Graduation Thesis

Analysis land use/cover change (LUCC) impact on sediment discharge and stream flow in the upstream of the Beiluo River, China.

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Preface

This report summarizes my Bachelor thesis work, done in the Land Dynamics group of Wageningen University during the 5 months from February to June 2012. I worked a lot in Atlas, one of the most characteristic buildings of the Wageningen Campus. This robust building was named after the muscle-man of Greek mythology. The open mesh structure on the outside of the building is very distinguishing, and actually supports the entire building. Atlas is used by Alterra and the Environmental Sciences Group (ESG). Picture 1 shows Atlas.

Picture 1: The Atlas of Wageningen
(http://www.wageningencampus.wur.nl/UK/Buildings/Atlas/29-05-2012)

The thesis is focused on Land Use/Cover Change (LUCC) influences on sediment discharge and stream flow in the upstream area of the Beiluo River, China.

There is a project called Joint Scientific Thematic Research Program which started in 2009. This five year project is focused on improving the hydrological and environmental conditions in the Wei River, China. The Beiluo River is a tributary of the Wei River, thus research of the Beiluo River is a small part of the overall bigger project.

As my major is International Water Management I was lucky to have the opportunity to join this project to do my BSc final thesis.

Abstract

This research was done in the Land Dynamic group of Wageningen University between February and June of 2012. The research is mainly focused on analysis of whether land use/cover change (LUCC) influences sediment discharge and stream flow in the upstream regions of the Beiluo River, China. Five methods (ArcGIS, SPSS, Excel, Cumulative Departure Curve and Double Mass Curve) were used to analyze the land use /cover change (LUCC) in 1985, 1995 and 2000, as well as the changes process and characteristics of sediment discharge, stream flow and precipitation from 1985 to 2008. After analyzing data of LUCC, sediment discharge and runoff, it was found that LUCC can reduce the amount of sediment discharge and runoff. In addition, this research also demonstrates that grassland (coverage>20%) plays an important role in the amount of sediment discharge and runoff.

Key words: stream flow; sediment discharge; precipitation; LUCC; Beiluo River

1 Introduction

1.1 Background

There is no doubt that loss of soil and water in the Loess plateau is a big problem in China. From 1952 to 2006, the average sediment discharge of the Yellow River was 770 million tons (Qin et al. 2010), and about one fourth of the sediment was deposited in downstream channels, causing river channel silting and flooding. At the same time, the river bed was raised year by year. For instance, in Kaifeng city of Henan province, the river bed is now about 7m-8m above the city. These problems restrict the area's ecological security and development. As a result, the sediment problem of the Yellow River has become a broader environmental issue.

In this thesis, the land use cover/change (LUCC) impact on sediment discharge and stream flow in the upstream area of the Beiluo River, China is analyzed. The Beiluo River is a second-class tributary of the Yellow River, which is located in Wuqi county of Shaanxi province. Wuqi County is located in the loess gullied-hilly region, where the terrain is complex, vegetation is scarce and there is serious loss of soil and water. When there is rain in Wuqi County, it leads to soil erosion and lots of sediment discharge to the Yellow River. In recent years, some measures have been taken by government to solve this problem. There is a project 'The Grain to Green' which has been carried out in China since 2000. 'Grain to Green' aims to protect and improve the ecological environment and prevents soil erosion. The rough concept of the 'Grain to Green' project is to stop the use of farm lands that are easily being eroded, and plant grass and forest on them. The Grain to Green project includes two aspects: first, converting farm lands to green fields; and second, afforestation of barren hills and wasteland. Wuqi County is a key area for implementation of the Grain to Green Project (China Forestry Bureau, 2010). The Grain to Green is one example of LUCC. In this thesis we try to find out whether LUCC has effectively influenced the amount of sediment discharge and stream flow.

1.2 Research objectives

The main objective of this bachelor thesis is to analyze the effect of LUCC on the amount of sediment discharge and stream flow in the upstream region of the Beiluo River, China.

The main research question:
What is the impact of land use/cover change (LUCC) on sediment discharge and stream flow in the upstream region of the Beiluo River in China?

The following three sub research questions:

- How has land use cover/change (LUCC) changed?
- How did sediment discharge change?
- What is relationship among the sediment discharge, stream flow and LUCC?

All questions will be answered in the following chapters.

1.3 Method

To answer these questions we used ArcGIS to make maps of LUCC in Wuqi County to see land use change. The years 1985, 1995 and 2000 were chosen as the study. And we also used SPSS, Excel, Cumulative Departure Curve and Double Mass Curve for analysis of the hydrological data and sediment discharge to see the relationship between them and their changes. In the meantime, relative articles were read to learn what others have done on similar themes.

1.4 Thesis outline

The chapter two provides background information about the study region, the Joint Scientific Thematic Research Program, failed method used and work contribution. The chapter three demonstrates the methodology applied in the research. The chapter four shows then data collected. The chapter five presents data processing. The chapter six analyzes the data of land use type; precipitation, sediment discharge, and stream flow and give the results. The chapter seven discusses and gives answers to the main question and sub questions. Finally, the last chapter draws some conclusions.

2 Background information

2.1The background for doing this Project

Since 2009, the Joint Scientific Thematic Research Program (JSTP) project has been underway. This project is 5 year cooperation between China and the Netherlands to improve the hydrological and environmental conditions in the Wei River, China. The Beiluo River is a tributary of the Wei River, thus research Beiluo River is a small part of this project.

2.2 Study area

2.2.1 Natural geography

The specific study region refers to the catchment in the upstream area of the Beiluo River which is measured by Wuqi hydrometric station in Shaanxi Province (Figure 1). The length of the Beiluo River is 680 kilometers and the area of the catchment is about 3424.4km^2. The study region is located south of Baiyu Mountain and west of Zi Wuling. The geographic coordinates are E 107^{0}32’40”--108^{0}32’45”, N 36^{0}44’53”--37^{0}19’28”. In the study region, the average rainfall for many years is 483.4mm (Wuqi Government, 2011). The greatest amount of precipitation is from June to September, accounting for 71.8% of one year (Wuqi Government, 2011). The annual average temperature is roughly 7.5℃(Wuqi Government, 2011) meaning a warm temperate continental arid monsoon climate.

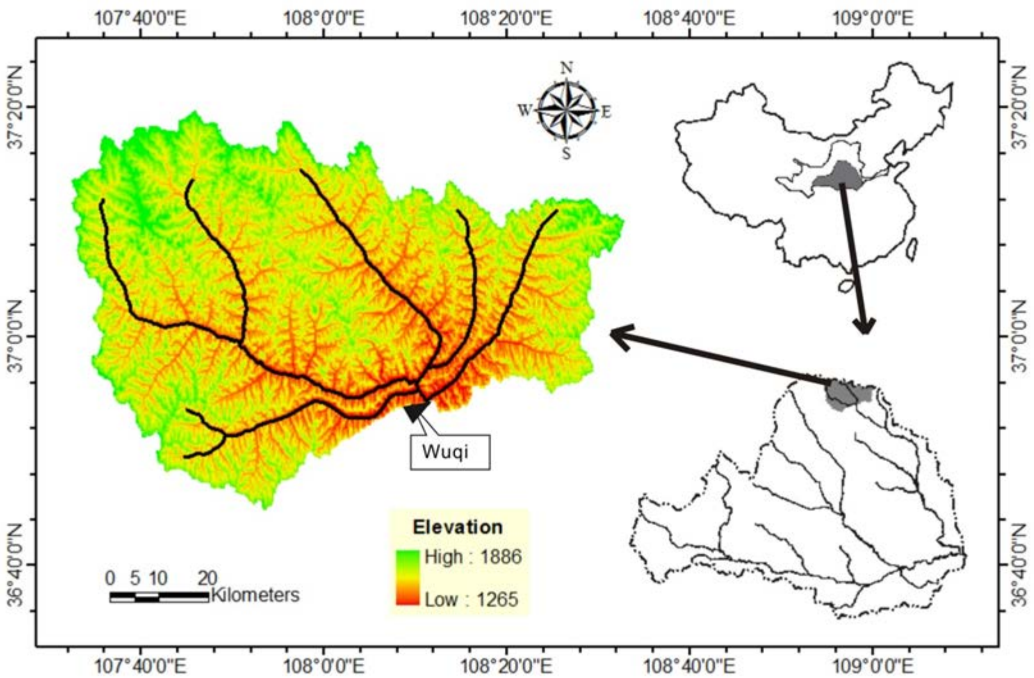


Fig. 1: The location of the study region in the Beiluo River basin

2.2.2 Situation of ecological construction

As mentioned above, Wuqi County has experienced serious loss of soil and water, and since 1999 has been a key area for the 'Gain to Green Program'. As of 2004, the total area of farmland returned to forest and grass was 734.9km^2 (Qin et al., 2010). There have been 361.5km^2 of cultivated lands converted to grass and forest and 373.4km^2 afforestation on the mountain area (Qin et al., 2010).

2.3 Land use classification mapping

At the beginning of this project, it was the plan to create maps of LUCC for 1990, 1995, 2000, 2005 and 2010 using Erdas Imagine. 'ERDAS IMAGINE' performs advanced remote sensing analysis and spatial modeling to create new information' (INTERGRAPH, 2011). The data was to come from the website of the U.S. Geological Survey. These figures are Landsat TM imagines which were obtained from satellites. These satellites are created by the Landsat Program. Landsat is a series of Earth-observing satellite missions jointly managed by NASA and the U.S. Geological Survey. "Since 1972, Landsat satellites have collected information about Earth from space. This science, known as remote sensing, has matured with the Landsat Program.

Landsat satellites have taken specialized digital photographs of Earth's continents and surrounding coastal regions for over three decades, enabling people to study many aspects of our planet and to evaluate the dynamic changes caused by both natural processes and human practices" (NASA, 2012). These Landsat TM imagines should be transferred by Erdas-Imagine to pictures. However, because of the complex landform, it was too hard to classify the land type. After many attempts and asking for professional assistance, we gave up. We then found another data set which also contained land use type information. However it only had data for 1985, 1990 and 2000 years. Therefore, we chose analysis of LUCC for 1985, 1990, and 2000.

2.4 Work contribution

This research was conducted by me and my colleague Gao Peng. He is a Post Doc and comes from the Institute of Soil and Water Conservation, CAS&MWR, in China. He is working in the JSTP project. The LUCC maps were done by Gao. The rest of the analyses including changes in rainfall, stream flow and sediment discharge (Excel and SPSS), the Cumulative Departure Curve of stream flow and sediment discharge and Double Mass Curve of stream flow-LUCC and sediment discharge-LUCC were done by me. The forms of detailed tasks are shown in Appendix 1.

3 Methodology

Before doing this project, it was important to know what factors should be analyzed and determine the best way to do it. Five methods were applied in this thesis, ArcGIS, SPSS, Excel, Cumulative Departure Curve and Double Mass Curve. The reason for applying these five methods is as follows:

The primary goal was to analyze land use type changes. ArcGIS is used to make maps to compare LUCC in 1985, 1995 and 2000. From these maps, it can be clearly seen that land use type changes. Then Excel was applied to indicate the characteristics of rainfall, stream flow and sediment discharge.

Another method is needed to clearly analyze and quantify the changes in sediment discharge and stream flow. Thus I read some articles in which sediment discharge was analyzed to find a method. In the research on 'Impact of human activities on runoff and sediment change of Yanhe River based on the periods by sediment concentration' (Wang et al., 2007) a method called Cumulative Departure Curve was applied to clarify sediment change. Therefore, I used this methodology to analyze changes of sediment discharge and stream flow. The Excel is a tool to complete the Cumulative Departure Curve.

In the meantime, to research the correlation among precipitation, stream flow and sediment discharge was used SPSS.

Lastly, analyze the relationship between LUCC, sediment discharge and stream flow. It is acknowledged that LUCC is one of human activities. Thus, this question can be transferred to the relationship among human activities, sediment discharge and stream flow. The article 'Theory of Double-Mass Curve and its applications in Hydrology and Meteorology' (Mu et al., 2010) indicates that "Double Mass Curve is based on the two factors (or variables) are proportional. As a result, in the application of the double mass curve method, the two variables would have the same physical cause or they would have an obvious causal relationship. In addition, the reference variable is the correct value, being unaffected by natural changes and other factors; particularly in the analysis of the relationship among precipitation, runoff and sediment, area precipitation would be used". The Double Mass Curve can be done by Excel.

The concepts of Cumulative Departure Curve and Double-Mass Curve are introduced in follows.

Cumulative Departure Curve:

In the thesis, cumulative departure curve is applied in segmenting the change process of stream flow and sediment discharge.

The formula shows as follows:

$$CD = \sum_{i=1}^{n}(K_i - \overline{K})$$

Where,

CD represents the i-year cumulative number

K_i is i year measured runoff and sediment discharge number

$\overline{K}$ is the average value of runoff and sediment discharge

CD values can be positive or negative. If the CD values become larger and larger, it means that the cumulative departure of the hydrological parameters continued positive in one period. When the CD values do not change, it indicates that cumulative departure was zero. If the CD values sustained decreases, it shows that departure cumulative of the hydrological parameters continued negative in one period. According to the CD values, it can directly reflect the inter-annual changes in phase of the runoff or sediment discharge (Wang et al., 2007).

Double-Mass Curve:

Double-Mass Curve is a common method to test the changes in the relationship between two parameters. The Double-Mass Curve illustrates the relationship between one continuous accumulated value with another continuous accumulated value for one period in a Cartesian coordinate system. This curve can be used to see whether human activities influence sediment discharge. In the thesis, human activities refer to LUCC. The vertical axis indicates the vaule of precipitation and the horizontal axis shows value of sediment yeild (Fig. 2). If there is no human activity, the curve is A A'. But, when human activities impact sediment discharge, the curve starts to change, like B or C. Curve B represents human activities that increase the amount of sediment discharge, while C shows human activities making the amount of sediment discharge decline. When B and C deviate significantly from A', it means the role of human actions are strong (Mu et al., 2010).

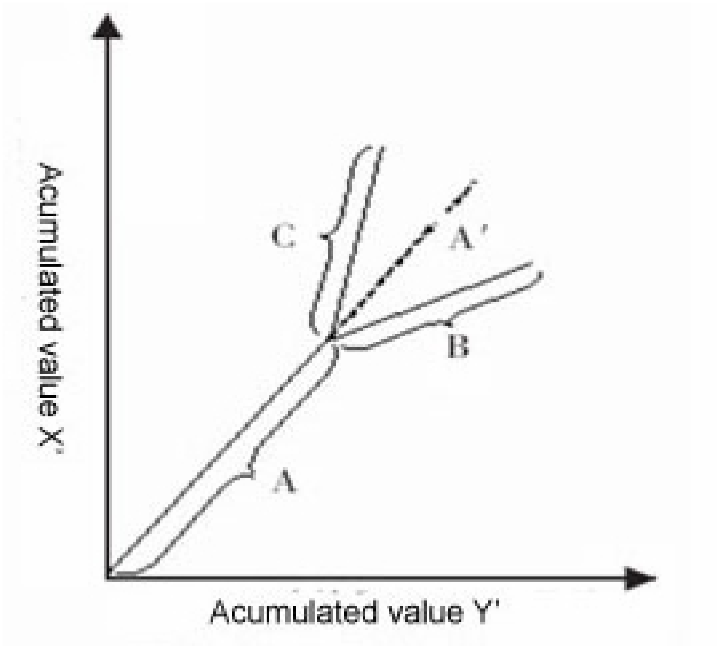


Fig. 2: Sketch map of Double Mass Curve (Mu et al., 2010)

4 Data collection

Stream flow and sediment discharge data came from Wuqi hydrological stations located in the upstream area of the Beiluo River from 1985 to 2008. These data were bought from Wuqi hydrological station. The precipitation data were provided by The National Meteorological Information Centre (NMIC) for the period from 1985 to 2008. The land use data was provided by 'Environmental & Ecological Science Data Center for West China, National Natural Science Foundation of China' (West Data Center, 2010).

5 Data processing

The data of precipitation, stream flow and sediment discharge are needed to be processed before analyze.

As a result of problems with the data resources, sediment discharge figures were only observed from April to October after 1995. In order to guarantee consistency of data from 1985 to 2008, we decided to select representative sediment discharge data from 1985 to 1994, and then calculate the average values of these representative figures. These averages were regarded as the annual sediment discharge data for these years.

The distribution of monthly sediment discharge is extremely uneven and mainly concentrated in the flood season (May-September) from 1985 to 1994 (Table 1). The sediment discharge in this period accounted for 99.0%. Thus, data for sediment discharge are averages of May-September from 1985 to 1994. The data after 1995 to 2008 also uses average values of May-September for data consistency.

Item	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year	May-Sep
S (10^4t)	0.0	0.2	6.8	9.5	112.2	389.1	1072.2	1379.7	153.5	13.6	0.4	0.1	3137.4	109.5
Percentage	0.0%	0.0%	0.2%	0.3%	3.6%	12.4%	34.2%	44.0%	4.9%	0.4%	0.0%	0.0%	100.0%	99.0%

Table 1: Distribution of monthly sediment at Wuqi station of Beiluo river basin from 1985 to 1994 (S=mean sediment discharge)

The raw data of precipitation, stream flow and sediment discharge were provided day by day. The Excel was applied to add figure one by one for one year (Tab. 2). The data analysis was based on these figures.

Table 2: Data of Rainfall, Stream Flow and Sediment Discharge from 1985 to 2008

	Rainfall(mm)	streamflow (10^4m^3)	Sed. discharge(10^4t)
1985	559.4	11433.0	6213.7
1986	287.0	4560.1	2055.7
1987	196.6	2977.9	1248.8
1988	423.3	9016.4	4634.1
1989	298.0	3881.8	1341.9
1990	413.4	9080.1	4708.6
1991	258.8	4898.9	1977.2
1992	380.3	12584.2	7172.6
1993	338.4	3129.8	743.5
1994	391.2	12865.8	8661.0
1995	390.0	4148.2	1199.5
1996	345.7	6193.7	2474.7
1997	321.5	7103.5	3292.1
1998	365.8	5214.9	1860.2
1999	349.4	7597.6	4092.7
2000	319.6	4725.0	2040.2
2001	422.2	7606.5	3407.9
2002	423.9	5710.5	2102.7
2003	502.8	3004.7	649.3
2004	329.9	3987.4	1348.5
2005	323.1	2986.8	653.3
2006	371.2	2114.1	166.1
2007	453.9	3992.3	1073.6
2008	300.9	1707.5	19.2

As mentioned above, the values used in Double-Mass Curve are accumulated. Therefore, accumulated values of rainfall, sediment discharge and stream flow from the period 1985 to 2008(Tab. 3).

Rainfall (mm)	Sed. discharge(10^4t)	streamflow(10^4m^3)	Accumulated precipitation (mm)	Accumulated Sed. discharge(10^4t)	Accumulated streamflow(10^4m^3)
559.4	6213.7	11433.0	559.4	6213.7	11433.0
287.0	2055.7	4560.1	846.4	8269.4	15993.1
196.6	1248.8	2977.9	1043.0	9518.2	18970.9
423.3	4634.1	9016.4	1466.3	14152.2	27987.4
298.0	1341.9	3881.8	1764.3	15494.2	31869.2
413.4	4708.6	9080.1	2177.7	20202.8	40949.3
258.8	1977.2	4898.9	2436.5	22180.0	45848.2
380.3	7172.6	12584.2	2816.8	29352.6	58432.4
338.4	743.5	3129.8	3155.2	30096.1	61562.2
391.2	8661.0	12865.8	3546.4	38757.1	74428.1
390.0	1199.5	4148.2	3936.4	39956.5	78576.3
345.7	2474.7	6193.7	4282.1	42431.2	84770.0
321.5	3292.1	7103.5	4603.6	45723.3	91873.5
365.8	1860.2	5214.9	4969.4	47583.5	97088.5
349.4	4092.7	7597.6	5318.8	51676.2	104686.0
319.6	2040.2	4725.0	5638.4	53716.4	109411.1
422.2	3407.9	7606.5	6060.6	57124.3	117017.6
423.9	2102.7	5710.5	6484.5	59227.1	122728.1
502.8	649.3	3004.7	6987.3	59876.4	125732.8
329.9	1348.5	3987.4	7317.2	61224.8	129720.2
323.1	653.3	2986.8	7640.3	61878.2	132707.0
371.2	166.1	2114.1	8011.5	62044.3	134821.1
453.9	1073.6	3992.3	8465.4	63118.0	138813.3
300.9	19.2	1707.5	8766.3	63137.2	140520.9

Table 3: Accumulated values of rainfall, sediment discharge and stream flow from 1985 to 2008

6 Data analysis and Results

6.1 Changes of land use pattern in 1985, 1995 and 2000

Based on data resource, there are fourteen land use types. But in the thesis, some types are combined into one type because several land use types were not obvious after finishing LUCC maps. For instance, water contains waterways and lakes, but in the thesis, both of them are referred to as water. As a result, in the study region, the land use classes were merged into seven broad classes. They are dry farmland, woodland, grass coverage >20%, grass coverage <20% and >5%, water body, residential land and bare land (vegetation cover <5%). In this study, woodland, water body, residential land and bare land were omitted from the discussion due to their small area and only minor changes (these areas occupy 3% of the total area).

Since 1985, the land was mainly used as dry farmland and grass.(Table 4) The area of dry farmland was 1472.5km^2, accounting for 42.9% of total area. The medium coverage grass land (coverage>20%) area was 1683.7km^2, occupied with 49.1%. However, the land use type had a big change between 1985 and 1995. The area of dry farmland was increased by 27km^2 while forest and medium coverage grass (coverage>20%) declined. The forest area decreased from 98.8km^2 to 80.2km^2. The medium coverage grass (coverage>20%) were almost degraded to low coverage grass (coverage <20% and >5%), which shifted from 1694.1km^2 to 82.9km^2. The reduction amounts to 95.1%. From 1995 to 2000, dry farmland declined to 1464.8 km^{2}and medium coverage grass land recovered. The area of medium coverage grass was 1678.5km^2; on the contrary, the low coverage grass was 168.6 km^2.

Year Land use type	1985	1995	2000
Dry farmland	1462.6 (42.7%)	1489.6(43.4%)	1464.8(42.7%)
Forest and shrubs	98.8 (2.9%)	80.2(2.3%)	101.9(3.0%)
Grassland: coverage>20%	1694.7(49.4%)	82.9(2.4%)	1687.5(49.2%)
Grassland: 20%>coverage>5%	167.8(4.9%)	1770.2(51.6%)	168.6(4.9%)
Water	2.9(0.1%)	3.3(0.1%)	2.9(0.1%)
Residential	1.9(0.1%)	2.5(0.1%)	3(0.1%)
Vegetation cover <5%	0.3(0.0%)	0.3(0.0%)	0.3(0.0%)
Total	3429	3429	3429

Table 4: The land use change in study region in 1985, 1995 and 2000(Km^2)

Fig.3 shows the main land use type changes from 1985 to 2000. The area of farmland did not fluctuate significantly while medium coverage grassland (coverage>20%) and low coverage grassland changed dramatically. The trend of medium coverage grassland decreases in 1995 then increases in 200, on the contrary, low coverage grassland rise first in 1995 declines in 2000.

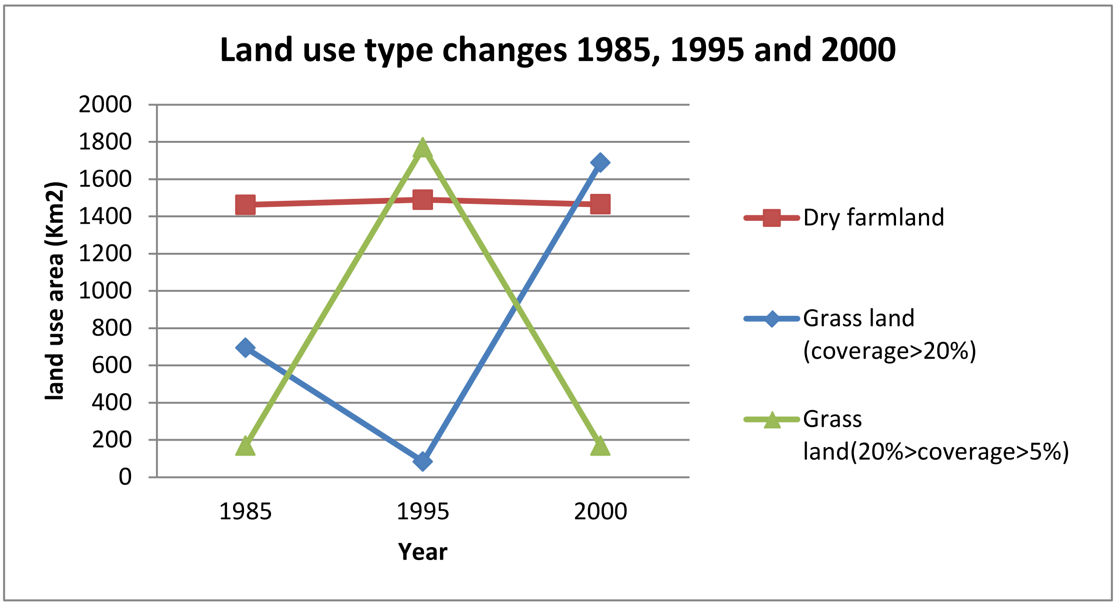
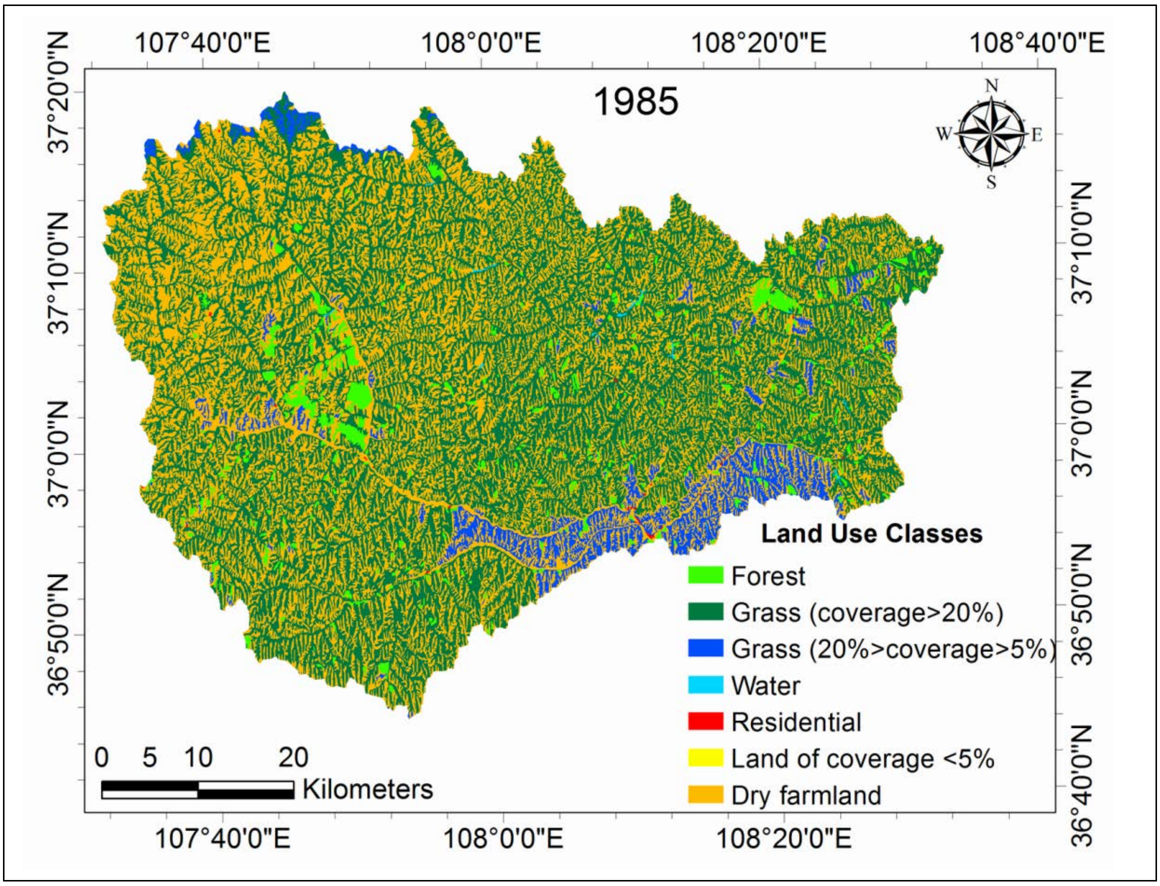


Fig 3: Land use type changes from 1985 to 2000

The maps in Figure 4 give another presentation of the LUCC between the years. From 1995, it can be seen that LUCC had a huge change when compared to that in 1985 and 2000 (Fig. 4). And 1985 and 2000 are looks same because since 2000, vegetation areas were recovered to that in 1985, which table 3 can support it.



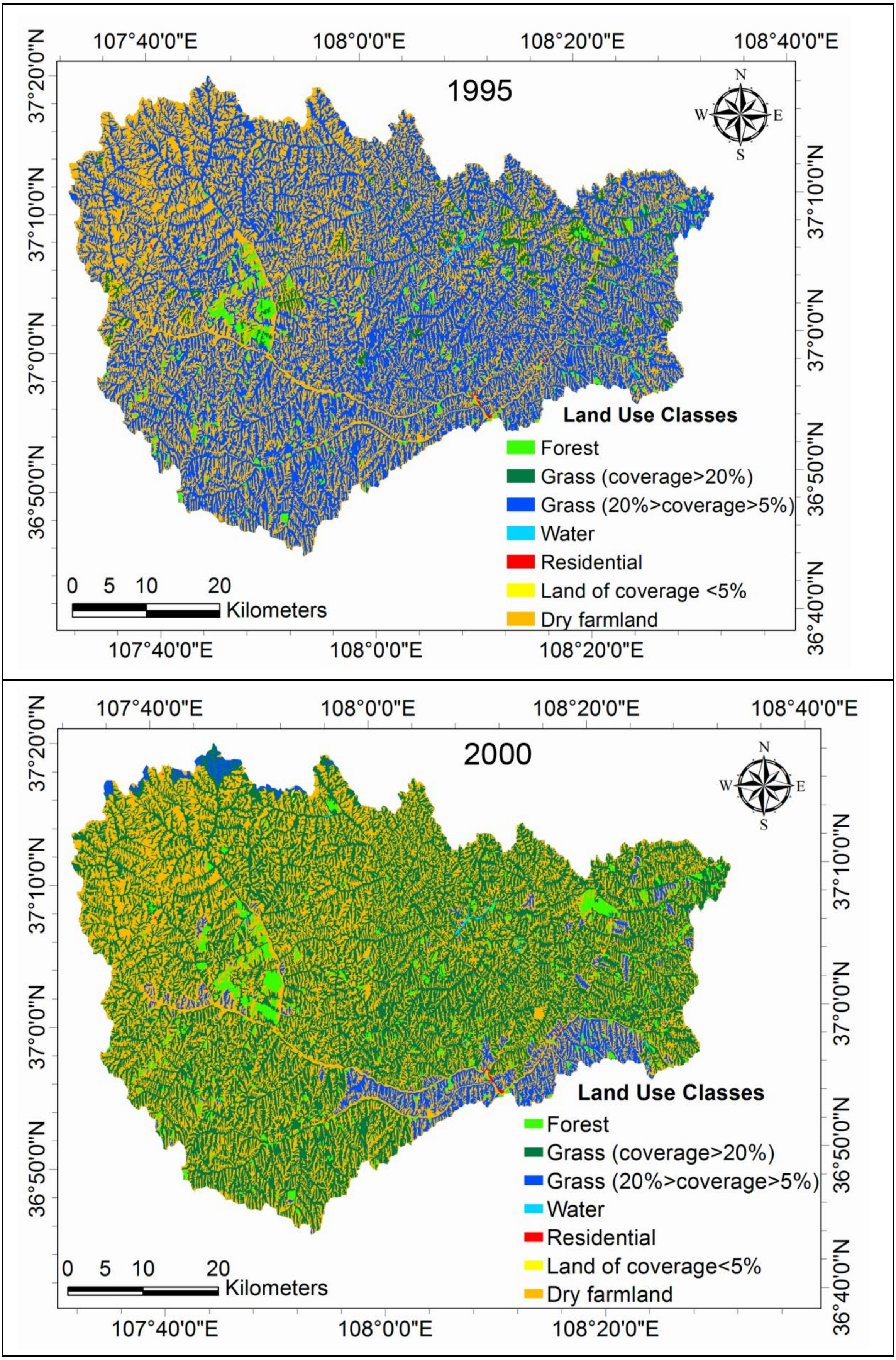


Fig. 4: Land use and cover of Wuqi watershed from 1985 and 2000 (the data is provided by "Environmental & Ecological Science Data Center for West China, National Natural Science

Foundation of China" , http://westdc.westgis.ac.cn).

There are four reasons for grass degradation from 1985 to 1995. First is overgrazing. An overload of grazing livestock over the long term leads to reduced seed germination and declining soil fertility. Secondly, some actions like inadequate reclamation, digging of herbs, cutting of firewood, etc. leads to wind erosion, water erosion, desertification, salinization, and exacerbated soil impoverishment. Third is mismanagement of vegetation. Due to the lack of protection and management measures, a variety of inappropriate factors strongly influenced the grasslands, causing it to become degraded. The last aspect relates to administrative privileges. Some farmers have unlimited use of grasslands, leading to degradation.

6.2 Changes in precipitation, stream flow and sediment discharge from 1985 to 2008

6.2.1 Characteristics of precipitation, stream flow and sediment discharge

LUCC is a slow and gradual process, thus it is common to analyze it over years. By contrast, rainfall is a continuously changing process effecting stream flow and sediment discharge. When studying them, a particular period of time needs to be defined. The data resources used in this study are from 1985 to 2008. We classified the time into four periods which are 1980s, 1990s, 2000s and 1985-2008 to reveal features of rainfall, stream flow and sediment discharge. It can be clearly seen that the average values of rainfall, stream flow and sediment discharge increased from the 1980s to the 1990s (Tab. 5). However, in the 2000s, while the mean rainfall was 383.1mm, which is the largest number over the whole time period, the stream flow and sediment discharge declined greatly.

Series	Rainfall (mm)	Stream flow (10^4m^3)	Sed. Discharge (10^4t)
1980s	352.9	6373.8	3098.8
1990s	355.5	7281.7	3618.2
2000s	383.1	3981.6	1273.5
1985-2008	365.3	5855.0	2630.7

Table 5: The characteristics of precipitation, stream flow and sediment discharge in different decades in the study region.

Figures 5 – 7 show that the trend line for rainfall stayed was flat over the years from 1985 to 2008, whereas the trends for both stream flow and sediment discharge showed a clear decrease.

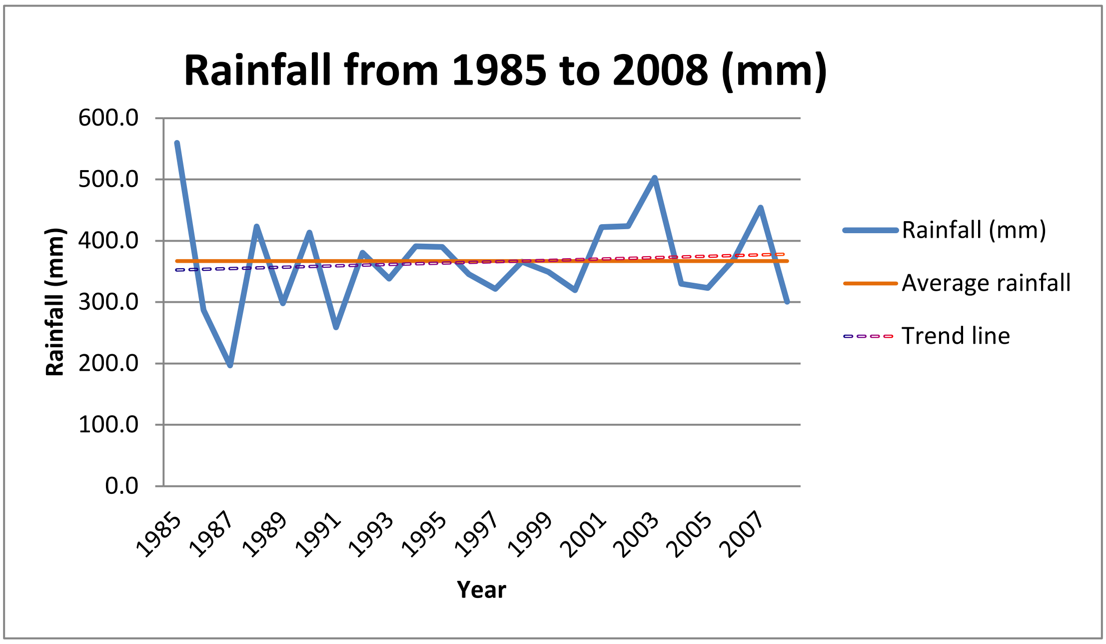


Fig. 5: precipitation from 1985 to 2008

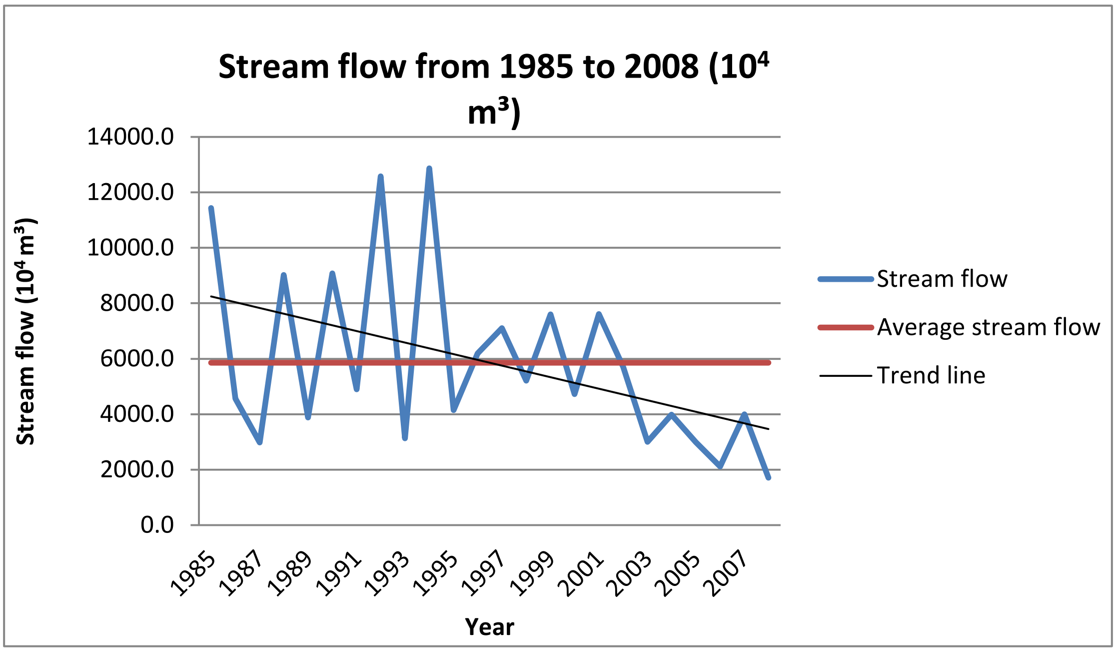


Fig. 6: Stream flow ($10^4 m^3$) from 1985 to 2008

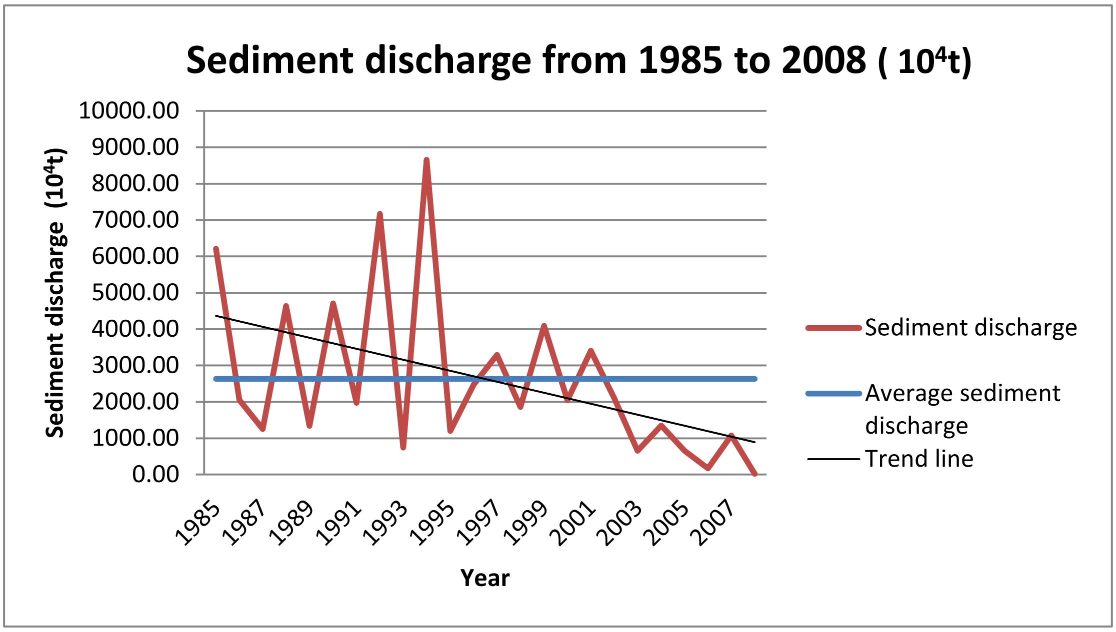


Fig.7: Sediment discharge (10^4t) from 1985 to 2008

6.2.2 Stage analysis of stream flow and sediment

From 1985 to 2001, the values for sediment discharge and stream flow increased dramatically with some fluctuation year by year (Fig. 8-9). However, between 2002 and 2008, it can be clearly seen that the amount of stream flow and sediment discharge decrease rapidly and dramatically. This shift shows means that in this period the amount of sediment discharge and runoff were below the average. The values of sediment discharge and stream flow are in low between 2002 and 2008. This strongly indicates that the change point is in 2002.

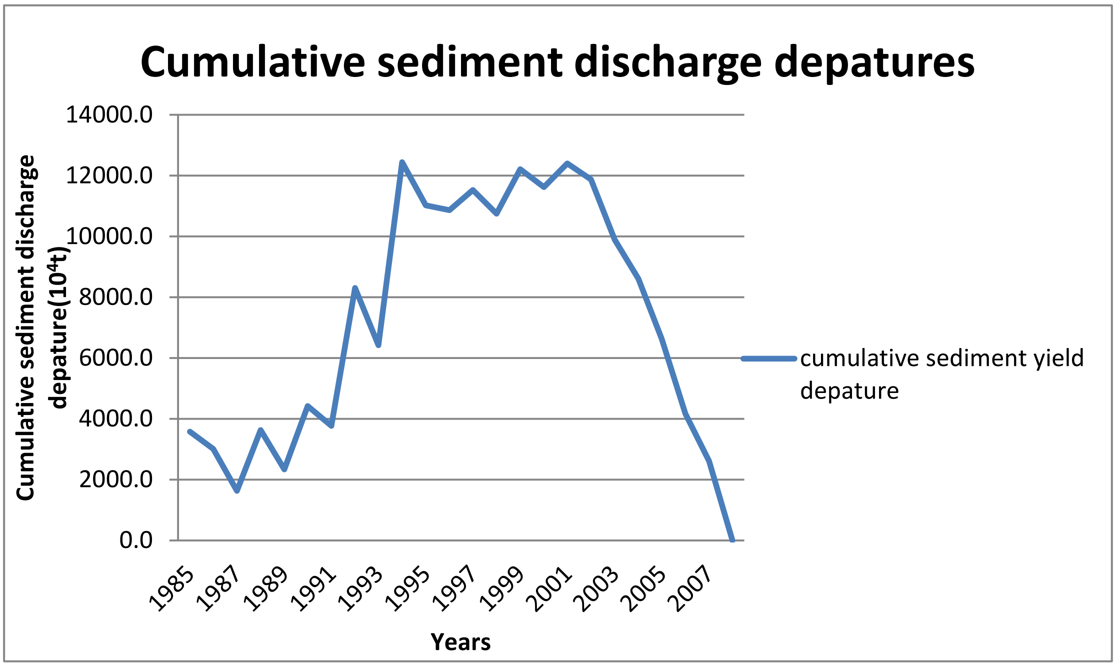


Fig. 8: Cumulative sediment discharge departure from1985 to 2008

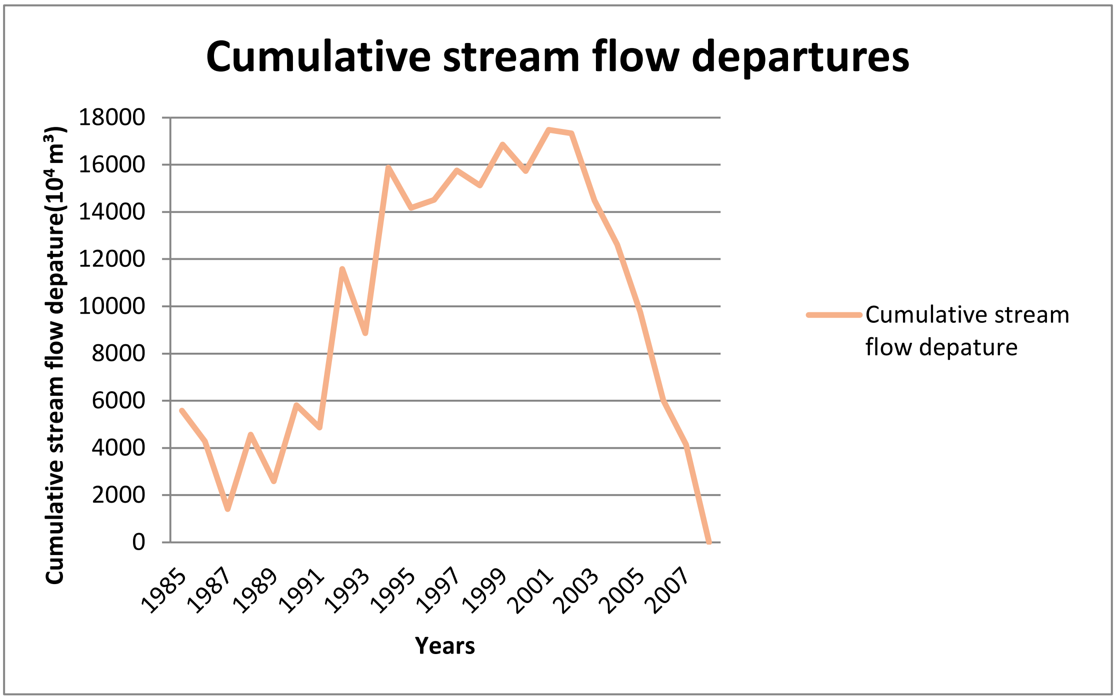


Fig.9: Cumulative stream flow departures from 1985 to 2008

6.3 Relationship between precipitation, stream flow and sediment discharge

It is well known that, without external interference, precipitation can directly influence the volume of stream flow and amount of sediment discharge. The correlation between rainfall, stream flow and sediment discharge from 1985 to 2008 was analyzed by SPSS (Table 6). Table 6 shows the value being tested (left column), and the correlation with values with the other values across the rows. In addition, the significance (2-tailed) was used to judge whether the research objects have correlation. In the end of Table 6, there are two numbers which are standard for evaluate Sig. (2-tailed). If numbers of Sig. (2-tailed) are between 0.01 and 0.05, it proves that research objects have a real correlation. The Pearson correlation is also to know whether research objects have positive or negative correlation. The criterium depends on positive or negative numbers for the Pearson correlation. From Table 5, in the first column, the values of Pearson correlation are 0.987 and 0.431 of sediment discharge and rainfall respectively. These two figures are positive, indicating that stream flow has positive correlation with sediment discharge and rainfall. In the meanwhile the values of Sig. (2-tailed) are 0.000 and 0.035 respectively, which is between 0.01 and 0.05(correlation significance standard). Thus the research objects have correlation. The same analysis applies to the remaining two rows. These results also show that stream flow has positive correlation with sediment discharge and rainfall while rainfall does not have correlation with sediment discharge. The question now is whether LUCC has an effect on sediment discharge. Double Mass Curve can help us to find answers.

Correlations

		Stream flow	Sediment discharge	Rainfall
Stream_flow	Pearson Correlation	1	.987**	.431*
	Sig. (2-tailed)		.000	.035
	N	24	24	24
Sediment_discharge	Pearson Correlation	.987**	1	.356
	Sig. (2-tailed)	.000		.088
	N	24	24	24
Rainfall	Pearson Correlation	.431*	.356	1
	Sig. (2-tailed)	.035	.088	
	N	24	24	24

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

Table 6: Correlations between rainfall, stream flow and sediment discharge from the period 1985 to 2008

6.4 Double-Mass Curve of precipitation-sediment discharge and precipitation-stream flow

To further define the transition years for stream flow and sediment discharge, the double-mass curve method was applied along with the linear regression lines, as shown in Fig. 10 and Fig. 11. There existed clear breakpoints (2002) between the two regression lines for both stream flow and sediment discharge in the basin, suggesting that the transition years, identified by cumulative departure curve method, are correct and meaningful. The slopes of the regression lines were lower after the breakpoints or transition years (i.e. at higher cumulative precipitation values) than before for both stream flow and sediment discharge in the basin.

The calculation method is as follows:
Accumulate values of stream flow, sediment discharge and precipitation. Accumulation of the numbers can eliminate variables' randomness and allow discovery of the change trend of the variables. The regression equation and R^2 are calculated by Excel. R is coefficient of determination and R^2 shows the value of the regression equation. When R^2 is close to 1, it means that the regression equation has high value.

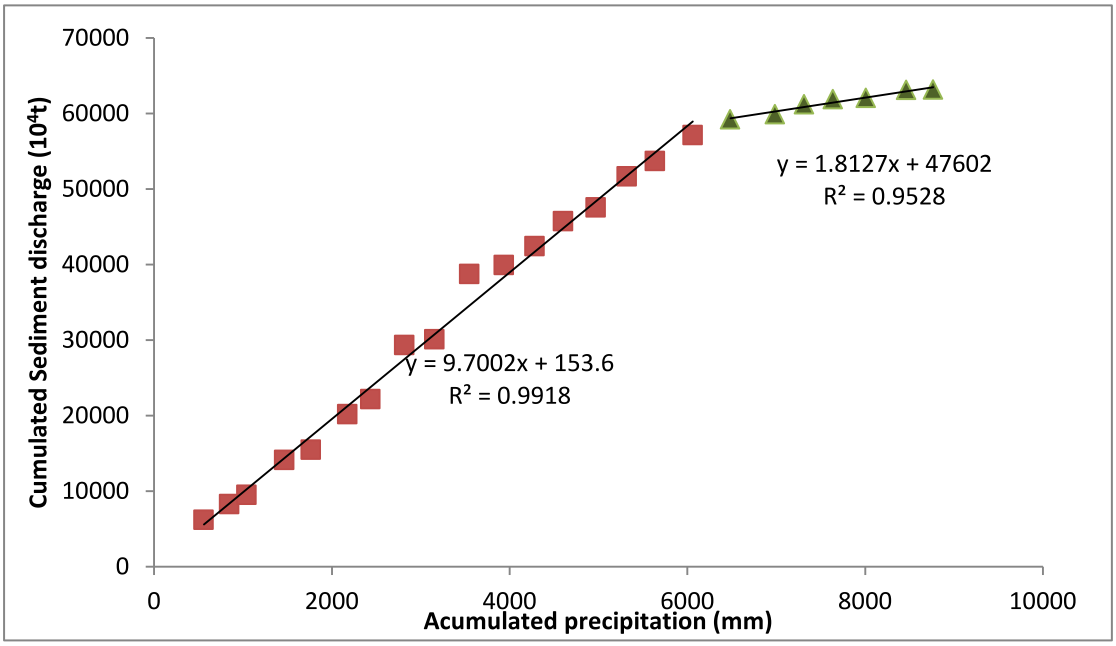


Fig. 10: The Double-Mass Curve of precipitation-sediment discharge from1985 to 2008

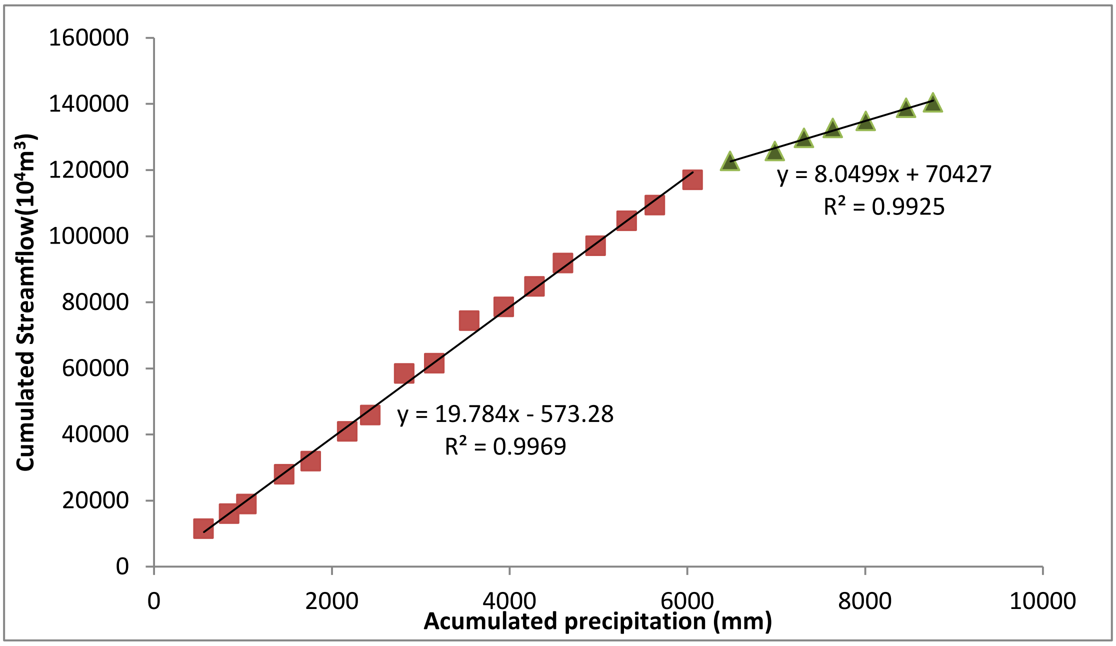


Fig.11: The Double-Mass Curve of precipitation-stream flow from 1985 to 2008

7 Discussion

The arid and semi-arid areas of the Loess plateau undergo serious water and soil loss. (Zhao et al., 2004) The study region is located in Loess gullied-hilly region of the Loess plateau, and belongs to the arid and semi-arid zones which are experiencing critical water and soil loss. This problem leads to a rise in the riverbed and restricts the area's ecological security and development. Faced with this problem, the government carried out the 'Grain to green" project, especially to plant grass. Increased vegetation coverage can reduce runoff and sediment discharge in arid and semi-arid regions (Zhang et al., 2008). What is more, increased grass vegetation often has a better effect on decreasing the amount of river runoff and sediment movement in the Loess plateau (Liu et al., 1978).

In 1985, the main vegetation was medium coverage grassland (coverage>20%) which was 1694.7 Km^2while the low coverage grassland (20%>coverage>5%) was only 167.8 Km^2. In 1990, medium coverage grassland is degraded to low coverage grassland. During this period from 1985 to 1990, average rainfall did not change much from 352.9mm to 355.5mm. However, the average values of sediment discharge and runoff was continuously increasing from 3098.8 (10^4t) to 3618.2 (10^4t) and 6373.8 (10^4m^3) to 7281.7 (10^4m^3) respectively. This indicates that the LUCC undergoes a degradation process. Since 2000, with implementation of the Grain to

Green Programme in Wuqi County by the government, the low coverage grassland has slowly recovered to medium coverage grassland. After 2000, the sediment discharge and stream flow decreased rapidly (fig. 8-9). Table 2 shows that in the 2000s, the average of stream flow was 3981.6 (10^4 m^3) which were declined by 2392.2 (10^4 m^3).

In the meanwhile, sediment discharge was from 7281.7 (10^4 t) to 1273.5 (10^4 t). But the average of precipitation was little increased to 383.1mm. The double-mass curve explains the reason why runoff and the amount of sediment discharge went down. If there is no external interference, the lines in coordinating axis will straight up but there existed clear breakpoints in 2002 and the lines tend to ease. As mentioned above, the average of precipitation was increased by just 27.6mm from the 1990s to the 2000s. This change cannot be held responsible for the tremendous drop in runoff and sediment discharge Ruling out the precipitation factor, LUCC plays a key role in reducing stream flow and sediment discharge. It can be seen that LUCC can affect the sediment discharge and stream flow, especially where the medium coverage grassland plays a great role. In addition, the sediment discharge reduces in the study region also can alleviate the sediment of Yellow River. From this angle, LUCC as an effective way to influence the sediment discharge and stream flow.

Conclusion

In this study, LUCC changes in 1985, 1995 and 2000 were analyzed. The most significant changes are medium coverage grassland (coverage>20%) and low coverage grassland (20%> coverage>5%). The areas of medium coverage grassland become small from 1985 to 1995 then recover by 2000. However, the changes of low coverage grassland are reversed. During 1985 to 2008, the significant downward trends in sediment discharge and stream flow were detected while the precipitation did not show any significant change trend. By use of the Cumulative Departure Curve and Double Mass Curve methods, it was found that sediment discharge and stream flow went down after 2002. As mentioned before, the function of Double Mass Curve is to find whether there is a human activity effect. The breakpoint indicates that sediment discharge and stream flow are influenced by LUCC (this is human activity). It is obvious that medium coverage grassland plays a key role in influencing the sediment discharge and runoff. Therefore, government can plant medium coverage grasslands in the study region. This thesis is qualitative analysis, so the next step is quantitative analysis to calculate how much percentage of human activities (LUCC) influence sediment discharge and stream flow.

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Violette Geissen (Land Dynamics Group, Atlas)

Bertus Welzen (International Water Management, Van Hall Larenstein)

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Appendix 1

Task schedule (%presents how much work did in the table)

Date	Tasks	Process	Who did it	Who assist it	Results	Time duration
2nd Feb.	Set Topic	/	Violette Geissen & Dr. Gao	/	Topic 'Analysis the LUCC impact on sediment discharge and stream flow'	1 day
6th Feb.	Put forward research questions	Discussion	Dr.Gao(80%)	Zhang Hui (20%)	Main research and sub questions are done	1 day
7th Feb.	Set brief procure for research	Discussion	Dr.Gao (50%) & Zhang Hui (50%)	/	1) Use Erdas-imagine and ArcGIS to classify land use type 2) To find mehods when analysis data of rainfall, stream flow and sediment discharge	1 day
8th Feb.	Download TM imagines data of LUCC from 1990, 1995, 2000,2005 and 2010 in USGS website	Apply data from USGS	Dr. Gao(70%)	Zhang Hui(30%)	Wait for data for several days	1 day
9th Feb.	Learn how to use Erdas-image	Find materials on the Internet	Zhang Hui (100%) & Dr.Gao (100%) {did it together but individually}	/	Find several materials in English and Chinese	1 day
10th	Read	/	Zhang Hui	/	Brief know how it works and	3 days

Feb.-14th Feb.	materials and install Erdas-Imagine		(100%) & Dr. Gao (100%) {did it together but individually}		still have questions	
11th Feb.	Apply land use data from Environmental & Ecological Science Data Center for West China, National Natural Science Foundation of China	Write application online	Dr.Gao (100%)	/	Wait being gave data of land use	1 day
15th Feb.-20th Feb.	Try how Erdas-Imagine works and hand in propose to Violette Geissen	1) the data from USGS were got on 14th Feb. and these data were TM imagines and transfer them to pictures by Erdas-Imagine 2) Haze process and classify land use type by Erdas-imagine following materials	Zhang Hui (100%) & Dr.Gao (100%) {did it together but individually}	/	Failed to classify the land use	4days
20th Feb. afternoon	Find a professional person	Send an e-mail to GEO-DESK	Dr.Gao (100%)	/	/	/
22nd Feb.	Go to Geo-Desk to find professional person called	By bike to find him	Zhang Hui (100%) & Dr.Gao (100%)	Bartholomeus Harm	Unfortunately, the complex landform of study region, it is hard to classify. But he gave us some suggestions if we want to continue. In the	1 day

	Bartholomeus Harm to ask questions about Erdas-Imagine		{did it together}		meanwhile, it is new software and not too many people to do it.	
27th Feb. -1st Mar. And 6th Mar.to 15th Mar.	Try again to use Erdas-Imagine to classify land use type	Following materials and some suggestions	Zhang Hui (100%)	/	Failed in the end.	11 days
19th Mar.	Find another way to classify LUCC	Fortunately, we got LUCC data on 29th Feb. which Dr.Gao applied on 11th of Feb. The data were 1985, 1995 and 2000	/	/	Find another data of LUCC	1day
20th Mar.	Division Tasks	Discussion	Zhang Hui (50%) & Dr. Gao(50%)	/	1)Dr. Gao was responsible for doing LUCC maps 2) Zhang Hui analyzed data* of rainfall, stream flow and sediment discharge.	1 day
21st Mar.-30th Mar.	Find materials about how to analysis data of rainfall, stream flow and sediment discharge	Search Internet and WUR library	Zhang Hui (100%)	/	Just find several articles	8 days
2nd Apr.-12th Apr.	Read articles and materials	Discuss the content and ask questions with Dr.Gao	Zhang Hui (70%)	Dr.Gao (30%)	Determine the research methods	8 days
16th Apr.-19th Apr.	Inductive data of rainfall, stream flow and sediment discharge	The data were provided day by day. It should add up them all to one year. The data were arranged from 1980 to 2008	Zhang Hui (100%)	/	Inductive data of rainfall, stream flow and sediment discharge in Excel	3 days

23rd Apr.	Learn from Dr. Gao about doing LUCC Maps with ArcGIS	1) Add data 2)clip study region 3) Statistics of various types of land area 4) Edit maps 5) Export map	Dr. Gao (100%)	/	Zhang Hui learned how it cooperate	1 day
24th Apr.-2nd May	Analysis data by Excel. Use Cumulative Departure Curve and Double Mass Curve methods	1) Simple to make the trend changes of rainfall, stream flow and sediment discharge 2) use concept of cumulative departure curve to stage analysis stream flow and sediment discharge 3)use concept of double mass curve to define whether LUCC impact on stream flow and sediment discharge	Zhang Hui (90%)	Dr. Gao (10%)	Graphs were came out	7 days
3rd May-10th May	Analysis the relationship between LUCC and rainfall, stream flow and sediment discharge	Discussion	Zhang Hui (100%) & Dr.Gao (100%) {did it together}	/	Conclusion was came out	
13th May –until deadline	Write the thesis	/	Zhang Hui (100%)	/	/	/

Appendix 2

Plan of Approach

Analysis land use/cover change (LUCC) impact on sediment discharge and stream flow in the upstream of the Beiluo River, China.

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23-02-2012

Chapter 1: Introduction

1.1 Background information of JSTP

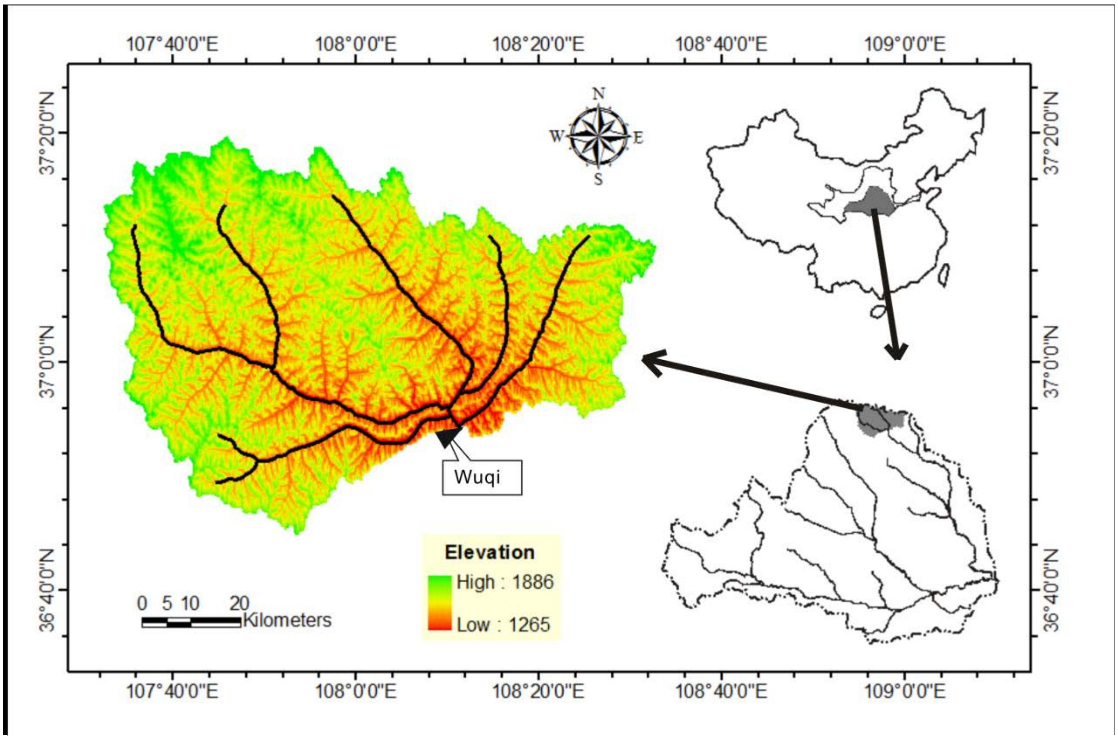
JSTP is stand for Joint Scientific Thematic Programme. Institute of Soil and Water Conservation, Chinese Academy of Sciences and Ministry of Water Resources has cooperated with the Land Degradation and Development Group of Alterra of Wageningen University to conduct a project named Joint Scientific Thematic Research Programme (JSTP). This project will be lasted five years. The main research of their project is development of strategies to improve hydrological and environmental conditions in the Wei River, China. The main aim of the proposed cooperated project is to develop a science-based integrated watershed management plan for the Wei River aiming at sustainable use and governance of natural resources that reduce the communities' vulnerability to the effects of climate change and related natural disasters.

The Beiluo River is a tributary of Wei River, therefore analyze Beiluo River is a small direction of this project.

1.2 Background of study region:

The Wei River is the largest tributary of the Yellow River in China mainly flow through the middle of Shaanxi Province. The Beiluo River is a second big tributary of the Wei River, stems from south mountains of Dingbian country in Shaanxi Province, which has 680 kilometers long and flows 2.69×10^4 square kilometers area, flowing through the Wuqi county in Shaanxi Province. Wuqi county is a gully region of loess plateau. The study region is catchment of upstream of the Beiluo River controlled by Wuqi hydrometric station. The geographic coordinates of Wuqi hydrometric station is E 108°12', N 36°53', and study region's area is 3,400square kilometers. Fig.1 shows the outline of study region. On the top of left side, the big black outline is China. The medium outline is Yellow River basin and inside is Wei He basin. On the bottom, the black part is the study region. The color one is magnify of the study region.

Fig.1: The location of the study region in the Beiluo River basin



1.2 The reason chooses this study region:

As we all know, Yellow River is the second long river in China and Chinese called it as "Mother River", thus it can be seen that Yellow River is important in China. However, Yellow River contains hosts of sediments because it flows through loess plateau that is easily being erosion. Therefore, the riverbed of the Yellow River was raised year by year. In the meanwhile, Wuqi county is located in Hilly and gully region of loess plateau, which is easily being erosion. The downstream of the Beiluo River is connect with the Yellow River, when the Beiluo River flows through Wuqi county, it will bring much sand and soil, thus much sediment is deposit in the Yellow River. Therefore, the Chinese government took measures to solve this problem; mainly measure is Grain to Green Program. The 'Grain to Green' aims to protect and improve the ecological environment and prevent soil erosion. The roughly concept of The 'Grain to Green' project is to stop use farm lands which are easily being erosion, then plant grass and forest on it. The Grain to Green project includes two aspects: first is making farm lands to greens. Second is the afforestation of barren hills and wasteland. Wuqi county is a key area to implantation the Grain to Green Project, much cultivated land turned to grass and forest. Now, the green area is occupied with about 60% of total area. In the meanwhile, some dams were constructed to prevent silt flowing away.

Currently, my research is to compare different years of Land use cover/ change

(LUCC) in Wuqi county to see whether influences sediment discharge and stream flow in the upstream of the Beiluo River.

1.3 Main Research Question:

What is the impact of land use/cover change (LUCC) on sediment discharge and stream flow in the upstream of the Beiluo River, China?

1.4 Sub Research Questions:

- How did Land use cover/change (LUCC) changes?
- How did sediment discharge changes?
- What is relationship between the sediment discharge and LUCC?

Chapter 2: Plan of work

It will use Erdas Imagine& AcGIS to analysis land use cover/changes in the upstream of the Beiluo River, China. 'Erdas Imagine is a remote sensing application with raster graphics editor abilities designed by ERDAS for geospatial applications, which aims primarily at geospatial raster data processing and allows the user to prepare, display and enhance digital images for mapping use in geographic information system (GIS) or in computer-aided design (CADD) software'. (INTERGRAPH, 2011). The data of LUCC are got from website of USGS, taking by Landsat, spans year from 1990, 1995, 2000, and 2005 to 2010. The data are TM images which are got from different bands reflex. The Erdas Imagine transforms TM images to pictures then classify them to different LUCC. After that, ArcGIS will help presenting data on the map and I can compare the differences in different years. After finished LUCC maps, it will analyze the data of rainfall, stream flow and sediment discharge and to link the LUCC. The methodology will be found during research.

Unfortunately, during research, the complex landform of study region leads to hard to classify the land type. After doing many times and asking to a professional person, I gave up. Then I found another data which also contain land use type information. But it just had 1985, 1990 and 2000 years. Therefore, I chose analysis of LUCC in 1985, 1990 and 2000.

Chapter 3: Results

The final result will get several maps represented different LUCC in different periods. And by compare and analysis of data precipitation, stream flow and sediment discharge to find the relationship with LUCC. The complete report will be about 30 pages with maps and diagrams.

Chapter 4: Time Schedule

One week and a half	Download LUCC data from USGC 1) First register 2) Look for used data 3) Apply for USGS to get data (wait 4 to 5 weeks)
One week	Install software of Erdas-Imagine&ArcGIS 1) Apply for SD to install 2) Install Erdas-Imagine&ArcGIS 3) Debug software
Nine weeks	Analysis change procedure of LUCC 1) Classify LUCC (1990, 1995, 2000, 2005 and 2010) with Erdas-Imagine& ArcGIS 2) Make use of these years ' figures to analysis changes of LUCC by ArcGIS
Two weeks	Analysis sediment yield changes
Two weeks	Analysis LUCC impact on sediment yield
Two weeks	Write final report