Integrated Water Management of Chao River, China

The current situation and possible measures for Chao River basin near Yingpan village

Institute: Van Hall Larenstein University of Applied Sciences

Alterra, Wageningen UR

Author: Zhao, Mingyuan mingyuan.zhao@wur.nl

Tutor: Welzen, Bertus Bertus.Welzen@wur.nl

External coach: Harmsen, Joop Joop.Harmsen@wur.nl

Abstract:

The subject of this project is to explore the problems and solutions about water quality and quantity in Chao River. It is a BSc Thesis of Van Hall Larenstein University of Applied Sciences. The Chao River is an important river in Chengde and it is one of the most important water sources for Beijing. The river is located in a semi-humid, semi-arid mountainous area. The living and sanitary condition in the catchment area is pretty poor. There are water scarcity problems caused by the unlimited sand excavation and climate change and water pollution from domestic garbage, sewage and fertilizer. In order to improve the situation of water supply and consumption for villagers nearby and citizens in Beijing, I first analysed the whole system and then analysed specific problems related to water quality and quantity in Chao River. The main method is survey through both deskwork (online searching, literature review, etc.) and fieldwork. After that several measures are raised according to main problems and the principle of integrated water management. Measures discussed are using new water resource like rainwater harvest, using new technology to deal with drought season and manage the pollution industries. The most important conclusion of this project is that these methods on their own are not sufficient, but that it is important to build an integrated management system which not only integrate the water quality and water quantity but also integrate water issues in different places and area, thus dealing with the problems in Chao river basin in a more effective, efficient and sustainable way.

Key words: Integrated water management, water quality, water quantity

Acknowledgment:

By the end of the thesis, I want to say thank you to all the teachers, classmates and friends who has offer their help to me during the whole thesis. I want to express gratitude to my supervisor, Dr. Joop Harmsen and Bertus Welzen who were abundantly helpful and offered invaluable assistance, support and guidance. I am also appreciating for the help of the colleagues and staff in Alterra, Wageningen University.

Especially, deepest gratitude is due Chen Yuetong, without whose assistance this study would not have been successful. She went to the study area personally and offered very valuable and helpful data and pictures to me. As I noted in the article and in reference, lots of information in the report is gotten from her.

I also want to express my love and gratitude to my beloved families; for their understanding, love and support, through the duration of my studies.

Zhao Mingyuan

2012-08-30

Contents

1. Introduction:

1.1 Background information

The Chao River is located in Chengde (which is in northeast of Beijing) and it is one of the most important water sources of Beijing. It originates in Shanghuangqi Village in Fengning County. The watershed area of Chao River in Chengde is about 4787.39km^2 and the length is 185.5km in 2008.Over 100billion m^3 water in Chao river flows to Miyun reservoir in Beijing every year (Wang, 2008), which means that about 56.7% of water in Miyun reservoir is from Chao River. The reservoir is an important source of water for China’s capital Beijing.

Yingpan is a village in Luanping County located nearby the Chao River Basin (Figure 1). The water level in the river near this village has declined recent years and there were also problems of water quality owing to the domestic garbage and the mining industry. Owing to the declining rainfall and increasing demand of water, the water scarcity has restricted the economic development in the river basin. How to guarantee the quality and quantity of water for the residents in Yingpan village under the pressure of supplying water for Beijing is an urgent issue.

I choose Yingpan village as the study area for several reasons. First of all, it is a village near Chao River and just in North of Miyun Reservoir. The location determines its importance, especially for Beijing. Secondly, the problems caused by sand excavation and mining here is most outstanding. Thirdly, it could be easier to get data of river water near Yingpan village because it is an important site in Chao River and the monthly water quality monitoring is taken there. Yingpan is also located in my hometown, which is more familiar for me and easier for me to collect data.

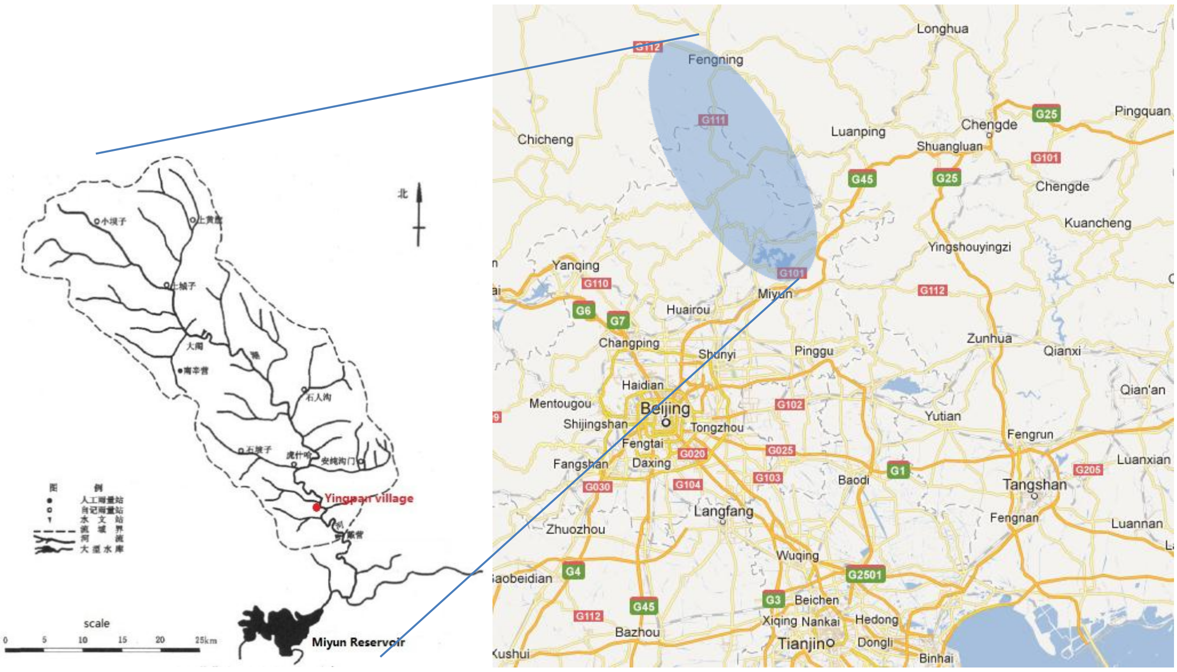


Figure 1: The catchment area of Chao River and the location of Yingpan Village and Miyun Reservoir

Figure 2: Bird eye view of Chao River in Yingpan village

1.2 Objective:

The objective of this thesis is to find out the current situation of water quality and quantity in Chao River as well as the causes that lead to that situation (by analyse the whole system and collect available data). And another objective is to find some possible measures to improve the situation. The results and conclusion described in this thesis can be used as input of next step. In this step the results are discussed with stakeholders and priorities are set. Based on the priorities action will be taken to obtain the necessary additional data and measures will be described in more detail.

1.3 Main and sub questions:

In this project, I am trying to define and analyse the water quality and quantity problems in Chao River near Yingpan village in order to find some possible measures in the area of integrated water management. The integrated water management is an important principle in the whole project. Not only because I am working in the group "Integrated water resource management" but also because it has big potential since it is not widely applied well in China yet.

In another words, I will answer the *main question* of this project: What are existing problems of Chao river near Yingpan village and what can be the possible measures in the whole river catchment to improve the situation?

In order to answer the main question, I started with several sub questions:

1) What is the current situation of the water in the whole Chao River catchment area?

This question is to find out the general condition of the whole Chao River basin in Chengde area, from the origin place till it gets to Gubeikou in Beijing. I try to answer this question by doing a system analysis of the whole area. The system consists of natural, geography and climate conditions and some water issues. This part is in Chapter 3: System analysis.

2) What is the current situation of water quantity in Chao River near Yingpan village?

From this question, the research is focus on the river basin near Yingpan village. I will analysis the water quantity condition including the data of discharge, the water demand and the factors that influence the water quantity condition. It is in Chapter 4.

3) What is the current situation of water quality in Chao River near Yingpan village?

About the water quality situation, I will collect and analyse some data about the water quality in Chao River and I will also find the causes that lead to the current situation. This part is also introduced in the Chapter 4, after the water quantity issues.

4) What are the causes of the current situation of the river?

It is important to find out the causes if we want to solve a problem. And it is also a part of the current situation. So I will find out the reason that leads to the water quantity and quality problems in Chao River. It is presented with the water quantity and quality condition in Chapter 4.

5) What can be the possible measures to improve the situation of the river?

Combining the problems, the whole environment, policy, economic condition and using the experience and technology of the water management in the Netherlands, I will list some possible measures that can improve the condition in the study area in the Chapter 6: Possible measures.

6) What is the final solution for Chao River with these measures?

After getting some possible measures, I will also evaluate the measures in Chapter 7 to find out the availability, feasibility, cost and time span of all the measures. After that I will conclude a scenario with the measures for the Chao River basin. It is presented in Chapter 8: Conclusion.

1.4 Target group:

This thesis is written for:

1. The local government including professionals on water management, but also general politicians and managers,
2. Professionals on integrated water management to act as a source of information to be used by future development of integrated water management in Chao River area.

2. Methodology:

At the beginning, I did a system analysis for the whole river catchment area to get the general information and determine what kind of data I need to collect and analyse in the rest project.

The necessary data were collected from specific documents and database of specific website. Besides that, the data are also collected by observations and interviews with the local farmers and municipality. The observation and interviews are mainly accomplished by Chen Yuetong. She went to the study area personally (The pictures are all taken by Yuetong and the information of current situation about mining, farming and domestic garbage is from Yuetong). I also took some telephone interviews and online interviews. The data got from documents and website database were evaluated with statistical analysis method.

The data collection in system analysis is all finished by literature review and some online interview. The population, land use and water use data is from the Internet, an official website about administrative division which include all basic information (area, population, main crops, climate data, etc.) in every region. The distribution of the mining industry is collected from a list of mining companies in Hebei province on a website. There are name and location information of the companies. I look up on Google map and marked it on the regional map(Figure 6).And there are also some information about the water and land use condition is gained from online interview with local residence.

The data about current situation about the water quantity and quality of Chao River near Yingpan village is partly done by literature review and interview in Wageningen and partly finished by field investigation and interview official from the local water bureau.

The interview in Wageningen is done by mail and telephone while the field investigation includes face-to-face interview and visiting to the study area. The list of the questions in the interview and the answers given by the Water Bureau is in Annex 3. But the water quality data and the criteria of water quality standard is collected on the website of Ministry of Environmental Protection of the People's Republic of China. And the information of droughts disaster and pollution from the domestic garbage is gotten by literature view. The information about mining industry gotten from the field research is not completely used in my thesis because I cannot be convinced. The information about mining industry is from interviewing the official and visiting guided by the official. But in my personal opinion, it is not very objective because there used to be cases that the official ganged up with the mining factory owner and cover up them for profit. Some villagers said there were illegal acts, which we did not get from the government. So I did not use all the data offered by the government.

3. System analysis:

To improve the situation in Yingpan village it is necessary to understand the situation in the total river catchment area. Therefore I start with making a system analysis.

The system analysis here means the analysis of general condition of the whole Chao River basin, which includes the location, the geographic condition, climate condition, land use pattern, population and so on.

The Chao River originates from Fengning County and flows through Luanping County. The system analysis of the catchment area of Chao River including basic information of land use and water use in 9 villages and towns located nearby Chao River in Fengning and Luanping (Figure 3). Among the 9 townships, ①Xiaobazi,②Huangqi, ③Tuchengzi, ④Dage town and ⑤Shirengou are located in Fengning county and the other 4 are located in Luanping county. There are several villages in each township. The Yingpan village is located near town ⑨Bakeshiying in the map.

The north part of Fengning(including ①Xiaobazi and ②Huangqi) is located in south edge of Inner Mongolian Plateau. And the south part of Fengning and all the area in Luanping is mountainous area.

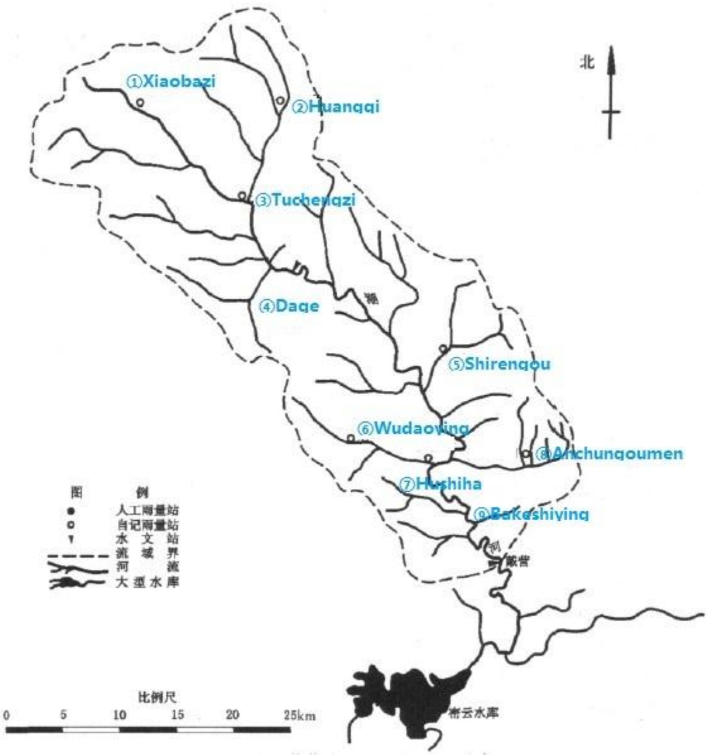


Figure 3 : 9 townships in the Chao River catchment area

3.1 Population:

Figure 4 shows the population and density of population in the 9 townships. The largest population is in Dage town because it is in the centre of the whole county. As can be seen from Figure 4, the population does not vary much among different villages but the densities have big differences. The population density in Luanping County (⑥⑦⑧⑨) is much higher than that in villages in Fengning. It is not a high level compared with that in the whole province and or in China, but still is a high density compared with the world standard. It is easy to understand that in this mountainous area not every counted square meter land can be used. So the most of the population is concentrate in the flat land. That is why I say it is still a high population density area.

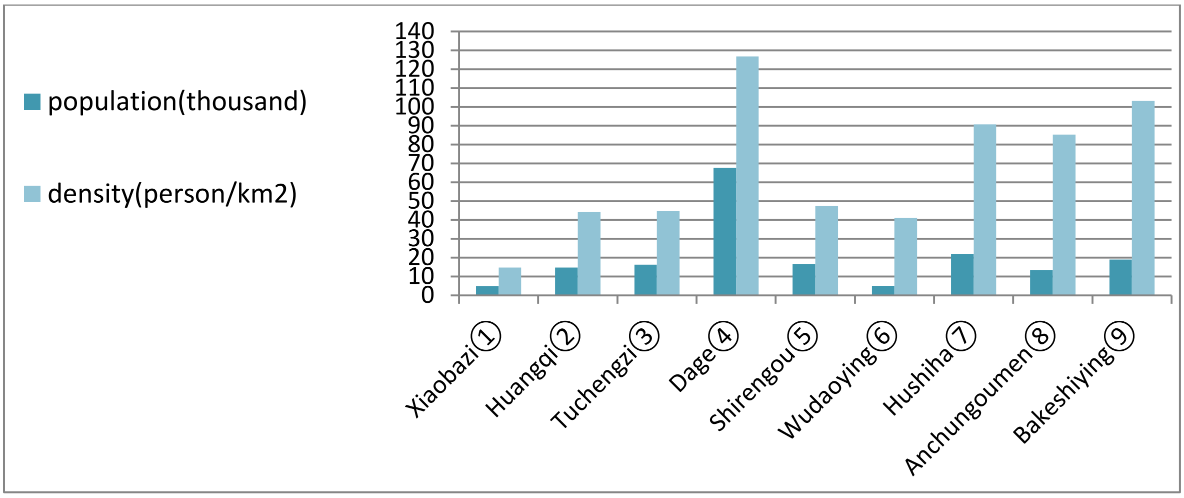


Figure 4: the population and population density in 9 townships

Source: http://www.cc.ccoo.cn/daj1/gzdt.asp?id=59881&cateid=498166

3.2 Climate:

The area is located in a semi-arid, semi-humid monsoon climate zone, which is a temperate continental climate. The temperature gets higher and the precipitation increases from the north to south. The annual potential evaporation is much higher than the annual precipitation. (Table 1) In this case, the evaporation amount is theoretical value. It means when the weather gets very arid, the real evaporation amount may not get that high. The reason of the possibility for this high evaporation in such low average temperature is that the temperature can be high during the daytime and in summer. In Figure 5 we can see the average temperature in 12 months in Fengning County. As we can see from Figure 6, the precipitation is very unevenly distributed over the different seasons. Over 60% of rainfall comes in summer and only about 2% comes in winter. So the driest seasons are spring and winter while the wettest season is summer.

Table 1: the climate data of the villages near Chao River

<table>
<tr><th>Place</th><th>Average temperature (°C)</th><th>Average annual precipitation (mm)</th><th>Average annual potential evaporation (mm)</th></tr>
<tr><td>①Xiaobazi</td><td>3.4</td><td>360</td><td rowspan="5">1595</td></tr>
<tr><td>②Huangqi</td><td>4.7</td><td>400</td></tr>
<tr><td>③Tuchengzi</td><td>5.5</td><td>395</td></tr>
<tr><td>④Dage</td><td>6.3</td><td>387</td></tr>
<tr><td>⑤Shirengou</td><td>7.3</td><td>480</td></tr>
<tr><td>⑥Wudaoying</td><td rowspan="3">7.7</td><td rowspan="3">565</td><td rowspan="4">1610</td></tr>
<tr><td>⑦Hushiha</td></tr>
<tr><td>⑧Anchungoumen</td></tr>
<tr><td>⑨Bakeshiying</td><td>11.7</td><td>615</td></tr>
</table>

Source: http://www.cc.ccoo.cn/daj1/gzdt.asp?id=59881&cateid=498166

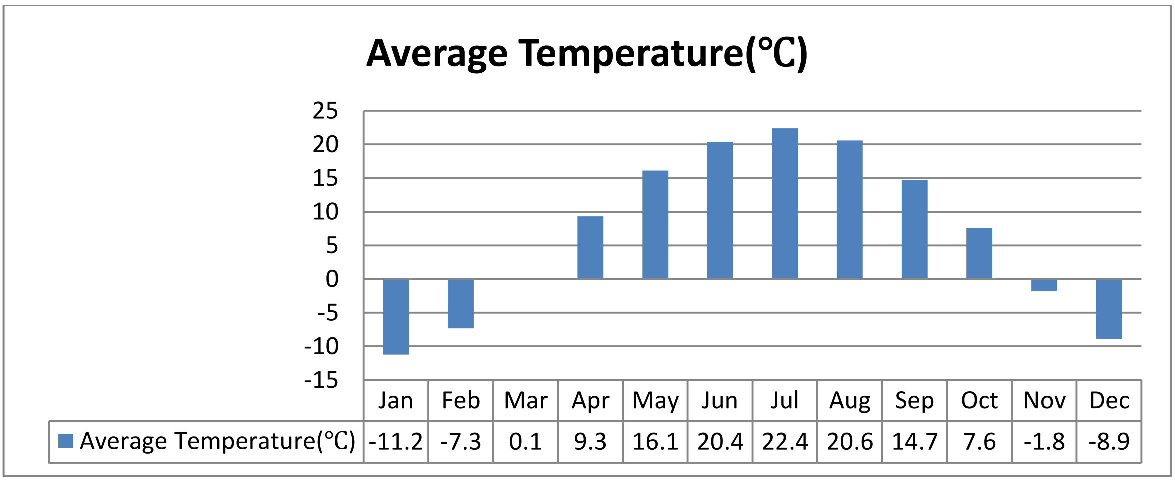


Figure 5: Average temperature in different months in Fengning from 1971-2000

Source: http://www.weather.com.cn/cityintro/101090408.shtml

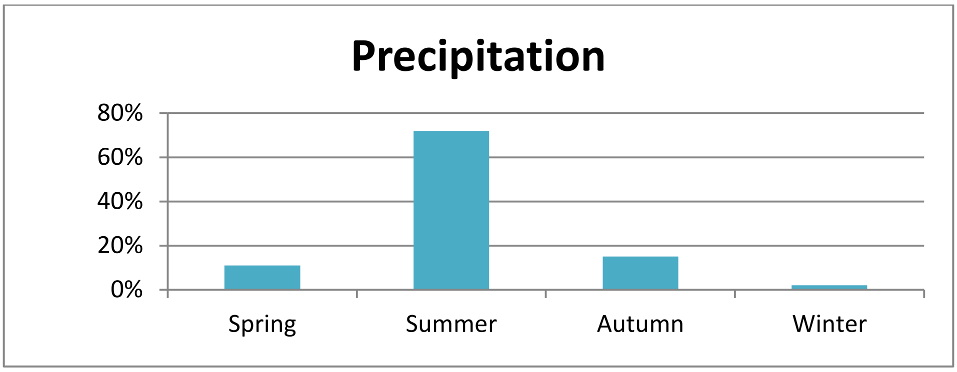


Figure 6: distribution of precipitation in each season

Source: Luanping Water Bureau, 2012

3.3 Land use:

Land of most villages is used as agricultural land and the main crops are maize, millet, bean and cereals. The agricultural land in the nine villages or towns varies from 6.2 km^2 to 35.3 km^2 and the average percentage of farmland among the whole land is about 7.8%. (Table 2) There used to be paddy farmland, but most of them are changed into maize land 5 to 6 years ago to save water for Beijing and to reduce pollution from fertilizer. (Use of nutrients and pesticides influence the water quality) Besides agriculture, the rest land is mainly used as pasture, forest residential land. And there are several mining industries near the river and most of them concentrate in ⑤Shirengou and ⑨Bakeshiying (Figure 7). The main mineral resource there is the gold mine and iron mine. It is said that in Yingpan village some people used Potassium hydride (poisonous) for heap leaching in order to get gold from ore. This highly threatened the water quality in Chao River. And in villages near ⑨Bakeshiying some sand excavation industries appeared about 10 years ago.

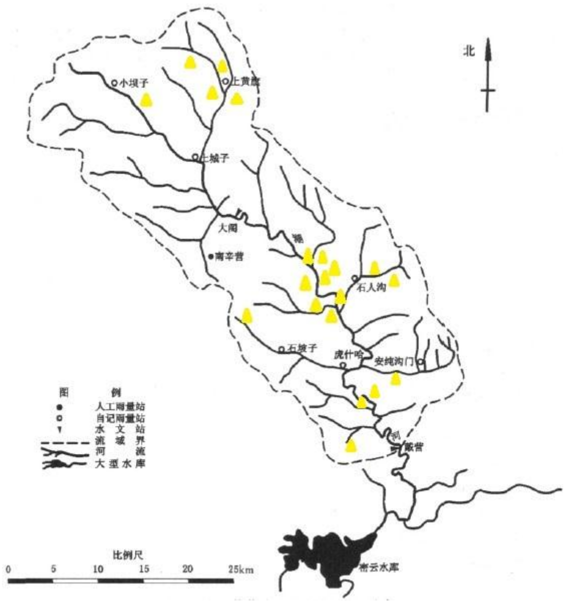


Figure 7: Mining industry distribution in the catchment area of Chao River

Source: http://www.sankeshu.net/mashup/9/mashup/9/p2/

Table 2: The agricultural area and percentage in each village or town

	Agricultural area(km^2)	Whole area(km^2)	Percentage of agricultural area
①Xiaobazi	26.66	311.15	8.6%
②Huangqi	24.38	310	7.9%
③Tuchengzi	34.98	344	10.2%
④Dage	35.3	361.1	9.7%
⑤Shirengou	19.3	348.2	5.5%
⑥Wudaoying	6.219	123.92	5%
⑦Hushiha	--(not found)	--(not found)	--(not found)
⑧Anchungoumen	11.638	157.16	7.4%
⑨Bakeshiying	--(not found)	--(not found)	--(not found)
Average	22.64	261.7	7.8%

3.4 Water use:

In the town, the residents can use tap water, but in the village the domestic water is gotten directly from the river or from the groundwater by using wells or. For irrigation the situations are also different in different villages. In richer villages, some simple irrigation systems are built to use water from the river to water the farmland while in poorer ones farmers transport water with bucket. The waste water in the town Fengning will be treated in the waste water treatment plant while the waste water in the rest villages are poured out on the ground most time. The toilet in the village is latrine and the faeces are used as manure. The water consuming aspects beside Chao River include rural field irrigation water, urban domestic water, rural domestic water, industrial water, mining and construction water use and water for environment.

3.5 Waste issues:

Most of the domestic garbage are stockpiled or incinerated. The agricultural residue such as straw are composted. There are refuse landfill sites in big towns but the domestic garbage in the villages in a threaten to the water in Chao River. According to the report of Water Bureau in Luanping, several refuse landfill sites were built in villages and towns to collect the domestic garbage and the water quality indeed got better since then. But not every village has the garbage cans or waste treatment plants, so the waste issues still exists. And it happened sometimes that the mineral waste residues were poured to the river in Yingpan village.

3.6 Conclusion of system analysis

The whole catchment area located in a semi-arid mountainous area with a relatively high population density. The main water demand are for domestic use and irrigation. Considering the living condition in this area, the domestic water demand is not high. The most serious problem of water use is for the irrigation. Especially in Yingpan village(near ⑨Bakeshiying), where the sand excavation caused serious water scarcity in recent years. And the main land use pattern is agriculture and mining industry. In aspect of water pollution, the main problem are the pollution from mining industry and the non-point source pollution from the domestic garbage and pesticides.

4. Analysis of current situation and leading reasons:

4.1 Water quantity:

Mean annual discharge of Chao River:

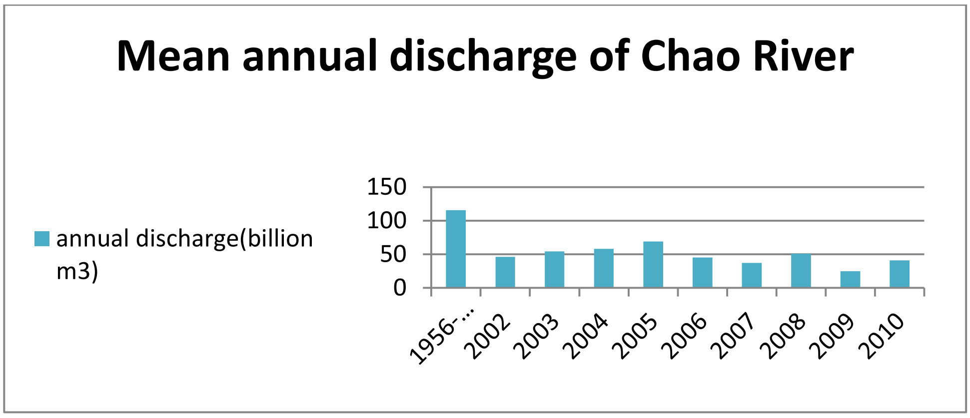


Figure 8 Mean annual discharge of Chao River in Yingpan

Source: Luanping Water Bureau, 2012

According to the data in Figure 8, the average annual discharge (the annual discharge means the total amount of water flows through a cross section in the river in a time span of one year) of Chao River from 2002 to 2010 is about 47.5 billion m^3, which is less than half of average runoff from 1956 to 2000. This may be caused by the introduction of sand excavation in the river basin and the decrease of rainfall. Because of the unlimited sand excavation, the water holding capacity of the riverbed gets lower and more water infiltrate to the groundwater. The lowest runoff appears in 2009 owing to the drought in North China.

The sand excavation appeared in Chao River basin about 10 years ago. In 2001, the policy was published that completely forbid excavating sand from riverbed in Beijing. However there is a huge demand of sand as construction material in Beijing, especially after the success of Olympic bid. (Meng, Xiangchao, 2011) As a result, some sand excavator moved their eyes to Yingpan, the village in catchment area of Chao River, which is very near to Beijing. The sand excavation brings much profit as well as problems. Mining sand from the river makes the stream course change and the water holding capacity of the riverbed sharply decrease thus causing the decline of water level in the river. The sand excavation broke the riverbed and a lot of water leaked away. Because of the lack of water for irrigation and the loss of area for storing the sand, some agricultural land becomes sand. The Figure 9 shows that the river way gets narrower because of the sand excavation and the storing of the sand near the river.

Another reason for the decreasing runoff is the climate change. During the last 50-60 years, the precipitation decreased in north China, especially from 1960s to 1980s and during the last few years in 20th century (Zuo, 2004). From 1959 to 2009, the average precipitation in north and northeast of China decreased 10%-30% and frequency of the occurrence of extreme weather events got higher. Take the drought disaster as an example, from 1990 there are drought happened in Northern China in 8 years out of 20years. (Liang Chuanchuan, 2011).

Figure 9: Sand excavation and storage near the river

Source: Left: Meng Xiangchao http://biz.cn.yahoo.com/ypen/20110629/440084_2.html
Right: photo by Chen Yuetong, 2012

Water demand:

The main water requirement in the village is for irrigation. Most of the domestic water and 60% of the irrigation water are from the groundwater and 40% of irrigation water is from the surface water. The demand of water for irrigation has decreased a lot since 2007. This is owing to the policy "change paddy into dry rice land " (in the study area is from paddy to maize). The changing of crop type near the catchment area has saved a lot of irrigation water (see Figure 10). As estimated, in Northern China, rice demands 900 m^3 per mu (1 mu=666.7 m^2) per year, while the maize only demands about 300 m^3. However the runoff in the river also decreased because of the decreasing rainfall and the sand excavation, so the water scarcity problem still exists. As the villager concludes, whenever the sand is excavated for one layer, there would be a drought in the village.

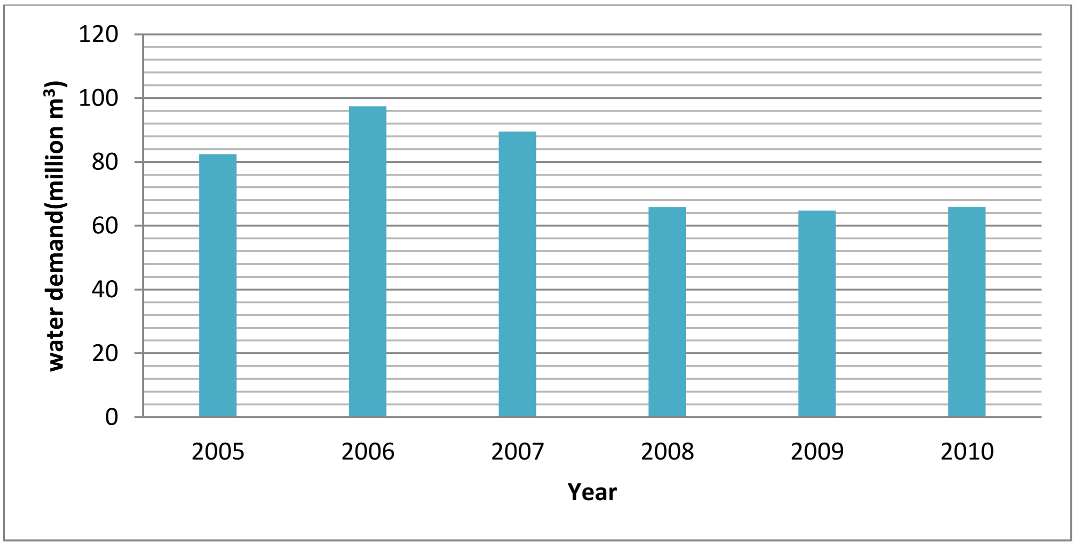


Figure 10 irrigation water demands near Chao River

Source: Luanping Water Bureau, 2012(Chen Yuetong)

It also can be seen in Figure 11, the river dried up for several weeks in each year from 2004 to 2006. The dry weeks are mainly distributes in winter. This is because of the low precipitation in the winter. However there are no dry up weeks any more after 2007. That could be owing to the changing of crop types saving much water from irrigation. But non dry up weeks does not mean there is no problem of water scarcity. In another word, the water quantity in Chao River is still low for the demand in Yingpan village and in Beijing.

The output of water supply in Chao River in 2000 is 98.72billion m^3 in total and the water demand in the area in that year is 116.12billion m^3. Among the total demand, 8.02billion (6.9%) is for domestic water consumption, 107.27billion m^3 (92.3%) is for production water consumption (agriculture and industry) and 0.82billion m^3 (0.8%) is ecological water use. The water shortage is 17.4 billion m^3 and the ratio of water deficiency is 14%. (Wang Zhansheng, 2008)

There is also a set of data predicted for the year 2030. As it predicated, the output of water supply in Chao River can get 153.1billiom m^3 if the water saving is strengthened, advanced groundwater and surface water exploitation works are built and ecological water use is arranged reasonably. However, the total water demand in 2030 is predicted as 195.99billion m^3 including 19.51 billion m^3 (9.9%) for domestic use, 173.15 billion m^3 (88.3%) production water consumption and 33.3 billion m^3 (2.8%) of ecological water consumption. The water shortage will be 42.89 billion m^3 and the ratio of water deficiency is 22%. (Wang Zhansheng, 2008)

4.2 Water quality:

From 2001 to 2005, the water quality level near the cross section where it flows out to Beijing was in Quality Level II and the main over-proof material was $NH\text{-}N_3$. And the water quality near the villages in Chengde was in Quality Level III and Quality Level IV; the over-proof materials were $NH\text{-}N_3$ and COD_{Mn}(permanganate index).

The water quality level mentioned above is from the <Surface water environment quality standard> which was defined and published by the National Environmental Protection Agency of China. The meaning of each quality level is:

Quality Level I: National Nature Reserves, no contamination

Quality Level II: relatively clean, drinkable after filtration

Quality Level III: can be used in industry after filtration and cleaning

Quality Level IV: normal agricultural water, can be used for irrigation

Quality Level V: normal landscape water

The criteria of each quality level are shown in the Table 3.

Table 3: Criteria of each water quality standard of surface water in China

	Quality Level I	**Quality Level II**	**Quality Level III**	**Quality Level IV**	**Quality Level V**
pH	6-9				
DO(mg/l)	≥7.5	≥6	≥5	≥3	≥2
COD_{mn}(mg/l)	≤15	≤15	≤20	≤30	≤40
NH_3-N(mg/l)	≤0.015	≤0.5	≤1.0	≤1.5	≤2.0

http://baike.baidu.com/view/340483.htm (Environmental quality standards for surface water)

Specific Water quality data:

Table 4: water quality data of Chao River in Gubeikou from 2004 to 2011

	pH	DO(mg/l)	COD_{mn}(mg/l)	NH_3-N(mg/l)	Quality level	Dry up(week)
2004	8.11	7.61	2.75	0.21	II	5
2005	8.20	8.01	3.22	0.12	II	13
2006	8.13	7.49	3.67	0.13	III	21
2007	7.94	8.24	1.99	0.13	II	0
2008	8.20	9.77	2.53	0.24	II	0
2009	7.74	8.70	1.62	0.18	II	0
2010	7.49	7.98	1.57	0.19	II	0
2011	7.95	7.78	2.03	0.25	II	0

Source:
http://datacenter.mep.gov.cn/report/water/water.jsp?year=2005&wissue=52&x=62&y=18
(Ministry of Environment Protection of the People's Republic of China)

More specific water quality data of Chao River in Gubeikou can be seen in the Annex.

The Ministry of Environmental Protection of China monitors the water quality in some cross sections of several main rivers every week. In Chengde, there are two cross sections in each county where the river is entering and leaving the region. And in fact there is one cross section in Yingpan village, but the data are not available for the public. That is why I use the data of Gubeikou instead (Gubeikou is a village in Beijing which is about 1.5 km away from Yingpan in the downstream). The monitored indicators include pH, Dissolved Oxygen, Chemical Oxygen Demand, Ammonia nitrogen. The water temperature, Electric conductivity, permanganate index and content of some metals are also monitored but not published to public. The data in Table 3 are the average of data from each week in a year.

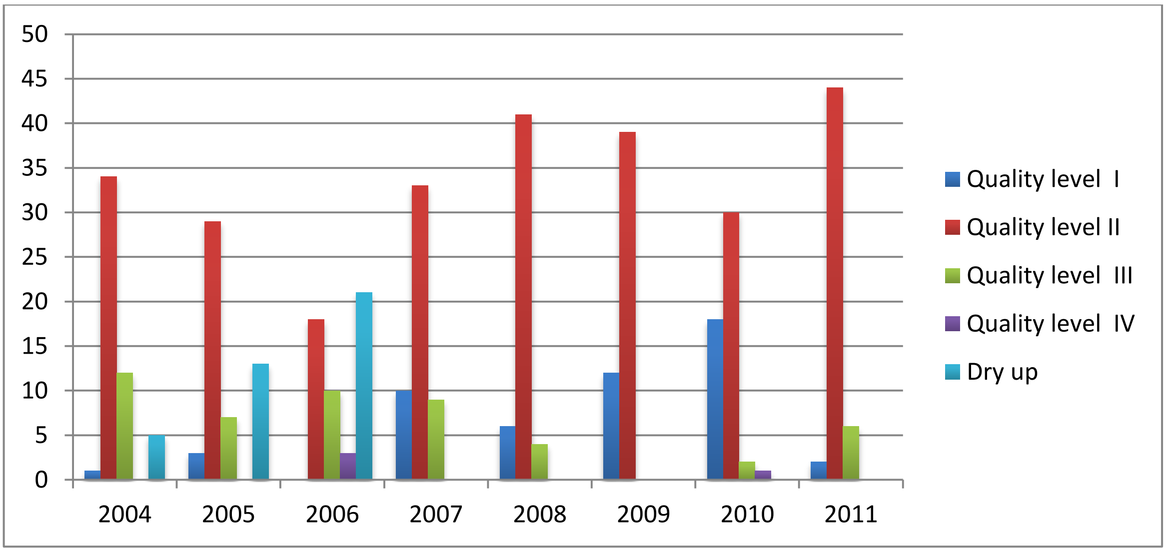


Figure 11 Distribution of water quality level in Gubeikou from 2004 to 2011(counted by weeks)

Source:
http://datacenter.mep.gov.cn/report/water/water.jsp?year=2005&wissue=52&x=62&y=18
(Ministry of Environment Protection of the People's Republic of China)

As can be seen from the chart, most times the water quality here is in Quality Level II; however the average water quality in Chao River near Yingpan village is in Quality Level III. Actually it is not at a very bad level comparing the other rivers and lakes in China. But it is not high quality water, especially used for drinking.

And we can see the water quality got a little better if we compare the data of first 4 years with the latter 4 years. For example, the weeks with quality level III and IV gets less while the Quality Level I and II gets more.

According to the recent water quality condition and with investigating by literature review and interviews, I found and analysed the possible reasons for the pollution.

Pollution from domestic garbage:

In Luanping County, 11 towns and 89 villages distribute along the Chao River and in these towns and villages there are almost 120,000 people living, which occupies 37% of the population in the whole county. Few years ago, in most of the villages beside Chao River, the domestic garbage was thrown away or stacked on the ground. And some garbage is even poured into the river directly. According to the estimation and calculation, the average amount of garbage in the villages and towns near Chao River in Luanping will be 39,100 ton per year from 2004 to 2013 and it will increase year by year. (Li, Benming 2009) The garbage brings several environmental problems because some organic matter decomposes and releases toxic gas. What is more the garbage also attracts lots of mice, mosquitos and flies, especially in summer. The river is polluted after the rainfall that brings the pollutants contained in the garbage into the water in river.

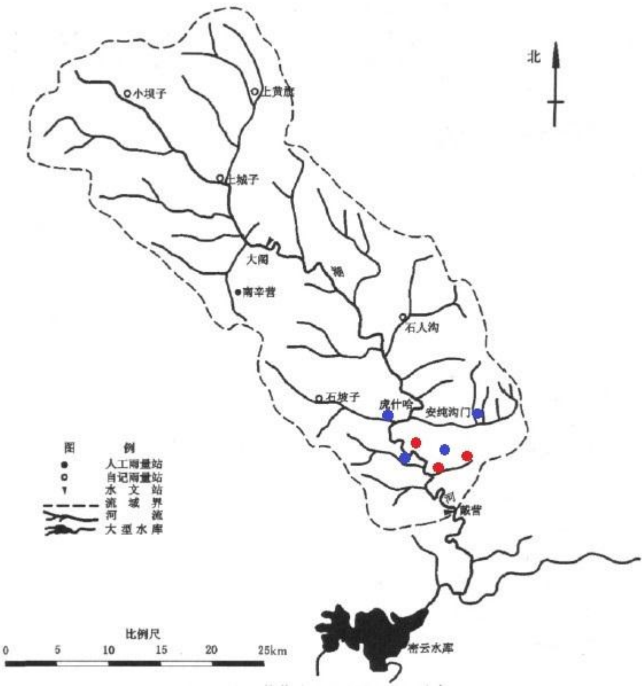


Figure 12 the location of the refuse landfill sites in towns along Chao River of Luanping

Since 2006, the plan of building refuse landfill sites in the towns has been brought into operation. In the year 2007, 3 refuse landfill sites were built and came into service. These 3 refuse landfill sites were built in the town Bakeshiying, Fujiadian and Liangjianfang. 4 refuse landfill sites in Mayingzi, Huodoushan, Hushiha, and Anchungoumen were built in 2010 and 2011, with the money subsided by Beijing. The location of these refuse landfill sites can be seen in Figure 12. The red dots show the three built refuse landfill sites and the blue dots show the location of landfills in plan of 2009. The use of the 3 refuse landfill sites had shown its effect. As can be seen in table 5, the quality of water in Chao River is improved after using the refuse landfills. In 2006, the three indicators were all lower than the sewage drainage standard of China while in 2008 all of the three indicators could meet up with that standard.

Table 5 the monitoring data of water quality in Chao River in 2006 and 2008

Test time / Section / Test items	August, 2006		September, 2008	
	Gangziqiao (Influx)	Yingpan (Out flux)	Gangziqiao (Influx)	Yingpan (Out flux)
Permanganate Index/ COD_{mn} (mg/l)	14.76	12.32	4.61	3.17
COD_{cr} (mg/l)	59.6	108	27.8	19.1
Ammonia Nitrogen (mg/l)	1.08	1.02	0.82	0.90

Permanganate index and COD are both indicators for the organic load of water. In China the permanganate index is often presented as COD_{Mn} and COD as COD_{Cr}. However, very often it is not clear which method has been used which may lead to confusion. The measurement of COD_{Cr} is usually much higher than COD_{Mn}.

However, there are still some problems existing when considering about the garbage treatment. Firstly, there is a capital scarcity for transporting the garbage. As the refuse landfill sites are mostly built in towns, the garbage in the village need to be transported to the towns. The average cost of the transport of garbage is about 30,000 Yuan (about 3,500 euro) per village per year, however the financial funds per village is less than 20,000 Yuan (about 2,400 euro) that include the salary for the village officials (Li, Benming 2009).
Secondly, the supporting facility is imperfect now. In some villages there is no garbage can and the existing ones have varying degrees of damage. Some new garbage cans equipped by the Environmental protection agency in the villages that have no garbage dumps were stole by some farmers to be used for storing food. Figure 13 shows the garbage dumps equipped in Yingpan village.

Figure 13: Garbage dump, taken by Chen Yuetong

Thirdly, the environmental awareness of some farmers needs to be improved. In the villages with garbage can or refuge storage places, some farmers do not get used to put garbage in the right place. This brings a lot of trouble for collecting and transporting the garbage. According to the interview with the officer from environmental protection agency in Luanping, over 90% of villages and towns have the refuse landfill sites till now. But owing to the above-mentioned reasons, the domestic garbage can still is considered as one factor that influences the water quality in Chao River.

Pollution from domestic sewage:

The living condition and sanitary condition in the villages in the catchment area of Chao River are relatively low. There is no concentrate water supply factory and seldom any flush latrines in the villages. The domestic sewage, like the shower water and the water from clothes washing, are poured out at will. That could be a problem if the villagers live very near to the river, because the pouring domestic sewage will directly pollute the water in the river. As we can see in Figure 11, there are a few weeks of Quality level IV from 2004 to 2011; the main indicator that exceeds the standard is the Permanganate Index. And this is mainly caused by the discharge of domestic sewage. While the high NH_3-N content also partly owes to the sewage.

Pollution from mining industry:

Some villagers once reported about the water pollution from the mining industry. As they informed, miners use the poisonous chemical --Potassium hydroxide to heap leaching to get gold. This action caused a serious threat to Chao River. However, according to the filed survey by Chen Yuetong, the problem of pollution from mining industry has been solved. There is no longer gold mining and the discharge from iron mining industry is quite clean. Figure 14 shows the drainage water from tailing pond, which seems clean. But as I speculate, the mining industry still has some negative influence to the river. It may happen beyond the administration of government, which means the management and monitor is not totally strict.

Figure 14 the drainage water from tailing pond, taken by Chen Yuetong in Yingpan village

Pollution from the agriculture (fertilizer):

It is said that in the sediments in the bottom of Miyun reservoir there is increasing accumulation of phosphorus. And this is partly caused by the non-point pollution of agriculture in the upstream of Chao River. The Ammonia Nitrogen is also partly from the run off of fertilizer. As Li Benming said, even though the paddy have been changed into dry rice land, there are still large amount of fertilizer used. This is one of the reasons of the relatively high NH_3-N content.

4.3 Management problem:

There is an interesting phenomenon I found during the data collecting stage. When I need data of water quality and quantity, I have to contact with people in different bureaus. The water quantity data is from the Water Bureau and the water quality data can only be gotten from the Environmental Protection Agency.

For a long time, the water management in China is under a "division" situation. That means total different departments manage the different aspects of water, and different departments also deal with the water problems in different places. And there is lack of communication between those departments. In Chinese legend, the Dragon King manages the water, so the management situation now is compared to "water management of various dragons". These dragons include Water Bureau, Land Resource Bureau, and Environmental Protection Agency, Agricultural Bureau, Health Bureau and some other water-related departments. It leads to several problems like the different policies and regulations, the mutual shuffle and mutual dispute when the problem occurs. And every department just focuses on its own task without considering the other procedures. It violates the natural law of recycling of water resource. (Zhang, Jianhua, 2000)

There is an example we can see from the water quality situation, it is obvious that the water quality in downstream in Gubeikou is better than in the upstream in Gongziqiao, this is because Gubeikou is in Beijing and the water bureau in Beijing monitor and manage the river more strictly. But the integrated management should not be limited in one small region. It may need more effort to manage one place without working with the surroundings. In this case, the key principle is to work together with upstream and solve the problem from the root.

In recent years, the integrated water management just started and institutional reform of water management were implemented in several cities (including Chengde). But it is still in a primary phase and the management system is imperfect yet.

To be more specific, in the study area, there isn't a department that is in charge of the whole water management. The Water Bureau pays more attention on guarantee the water supply while the Environmental Protection Agency pays more attention on prevent pollution. They are not working together well. And the local Water Bureau and Environmental Agency is only in charge of their own administering area with seldom cooperation with the upstream and downstream. So there is no one in charge of the management of the whole river.

5. Definition of current situation and problem:

After analysing the data about water quality and quantity in the Chao River we can make a problem definition for the study area.

The water quantity in the downstream of the Chao River dropped sharply since the beginning of this century because of the changing climate and unlimited sand excavation. Even though the policy" changing paddy land into dry rice land" leads to a decrease of water demand of irrigation and saves some water for the river, there is still problem of water scarcity in the villages in the Chao River basin and the water for Beijing is also not very sufficient. We can also say that the pressure of supplying water for Beijing besides the climate issues and sand excavation also causes the water scarcity in Yingpan village. Besides the problem of water resource shortage there is a problem of balancing the water consumption in Yingpan (and other villages near Chao River) and Beijing.

Considering the water pollution problem, the main contaminant is the domestic garbage, domestic sewage and fertilizer. The pollution from mining industry was a problem several years ago and it has almost been solved. In general, the average water quality level in the Chao River near Yingpan village is Quality Level III, which is can be used in industry after filtration and cleaning. It means the water is not seriously polluted but it is still not clean enough for drinking. However the water quality is a little better in downstream in Beijing.

The common reason for all these problems is backward condition in the village, the lack of environmental protection awareness of villagers and factory owners and the imperfect water management system. This mainly leads to the pollution of the river.

6. Possible measures:

In order to deal with all the existing water quality and quantity problems with the integrated water management principle, we should take several aspects into consideration.
"Integrated water management means putting all of the pieces together. Social, environmental and technical aspects must be considered." We need to meet the demand of the villagers and citizens in both upstream and downstream area and the measures should be realistic in technical and economic aspects.
Besides the integration of spaces and different aspects, the integrated water management also requires the integration of water quality and water quantity.
Keeping all these principles in mind, I get some possible solutions for Yingpan village. Some of these measures are from the success experience of the Netherlands and some are already tried in China that can be continued or spread.

6.1 Basic measures:

Implement integrated water management principle:
In the Netherlands, the water boards are in charge of managing the water barriers, the waterways, the water levels, and water quality and sewage treatment in their respective regions. There are only 25 water boards in total in the Netherlands in 2011. "The water board is a government body of functional decentralized administration with its own governing body and financing structure, and is solely concerned with the execution of tasks in the field of water control." The water board is established as decentralized functional government authorities. "This means they have a dedicated task regarding local and regional water management. They are operationally independent to a high degree and supervised by the provinces." This is a good idea that we can take as an example for China. The water quality and quantity should be managed together, economic; landscape and ecological function

should all be considered. And with this model, there will be specific regional management methods taking place of the general one in the whole country. (Rafael Lazaroms, Dimitri Poos, 2004)

Advertise and educate:

The awareness of the villagers and farmers is one of the most critical issues. As we can see from the fact that some of the new garbage cans equipped in the village are stole, some of the villagers may not aware the importance of environmental protection. We can get the same conclusion also from the thrown about batteries and pouring of the domestic sewage. The villagers should be educated how to protect the water resource by changing their daily manners. For example, the phosphate-free laundry detergent powder should be advocated to replace the phosphate-containing ones; the old batteries and mercury thermometer should be collected. And the farmers should cooperate with the government to change the type of crops, improve the irrigation method and choose more environmental-friendly fertilizer, etc. The communication and corporation between government, policy and decision maker and the public is very important.

Define reward and punishment system:

The polluter should not only take the responsibility to deal with the pollution but also get punishment for the polluting actions. And the villagers or factories that have outstanding contribution to the water protection should get praise and honour. In the Netherlands, the budget for flood prevention and water management is firstly invested by the beneficiary department and then by the beneficiary district and finally by the central finance funds. This can be used for reference.

6.2 New water resources:

Rainwater harvest:

As we can see from the data about average precipitation and evaporation in the system analysis, the annual potential evaporation is much higher than the precipitation. The rainfall concentrates in summer, which is also a season of highest evaporation. It means that some rainwater falls to the field and replenishes the groundwater and the river, but lots of the rainwater is lost by evaporation. And there is no rainwater harvest equipment in any villages or towns near Chao River. And as can be seen from the system analysis, most of the area is not used for agriculture. In this natural area the water will flow by small streams to the river or infiltrate. Harvesting this water before infiltration can be a new source of water. Considering this, the rainwater harvest is a possible measure with relatively great potential.

Several rainwater collecting devices can be built in each village, especially near the houses where the ground is cement floor. The water collected can be directly used for irrigation so there is no need of complex cleaning of the rainwater. And the summer is also the season of highest demand of irrigation water.

Artificial precipitation:

The drought happens mainly in spring and winter. Spring is the season when the crops need much water and in summer the evaporation still exceeds precipitation. Considering this situation, the artificial precipitation technology can be applied to mitigate the drought when necessary. Using the rocket to accomplish artificial precipitation enhancement, intercept water vapour in the sky to build the so-called ” air reservoir ”. But this should cost a lot, so it can be used only when it is necessary.

Figure 15: Artificial precipitation
Pictures from the Internet

6.3 Water saving measures:

Change crop pattern:

The policy “change paddy into dry rice land” has great effect in saving water. From the figure in the data analysis chapter we can see the water demand of irrigation in 2008 is 23 million m3 less than that in 2007. So continue changing the paddy land into dry rice land near the Chao River basin is a possible measure to solve the water scarcity problem. Of course, the farmers should get some subsidy by changing the crop type as the dry rice brings lower economic benefit.

Improve irrigation manners:

During a long time in the past the main irrigation method in the study area was flood irrigation and canal irrigation, which is quite inefficient and wastes a lot of water. According to the newest investigation by Chen Yuetong, there is already some advanced micro irrigation been introduced and used. Spreading the micro irrigation method has improved the efficiency of irrigation and will save some water. Drip irrigation, sprinkle irrigation and infiltrating irrigation are all methods that can be attempted.

Water reuse:

In the villages, there is no tap water so there is no fee paid for the water used during daily life. This leads to a result that most villages have no idea about saving water even though the water resource is not that sufficient.

In the short term, the villagers can try to reuse water during daily life, like to use the water for gardening after washing the rice or vegetables.

In the long term, the installation of water recycling and reuse system should be kept in mind. As the development of economy and technology, the modernization will take place in the villages sooner or later. In this trend, the water supplying and treating system will be built and the flush toilet will replace the latrines. At the very beginning of all these constructions, the possibility of water reuse should be taken into consideration. For example, the drainage pipeline of grey water from the bath, shower, bathroom wash basins, washing machines, and laundry trough can be linked with a simple cleaning system in each house or building, after that, the water can be lead to a sink for flushing the toilet. And the sewage tank can also be designed to apart the urinate and faeces, the faces can be used for producing fertilizer while the urinate can be cleaned as water resource. In this way, the backward can be an advantage in these “fall behind” area. Unlike the cities, the sustainable design here can be used at the beginning so there is no need to waste money on converting the water supplying, treating and drainage system. Using all these technologies and innovations at the very beginning of new constructions could save a lot of money and time compared with the converting work afterwards.

Figure 16: An example of domestic water reuse

Picture from the Internet

6.4 Pollution prevention

Banning the illegal sand excavation:

In the year 2001, sand excavation from the river was banned in Beijing, but the demand of sand for the construction was increasing, especially after the success of Olympic bid of Beijing. Considering the water scarcity in Yingpan village is mainly caused by the unlimited sand excavation, banning the sand excavation in the Chao river basin or at least manage the sand excavation is a necessary measure. The sand excavation should be limited for the local demand, which means not to supply sand for market in Beijing or anywhere else.

Built more waste water treatment plant and refuse landfill sites:

The fact is that in the whole catchment area of Chao River, there is only one waste water treatment plant in the town Fengning. And we can see there is one remarkable water pollution indicator in Chao River—the over-proof of permanganate index. This is mainly caused by the pouring of the domestic sewage. Hence, built the wastewater treatment plant in the villages and towns in Chao River basin is necessary. And the importance of building refuse landfill site and its effect is explained in the data analysis chapter. Continue to equip some garbage cans and build the refuse landfill sites are also an important action to improve the water quality in Chao River.

Manage the mining industry:

Tailing Pond of the mining factory should be built to forbid the emission of pollutants and toxic materials. And the government should strengthen the regulation and monitoring of the mining factories. The factories, which discharge substandard matters and water, should be severely punished.

Manage using of fertilizer:

The NH_3-N content in the river is relatively high partly because of the use of nitrogen fertilizer. The farmers can use more organic fertilizer instead of chemical fertilizer. And at the same time, the application of fertilizer should be under control because the excessive fertilizer that cannot be absorbed by the crop will pollute the water.

7. Evaluation of measures :(importance; time span; feasibility; cost)

Implement integrated water management:
The political system in China is quite different from that in the Netherlands. China is a much bigger in area and the situation is more complex. The idea to set up departments like water boards for regions to take dedicated regional task in a more integrated way is actually fits for China as it is quite a big country and it is difficult to make general, common law and regulation. But for the same reason it will also be a difficult reformation and will take a long time.

Advertise and educate:
The communication and cooperation with the villagers is a foundation of implementing all the other measures. Therefore the advertising and educating is the first step and should be taken in both short and long term. In short term, it is to raise the villager's awareness of protecting the water resource while in long term, the new ideas and innovations to improve the situation of the river should be advertised to the public in time. It is realizable and will not cost much.

Define reward and punishment system:
This measure needs the effort of the government and legislative department. There are already laws and regulations about the water consumption and protection of water resource. The laws should be, clearly defined, strictly implemented and should be advance with the time. This measure is also necessary and important. As the conditions may change all the time together with the development of the rural area, the climate change, etc., this would be a long-term measure.

Rainwater harvest:
The rainwater harvest can be treated as a good plan to deal with the water scarcity. But it may cost a lot. In the short term, the rainwater-collecting containers could be simple as bucket and tank in the yard and the collected water can be used for gardening and filed irrigation. In the long term, more complex and advanced equipment for collecting and cleaning the rainwater can be installed with the constructing of the houses. And there will also be more application ways of the water, like flushing toilet. The installation will be a little costly, but considering the flourishing trend of rainwater harvest, this measure is quite feasible.

Artificial precipitation:
Considering the difficulty and high cost of the artificial precipitation, this measure may be only used when the drought is extremely serious that affects the agriculture and even daily life. This measure has already been taken for several times in other place to deal with the forest fire or serious drought since 1958 in China, so it is realizable though it costs a lot.

Change crop pattern:
We have already seen the effect of changing the paddy land into dry rice land. It helps save much water from the irrigation. If the problems of water scarcity remain, this could be a possible measure—continue to change the crop pattern. Even though much effort and some economic sacrifice are needed to implement this task, it is still a worthy action considering the situation of water demand and supply in Beijing and the nearby area. This could be considered as a short-term measure as most of the field has already been changed in the recent years and got significant achievement, so the rest will be changed in a short time.

Improve irrigation manners:
The irrigation is the main water demand aspect in villages like Yingpan and the main irrigation method is flood irrigation and canal irrigation although the sprinkle irrigation has been applied somewhere. To improve irrigation manners like changing it into sprinkle irrigation or drip irrigation would be quite remarkable in saving water. This could be a long-term measure and it is not very costly but can help save much irrigation water.

Water reuse:
As it explained in the last chapter, the water reuse can be used in both short term and long term. In the short term, the main pattern is changing daily behaviours to recycle and reuse the water while in the long term it comes with the new innovations and new constructions. This is an inevitable trend for villages as it develops.

Banning the illegal sand excavation:
Considering the serious damage brought by the unlimited sand excavation, this is a quite necessary measure and it should be taken soon in short term. But the banning policy should last long. Of course it needs economic sacrifice but it must be implemented soon facing the problem in Chao River.

Built more waste water treatment plant and refuse landfill sites:
To guarantee the water quality in Chao River, the garbage and wastewater must be treated properly. There are already several refuse landfill sites built in some towns recently and we still need more in both towns and villages. This would be a short-term method. But the building of waste water treatment plant will takes a long time since it is much more complex and more costly.

Manage the mining industry:
The gold mining has already been banned and the discharge in tailing Pond is also under control. The most important thing is to continue supervising and monitoring. This would be a long-term measure.

Manage using of fertilizer:
After the changing of crop types, there may also be change of the fertilizer types. The government should encourage and subsidies the farmers to use organic fertilizer. But this is not a serious problem so this measure is not that important.

8. Conclusion:

The Chao River, located in Chengde in northeast of Beijing, is a very important water source for Beijing. The catchment area of Chao River is located in plateau and mountainous area. The climate is semi-arid, semi-humid in this area where the temperature and precipitation varies much over different seasons. In the catchment area of Chao River, most of the land is used as residential area, pasture land or agricultural land. And there are also some industrial area and some mining factories in the river basin. The living and sanitary condition of the whole is pretty poor. There is a lack of basic infrastructure for water supply and water treatment.

After the system analysis, the orientation about the data collection is determined. Some information about the water quantity and quality is obtained and analysed. Chao River near Yingpan village has water scarcity problem and suffers several droughts in springs these years. Even though after the police “changing crop pattern”, the water demand has decreased to some extent, the water scarcity problem still exists in Yingpan and some other villages. That means the river still cannot provide enough water for both Chengde and Beijing, even if Chengde has made much sacrifices. This situation is mainly caused by the unlimited sand excavation, declining precipitation in the changing climate and lack of saving water awareness.

The average level of water quality near Yingpan village is Level II, which means is not that bad compared with all the other rivers in China, and it indeed got better in recent 4 to 5 years. But it is still not clean enough for drinking and domestic demand. The water pollution is mainly caused by the discharge of domestic sewage, the stacked garbage and chemical fertilizer. And the water management system is incomplete and there is no one department is in charge of the whole river. Even though several measures like, banning illegal industries, building refuse landfills sites have been taken and got notable achievements, there are still water pollution problems exist.

After analysing the current situation and possible reasons, some measures are raised and evaluated. In these measures, some are technical measures while some are governance measures. The technical measures include rainwater harvest, artificial precipitation; improve irrigation pattern and domestic water reuse. The governance measures include the most important principle—integrated water management, managing mining industry, sand excavation and fertilizer using and changing crop pattern, etc. By evaluating all these measures, I found there is certain difficulties can be expected in implementation. Some measures may cost much, like artificial precipitation and some measure may need high technology, like rain harvest and long-term domestic water reuse. And most of the measures need the cooperation between government and the villagers. So it may take a long time to implement these measures.

In conclusion, in order to guarantee the water supply and water quality for all villagers and citizen near Chao River, the water management system should be reformed in a more integrated and effective one. To be more specific, there should be an organization in charge of the whole river basin, manage water quality, water quantity and balance of water supply in different areas and balance of society, economy and ecology problem related with the river. The government should coordinate different departments and work with the residents.

For next step it will also necessary to collect more quantitative information on the issues mentioned in this report.

9. Reference:

Literature:

{1} Wang, Z. (2008). "The exploitation, utilization and protection of water resource in Chao River."<Water Science and Engineering Technology>

{2} Zuo, H., S. Lv, et al. (2004). "The analysis of changing temperature and precipitation in last 50 years in China." PLATEAU METEOROLOGY.

{3}Liang, C. (2011). "Notable warming and drought in North China ".<Police and action coping with climate change in China>

{4} Li, B. (2009). "Make refuse landfill an effective prescription of rural environmental management." <Environmental Protection in Hebei> 2009-03

{5}Zhang, J. (2000). "Strengthen comprehensive management to accomplish sustainable development." Jiangsu Water Conservancy.

{6}Meng, X. (2011). Chao River is a mass of bruises after 10 years' sand excavation. Beijing News. Beijing.

{7}Herman Bouwer (2000). Integrated water management: emerging issues and challenges. <Agricultural Water Management> Volume 45, Issue 3, August 2000, Pages 217－228

{8}Rafael Lazaroms, Dimitri Poos (2004) The Dutch Water Board Model. <Governance Issues and National Water Law: National Case Studies In Governance>

Interview:

{9} Li Benming, official of Environmental Protection Agency of Luanping, 2012/04

{10} Chen Xiu, resident/farmer of Yingpan village, 2012/04

{11}Fan Baodong, official of Water Bureau of Luanping, 2012/05

Annex 1: Plan of Approach (Proposal)

1. Background information:

The Chao River originates from Fengning County, flows through Luanping County and finally flows into Miyun Reservoir. It is one of the most important water sources for Beijing. The 56.7% of water in Miyun reservoir is from Chao River. Yingpan is a village in Luanping County located nearby the Chao River Basin (Figure 1). The water level in the river near this village has declined recent years for several reasons, like the unlimited sand excavation. There are also problems of water quality owing to the domestic garbage and the mining industry. How to guarantee the quality and quantity of water for the residents in Yingpan village under the pressure of supplying water for Beijing is an urgent issue.

Figure 1: The catchment area of Chao River and the location of Yingpan Village and Miyun Reservoir

2. Motivation:

The Chao River is an important river in my hometown and it is also important water resource for Beijing. On the one hand, the residents in Yingpan village near Chao River face pressure of water scarcity as they need leave water for Beijing. On the other hand, the water quality in Chao River is closely related to residents in the surrounding village as well as in Beijing. However the problem of water scarcity and water pollution in Chao River are quite serious recently.

And it is widely known that the Netherlands is with authority in integrated water management, which is also why I chose to study about water management here. It seems meaningful for me to find feasible solutions for Chao River with the knowledge and experience I got in the Netherlands. That is the reason I choose this topic for my final thesis.

3. Objective:

The objective of this project is to find out the current situation of water in Chao River, including the water quantity and water quality. And another objective is to come up with some possible measures to improve the situation by analysing the actual state and applying the idea of integrated water management. All in all is to find solutions to solve problems of water scarcity and water pollution so that the water security for local residents and residents in Beijing can be guaranteed.

4. Key words:

Chao River, water quality, water scarcity, integrated water management

5. Research question:

What are existing problems of Chao River near Yingpan village and what can be the possible measures to improve the situation?

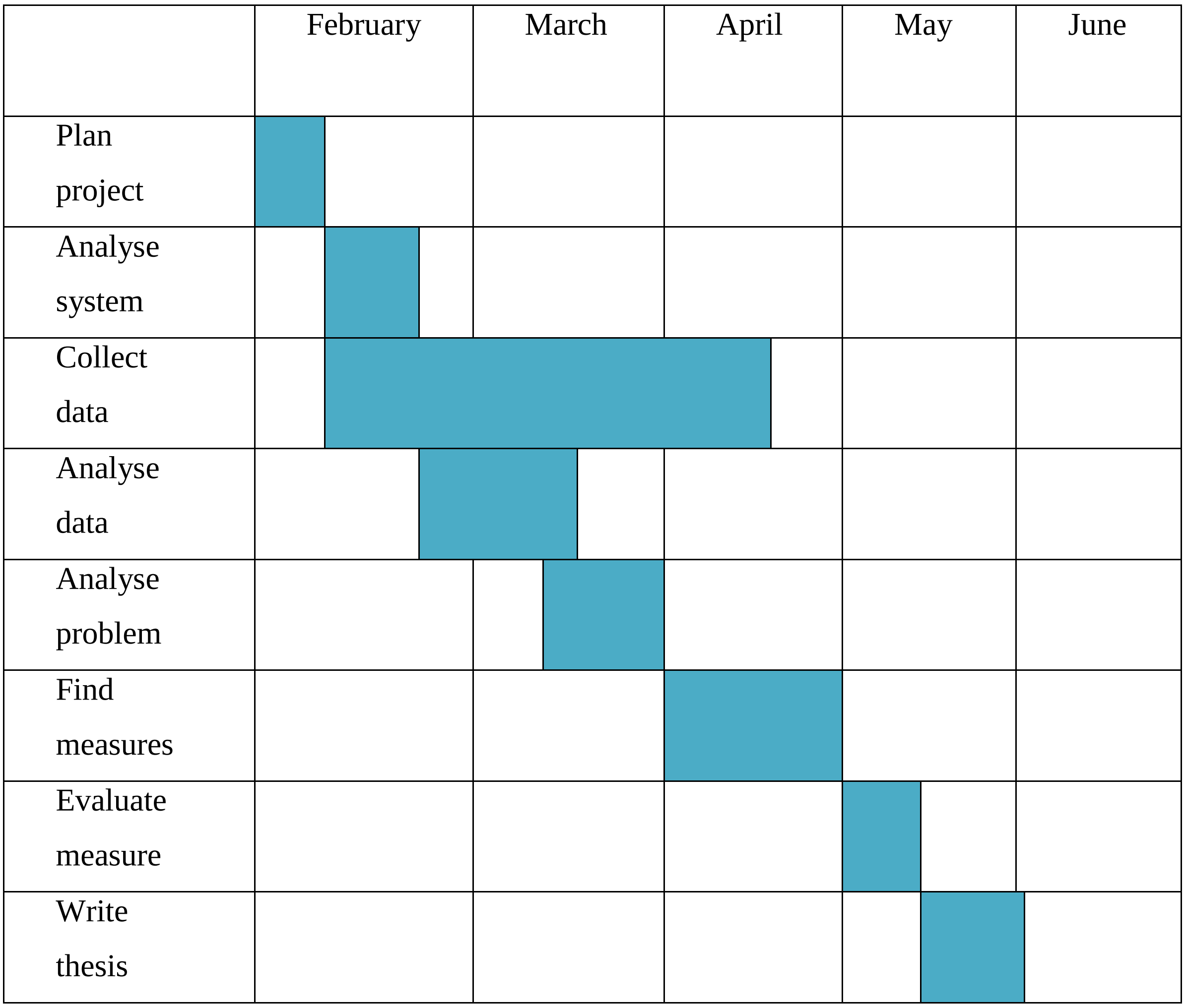
Sub questions:

7) What is the current situation of the water in the whole Chao River catchment area?
8) What is the current situation of water quality in Chao River near Yingpan village?
9) What is the current situation of water quantity in Chao River near Yingpan village?
10) What are the causes that leading to the current situation of the river?
11) What can be the possible measures to improve the situation of the river?
12) What is the final solution for Chao River with these measures?

6. Methods:

To improve the situation in Yingpan village it is necessary to understand the situation in the total river catchment. Therefor I will start with making a system analysis. I will get real data about the water in the river and the information of the surrounding from the local Water Bureau and Environmental Protection Agency. Some *interviews* with the person in the local municipality and local farmers will be arranged through telephone or internet if necessary. The data will also be gotten from *literature review*. The knowledge about the integrated water management I need will be obtained by consulting my tutor or other external coaches.

7. Time schedule:



February 13rd –April 1st（7 weeks）: data collection (collect data about the river and situation nearby)

February 13th –February 26th (2 weeks): system analysis (analyse the whole river catchment area)

February 27th –March 18th （3 weeks）: data analysis (current situation; find focus problem)

March 12^{th} –April 1^{st} （3 weeks）: problem analysis (leading causes of the problem; problem definition)

April 2^{nd} –April 29^{th} （4 weeks）: find possible measures

April 30^{th} –May 13^{th} （2 weeks）: evaluate measures (time span, feasibility)

May 14^{th} –June 3^{rd} （3 weeks）: write the thesis (the thesis is writing during the former process)

June 4^{th} –June 24^{th} （3 weeks）: prepare for the colloquium and interview

During April, my junior fellow student Chen Yuetong will go back to China and collect some more data in the study area, so some addition or adjustment of data will be also worked on in April.

8. Risk analysis:

List of risks:

1) Fail to find specific data about Chao River and surrounding area(probability2.0;severity 3.0;score 6.0)
2) Few measures in the Netherland fit for situation in China(probability3.0;severity 2.0;score 6.0)

Methods to prevent and manage:

1) Get contact with person in Water Bureau and Environmental protection Agency; Collect data in larger scale
2) Try to find measures that can be adjusted to fit situation in China;

Annex2: Original weekly water quality data of Chao River in Gubeikou from 2004 to 2011

	PH	DO(**mg/l**)	COD mn(**mg/l**)	NH3-N(**mg/l**)	Quality level
2004/01	8.1	8.42	2	0.35	II
2004/02	7.73	8.7	3.2	0.34	II
2004/03					Dry up
2004/04	8	8.9	2	0.37	II
2004/05	7.96	8.8	1.5	0.33	II
2004/06	7.96	9.15	1	0.24	II
2004/07	6.75	8.79	2	0.22	II
2004/08	8.05	8.79	2.6	0.33	II
2004/09	8.18	8.77	2.3	0.3	II
2004/10	8.24	8.89	1.8	0.3	II
2004/11	8.12	8.34	2.8	0.26	II
2004/12	8.14	8.34	2.3	0.28	II
2004/13	8.06	7.9	2.4	0.25	II
2004/14	7.54	9.55	2.8	0.2	II
2004/15	8.27	7.98	2.4	0.24	II
2004/16	8.2	7.98	3.2	0.24	II
2004/17	8.21	7.07	2.7	0.22	II
2004/18	8.22	7.52	2.1	0.19	II
2004/19	8.25	7.24	3.6	0.23	II
2004/20	8.21	7.01	2.9	0.23	II
2004/21	8.18	7.16	3.1	0.23	II
2004/22	8.13	6.66	3.7	0.25	II
2004/23	8.1	6.47	3.8	0.29	II
2004/24	7.93	6.16	3.3	0.22	II
2004/25	8.04	6.31	2.7	0.38	II
2004/26	7.91	6.16	4.6	0.3	III
2004/27	7.97	5.9	3.4	0.34	III
2004/28					Dry up
2004/29					Dry up
2004/30					Dry up
2004/31	8.04	5.17	3.7	0.25	III
2004/32	8.12	5.07	4.4	0.14	III
2004/33	8.07	5.39	2.8	0.09	III
2004/34	8.07	5.81	2.4	0.16	III
2004/35	8.02	5.81	1.5	0.12	III
2004/36	8.07	5.97	2.6	0.1	III
2004/37	8.08	6.17	3	0.1	II
2004/38	8.22	6.47	2.6	0.09	II
2004/39					Dry up
2004/40	8.25	7.01	2.2	0.12	II
2004/41	8.25	7.01	2.1	0.08	II
2004/42	8.25	7.33	1.5	0.16	II
2004/43	8.25	7.54	1.2	0.08	I
2004/44	8.27	7.96	1.1	0.16	II

2004/45	8.35	8	1.6	0.17	II
2004/46	8.31	8.3	3.1	0.15	II
2004/47	8.27	8.35	5.3	0.15	III
2004/48	8.28	8.56	4.4	0.16	III
2004/49	8.32	8.61	4.2	0.15	III
2004/50	8.28	8.56	4.4	0.16	III
2004/51	8.44	10.7	2.3	0.12	II
2004/52	8.47	10.8	2.5	0.11	II

	PH	DO**(mg/l)**	COD**(mg/l)**	NH3-N**(mg/l)**	Quality level
2005/01					Dry up
2005/02					Dry up
2005/03					Dry up
2005/04					Dry up
2005/05					Dry up
2005/06					Dry up
2005/07					Dry up
2005/08					Dry up
2005/09					Dry up
2005/10					Dry up
2005/11					Dry up
2005/12					Dry up
2005/13					Dry up
2005/14	8.65	9.24	4	0.13	II
2005/15	8.43	10.3	4.7	0.13	III
2005/16	8.3	10.5	2.8	0.12	II
2005/17	8.65	10.5	3.1	0.13	II
2005/18	8.66	10.7	3.3	0.14	II
2005/19	8.65	11.2	3.1	0.15	II
2005/20	8.59	9.96	2	0.13	I
2005/21	8.53	9.23	3	0.14	II
2005/22	8.51	8.97	2.5	0.12	II
2005/23	8.48	9.08	2.7	0.12	II
2005/24	8.37	8.99	2.4	0.15	II
2005/25	8.47	9.13	3.6	0.16	II
2005/26	8.48	9.04	3	0.14	II
2005/27	8.44	8.65	3.2	0.18	II
2005/28	8.55	8.53	3.5	0.21	II
2005/29	7.65	8.35	3.3	0.14	II
2005/30	8.17	7.74	3.5	0.11	II
2005/31	8.11	5.51	4.3	0.11	II
2005/32	8.16	5.56	4.4	0.09	III
2005/33	8.13	5.5	4.1	0.1	III
2005/34	8.04	5.64	3.4	0.08	III
2005/35	8.16	5.84	5.2	0.06	III
2005/36	7.11	5.9	5.2	0.08	III
2005/37	8.16	5.92	3.4	0.09	III

2005/38	7.78	6.98	2.9	0.1	II
2005/39	7.86	6.27	3.6	0.11	II
2005/40	7.21	8.52	2.8	0.2	II
2005/41	7.97	8.92	1.8	0.14	I
2005/42	8.12	6.25	3.6	0.09	II
2005/43	8.21	6.81	2.1	0.09	II
2005/44	8.2	6.92	1.3	0.07	II
2005/45	8.19	7.09	3.7	0.1	II
2005/46	8.18	7.11	4	0.1	II
2005/47	8.18	7.25	3.3	0.09	II
2005/48	8.15	7.47	1.9	0.09	II
2005/49	8.01	8.66	1.8	0.1	I
2005/50	8.13	8.18	2.3	0.18	II
2005/51	7.98	7.69	3.1	0.08	II
2005/52	8.01	8.45	3.5	0.09	II

	PH	DO**(mg/l)**	COD**(mg/l)**	NH3-N**(mg/l)**	Quality level
2006/01	8	8.32	3.6	0.9	II
2006/02	7.87	8.77	4	0.09	II
2006/03	7.65	8.79	4.1	0.09	III
2006/04					Dry up
2006/05					Dry up
2006/06					Dry up
2006/07					Dry up
2006/08					Dry up
2006/09					Dry up
2006/10					Dry up
2006/11					Dry up
2006/12	7.52	7.99	5	0.12	III
2006/13	7.64	7.76	3.4	0.09	II
2006/14	7.39	7.62	4	0.12	II
2006/15	8.27	9.12	2.6	0.14	II
2006/16	8.22	9.1	2.8	0.14	II
2006/17					Dry up
2006/18					Dry up
2006/19					Dry up
2006/20					Dry up
2006/21	8.31	6.73	1.5	0.1	II
2006/22	8.13	6.85	1.1	0.08	II
2006/23	8.11	6.11	2.5	0.06	II
2006/24	8.13	6.34	3	0.08	II
2006/25	8.21	6.26	1.7	0.08	II
2006/26	8.13	6.23	1.5	0.17	II
2006/27	8.14	5.91	2.5	0.05	III
2006/28	8.19	7.09	8.9	0.21	IV

2006/29	8.22	7.04	7.7	0.22	IV
2006/30	8.21	7.07	6.7	0.2	IV
2006/31	8.15	6.97	5	0.22	III
2006/32	8.69	7.11	4.6	0.04	III
2006/33	8.51	7.01	4.5	0.02	III
2006/34	8.22	7.02	4.2	0.02	III
2006/35	8.29	7.09	4.3	0.02	III
2006/36	8.32	7.15	4.2	0.02	III
2006/37	8.21	6.94	1.6	0.16	II
2006/38	8.24	6.82	1.9	0.07	II
2006/39					Dry up
2006/40					Dry up
2006/41					Dry up
2006/42					Dry up
2006/43					Dry up
2006/44					Dry up
2006/45					Dry up
2006/46					Dry up
2006/47					Dry up
2006/48	8.25	8.03	2.8	0.12	II
2006/49	8.23	8.01	2.6	0.13	II
2006/50	8.21	9.01	4.4	0.06	III
2006/51	8.15	8.97	3.6	0.05	II
2006/52	8.07	8.98	3.6	0.08	II

	PH	DO**(mg/l)**	COD**(mg/l)**	NH3-N**(mg/l)**	Quality level
2007/01	7.92	8.17	3.4	0.1	II
2007/02	7.88	8.3	3.3	0.1	II
2007/03	8.04	8.25	3.4	0.13	II
2007/04	8.02	8.41	3.3	0.14	II
2007/05	8.02	8.23	3.2	0.16	II
2007/06	8	7.97	3	0.16	II
2007/07	8.04	8.05	0.4	0.17	II
2007/08	8	7.98	0.2	0.2	II
2007/09	8.01	7.59	2.8	0.09	II
2007/10	8.01	8.08	2.6	0.11	II
2007/11	7.67	8.93	1.1	0.12	I
2007/12	7.55	8.73	1.1	0.15	I
2007/13	7.6	8.63	2.8	0.19	II
2007/14	7.95	11.1	2.1	0.31	II
2007/15	7.57	8.31	1.3	0.1	I
2007/16	7.56	12.5	0.5	0.08	I
2007/17	7.68	12.4	0.4	0.07	I
2007/18	7.67	12.9	2.8	0.07	II
2007/19	8.04	9.36	2.5	0.22	II

2007/20	8.33	7.07	1	0.12	II
2007/21	7.69	6.74	1.4	0.12	II
2007/22	7.03	6.12	1.5	0.18	II
2007/23	6.65	6.08	1.1	0.1	II
2007/24	6.71	5.91	0.9	0.13	III
2007/25	7.67	5.83	1.7	0.06	III
2007/26	7.23	5.94	1.5	0.07	III
2007/27	7.88	5.98	2	0.15	III
2007/28	6.59	5.48	2.1	0.09	III
2007/29	7.97	8.54	1.4	0.04	I
2007/30	7.8	6.27	1.4	0.03	II
2007/31	7.65	6.16	2.4	0.08	II
2007/32	8.15	7.97	3.1	0.12	II
2007/33	8.22	7.95	3.2	0.13	II
2007/34	7.84	6.18	1.8	0.18	II
2007/35	7.81	5.89	1.2	0.19	III
2007/36	8.16	5.84	1.4	0.17	III
2007/37	8.35	7.11	1.8	0.17	II
2007/38	8.41	6.04	2.4	0.15	II
2007/39	8.45	6.55	3.1	0.15	II
2007/40	8.42	6.43	2.7	0.16	II
2007/41	8.44	5.83	2.5	0.18	III
2007/42	8.5	5.54	2.3	0.14	III
2007/43	8.54	8.17	2.8	0.11	II
2007/44	8.6	10.2	2.7	0.09	II
2007/45	8.47	10.3	2.7	0.08	II
2007/46	8.23	10.8	2	0.1	I
2007/47	8.56	11.1	1.2	0.1	I
2007/48	8.29	11.3	1.4	0.09	I
2007/49	8.56	11.5	1.9	0.08	I
2007/50	8.01	11.2	1.8	0.23	II
2007/51	8.06	11.2	1.5	0.22	II
2007/52	8.13	11.3	1.6	0.21	II

	PH	DO**(mg/l)**	COD**(mg/l)**	NH3-N**(mg/l)**	Quality level
2008/01	8.47	10.9	2	0.08	I
2008/02	8.33	11	1.8	0.07	I
2008/03	8.31	10.8	1.7	0.08	I
2008/04	8.37	11.2	1.7	0.11	I
2008/05	8.85	11.7	1.6	0.16	II
2008/06					II
2008/07	8.75	11.9	4.2	0.12	III
2008/08	8.49	11.9	3.9		II
2008/09	8.34	11.6	2.8	0.18	II
2008/10	8	11	4.5	0.13	III

2008/11	8.28	10.7	4	0.18	II
2008/12	7.72	10.4	2.6	0.2	II
2008/13	6.96	10.3	0.8	0.26	II
2008/14	8.27	10.1	1.4	0.31	II
2008/15	8.22	9.47	1.4	0.31	II
2008/16	8.22	10.6	2.6	0.08	II
2008/17	8.28	10.4	2.8	0.07	II
2008/18	8.28	10.2	2.7	0.05	II
2008/19	8.34	10.5	2.8	0.06	II
2008/20	8.46	9.89	2.8	0.07	II
2008/21	7.97	9.3	3	0.18	II
2008/22	7.69	9.17	2.7	0.18	II
2008/23	8.12	9.18	2.6	0.19	II
2008/24	8.54	8.84	2.6	0.23	II
2008/25	7.99	8.74	3.2	0.26	II
2008/26	7.86	8.63	3.8	0.16	II
2008/27					Dry up
2008/28	8.33	7.88	4	0.49	II
2008/29	8.36	7.92	4	0.43	II
2008/30	7.9	8.78	1.5	0.14	I
2008/31	7.97	8.97	4.2	0.14	III
2008/32	7.39	8.75	2.2	0.19	II
2008/33	7.96	8.49	2.6	0.27	II
2008/34	8.31	8.41	1.9	0.22	II
2008/35	8.07	8.36	3	0.22	II
2008/36	7.71	8.44	2.6	0.22	II
2008/37	8.1	8.46	3.1	0.27	II
2008/38	8.57	8.59	1.8	0.25	II
2008/39	8.33	8.64	2.1	0.34	II
2008/40	8.64	9.2	2	0.32	II
2008/41	8.75	9.39	2.2	0.35	II
2008/42	8.91	9.36	2.1	0.36	II
2008/43	8.45	9.67	2.1	0.37	II
2008/44	8.61	9.86	2.1	0.37	II
2008/45	8.32	10	2.3	0.5	II
2008/46	8.97	10.1	2.7	0.76	III
2008/47	8.59	10.1	2.3	0.07	II
2008/48	8.09	10.1	1.5	0.06	I
2008/49	7.32	9.53	2	0.44	II
2008/50	6.86	10.3	2.4	0.39	II
2008/51	8.18	10.4	2.1	0.35	II
2008/52	8.59	10.5	1.7	0.36	II

	PH	DO**(mg/l)**	COD**(mg/l)**	NH3-N**(mg/l)**	Quality level

2009/01	8.08	11.8	1.3	0.42	II
2009/02	7.72	10.6	1.4	0.33	II
2009/03	7.84	10.7	1.5	0.23	II
2009/04	7.87	10.7	1.3	0.17	II
2009/05	7.74	10.1	1.3	0.13	I
2009/06	7.96	10.8	1.8	0.12	I
2009/07	7.81	10.5	1.9	0.23	II
2009/08	7.77	10.3	1.7	0.28	II
2009/09	7.49	10.4	1.6	0.22	II
2009/10	7.67	10.3	1.8	0.18	II
2009/11	7.25	9.97	2	0.14	I
2009/12	7.9	9.37	2.2	0.1	II
2009/13	7.91	9.5	2.7	0.11	II
2009/14	7.86	9.45	2.7	0.22	II
2009/15	7.77	8.8	2.7	0.14	II
2009/16	7.18	8.65	2.5	0.17	II
2009/17	7.35	8.87	2.6	0.16	II
2009/18	7.94	8.84	2.7	0.14	II
2009/19	7.76	8.6	2.5	0.15	II
2009/20	7.56	8.64	0.9	0.17	II
2009/21	6.84	8.69	1.7	0.11	I
2009/22	7.46	8.72	2.1	0.1	II
2009/23	7.84	8.52	1.4	0.07	I
2009/24	7.39	8.5	1.5	0.18	II
2009/25	8.85	8.32	1.6	0.25	II
2009/26	8.08	8.11	1.4	0.14	I
2009/27	7.6	8.27	1.5	0.12	I
2009/28	7.5	8.25	1.3	0.17	II
2009/29	7.42	8.23	1.3	0.18	II
2009/30	7.22	8.08	2.1	0.22	II
2009/31	7.11	8.11	3.3	0.21	II
2009/32	7.77	7.34	2.9	0.16	II
2009/33	8.01	7.5	2.1	0.18	II
2009/34	8.23	7.59	1.6	0.17	II
2009/35	8.32	7.41	1.2	0.22	II
2009/36	7.76	6.57	0.7	0.2	II
2009/37	7.67	6.71	0.8	0.22	II
2009/38	7.4	6.94	1.6	0.23	II
2009/39	7.58	6.77	1.4	0.2	II
2009/40	7.69	6.71	1.4	0.21	II
2009/41	7.82	7.12	1	0.16	II
2009/42	7.88	7.28	1	0.15	II
2009/43	7.85	7.58	1.2	0.2	II
2009/44	7.65	7.64	1.2	0.23	II
2009/45	8	8.21	1.3	0.09	I
2009/46	8.04	8.43	1	0.09	I

2009/47	7.97	8.92	1	0.13	I
2009/48	7.91	8.87	0.9	0.14	I
2009/49	7.87	9.06	0.8	0.16	II
2009/50	7.88	9.15	0.7	0.16	II
2009/51	7.81	9.26	0.5	0.15	I
2009/52					Dry up

	PH	DO**(mg/l)**	COD**(mg/l)**	NH3-N**(mg/l)**	Quality level
2010/01	7.76	9.36	0.3	0.13	I
2010/02	7.74	9.31	0.2	0.12	I
2010/03	7.68	9.32	0.4	0.14	I
2010/04	7.71	9.14	0.4	0.14	I
2010/05	7.55	9.25	0.5	0.13	I
2010/06	7.44	9.22	0.6	0.13	I
2010/07	7.18	10	0.8	0.14	I
2010/08	7.19	9.75	1	0.14	I
2010/09	7.17	8.98	1.4	0.13	I
2010/10	7.17	8.98	1.4	0.13	I
2010/11	7.03	8.97	0.4	0.11	I
2010/12	6.97	8.87	0.9	0.11	I
2010/13	7.17	8.51	1.2	0.09	I
2010/14	7.18	8.24	1.4	0.15	I
2010/15	7.09	8.01	1.2	0.09	I
2010/16	7.85	8.45	1	0.04	I
2010/17	7.88	7.78	1.2	0.06	I
2010/18	7.79	7.74	1.3	0.09	I
2010/19	7.7	7.11	1.4	0.1	II
2010/20	7.32	7.31	0.8	0.1	II
2010/21	7.31	7.13	0.9	0.12	II
2010/22	7.39	6.94	2.1	0.13	II
2010/23	7.41	6.8	2.8	0.13	II
2010/24	7.39	6.62	2.6	0.14	II
2010/25	7.4	6.54	2.3	0.17	II
2010/26	7.58	6.4	2.8	0.14	II
2010/27	7.63	6.66	1.3	0.13	II
2010/28	7.45	6.62	2.1	0.09	II
2010/29	7.24	6.39	5.9	0.43	III
2010/30	7.61	6.56	3.4	0.46	II
2010/31	7.48	6.49	2.2	0.46	II
2010/32	7.23	6.79	7.3	0.39	IV
2010/33	7.75	6.94	2.1	0.27	II
2010/34	7.61	6.89	1.7	0.24	II
2010/35	7.67	6.9	1	0.23	III
2010/36	7.68	6.88	1.3	0.23	II
2010/37	7.56	7.09	0.9	0.22	II

2010/38	7.45	7.02	0.6	0.26	II
2010/39	7.04	7.25	2.4	0.26	II
2010/40	7.13	7.34	1.6	0.25	II
2010/41	7.2	7.23	1.4	0.23	II
2010/42	7.27	7.4	2.2	0.25	II
2010/43	7.22	7.94	1.7	0.26	II
2010/44	7.51	8.33	0.9	0.27	II
2010/45	7.79	8.47	1.5	0.27	II
2010/46					Dry up
2010/47	7.86	8.98	1.5	0.23	II
2010/48	7.9	9.28	1.5	0.22	II
2010/49	7.86	9.65	1.3	0.21	II
2010/50	7.83	9.65	1.3	0.19	II
2010/51	7.83	9.81	0.9	0.21	II
2010/52	7.91	9.79	0.8	0.27	II

	PH	DO**(mg/l)**	COD**(mg/l)**	NH3-N**(mg/l)**	Quality level
2011/01	7.91	9.84	0.7	0.28	II
2011/02	7.91	9.94	0.7	0.28	II
2011/03	7.76	10.1	0.5	0.29	II
2011/04	7.77	10.1	0.4	0.29	II
2011/05	7.83	10.1	0.4	0.27	II
2011/06	7.93	9.88	0.6	0.18	II
2011/07	7.99	9.6	0.7	0.14	I
2011/08	7.89	9.77	0.8	0.15	I
2011/09	7.82	8.45	0.7	0.21	II
2011/10	7.84	8.43	0.9	0.28	II
2011/11	7.99	8.49	1	0.23	II
2011/12	8.13	8.2	1.1	0.2	II
2011/13	8.1	7.98	1.1	0.21	II
2011/14	8.45	8.06	1.3	0.25	II
2011/15	8.59	7.92	1.2	0.27	II
2011/16	8.49	7.64	1.3	0.25	II
2011/17	8.44	7.65	1.5	0.24	II
2011/18	8.45	7.78	1.2	0.26	II
2011/19	8.21	7.49	1.6	0.3	II
2011/20	8.06	7.34	1	0.25	II
2011/21	8.4	6.88	1.7	0.21	II
2011/22	8.19	6.7	2.2	0.22	II
2011/23	8	6.53	2.5	0.22	II
2011/24	7.93	6.22	2.2	0.22	II
2011/25	7.36	6.04	3	0.26	II
2011/26	6.72	5.86	4	0.28	III
2011/27	7.16	6.12	2.5	0.35	II
2011/28	7.83	6.16	2.4	0.22	II

2011/29	8.04	6	2.5	0.3	II
2011/30	8.04	6.08	3.5	0.42	II
2011/31	7.89	6.03	4.5	0.28	III
2011/32	8.05	6.07	2.9	0.1	II
2011/33	8.11	6.02	2.9	0.13	II
2011/34	7.92	6.09	5	0.16	III
2011/35	7.84	6.24	4.4	0.13	III
2011/36	7.69	6.3	4.8	0.14	III
2011/37	7.52	6.58	4.2	0.11	III
2011/38	8.2	6.83	2.3	0.29	II
2011/39	8.25	7.02	2.6	0.17	II
2011/40	8.26	7.06	2.2	0.22	II
2011/41	8.24	7.34	2	0.22	II
2011/42	8.1	7.21	2.1	0.25	II
2011/43	7.6	7.41	2.3	0.27	II
2011/44	7.91	7.71	2.3	0.36	II
2011/45	7.62	7.42	2.3	0.39	II
2011/46	7.27	8.07	2.1	0.37	II
2011/47	8	8.22	2.4	0.36	II
2011/48	8.05	9.64	2.3	0.36	II
2011/49	8	9.83	1.9	0.44	II
2011/50	7.82	9.98	1.7	0.41	II
2011/51	7.94	10	1.5	0.37	II
2011/52	7.93	10	1.8	0.33	II

Annex3: Interview questions & answers

1) Land use:

- What is the land near the river used for? Mining? Sand excavation? Agriculture?

  Agriculture

2) Water quantity:

- Runoff of Chao river in each season

The average annual runoff of Chao River is 304 million m^3

Spring (April to May) 4.9%

Summer (June to August) 54.8%

Autumn (September to October) 21.5%

Winter (November to March) 18.8%

- What are the main water resource of water for irrigation and domestic consumption? Underground water or river water?

The main water resource for irrigation and domestic water consumption are surface and ground water. The domestic water consumption is mainly from the groundwater while for irrigation, 60% are from groundwater and 40% from surface water.

- Water demand for agriculture near Chao river, especially the change from 2007

The water demand for agriculture near Chao River (including both Luanping and Fengning)

Year	Water demand (million m^3)
2005	82.33
2006	97.41
2007	89.44
2008	65.85
2009	64.72
2010	65.90

- In which season the demand is highest?

In spring and summer the crops need most water. Spring is the season that the water demand for agriculture is highest.

- How do people get domestic water? Centralized Water Supply or Non-central water supply?

  In the town Fengning, the type of domestic supply is centralized water supply and in the rest villages the type is non-central water supply.

3) Water quality:

- How is the water quality in Chao River? Is there peculiar smell? Is the water seems clear? (Observe) Is the water in the river drinkable? Are the water in the river can be used for irrigation directly? Is there any change of fish species in the river? Can people swim in the river? (Interview)

The water quality in Chao River is pretty well, no peculiar smell. It can be drinkable after simple disinfection and can be used for irrigation directly. Nobody swims in the river.

- Sanitary condition： the condition and type of toilet(Observe & interview)
- In most villages near the river basin, the sanitary condition is low and the toilets are pit latrine. Only in Fengning town and some big villages there are flush toilets.
- Solid waste treatment: how is the domestic garbage and industry garbage treated? Are they influence the water in the river?(Observe & interview& water bureau)
- Just like the sanitary condition, only in the town and some big villages there are solid waste landfill sites (like Fengning, Bakeshiying, Fujiadian, Liangjianfang). In the other villages, dispersedly stacked solid waste has certain influence to the river water.
- Waste water treatment: how is the domestic and industry waste water treated? Are they influencing the water in the river? (Observe & interview& water bureau)
- Till now there is only one wastewater treatment plant in the Chao River basin, which is in the Fengning town with the function of centralized treatment of domestic wastewater and industrial sewage. And in Pianqiao village in Luanping there is a small site for wastewater treatment. In all the other villages there is no wastewater treatment plant, the dispersed emission of domestic and industrial sewage have some pollution to the Chao River.
- What are the main factors influence the water quality and water quantity in Chao river? (interview)

  1. The urbanization level in the river basin area is very low. The living and sanitary condition is pretty poor. For instance, there is few centralized water supply site or flushing toilets. Due to the behindhand life style and living habits and mismanagement, there are phenomenon like dispersedly stacked solid waste, the domestic sewage is poured anywhere, the residue of fertilizer and laundry sewage polluting the soil and water and the thrown away waste battery and mercurial thermometer causing the heavy metal like Hg and Mn flow with the rainwater to the groundwater aquifer, etc.
  2. Lack of infrastructure and equipment like the wastewater treatment plant, the refuse landfills and the water collection facilities. The unconventional water like rainwater and recycled water is underutilization.
  3. The discharge of mining industry and sand excavation near the river pollute the water. The reconstruction of tailing race and river management needed to be enhanced.
- What can be the measures to manage and improve the water condition in Chao River？(Interview)

  1. Accelerate the urbanization process, improve the living and sanitary condition in the villages in river basin. Build more wastewater treatment plant and refuse landfill. Enhance the reconstruction of tailing race and river management, build up-to-standard tailing race. Use more organic fertilizer instead of chemical fertilizer and encourage producing and using phosphate-free laundry power.
  2. Implement the project" change paddy into dry rice land". Spread the micro irrigation technology. Encourage residences to save water during daily life. Enhance the rainwater resource control and utilization. Using the artificial precipitation technology when it is necessary.