater problems in Hebei? (For instance, Zuid-Holland used saline groundwater irrigating the high profits plants.)
5. Could you please explain more about a project to store the water in the subsoil to solve the groundwater quantity problems in Hebei?
6. Are there any regulations contain the reference level about the groundwater quantity and quality to define and compare the groundwater problems?
7. Could you please give some names of the policies that related to groundwater management in Hebei?
8. What does Hebei want to learn from Zuid-Holland about the groundwater management though the cooperation? Technology related to groundwater?
9. What does Zuid-Holland want to learn from Hebei about the groundwater management and monitoring during the cooperation?
10. What does Water Department in Hebei want to learn through the pilot groundwater management and monitoring? Do you have any advices for the pilot?
11. Do you have any suggestions for the exchange of experts?

Appendix 5 List of Interviewees

Jan Meijles

Policy Officer

Province Zuid-Holland

Tirza Molegraaf

Senior Policy Officer

Province Zuid-Holland

Xu Zhenci

Director

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