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# ABSTRACT

Over the last several decades there has been a worldwide concern about possible climate change. Developing countries are especially susceptible to these changes. In recent years, research has focused more on the impacts of global change. China has a population above one billion, a shortage of arable land and a water deficit, which makes the agriculture very dependent on the climate. In the past serious damage to the economy, agriculture and human life has been associated with droughts or floods caused by monsoon rainfall variability. How do global conditions impact local climate variations? How do these variations affect farmers, agriculture and land use? Can the farmers perceive and respond to climate changes?

In this Minor Field Study (MFS) an attempt was made to link local and regional precipitation variations with sea surface temperature (SST) through empirical orthogonal function (EOF) analysis. The fieldwork was performed in Danangou watershed, Shaanxi Province. The watershed covers an area of 3.5 $km^2$ and includes two villages. Further, different interview methods were used to determine the farmers' perception of climate variations and how these variations have influenced their land use.

The analysis of measurement shows that the local climate is getting warmer and drier. The drying trend is uncertain, since large annual variations make it likely to be a natural variation. The relationship between precipitation and SST is complex. The strongest correlation (0.44 with 95% significance) between precipitation in the Shaanxi region and SST was found in the Niño 3.4 region (located in the equatorial Pacific Ocean) during the summer. Farmers' perception of climatic variations corresponds well with the climatic records. They can give detailed descriptions of the weather the last few years. Further back in time they recognize trends and remember extreme events. During the last 20 years the farmers have transferred from being dependent on agriculture to a more diversified livelihood due to governmental reforms. This adaptation makes them less vulnerable to climate variations. It was found that the government has a stronger influence, in terms of the farmers' choice of cropping system, than climate variations on the land use in Danangou watershed. Farmers' restricted living situation gives them few possibilities to prepare to future climate changes without governmental help.

KEYWORDS: climate variations, land use, farmers' perception, SST, rainfall, EOF, interview, China, Danangou in Shaanxi province

# 摘　　要

20世纪后半期以来，气候变化引起世界范围内的广泛关注，其中发展中国家尤其容易受到这种变化的影响。目前的研究主要集中在全球变暖会造成什么影响，以及会带来哪些相关的气候变化。中国是一个人口在12亿以上的农业大国，耕地资源和水资源都比较匮乏，农业生产对气候的依赖性很强。在过去的几十年里，由于季风气候的强降水变率，导致干旱或洪涝灾害频发，严重影响了农业生产和人民的生活，并对经济发展带来危害。全球气候变化背景如何影响局地尺度的气候变化？这种局地变化又会对农民、农业生产、以及土地利用产生什么影响？农民们能否理解这种变化，并对其做出反应？

本研究选择中国黄土高原地区一个3.5$km^2$的小流域，通过采用小区域调查和统计方法，试图回答以上问题。利用经验正交函数（EOF）分析，探讨局地或区域降水变化与海洋表面温度（SST）之间的关系。采用不同的访谈方法，通过对陕西省安塞县大南沟小流域2个村庄农民的调查，了解农民们对气候变化的理解，以及这种变化如何影响他们对土地的利用。

研究结果表明：近20年来，该地区的气候变得暖而且干，但干旱趋势能否继续难以确定，主要表现为年际之间大的波动。区域降水与SST之间的关系较为复杂，其中该地区夏季降水与厄尼诺3、4区（赤道太平洋）SST之间的相关系数最大，为0.44（95%置信度）。农民们对气候变化的理解与观测的气候记录十分吻合。农民们能够对近几年的天气状况刻画得十分清楚，但再往前的较长尺度，他们只能描述出变化趋势和极端事件。由于中国政府采取的改革政策，在过去20年间，农民们的生活已发生了很大变化，由过去单一的农业活动转向现在多种经济活动，这种转变增强了他们对气候变化的应变能力。此外，在种植业生产和对土地利用变化的影响中，政府的作用要远远大于气候变化的影响。由于农民们的生活水平有限，如果没有政府扶持，他们几乎没有可能进行准备，以应付未来的气候变化。



关键词：气候变化，土地利用，农民的理解，海洋表面温度，降水，经验正交函数，访谈，中国，陕西省大南沟

# FOREWORD

This study (20 credits according to the Swedish system) completes a master degree program in Physical Geography for Hageback and Earth Science for Sundberg, at the Earth Science Center, Göteborg University, Sweden. It is a Minor Field Study (MFS) funded by the Swedish International Development Cooperation Agency (Sida). The study was carried out in the spring of 2002 and included fieldwork in China (April 1st to June 19th). Prof. Deliang Chen, Dr. Madelene Ostwald and Dr. Yun Xie supervised the study.

The field study can be considered part of the 2-year Sida project that our supervisors and social anthropologist Mr. Knutsson are involved in. We were therefore very fortunate to receive a field visit from them, while we were in Danangou watershed, Shaanxi province.

The authors' different backgrounds in Earth Science enabled an interdisciplinary study based on EOF analysis and interviewing. Sundberg specialized in EOF analysis and Hageback in interviewing. The authors have taken primary responsibility for their specialties, but the fieldwork and the final thesis is a result of good teamwork and both authors have contributed equally to each part.

# ACKNOWLEDGEMENTS

First of all we want to thank our supervisors Prof. Deliang Chen, Dr. Madelene Ostwald and Dr. Xie Yun for your never-ending support, encouragement and feedback. You have made this study to an inspiring and educational experience! Special thanks to Mr. Per Knutsson for the invaluable advise on the interview technique and Mr. Mattias Green, who patiently has shared his MATLAB knowledge. This study was financed through MFS scholarships from Environmental Economics Unit, Department of Economics, Göteborg University. A special thank to Dr. Gunnar Köhlin. Geographical Society in Göteborg also sponsored the study. This study can be considered part of the 2-year Sida project (SWE-2001-154) that our supervisors and Mr. Knutsson are involved in. Thank you for supporting this study!

We are very grateful to many people in China, where we were met with an incredible hospitality. Once again we want to thank our local supervisor Dr. Xie, who made us feel welcome and mediated contacts. We also want to thank Prof. Liu, Head of Department Natural Resources and Environmental Science, Beijing Normal University, for your help and making it possible for us to attend the *International Symposium on Ecological Environment Rehabilitation and Sustainable Development in Western China* in Yangling, Shaanxi province. Dr Yang Qiu at Beijing Normal University, who shared information about the study area, also deserves thanks. National Climate Centre (NCC) in Beijing, lead by Prof. Weijing Li was of much assistance in supplying scientific knowledge and data. We especially want to thank; Prof. Guoyu Ren, Prof. Panmao Zhai, Dr. Ge Gao, Prof. Xiuzhi Zhang, Dr Jianglong Li, Prof Futang Wang, Mr. Wenquan Liu and Prof. Min Dong. We also want to thank Prof. Xiaodong Li and Prof. Shaowu Wang at Beijing University, who we were fortunate to meet. Thank you for taking the time to help us! A special thanks is needed for Dr. Wei Li Qiu and his family, who taught us to make real Chinese dumplings. They were the best tasting dumplings we ate in China!

The fieldwork, conducted in Danangou watershed, was based on interviews and dependant on the farmers' hospitality and cooperation. We would like to thank the township of Zhengwudong and all the farmers in Danangou watershed that welcomed us and made this fieldwork successful. It would have been impossible to carry out the fieldwork without the help from our two translators, Ms. Qingmei Chen and Ms. Yan Lin from Beijing Normal University. Much of the results in this study are based on work performed together with them. They also helped us with innumerable practical details in our daily life in China. We will always remember our laughs together and hope that we didn't cause you too much trouble… During the fieldwork we lived at Ansai research station of soil and water conservation. We want to thank Prof. Guobin Liu, Mr Xilu Hou, Mr. Ruijun Wu and Prof Daiqiong Li, who kindly supplied local knowledge as well as Mr. Hengzhong Li and Mr. Weibo Zhu. We are also very grateful to our friends Mr. Yaoyang Zhao and Mr. Congfeng Pu, two students at Ansai station, who gave additional translating help when needed.

Finally we would like to thank Eric Jenkins for proofreading and correcting our English. Johanna gives a special thank to Eric for all the support and encouragement throughout the study. We also want to thank Anders Cronholm and Jakob Svensson for the help with the maps and the staffs at the Earth Science Centre for help in large and small emergencies.

Only some of all the people that kindly shared cultural and scientific information with us, as well as helped us with practical details, are mentioned here. Remember though that we are grateful to all of you! Thank you - Xie Xie!

# 1. INTRODUCTION

Over the past several decades global warming has captured the attention of the entire world. The worldwide concern about possible climate change and its effects was expressed through the establishment of the IPCC (Intergovernmental Panel on Climate Change) in 1988. Ten years later IPCC´s main concern had shifted to which degree a climate change will affect human conditions, and the natural environment. The report “The regional impacts of climate change - an assessment of vulnerability” assesses the vulnerability of ten regions around the globe to climate change (IPCC, 1998). Developing countries are especially susceptible to climate variations that can affect vital agriculture with disastrous results. The impact on agriculture in Asia has accounted for much research (Luo and Lin, 1999; Wang, 1997; Wang, 2001) and model simulations have frequently been used. However, researchers (Reilly and Schimmelpfenning, 1999; Roncoli et al., 2001; Vedwan and Rhoades, 2001) have aknowledged the problems using these models on a more local level, hence more site-specific studies are needed, which is the scope of the thesis.

## 1.1 CLIMATE CHANGE AND THE MONSOON IN CHINA

IPCC’s third assessment report was presented in 2001. According to "Climate change 2001: impacts, adaptation and vulnerability" (Chapter 11. Asia) the current General Circulation Models (GCM) predict that in the decade of 2050’s the average mean annual warming would be about 3°C and annual mean rainfall would have increased with 7% in Asia. Despite this a decline in summer precipitation is likely over the central parts of arid and semi-arid Asia. The rainfall over this region is already low, so an increasing temperature in combination with depletion of soil moisture could lead to expansion of deserts and result in severe water-stress conditions. The projected climate change of high temperature, severe drought and flood conditions and soil degradation would lead to severe losses in the agricultural productivity in Asia. The food security would be under tremendous threat to many of the developing countries in this region. GCMs show high uncertainty of winter and summer precipitation over south Asia. Tropical Asia is intrinsically linked with the annual monsoon cycle and a better understanding of the future behaviour of the monsoon and its variability is needed to decrease the uncertainty of the models (IPCC, September 15$^{th}$ 2002, http://www.grida.no/climate/ipcc_tar/wg2/412.htm)

Many researchers (Gong and Wang, 2000; Huang et al., 1998; Qian and Zhu, 2001) have emphasized the close connection between the East Asian Monsoon and rainfall variability in China. Serious damage to economy, agriculture and human life in China is associated with droughts and floods caused by the monsoon rainfall variability (Huang et al., 1998). Qian and Zhu (2001) believe that the main factors affecting agriculture and the hydrological cycle are climate (temperature and precipitation) and environmental condition (drought and flood). Changes in the number, frequency or intensity of extreme climate events probably have a much greater impact on natural and human systems than a small change of mean values (Gong and Wang, 2000). One of the world’s worst natural disasters on record was the great flood of the Yangtze River in the summer of 1998. Yet, the previous year northern China experienced record drought (Lau and Wu, 2001). The heavy rainfalls in northern China are known for their severity and long persistence. Statistics show that the Huaihe River, the Yellow River and Haihe River Valleys, located in northern China, are the regions most vulnerable to droughts (Ding, 1994).

With these conditions in mind it is easy to understand that it is of utmost importance to be able to predict these events (Dong et al., 2000; Huang et al., 1998; Wei et al., 2000). National Climate Center (NCC) in China was established in 1995. Its two main goals are to predict seasonal and interannual precipitation variations and to report on the long-term climate change (Prof. Ren, oral communication, April 2002). A lot of research has been done to develop models that simulate and predict the seasonal precipitation variations in China (Huang et al., 1998; Wei et al., 2000; Zhao et al., 2000). Due to the complexity of the interannual and intraseasonal variability of the Asian monsoon it has been a significant scientific problem since the end of the 19$^{th}$ century (Huang et al., 1998). Especially precipitation is very difficult to predict and further studies are necessary (Dong et al., 1999; Zhao et al., 2000).

Simplified it can be said that droughts and floods occur when the large-scale circulation is unusually stable. Large-scale flow patterns determine the location and intensity of heavy rains. It also determines moisture sources and transport. Variations of the summer monsoon rainfall over China are closely related to the variations in position of the subtropical high over the western Pacific Ocean. One of the factors influencing the subtropical high is sea surface temperature (SST) (Ding, 1994). It is also found that El Niño can influence the precipitation in China significantly during its mature phase. The physical process behind this connection includes the subtropical high in the western Pacific Ocean and SST (Zhang et al., 1999). Many researchers have contributed to the further understanding of the relation between SST and the precipitation in China (Wang, 2002; Xue, 2001; Yu et al., 2001; Zhang et al., 1999; Zhang and Qian, 2001). According to Alpaty et al. (1995) and Zhao et al. (2000) sea surface temperature plays a very important role in the prediction of summer monsoon rainfall.

## 1.2 SUSTAINABLE DEVELOPMENT IN CHINA

A population above one billion, a shortage of arable land and a water deficit makes the agriculture in China very dependent on the climate and susceptible to climate changes (Smit and Cai, 1996). Smit and Cai's paper synthesize information from a variety of studies on Chinese agriculture and climate, including impact, vulnerability and adaptation to the climate in the past. Already in Qing Dynasty people were aware of the important relationship between agriculture and climate "Cultivation is made by man, supported by land, and grown by climate" (Buwei, 221-207 BC according to Smit and Cai, 1996, p 207).

Agriculture is an important part of China's national economy. Dr. Gao (oral communication, April 2002) from the section of Impact Assessment and Applied Climatology at NCC conduct studies on climate change and its impact on agriculture in China. The impact of climate change on agriculture was part of the national key project (1996-2000) "Studies on short-term climate prediction system in China". Included in this project were studies on strategies of reducing impact of climate disasters on agriculture. Examples of strategies to prevent drought were: using different kinds of irrigation and planting trees and grass. Floods can be prevented by for example planting trees and harvesting in certain time frames (NCC, 2000).

The government in China has realized the importance of a sustainable agriculture. Integrated control of soil erosion and development of sustainable agriculture have been major projects. Over the past 20 years special attention has been given to the Loess Plateau (figure 1), with its deep loess and severe soil erosion (Liu, 1999). According to Liu (1999, p 663) 45% of the area is affected by erosion. The Loess Plateau covers five provinces: Shaanxi, Gansu, Ningxia, Qinhai, and Neimeng. This region is very important to the agriculture in China, since the soil provide favourable conditions for plant growth and high productivity.

Ansai watershed, where this study was conducted, has a soil and water conservation station and is one of the 11 case- study sites that scientists have been using during the project sponsored by the Chinese government (Liu G, 1999). Earlier research in China, where dynamic crop models and statistical models were used, showed that the Loess Plateau would be affected negatively by a climate change. Shaanxi is one of seven provinces with high vulnerability and less capability to adapt to climate change (Luo and Lin, 1999).

*Figure 1. The landscape surrounding Danangou watershed. Danangou is located on the middle part of the Loess Plateau in Ansai county, Shaanxi province. Photo: Sundberg, May 2002*

A large project that has focused on the selected study area, Danangou watershed, is the EROCHINA project (1998-2001) ”A participatory approach for soil and water conservation planning, integrating soil erosion modeling and land evaluation, to improve the sustainability of land use on the Loess Plateau in Northern China - EROCHINA”. The aim was to develop alternative land use and soil water conservation strategies to increase sustainability by reducing soil and water losses. The project included a number of contractors and the Swedish University of Agriculture Sciences was one of the individual partners. Messing and Hoang Fagerstöm (2001) believe that a farmer’s perception of land quality is more appropriate than a scientist’s, due to the scientist’s lack of local experience. The farmers in Danangou watershed has been interviewed several times with focus on land use and various socio- economic aspects (Carlsson, 2000; Chen et al., 2001; Rosmuller, 1999). The relationship between land use and soil conditions in Danangou watershed has been thoroughly studied (Fu et al., 2000; Qiu et al., 2001; Wang et al., 2001). However, no research has focused on climate variations and its relation to the land use in Danangou watershed.

## 1.3 THE SCOPE OF THE STUDY

As mentioned above further studies are necessary to improve the future predictions of the climate. To be able to apply these future predictions on a local scale a better collaboration between meteorological, agricultural, and social sciences is necessary, hence more research on a micro-level (Magistro and Roncoli, 2001; Roncoli et al., 2001). According to Reilly and

Schimmelpennig (1999) there are many uncertainties on how the climate will impact agriculture, for example how farmers will respond to a climate change. They demand a better understanding of the social and economic factors influencing farmers to percieve and respond to a changing climate. In other words, it is difficult for the farmers to respond to a climate change if they are not aware of the change. Johnston and Chiotti (2000) stress the importance of studying adaptation at the individual farm level. This has resulted in more local level research, where the farmers' perception and response to climate variability has been studied (Ovuka and Lindqvist, 2000; Roncoli et al., 2001; Vedwan and Rhoades, 2001).

Local studies must be placed in the context of a global change (Ribot et al., 1996). It is important to recognize how global conditions impact local climate variations and how these variations affect farmers, agriculture and land use. To achieve a comprehensive understanding of this complex system interdisciplinary research is demanded. In this Minor Field Study (MFS) an attempt is made to link local and regional precipitation variations with SST. The field study is focused on the farmers and their perspective on the impact of climate change. China is a suitable study area, since it is a developing country in a monsoon climate, dependent on a very limited agriculture and therefore very vulnerable to climate change. Hopefully this will lead to a better understanding of climate variations and its impact on a local scale and thereby help developing useful methods or techniques to lessen undesirable effects on a local level.

## 1.4 OBJECTIVES

Several focal points have to be highlighted to address the issue:

- To investigate local and regional climate variations, focusing on rainfall, in relation to sea surface temperature (SST) in the Pacific and Indian oceans.

- To examine farmers' perception of climate and correlate it to climatic records.

- To identify possible links between climate variations and land use changes, hence farmers' ability to adapt and prepare to changes in the climate.

# 2. STUDY AREA

## 2.1 CHINA

China, situated in the eastern Asia, is the world's third largest country with an area of about 9.6 million $km^2$ (Höglund, 1998). The people's republic of China is the largest agricultural nation in the world. China has always tried to make the most of its cultivated land through a very labour intense agriculture, because of the lack of arable land. About 10% of the total land area is cultivated. This means that 7% of the world's cultivated land has to feed 22% of the world's population (Kjellgren, 2000).

### Topography and landforms

China has a complex and diverse topography, mainly consisting of plateaus, mountains, basins, plains and hills. The land elevation decreases from west to east in a way that can be described as a three-step staircase beginning in the west with the Tibet plateau (Hsieh, 1973). Looking at these steps from a climatic view the 105°E longitude boundary between step one and two is a very significant dividing line (Domrös and Peng, 1988). It divides the monsoon and non-monsoon zones (Dr. Xie, oral communication, September 2002). Most of the major mountains ranges run from west to east. These features including the size of the country gives China a broad range of climate zones (Hsieh, 1973). The extremely varied landforms are noticeable in differences in temperature, precipitation and wind (altitude and foehn effect) (Domrös and Peng, 1988).

### Monsoon circulation

There are four seasons in China, but winter and summer conditions prevail, while spring and fall are transitional seasons. According to Domrös and Peng (1988) Chang (1934) studied the regional variations of the duration of the four seasons and found remarkably large differences in different parts of China.

The climate in China is strongly influenced by both the huge continental landmasses and the Pacific Ocean water bodies. The circulation in China can be summarized into an anticyclonic field prevailing from Sep/Oct- April/May, and a cyclonic field between May/June- Sept. Very simplified the surface winds during the winter are dry and cold northerlies (winter monsoon), while warm and moisture-laden southerlies prevail during the summer (summer monsoon) (Domrös and Peng, 1988).

Ramage (1971) defined the monsoon region as the area between about 35°N – 25°S and 30°W – 170°E. The definition of a monsoon region includes:

- A shift of the prevailing wind direction by at least 120° between January and July.
- An average frequency of prevailing wind direction exceeding 40 % in January and July.
- At least one of the months with a mean resultant wind exceeding 3 m/s.

The Asian monsoon consists of two different systems, the Indian monsoon and the East Asian monsoon. Although there is an interaction between them, unique features as a different wind regime and components, different heat sources and different weather conditions characterize the East Asian monsoon (Ding, 1994).

The activity of the summer monsoon affecting China is complicated since it originates in three airflows (figure 2). The *Indian summer monsoon* airflow from the southwest may often advance deep into China mainly during break in the monsoon airflow. *The cross-equatorial airflow* flows over Southeast Asia and the South China Sea. This is a low-level southwest airflow that originates in the Australian region. *The southeast monsoon* comes from the south part of the subtropical high over the western Pacific (Ding, 1994).

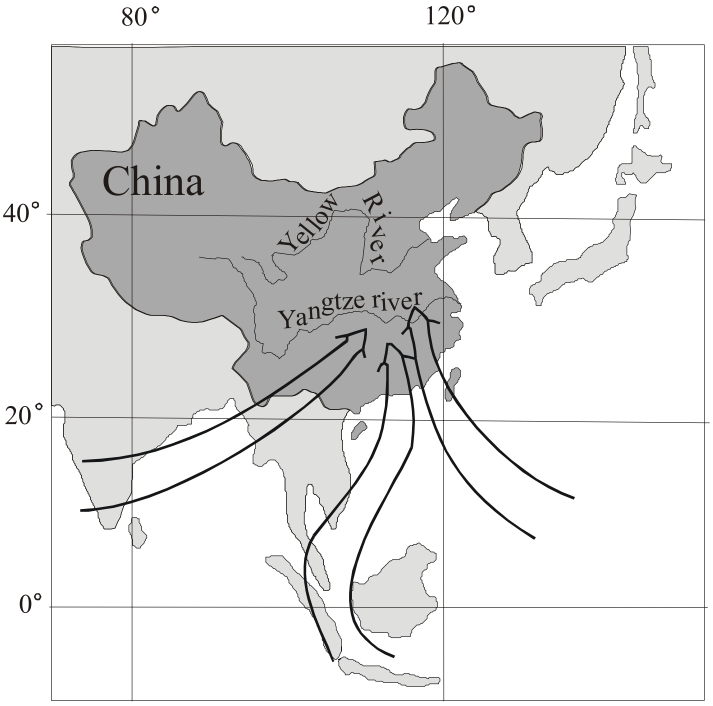



*Figure 2. The summer monsoon in China originates from three airflows. From left the three airflows are the Indian summer monsoon airflow, the Cross-equatorial airflow and the Southeast monsoon (modified from Ding, 1994).*

The advance of the summer monsoon does not act in a continuous way but in three steps. The three northward steps of the summer monsoon correspond to seasonal change in the general circulation in East Asia, most importantly the development of the upper-level planetary frontal zone, the westerly jet stream and the subtropical high. The retreat of the summer monsoon in China is very fast. It takes only one month or shorter to withdraw from northern to southern China starting in the end of August or early September. Like the advance of the summer monsoon the retreat is also related to changes in the general circulation in East Asia (Ding, 1994).

In the middle of July the summer monsoon advances to northern China. The highest latitude of northward advance is 45°N, further north the westerlies dominate. Already in the middle of August the summer monsoon starts to weaken and withdraw. This means that the summer monsoon in northern China only lasts for a month and during this period the region receive most of the annual rainfall. The region is very sensitive to variations in the summer monsoon. A week summer monsoon might not reach northern China or have a shorter duration than normal, which leads to droughts. On the other hand, floods often occur in case of a strong summer monsoon (Ding, 1994).

## Temperature and precipitation

There is a large thermal difference in the mean annual temperature distribution in China. Two main temperature patterns can be found: the western pattern caused by topography (Tibet Plateau), and the eastern pattern influenced by sun isolation and its relation to latitude.

The annual range of mean air temperature between January-June varies from 10°C in south to 48°C in northeast China. This results in more pronounced seasons in north, while the seasons in south China are weak. Major factors influencing the temperature in China is latitude, continentality, radiation, and altitude (Domrös and Peng, 1988).

Two major factors influence the spatial and temporal variations of precipitation in China: the effect of seasonally changing air masses (dry continental and moist oceanic), and the extremely contrasting landforms extending over a huge country. The mean annual total precipitation in China varies from less than 25 mm in the northwest to more than 2000 mm in the southeast, with a mean of 630 mm per year representing the whole country. China can be divided in two major precipitation regions. A dry western part influenced by dry continental air, and a semi-wet to wet eastern part influenced by oceanic air (Domrös and Peng, 1988).

## 2.2 DANANGOU WATERSHED, ANSAI COUNTY

The Danangou watershed (36°53'N; 109°19'E) is located on the middle part of the Loess Plateau in Ansai county in northern Shaanxi province (figure 3). Ansai town, the seat town of the county, is situated within 7 km from Danangou.

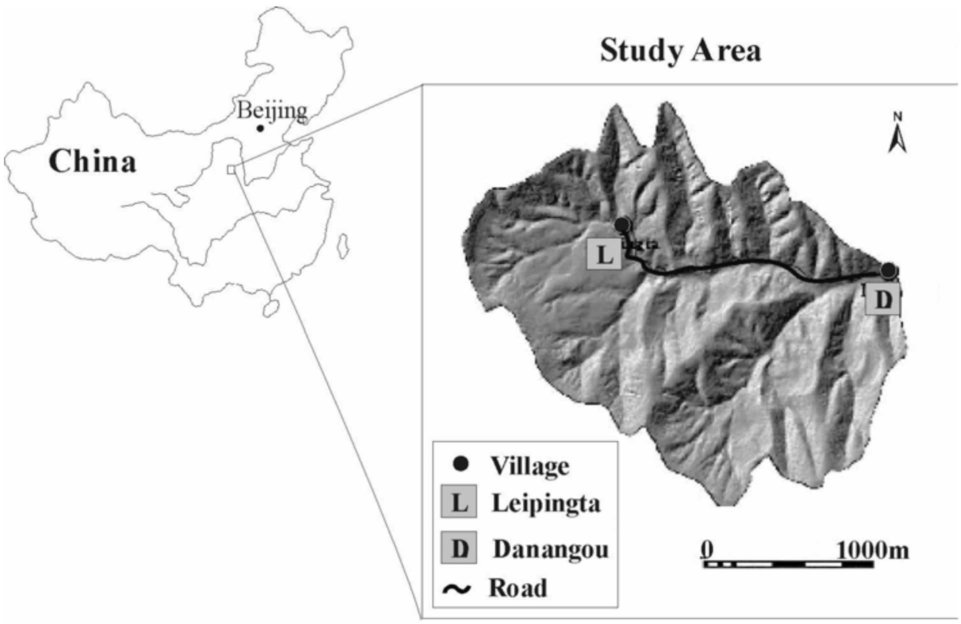



*Figure 3. Location of the study area in northern Shaanxi province. A topograpic map of Danangou watershed (modified from Chen et al., 2001).*

Danangou means "Village faces south, but mouth of the gully faces north" (male farmer, 66 years old, oral communication). Two villages, Danangou and Leipingta (figure 4 and figure 5), can be found in the watershed, which covers an area of 3.5 km$^2$. The total population is around 215 people and it is distributed among 48 households. The main valley of the watershed, with an altitude ranging between 1000-1350 m.a.s.l, consists of four valleys where several smaller valleys end. The serious erosion in this area is well noticeable though the ground surface has been incised strongly, developing rills and gullies. Although according to the farmers the living standard is better today than in the past. A general statement among the farmers were: "it is getting better and better" (Wang et al., 2001; farmers in Danangou, oral communication, April 2002).

*Figure 4 a and b. Danagou village. The houses in Danangou village are distributed along the outlet of the gully and this photo only displays a part of the village (a). Photo: Sundberg, May 2002. The photo to the right (b) presents the limited land area that can be used for cropping. Photo: Hageback, May 2002.*

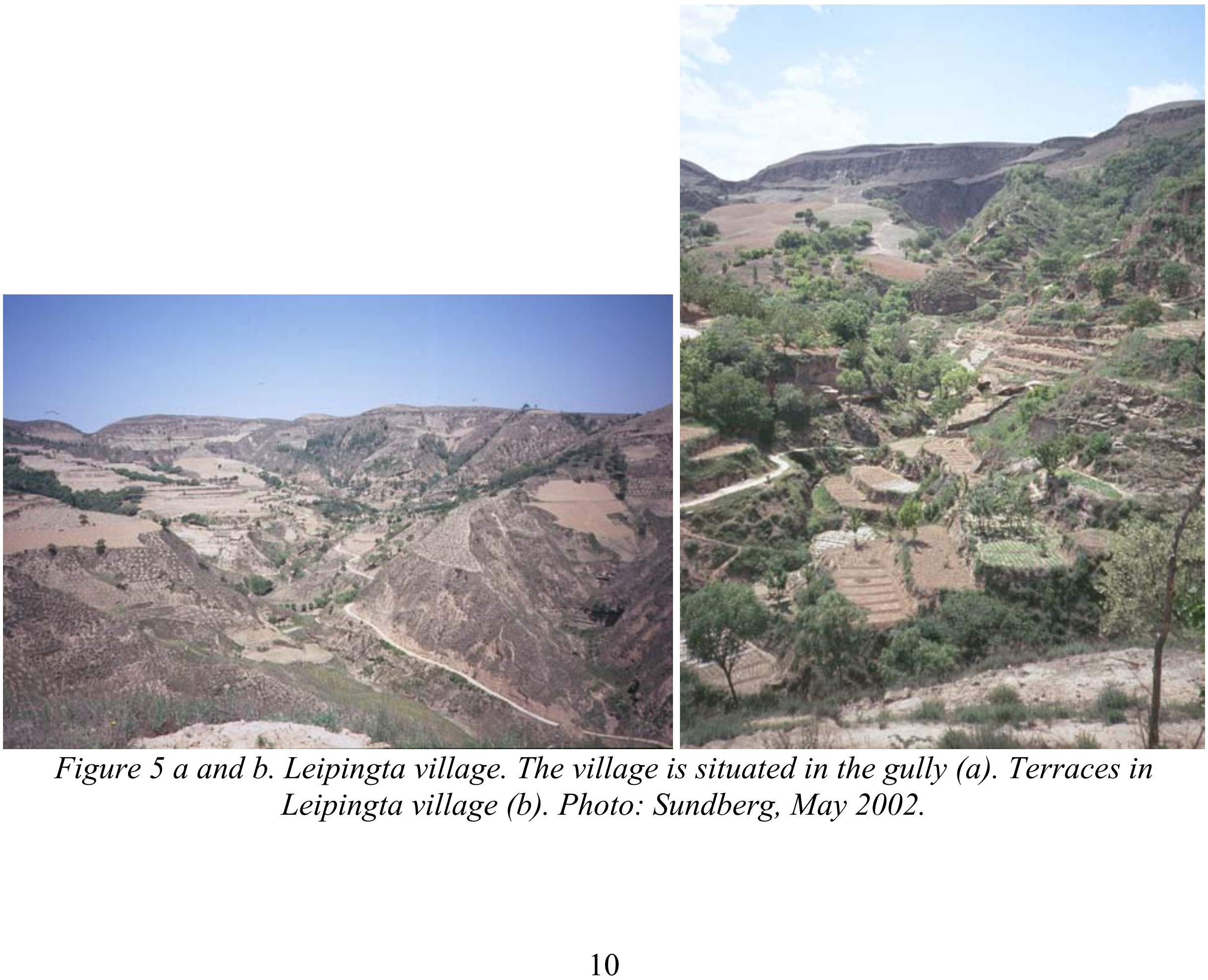


*Figure 5 a and b. Leipingta village. The village is situated in the gully (a). Terraces in Leipingta village (b). Photo: Sundberg, May 2002.*

## Climate

The climate is semi-arid with an average annual temperature of 8.8 °C and monthly mean ranging from 22 °C in July to –7 °C in January. In one year the number of frost-free days is 144. The average annual precipitation is 562 mm (max: 645 mm in 1978, and min: 297 mm in 1974). 60% of the rainfall falls between July and September (Wang et al., 2001). The precipitation distribution during a normal year is described in figure 6.

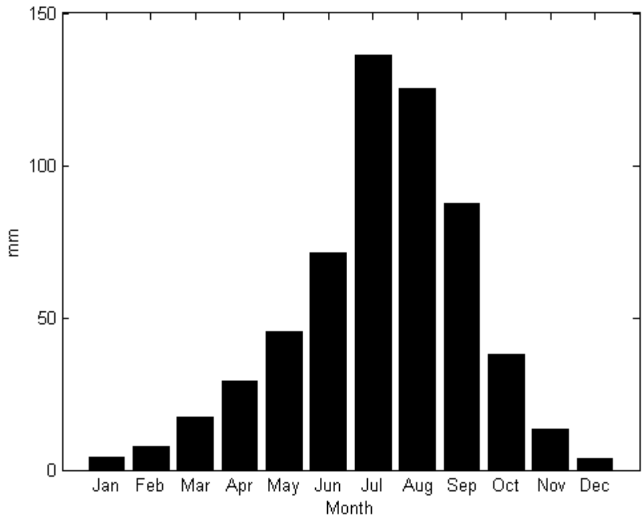



*Figure 6. The precipitation distribution during an average year in Ansai (daily precipitation data from Ansai weather station, 1970-2001).*

## Soil and land use

The wind-deposited loess soil is predominating in this area and according to FAO-UNESCO (1977) soil classification system this soil is classified as Calcic Cambisol. It has a texture of silt ranging from 64-73%, and clay varying from 17-20%. This soil is weakly resistant to erosion (Wang et al., 2001).

Chen et al. (2001) classified the land use into slope farmland, terrace land, orchard, bush land, woodland, traffic land, residential land and sparse wild grassland. The crops cultivated in Danangou watershed are: millet, maize, sorghum, potato and bucket wheat. Only a small fragment of natural vegetation exists in the study area. The run-off is very high during the rainy season and low during the dry season.

## History of Danangou

Danangou was founded in the 1930's when the village separated from another larger village. The land use in this watershed has experienced several changes through the recent past. The history of the study area can be broadly divided into three periods:

1. *Before the communist takeover in 1949*: during this period only a few people lived in the area and landlords, from whom the farmers had to rent, owned most of the land. Because of the low yields large areas were used as farmland.
2. *1949-1982*: the first land reform took place in 1956, when a commune was established. Land of individual farmers was collected as common land of the community and the community managed and used the land according to the state policy.

3. *1982-*: the second land reform, *household responsibility system,* was introduced in Danangou during 1982. The central government decided to resolve the communes and the land use rights were once again distributed to individual farmers. Due to the emigration of people two minor reallocations of land ownership occurred 1992 and 1995 (Chen et al., 2001; farmers in Danangou, oral communication, April 2002).

## Governmental system on local level

Danangou watershed belongs to Zhenwudong Township in Ansai County. This local government covers more than 100 villages. Each village has their own president. The farmers in the village select the president during a meeting arranged by the local government. The village president is only in charge of village business, such as assisting the local government to collect taxes from the farmers. The agriculture tax depends on how much land (crops and trees) the farmer has. This tax is paid in money. The farmers also have to sell a certain amount of the harvest to the local government. The local government pays them, but less than the market price. There is no insurance in case of a bad harvest. In bad years the local government has given them some food as compensation. They also get help from family and neighbours (farmers in Danangou, oral communication, April 2002).

# 3. DATA & METHODS

A wide range of methods from different disciplines has been used, to meet the complex objectives. The authors' different backgrounds have been utilized and a combination of climate analysis and interviewing was used to produce the results. To make this chapter perspicuous it has been divided into two parts, the first part covers the climate analysis and the second part the interviews. Each part is initiated with a short theory explaining the methods, since these methods are not commonly used during basic education within natural science.

## 3.1 CLIMATE DATA ANALYSIS

### Theory of Empirical orthogonal function (EOF) analysis

The method used when searching for a connection between regional rainfall and SST is called Empirical Orthogonal Function (EOF) analysis. It is a statistical method to describe the spatial and temporal variability of data series. The variance is shown as orthogonal functions, where the first few may be linked to dynamical processes. EOF analysis is very efficient in compressing data into a minimum number of patterns. Another advantage is that the EOF patterns can be regarded as uncorrelated (orthogonal). It is important to remember though, that no direct physical or mathematical relationship necessarily exists. EOF is only a statistical tool that might not describe real dynamical features (Busuioc et al., 1999; Emery and Thomson, 1998).

***EOF interpretation***

The EOF patterns can be described both in time and space. In an ocean region the first spatial pattern could be that the SST in all stations vary together, the temperature increase or decrease in all locations simultaneous. This indicates that large-scale processes cause the variability. The next spatial pattern could be a seesaw pattern, where the temperature increases in one end of the region while it decreases in the other end. Higher patterns are more and more complex. Each spatial pattern has a corresponding time coefficient that describes how the pattern varies in time. It can be seen as a time series of weights, giving more or less weight to a particular space vector each month. There are as many detectable EOF patterns as there are measuring locations in the ocean region. All patterns appear simultaneous. The main part of the variance is explained in the first EOF pattern, which is the most important one. The second EOF pattern is the second most important and so on (Busuioc et al., 1999; Emery and Thomson, 1998; Svensson, 1999).

While interpreting the EOFs it is important to once again note that empirical patterns do not necessarily correspond to true dynamical patterns of physical behaviour. A single physical process might be spread over more than one EOF and on the other hand more than one physical process might contribute to the variance contained in a single EOF. The EOFs cannot be considered as physical patterns themselves, but has to be considered in the light of known physical mechanisms. Another limit is that conventional EOF analysis can only detect standing oscillations, not propagating waves (Busuioc et al., 1999; Emery and Thomson, 1998).

***EOF formulations***

Emery and Thomson (1998) describes the mathematics behind the EOF computation as follows. Consider N ocean maps available every month. Each map shows monthly mean sea surface temperature (SST) $\psi_m(t)=T_m(t)$ $(1 \le m \le M)$ recorded at M different 2°×2° latitude-longitude grid boxes located at $\mathbf{x}_m=(x_m,y_m)$.

The goal is to write the data series $\psi_m(t)$ at any given location $\mathbf{x}_m$ as the sum of M orthogonal spatial functions $\phi_i(\mathbf{x}_m)= \phi_{im}$ such that

$$\psi(x_m,t) = \psi_m(t) = \sum_{i=1}^{M}\left[a_i(t)\phi_{im}\right] \qquad (1)$$

where $a_i(t)$ is the amplitude of the i:th orthogonal pattern at time $t=t_n$$(1 \le n \le N)$.
In other words equation 1 says that the time variation of the dependent scalar variable $\psi_m(\mathbf{x}_m,t)$ (SST) at each location $\mathbf{x}_m$ results from the linear combination of M spatial functions, $\phi_i$, whose amplitudes are weighted by M time-dependent coefficients, $a_i(t)$, $(1 \le i \le M)$. The weights $a_i(t)$ tell us how the spatial patterns $\phi_{im}$ vary with time. There are as many detectable patterns as there are time-series stations (M), so the combined variance in the original time series can be accounted for at each time, t.

The condition for $\phi_i(\mathbf{x}_m)$ to be orthogonal is

$$\sum_{m=1}^{M}\left[\phi_{im}\phi_{jm}\right] = \delta_{ij} \qquad (2)$$

where the summations are over all observation locations and $\delta_{ij}$ is the Kronecker delta

$$\delta_{ij} = \begin{cases} 1, & j = i \\ 0, & j \neq i \end{cases} \qquad (3)$$

Two functions are namely said to be orthogonal when the sum of their product over a certain defined space or time is zero, i.e. when their vector product is zero.

There is a large amount of functions, $\phi_i$, that satisfy equation 1 and 2. The EOFs are determined among them with the constraint that the time amplitudes $a_i(t)$ are uncorrelated over the data. The uncorrelated time variability condition is

$$\overline{a_i(t)a_j(t)} = \lambda_i\delta_{ij} \qquad (4)$$

where the overbar denotes the time-average value and

$$\lambda_i = \overline{a_i(t)^2} = \frac{1}{N}\sum_{n=1}^{N}\left[a_i(t_n)^2\right] \qquad (5)$$

is the variance in each orthogonal pattern.

Forming the covariance matrix $\psi_m(t)\psi_k(t)$ for the known data and then multiplying both sides with $\phi_{ik}$, summing over all k and using the orthogonal condition (equation 2) yields

$$\sum_{k=1}^{M} \overline{\psi_m(t)\psi_k(t)}\phi_{ik} = \lambda_i \phi_{im} \quad (6)$$

This is a form of eigenvalue problem. The EOFs, $\phi_{im}$, are the i:th eigenvector at the $\mathbf{x}_m$ locations. The mean-square time amplitudes, $\lambda_i$, are the eigenvalues corresponding to the mean product, **R**, which has elements

$$R_{mk} = \overline{\psi_m(t)\psi_k(t)} \quad (7)$$

The M empirical orthogonal functions corresponding to the M eigenvalues in equation 5, forms a complete basis set of linearly independent (orthogonal) functions such that the EOFs are uncorrelated patterns of variability. If the record averages $\psi_m(t)$ have been removed from each of the M time series, equation 6 can be written in matrix notation

$$\mathbf{C}\phi - \lambda\mathbf{I}\phi = 0 \quad (8)$$

where the covariance matrix, **C**, consists of M data series of length N with elements

$$C_{mk} = \overline{\psi_m(t)\psi_k(t)} \quad (9)$$

**I** is the unity matrix and $\phi$ are the EOFs.

The "energy" or variance associated with each statistical pattern is ordered according to its corresponding eigenvector. In other words the pattern containing the highest percentage of the total variance is the first pattern, $\lambda_1$, and the second pattern, $\lambda_2$, has the highest percentage of the remaining variance and so on. The sum of the variance in the data equals the sum of the variance in the eigenvalues.

$$\sum_{m=1}^{M} \left\{ \frac{1}{N} \sum_{n=1}^{N} [\psi_m(t_n)]^2 \right\} = \sum_{j=1}^{M} \lambda_j \quad (10)$$

Finally the time-dependent amplitudes of the i:th statistical pattern is derived

$$a_i(t) = \sum_{m=1}^{M} \psi_m(t)\phi_{im} \quad (11)$$

## Data and program used

During all climate data analysis MATLAB 6.1 in combination with "Användarhandledning för MATLAB 5" (Pärt-Enander and Sjöberg, 1998) was used.

Daily precipitation and temperature data was bought from Ansai weather station, Shaanxi, in May 2002. The data covers the period from January 1$^{st}$ 1970 to December 31$^{st}$ 2001.

The regional rainfall data was received from NCC and given by Prof. Li (2001). Six rainfall stations in the region within longitude 106-112°E and latitude 33-40°N, around Ansai, Shaanxi were chosen. The stations were Xi'an, Linfen, Yulin, Yan'an, Xifeng and Yinchuan (figure 7). The received data was monthly precipitation during the time period from January 1951 to December 1999.

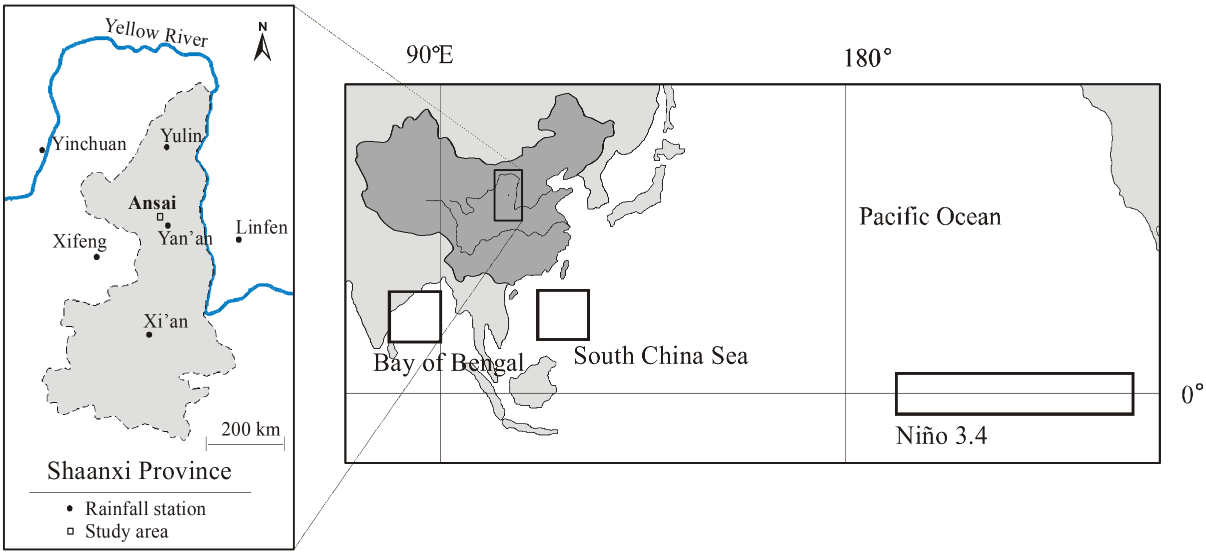



*Figure 7. The left map shows the location of the six regional rainfall stations and the local rainfall station. The right map display the locations of the three ocean regions used in the EOF analysis.*

Monthly sea surface temperature (SST) data was requested from COADS (Comprehensive Ocean-Atmosphere Data Set) at NOAA (National Oceanic and Atmospheric Administration, March 2002, www.cdc.noaa.gov/coads/products.html,). Three ocean areas were chosen for the analysis (figure 7), Bay of Bengal (10-20°N, 80-90°E), South China Sea (10-20°N, 110-120°E) and Niño 3.4 (5°N-5°S, 120-170°W) (Park and Oh, 2000). Bay of Bengal lies in the northern Indian Ocean east of India. According to Ding (1994) there is a correlation between the rains in northern China and India and Bay of Bengal is an important moisture source for the rains in China. South China Sea belongs to the East Asian Marginal Seas and is located south of China. It is also an important moisture source for the rains in China. Ding (1994) also mentions a relationship between convective activities around South China Sea and Philippines and the subtropical high, which may be related to the ENSO (El Niño-Southern Oscillation) cycle. The Niño 3.4 region lies in the equatorial Pacific Ocean and is important in showing the ENSO cycle of the SST. During the onset year of El Niño the SST in the eastern equatorial Pacific is warmer than normal. The following year the SST in the region becomes colder (Ding, 1994).

The SST data was received in 2°×2° latitude-longitude boxes and from the time-period of January 1967 to December 1997. Because of this the Niño 3.4 region was only represented from 4°N to 4°S, not 5°N to 5°S. Totally the Niño 3.4 region consisted of 100 boxes, while Bay of Bengal and South China Sea consisted of 25 boxes each. Niño 3.4 indices were collected from Internet (NOAA, April 4th 2002: www.cpc.ncep.noaa.gov/products/monitoring_and_data/oadata.html). The data covers the period from January 1968 to December 1997 with one value per month. The Niño 3.4 indices were used to compare with the EOF calculation of the Niño 3.4 region.

## Local precipitation and temperature analysis

The local temperature data only contained a few errors, which were interpolated manually. In the local rainfall data 9.3 % were missing. The missing data was spread over the entire period, but more frequent during the summer part of the year. The data was interpolated linearly in the time-dimension.

Monthly and yearly means of the daily precipitation and temperature was calculated. To be able to detect any trends the temperature and precipitation was plotted against time and a line was adjusted to the time series according to the least-square method. This was done both yearly and seasonally. Winter was defined as Dec-Feb, spring as Mar-May, summer as Jun-Aug and fall as Sep-Nov (Domrös and Peng, 1998). The correlation coefficient and significance level was calculated as well as the mean precipitation, standard deviation, annual change and total change. Each year, January to December, was plotted in the same diagram to see the yearly variations. Also an average year was calculated and plotted. In the daily rainfall data certain periods mentioned by the farmers were taken out and studied more closely.

## Regional precipitation analysis

The regional rainfall data was adjusted and contained no missing values when received. An exceptional high value, 744 mm, was found in July 1983 in Xifeng, when a control plot was made. At NCC, in Beijing, the data was compared to Prof. Zhai's (oral communication, April 2002) original unmodified data. With his help the value was found to be 74.4 mm instead of 744 mm.

A mean of all 6 stations was calculated. The same analysis was then conducted as on the local rainfall. The local precipitation was compared to the regional.

## EOF analysis of regional precipitation and SST

To be able to conduct EOF analysis the data had to be organised in a two-dimensional matrix, which shows time series for each location. A program in MATLAB was used to sort the SST data in this way. Some locations were taken out of the analysis because more than one fourth of the values were missing. Bay of Bengal now retained 21 boxes out of 25 and Niño 3.4 38 boxes out of 100. Most of the boxes in the Niño 3.4 were in the west of the region. Therefore another 8 boxes were taken out so they would be more evenly distributed. The South China Sea was very well represented, with little missing data. The missing data was interpolated linearly in the time-dimension. No consideration was taken to the ambient boxes. When data was missing in the last couple of months in the time series it was interpolated manually from ambient boxes. Regional precipitation and SST data for 30 years (1968-1997) were taken out for the analysis. More recent SST data were not available.

A MATLAB program received from Prof. Chen (2002) was used when conducting the EOF analysis. EOF analysis was done on the six regional precipitation stations and on each of the three ocean regions.

The dominating EOF in all ocean regions was the seasonal cycle. To be able to study processes on other time-scales the data had to be modified, so the seasonal cycle would not influence the outcome. Therefore a 30-year-mean was calculated for each month and then subtracted from that month. In this way less dominating EOFs were shown, which could be important on longer time-scales.

- The first two EOF patterns from all three ocean regions were compared to the first two EOF patterns of regional precipitation. These patterns correspond to most of the total variance. Calculation of the correlation coefficient was used to detect a relationship. The significance level was also calculated.
- Moving average was applied to the time series to see if there was a correlation on longer time scales. Moving average was calculated for 5, 25, 37 and 61 months for the same EOF patterns as above. 5 months moving average was chosen because it removes the seasonal cycle. 25, 37 and 61 months moving average was chosen to see if there was a relationship on time scales longer than 2, 3 or 5 years. Moving average has to be calculated over an odd number of months. The new time series were compared through calculating correlation coefficient and significance level.
- To try to see if a time lag existed between the regional precipitation and SST correlation coefficients were calculated for the first two EOF-patterns using different time lags. The time lags investigated were 1, 2, 3, 4, 5, 6, 12 and 24 months. According to Prof. Zhai (oral communication, April 2002) a reasonable time-lag between SST and precipitation is between one and six months. According to Ding (1994) El Niño influences the precipitation differently during the mature phase and the year after. The 1 and 2 year time lags were chosen to see if this is caused by a delayed response.

To investigate a possible interannual relationship the months July and August were taken out from the first two EOF patterns in all ocean regions and for precipitation. July and August were chosen since it is during these months most of the monsoon rain falls (figure 3). A mean was calculated from these two months and then all ocean regions were compared to precipitation. The existence of one or two month time lag was examined through calculating a new mean in the ocean regions including June-August or May-August and compare this mean with the July-August mean for precipitation.

Niño 3.4 index was plotted and compared to the EOF-patterns calculated from the Niño 3.4 region. Niño 3.4 index is calculated through EOF (Prof. Chen, oral communication, August 2002).

## 3.2 INTERVIEWING

### Theory of interviewing

Interviewing can simply be described as a conversation designed to gather specific information (Berg, 1998). It is a method based on communication between people that can result in both quantitative and qualitative data. It sounds very simple, but those who have tried interviewing as a research method, know that this is not the case. Interviewing is an excellent research method, but as any other research method it has to be tested and reviewed to find the most suitable and effective way to attain data in order to achieve ones main purpose. Information generated from a successful interview can explain or clarify conclusions or fill in the holes that other methods could not account for.

***Methods divided by level of control***

Depending on the type of survey different kinds of interview methods are used. The interviewer determines the degree of control of the interview and the respondent's (the interviewed) answers. Based on the degree of control desired the interviewer can decide which of the four following interview methods to use (Bernard, 1995).

The *informal interview* lacks any kind of control or structure. It is usually used in the beginning of a field study when the researcher is getting familiar with the surroundings and local population. Informal interviews can simply come out as notes taken from daily conversations.

*Unstructured interviewing* is based on a plan with a central purpose, but is kept open for changes and gives the respondents the opportunity to freely answer the questions at their own pace and understanding. This method is very time consuming, and therefore most commonly used during longer fieldwork, where the same respondent can be interviewed more than once.

Another type is *semi structured interviewing.* This method is more controlled and well prepared since it is based on an interview guide. The interview guide is a set of clear instructions. For example, "Determine if farmers use fertilizer, and probe to see how it affects food production." This is a guide that should be followed as much as possible, but the interviewer is still flexible to explore new information. The researcher knows what information is important, but still lets the respondent openly answer the questions. Bernard (1995) recommends using this method when there is only one opportunity to interview the respondent.

The last method is called *structured interviewing,* and is the most controlled one. The respondents are given the exact same questions. A questionnaire, which consists of instructions and a set of questions, can be used to receive the data. The idea is that by controlling the information that is given the answers can be reliably compared.

***In-depth interview***
Sometimes having in-depth interviews with a few informants is more appropriate for the study than a representative sample. Berg (1998) defines an informant as a person who has experience and knowledge in the particular subject. Bernard (1995) express that with this kind of interview more time has to be spent on selecting the informants, since the study is dependent on only a few key informants. It is important to choose the informants for their competence rather than just whom they represent. In-depth interviews in combination with interviewing a large sample of people could give a more exhaustive result, when there is time.

***Focus group discussion***
The method consists of a selected group of people that discuss a particular topic. A group discussion simulates interaction between people and leads to verbally expressed thoughts and opinions about the topic. Group conversations produce ethnographically rich data and come up with more ideas and issues than an individual interview. It is also less expensive and requires less time than interviewing the same amount of people individually. The major disadvantage is obtaining less detailed data. Keep in mind that these group discussions are not comparable with natural conversations and the data received is group data, not individual data (Bernard, 1995; Berg, 1998).

## Preparing the fieldwork
The fieldwork was prepared, early spring 2002, in Gothenburg. Literature study and a class “Chinese for beginners” were accomplished. To be able to perform a good interview and receive the demanded data good preparation work is essential (Berg 1998). Bergs recommendations were carried out and supervised by the social anthropologist Knutsson, who has own experience in interviewing farmers in a developing country. The following preparations were conducted:

- Brainstorming
- Deciding the main goals/aims with the interviews.
- Discussing what kind of analyses that are planned, and how the data should be presented. What kind of data is required?
- Discussing preferable interview methods.
- Formulating the questions and the topics that would be used during the interviews.

The first two weeks in China were spent in Beijing. Information and climate data were collected by visiting libraries and through nine informal interviews with selected informants (experts and professors) from Beijing Normal University, Beijing University and the National Climate Center. Our local supervisor Dr. Xie, introduced her two students, Ms. Chen and Ms. Lin, whom she recommended as translators. To be able to test the translators and the questions two test interviews were performed in a small village outside Beijing. The test interviews were discussed with the translators, who were also made aware of their part in the study.

Conducting research in China meant that the wording and phrasing of the questions was even more important since they need to be translated. To make sure that the questions were phrased properly in Chinese *back translation* (Bernard, 1995) was used. In this study the questions were first written in English. Thereafter a bilingual person, the translator, translated it into Chinese. During this translation the bilingual person and the interviewer worked together. Finally another bilingual person, an undergraduate student at Beijing Normal University, translated it back to English. The back-translated questions were then compared to the original questions.

## Fieldwork in Danangou watershed

Six weeks were spent in the field using interviewing as a research method. To receive more accurate results as many methods as possible were used (Bernard, 1995). This also made it possible to compare the usability of the different methods. To get familiar with the study area the first two weeks consisted of gathering background information. This information was collected through informal and in-depth interviews. The next two weeks the questionnaire was designed. This questionnaire was used during the last two weeks. The fieldwork in each village was concluded by focus group discussions concerning topics that had not been included in the questionnaire. It should be mentioned that each respondent was paid a fee.

"The difference between field*work* and field *experience* is field *notes*" (Bernard, 1995, p 191). Bernard (1995) and Mr. Knutsson (oral communication, February 2002) strongly suggested that the time for discussing and writing up field notes should be included in the daily plan. Therefore interviews were conducted in the morning, so that discussion and rewriting notes could be done in the afternoon.

***Informal interviews***

This method was used to become familiar with the area, including the local governmental system. We were introduced to the highest leader in the township and to the former president in Danangou village.

***Unstructured and semi-structured in-depth interviews***

- Choosing respondents: Dr. Xie (oral communication, March 2002) suggested the former president in Danangou village as a key informant. The topics were given to the key informant and he arranged appointments with farmers, including himself, that he thought was suitable to the specific topic.

- The topics were: history of the village, agriculture and climate calendar, local governmental system, education, subsidy and land owning system.
- A total of ten interviews were conducted.
- Time axis made on the local traditional lunar calendar was used as a help tool when the agriculture and climate calendars were constructed.

***Structured interviews using a questionnaire***

The questionnaire was constructed together with the translator. The aim was to design a questionnaire that would take approximately one hour. Preparations, similar to the ones described earlier in the chapter, were conducted. Practice interviewing and pretesting the questionnaire are essential for conducting a successful interview (Berg, 1998; Bernard, 1995; Pallant, 2001; Weiss, 1994). Bernard (1995) suggests that the pilot studies should be conducted under the same circumstances with similar respondents as in the planned research. This will present a more reliable result. The main emphasis was therefore on testing the questions. During a week test interviews were combined together with rephrasing and limiting questions. Altogether six test interviews were conducted. The questionnaire was divided into the main topics: background information, crops, weather, rainfall, disasters and future. It included totally 40 questions (appendix). During the earlier fieldwork it was noticed that the farmers had difficulties remembering the climate in the past, so the questions comparing today and the past was related to a well known event, the introduction of the *household responsibility system* in the beginning of the 1980's.

The final step was to use the questionnaire:

- Choosing respondent: most of the questions concerned 20 years in the past, so respondents above 30 were reasonable. The women usually moved when they got married, so most women in the study area had not lived there 20 years. Therefore men above 30 years old and a few old women to compare with were the criteria of the respondents. Bernard (1995) calls this quota sampling. It is a form of nonprobability sampling. Generalizing beyond the sample cannot be made, but quota sampling combined with ethnographic data is often highly credible.
- A total of 38 farmers, 27 men and 11 women, were interviewed (including six test interviews) in Danangou watershed. In other words, 38 of 48 households were interviewed.
- The interviews lasted between 1/2-2 hours, with an average of 50 minutes.

***Focus group discussions***

This method was used as a complement to the questionnaire. The reactions from at least two groups, for example female and male, should be compared (Bernard, 1995; Mr. Knutsson, oral communication, May 2002). One female and one male focus group discussion were conducted together with Dr. Ostwald and Mr. Knutsson. Notes including the respondents' reactions and feelings were taken.

We conducted four additional focus group discussions:

- Choosing respondents: the topics were focused on climate change, and respondents that had shown interest in this during the other interviews were chosen first. There after who ever was available. Mr. Knutsson suggested groups of 5-6 people (oral communication, May 2002). The age distribution was also considered.

- One female and male discussion was simultaneously conducted in Danangou, and then later in Leipingta.
- The procedure and the main topics were the same, so that any gender or village differences could be analyzed.
- A *climate game* was constructed to help the farmers visualize and give a general picture of the climate change in this area. All four discussions were concluded with this game (figure 8).

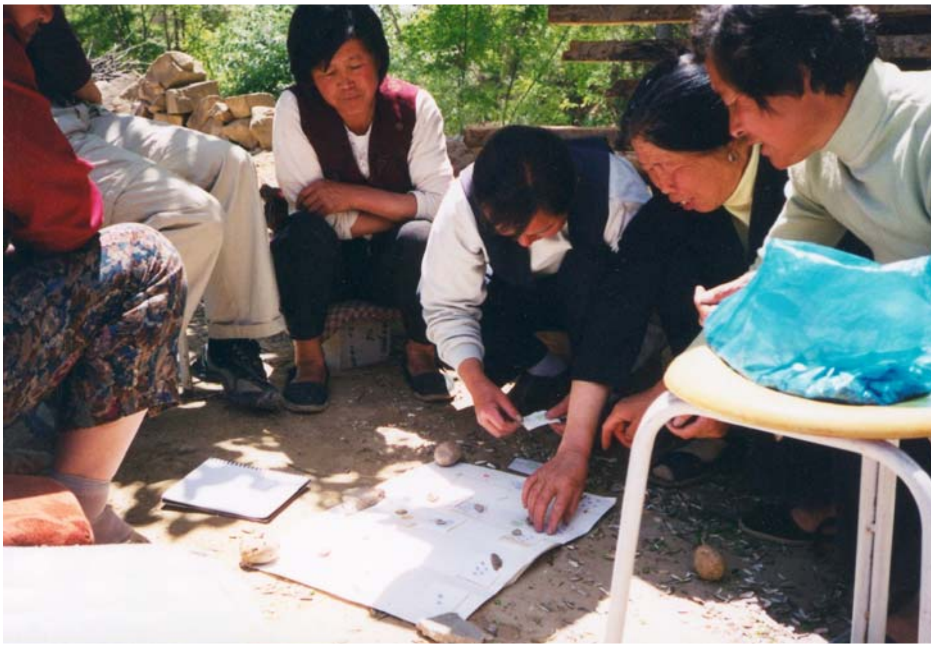


*Figure 8. Female group discussion in Danangou. This is in the end of the group discussion when the women used the climate game to describe climate changes. Photo: Ms. Lin, May 2002.*

The interactive tool, called c*limate game*, was invented by the authors and used during the group discussions. It consisted of a diagram/table where the x-axis was divided into ten-year periods (1962-2012), and the y-axis was divided into four groups: temperature, rain, wind and snow. These four groups where symbolized by drawings along the y-axis. The same drawing for example temperature was also made on four small separate cards. Suns in four different colors and sizes, where the reddest and largest one was the warmest and the smallest and yellow one was coldest, symbolized the temperature. Each group had four cards describing four different levels. Starting with the temperature the farmers had to place these four cards on the time-axis consisting of four ten-year periods. The same procedure was conducted with rain, wind, and snow. Thereafter the farmers had to predict the weather in ten years (2012) and finally they had to choose the optimal climate for their agriculture.

## Statistical analysis of the questionnaire data

The questions from the questionnaire that were suitable to be statistically analysed were coded and entered into SPSS 10.0 (Statistical Programme for Social Sciences). Descriptive statistics, frequencies, standard deviation, minimum, maximum, range, mean and graph were done on each variable. First the input of the data was controlled and thereafter the output was analysed. Crosstabulation was used to find possible relationships between two variables, for example village and irrigation.

# 4. RESULTS

The results are divided into three main parts due to the complex objectives. First the results from the analyses of the climate data are presented. Thereafter the farmer's perception of the climate is described and compared to the climatic records. Finally the possible relation between land use changes and variation in climate is studied.

## 4.1 CLIMATE DATA ANALYSIS

### Local precipitation and temperature

Table 1 shows the result from the Ansai rainfall analysis. 58% of the precipitation falls during summer, when the monsoon rain arrives. The start of the monsoon rain varies from June to September. A decreasing tendency of the rainfall can be seen during the period in all seasons except spring. The trend is not significant, since there are large variations of the amount precipitation from year to year.

*Table 1. Ansai precipitation 1970-2001.*

| | *Yearly* | *Spring* | *Summer* | *Fall* | *Winter* |
|---|---|---|---|---|---|
| **Mean** (mm) | 579 | 92.1 | 333 | 139 | 15.9 |
| % of yearly total | | 16% | 58% | 24% | 2.8% |
| **Std** (mm) | 129 | 44.7 | 105 | 66.0 | 13.6 |
| **Trend** (mm/year or season) | -2.6 | 0.3 | -1.1 | -1.5 | -0.4 |
| **Correlation** | 0.2 | 0.1 | 0.1 | 0.2 | 0.3 |
| **Total change calculated from the trend** (mm/32 years and %) | -81.9<br>-14% | 9.9<br>11% | -34.6<br>-10% | -47.0<br>-34% | -12.4<br>-78% |

No significant correlation according to student's t-test. N=32
Std = standard deviation of the observations

The temperature in Ansai shows a significant increasing trend. The increase appears mostly during winter. In 32 years the yearly temperature has risen 1°C (table 2).

*Table 2. Ansai temperature 1970-2001.*

| | *Yearly* | *Spring* | *Summer* | *Fall* | *Winter* |
|---|---|---|---|---|---|
| **Mean** (°C) | 8.97 | 10.51 | 21.49 | 8.71 | -4.81 |
| **Std** (°C) | 0.60 | 0.87 | 0.71 | 0.77 | 1.22 |
| **Trend** (°C/year or season) | 0.03 | 0.02 | 0.01 | 0.03 | 0.06 |
| **Correlation** | 0.48** | 0.23 | 0.21 | 0.39* | 0.47** |
| **Total change calculated from the trend** (°C/32 years) | 0.96 | 0.64 | 0.32 | 0.96 | 1.92 |

* = 95% significant, ** = 99% significant according to student's t-test. N=32
Std = standard deviation of the observations

### Regional precipitation

In table 3 the results from the regional rainfall analysis can be seen. More than half of the precipitation in the area falls during the summer months (June-August). All seasons show a decreasing trend. The trend is significant in the fall and during the entire year. The correlation is not so strong because of the large variations from year to year.

*Table 3. Regional precipitation (6 stations) 1951-1999.*

| | *Yearly* | *Spring* | *Summer* | *Fall* | *Winter* |
|---|---|---|---|---|---|
| **Mean** (mm) | 457 | 87.6 | 240 | 117 | 12.5 |
| % of yearly total | | 19% | 53% | 26% | 2.7% |
| **Std** (mm) | 78.2 | 32.0 | 55.9 | 43.1 | 7.7 |
| **Trend** (mm/year or season) | -1.8 | -0.0 | -0.7 | -0.9 | -0.1 |
| **Correlation** | 0.3* | 0.0 | 0.2 | 0.3* | 0.1 |
| **Total change according to the trend** (mm/49 years and %) | -86.2<br>-19% | -1.5<br>-2% | -33.8<br>-14% | -45.6<br>-39% | -2.9<br>-23% |

* = 95% significant according to student's t-test. N=49
Std = standard deviation of the observations

In figure 9 the local rainfall is compared to the regional. It rains more in Ansai than in the region in general. The rainfall trend in Ansai is decreasing except in spring, when a weak increasing trend occurs. In the regional data the rainfall is decreasing in all seasons. It shows that rainfall is local and can differ also in a small region. The winter rainfall decrease in Ansai during the period is much greater than the decrease in the region (table 1 and table 3). It is also a sign of the large spatial differences in rainfall. This study is focused on spring and summer rainfall, since it is during this period the rain is important to the farmers' crops. The differences in winter precipitation have therefore not been studied more thoroughly. There are no other large differences between local and regional rainfall.

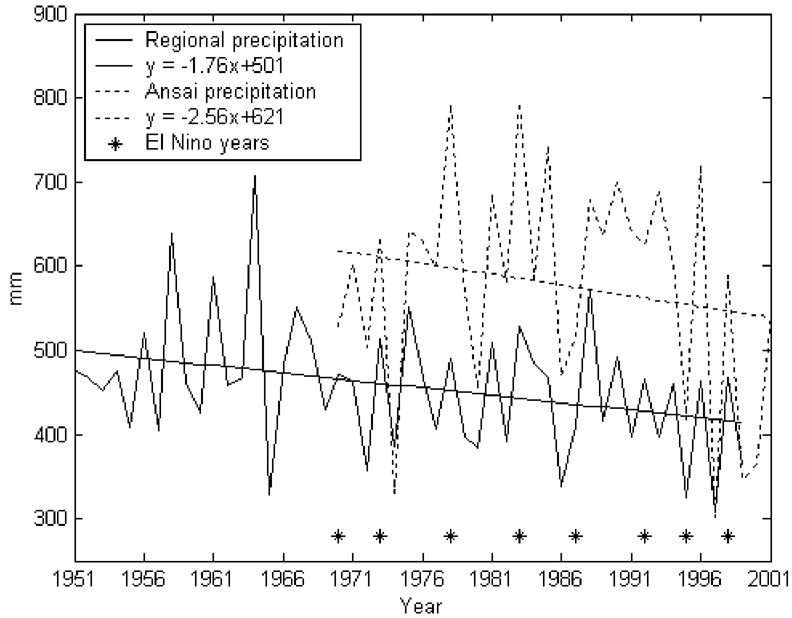



*Figure 9. A comparison of local precipitation in Ansai and regional precipitation in the Shaanxi area. The graph shows mean yearly precipitation. The dots display the El-Niño years according to the time coefficient of the first EOF in the Niño 3.4 region, which can be seen in figure 11.*

## The relation between regional rainfall and SST

The first EOF patterns contain most of the variance in a region and are therefore most important. Table 4 shows how much of the total variance the first two EOF-patterns correspond to in each area.

*Table 4. Variance of the first two EOF-patterns.*

| | *EOF 1* | *EOF 2* |
|---|---|---|
| **Bay of Bengal SST** | 17 % | 15 % |
| **South China Sea SST** | 67 % | 18 % |
| **Niño 3.4 SST** | 43 % | 23 % |
| **Regional precipitation** | 46 % | 22 % |

Each EOF pattern can be described both in space and time. To illustrate the analysis of the spatial patterns an example is given in figure 10. This figure shows the spatial pattern of the first EOF in South China Sea. The first EOF in South China Sea, the second in Bay of Bengal and the second in the Niño 3.4 region have two regions with opposite signs. The SST varies in a seesaw pattern. For example in South China Sea (figure 10) the SST increases in the northwest part of the region while it decreases in the southeast part. At other times the SST increases in the southeast part of the region, while it decreases in the northwest. In South China Sea the gradient has a northwest-southeast direction, in Bay of Bengal a north-south direction and in Niño 3.4 an east-west direction. The spatial pattern of the first EOF in Bay of Bengal, the second EOF in South China Sea and the first EOF in the Niño 3.4 region have the same sign of variability. This means that the SST increases or decrease simultaneous in all locations in the region. It indicates that large-scale processes cause the variability. How the pattern varies in time is described through the corresponding time coefficient.

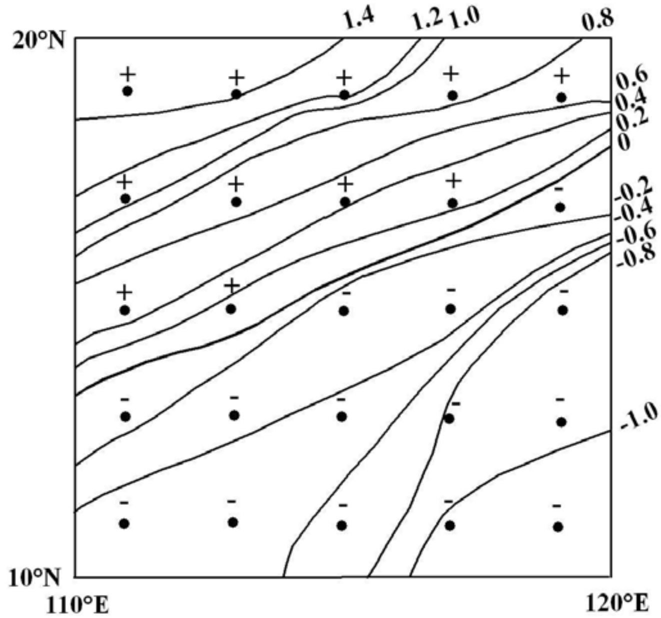



*Figure 10. The spatial pattern of the first EOF in South China Sea displays a seesaw pattern with a northwest-southeast gradient. The dots are the 25 measuring locations. The location of South China Sea is displayed in figure 7.*

Figure 11 shows time coefficients of the EOF patterns from the different regions. The time coefficient of the first EOF from South China Sea has a very strong seasonal cycle, 30 peaks in 30 years, even though the data has been modified to make it less obvious. The time coefficient of the first EOF from the Niño 3.4 region has 8 peaks in 30 years with the biggest one in 1997. It indicates that it is the El Niño oscillation. The Niño 3.4 index is almost identical to the time coefficient of the first EOF from Niño 3.4. In other words the EOF analysis is a good way of synthesizing spatial and temporal variability despite large amounts of missing data.

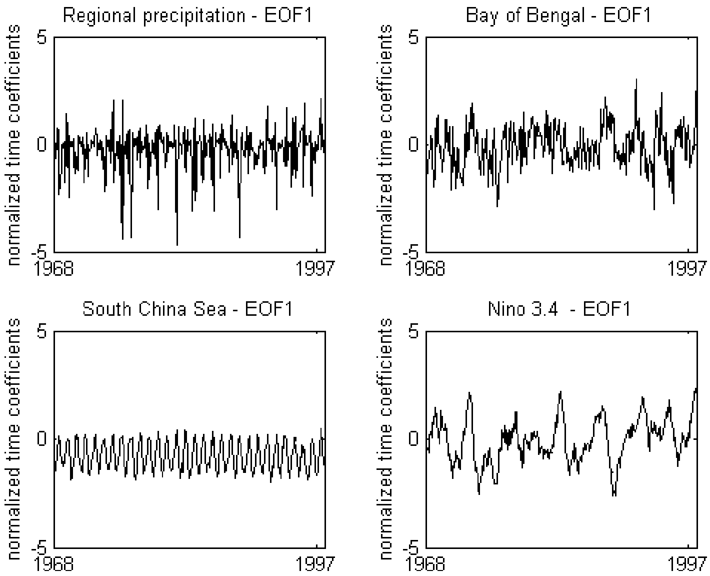



*Figure 11. The time coefficients of the first EOF in the different regions.*

The time coefficients from the first two EOF patterns in each ocean region were compared to the time coefficient of the first two EOF patterns for precipitation. As can be seen in table 5, there is a significant correlation between precipitation and the second EOF-pattern from Bay of Bengal, the first EOF-pattern from South China Sea and the first EOF-pattern from the Niño 3.4 region. Even though the correlation is significant it only explains a very small part of the total variance (2-4%).

*Table 5. Correlation between precipitation and SST.*

| | *Bay of Bengal* | | *South China Sea* | | *Niño 3.4* | |
|---|---|---|---|---|---|---|
| ***Precipitation*** | **EOF 1** | **EOF 2** | **EOF 1** | **EOF 2** | **EOF 1** | **EOF 2** |
| **EOF 1** | -0.06 | 0.15** | -0.19** | -0.07 | 0.15** | 0.07 |
| **EOF 2** | -0.01 | 0.19** | -0.15** | 0.01 | 0.01 | -0.09 |

** = 99 % significant according to student's t-test. N=360

The time series are smoothened and extreme values disappear, when moving average is calculated. In this way it can be seen if there is a correlation on longer time scales. All the significant correlation coefficients in table 5 did increase after applying moving average. 5 months moving average gave the highest correlation in Bay of Bengal and South China Sea, while the 2 years (25 months) moving average gave the highest correlation in the Niño 3.4 region. The exact numbers are not meaningful, since the data-series no longer are independent after applying moving average (Prof. Fu, oral communication, August 2002). It is interesting to note that a relationship on longer time-scales exists, but it is still weak.

Table 6 shows the correlation when the monsoon-rain months (Jul-Aug) are considered.

*Table 6. Correlation during the monsoon months July-August.*

| | *Bay of Bengal* | | *South China Sea* | | *Niño 3.4* | |
|---|---|---|---|---|---|---|
| ***Precipitation*** | **EOF 1** | **EOF 2** | **EOF 1** | **EOF 2** | **EOF 1** | **EOF 2** |
| **EOF 1** | -0.30 | 0.22 | 0.03 | -0.16 | 0.44* | 0.33 |
| **EOF 2** | -0.11 | -0.06 | -0.18 | 0.11 | 0.05 | -0.25 |

* = 95% significant according to student's t-test. N=30

Only one EOF–pattern has a significant correlation with precipitation. It is the first EOF from the Niño 3.4 region and the first EOF-pattern of precipitation and can be seen in figure 12. Positive SST anomalies in the Niño 3.4 region during July and August lead to more rainfall in Shaanxi. In this study SST in Bay of Bengal and South China Sea has not been found to influence the precipitation in the Shaanxi region.

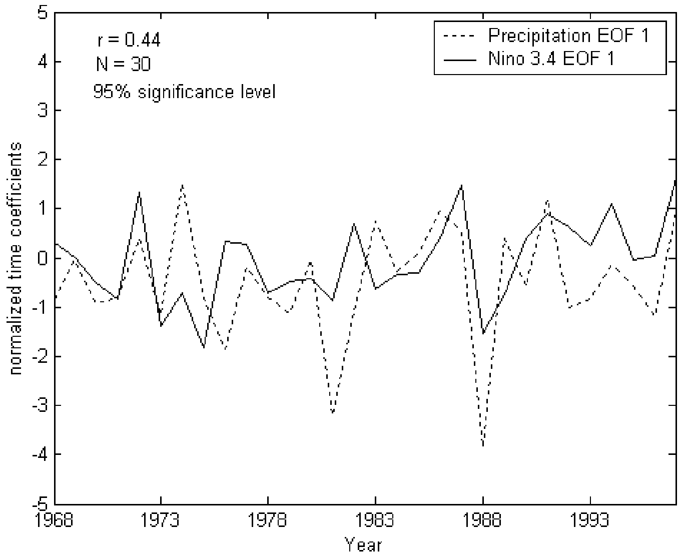



*Figure 12. The correlation between the time coefficients for the first EOF of SST in the Niño 3.4 region and the first EOF for precipitation is 0.44 with 95% significance level.*

No time lag exists between the SST and precipitation. The correlation did not increase on either yearly or seasonal basis. The processes behind the correlation between SST and precipitation are faster than one month.

## 4.2 FARMERS PERCEPTION OF THE CLIMATE

The statistical results in part 4.2 and 4.3 are based on 38 structured interviews (questionnaire), if no other count is given. 50% of the farmers had no education. 26% of the farmers think they are poor compared to the others in the village, 53% consider themselves as average and 18% rich.

During the group discussions the farmers were asked to describe the difference between climate and weather. One man and one woman in Danangou could define the difference between weather and climate, while the others were confused. In Leipingta they all thought the words had the same meaning. The farmers were also asked if they have heard the expressions *Global Warming* and *El Niño*. Some of the farmers in Danangou had heard the expression *Global Warming*. One male farmer in Danangou remembered reading "Global warming might melt the ice mountains on the north pole and flood the whole earth". They all agree that it is getting warmer. They were also asked what they think causes global warming. The same farmer in Danangou explained: "The pollution in the air covers the earth like the plastic covers the fields". No one had any comments or thoughts concerning *El Niño*.

### Climate Calendar

The farmers in Danangou watershed use the lunar calendar instead of the solar. It has been used in the Chinese countryside for many centuries and is based on agricultural activities. One lunar year has 360 days and can be divided into 12 months. Every fourth year there is an extra month. The month that appears twice is different depending on the year. The lunar year can also be divided into 24 units. Every unit reflects a weather change. It is always the same interval between units, about 15 days, but the units do not occur on the exact same date in the lunar calendar every year. It can vary about a week. The lunar calendar is displaced roughly one to one and a half month, when compared to the solar calendar (in-depth interviews; Dr. Xie, oral communication, September 2002).

The following calendar (table 7) describes a normal year in 1990's based on the lunar calendar. The farmers' know the temperature from the weather forecast on TV, while the rest are estimations based on own experience.

*Table 7. Climate calendar according to the farmers based on lunar calendar (three male farmers, in-depth interviews, April and May 2002.)*

| **Seasons** | ***Spring*** | | | | | | ***Summer*** | | | | | | ***Autumn*** | | | | | | ***Winter*** | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Solar Months** | Feb | | Mar | | April | | May | | Jun | | July | | Aug | | Sept | | Oct | | Nov | | Dec | | Jan | |
| **Lunar Months** | Jan | | Feb | | Mar | | April | | May | | June | | July | | Aug | | Sept | | Oct | | Nov | | Dec | |
| **The Chinese names of the 24 units used in the lunar calendar** | Lichun | Yushui | Jingzhe | Chunfen | Qingming | Guyu | Lixia | Xiaoman | Mangzhong | XiaZhi | Xiashu | Dashu | Liqiu | Chushu | Bailu | Qiufen | Hanlu | Chuanjian | Lidong | Xiaowue | Daxue | Dongzhi | Xiaohan | Dahan |
| **Temperature** | The temperature can fluctuate with 10-15°C between day and night. | | | | | | | | | | | | | | | | | | | | | | | |
| Max (°C) | + 27-28 (late March) | | | | | | + 34 (June) | | | | | | + 30 (early July) | | | | | | + 16-17 (early October) | | | | | |
| Min (°C) | - 2-3 (early January) | | | | | | + 23-24 (early April) | | | | | | + 14-15 (late September) | | | | | | - 17 (early November) | | | | | |
| Average (°C) | + 14-15 | | | | | | + 25 | | | | | | + 22-23 | | | | | | ~0 | | | | | |
| **Precipitation** | | | | | | | Driest | | | | | | Wettest | | | | | | | | | | | |
| There is no regularity in how often and when there is precipitation | In January it usually both rains and snow. It seldom rains and the rain is little with duration of 1-2 days. | | | | | | Heavy rains comes more often, with a duration of less than 30 min. | | | | | | Small rains with duration of 2-3 days. Another farmer says that they have continuous cloudy rain for a month. | | | | | | First snow comes in early October. It is usually a mix of rain and snow. The snow cover is usually ~10 cm deep, and may stay for a month | | | | | |
| **Wind** | Strongest | | | | | | | | | | | | | | | | | | Weakest | | | | | |
| Direction | Leipingta is located in a gully surrounded by hills. The local wind circulation is complex, and hard to describe. During drought there are north and northwest winds. When it rains the wind comes from southeast. Northwest winds are most commonly during all seasons. | | | | | | | | | | | | | | | | | | | | | | | |

The farmers discussed the different rain types during the group discussions, and defined the different rains as:

- Small rain: the raindrop size is similar to foxtail millet. The rain is very thin, similar to fog, and causes no runoff. The duration is 1-3 days.
- Middle rain: the size of the raindrop is similar to a soybean. There is some runoff before the rain makes the soil totally wet. The duration could range from several hours to 2-3 days.
- Heavy rain - rainstorm: it is hard to distinguish between heavy rain and rainstorm. Raindrop diameter is between 2-3 cm. It is often rain with thunder and results in floods. The duration range from a few minutes to 30 minutes.

The following three rain periods are defined according to the lunar calendar (in-depth interview):

- *Chun yu* (spring rain): starts in February and ends in the beginning of May.

- *Fu yu* (summer rain): starts in the beginning of May and ends in the beginning of July.
- *Qiu yu*: all the rain after the beginning of July is called this.

The informant described their importance as followed: "*Chun yu* is as expensive oil, but *fu yu* is the most important one for the crops, because during this period the sun is very strong " (male, 66 years old).

The same opinion was found in the questionnaire where 29% thought that *chun yu* is most important, 63% thought that *fu yu* is most important and 8% thought both have the same importance. The farmers were also asked why the chosen rain period was the most important one. The general opinion was that *chun yu* is important because they need rain to be able to plant and *fu yu* because it is the growing period. According to a research assistant at Ansai research station of soil and water conservation (Mr. Hou, in-depth interview, May 2002) *fu yu* decides if there will be any production and when the farmer can harvest. During the structured interviews many farmers had problems choosing only one rain period, for example: "The spring rain is most important. The fall rain influences the crops most. The key rain is in the summer" (male, 36 years old).

Figure 13 shows that the farmers believe that during the summer, *fu yu*, heavy rain and rainstorms have decreased (from 38% to 21%), while small and middle rain has slightly increased during the past 20 years. The high percentage of "do not know" indicates the difficulties to distinguish between different rain types, and it is mainly men (84%), who have chosen this option.

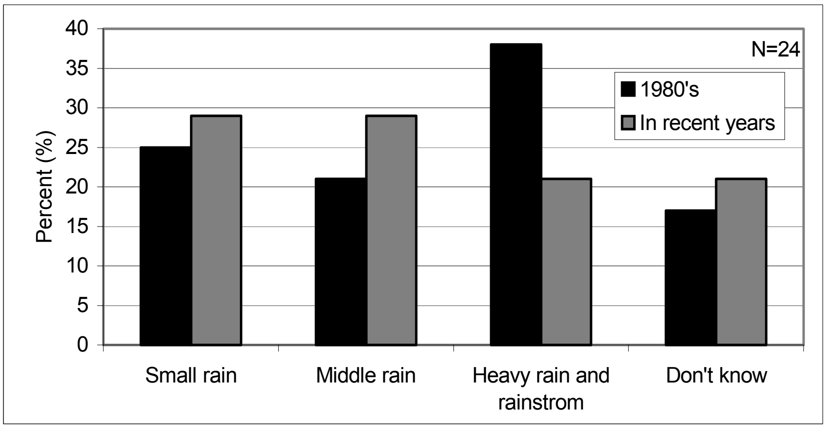



*Figure 13. Main rain type during the summer (fu yu) in the 1980's and in recent years. The graph is based on 24 farmers.*

## Climate variations

One way to perceive climate variations in the past is to look at the changes of the extreme events. The main disasters in this region are drought, flood, hail and frost (in-depth interview). During the structured interviews the farmers were asked to choose which disaster that has occurred most frequently and which one that causes most damage to their agriculture 20 years ago and in recent years. Figure 14 (a) displays a large distribution among the most frequent disaster in the 1980's, while figure 14 (b) shows that 82% of the farmers agree that drought has occurred most frequently in recent years. One interpretation is that it is hard to remember the past, especially for men above 50 who stand for 60% of the "do not know" answers, while younger men (between 29-39) represent 60% of the "no disaster" alternative in figure 14 (a). It is interesting to see that even though hail occurs most frequent in 1980´s drought is still the disaster that causes most damage to their agriculture. During one of the group discussion it was also mentioned that during the recent years floods have decreased and rainstorms happen less often in recent years.

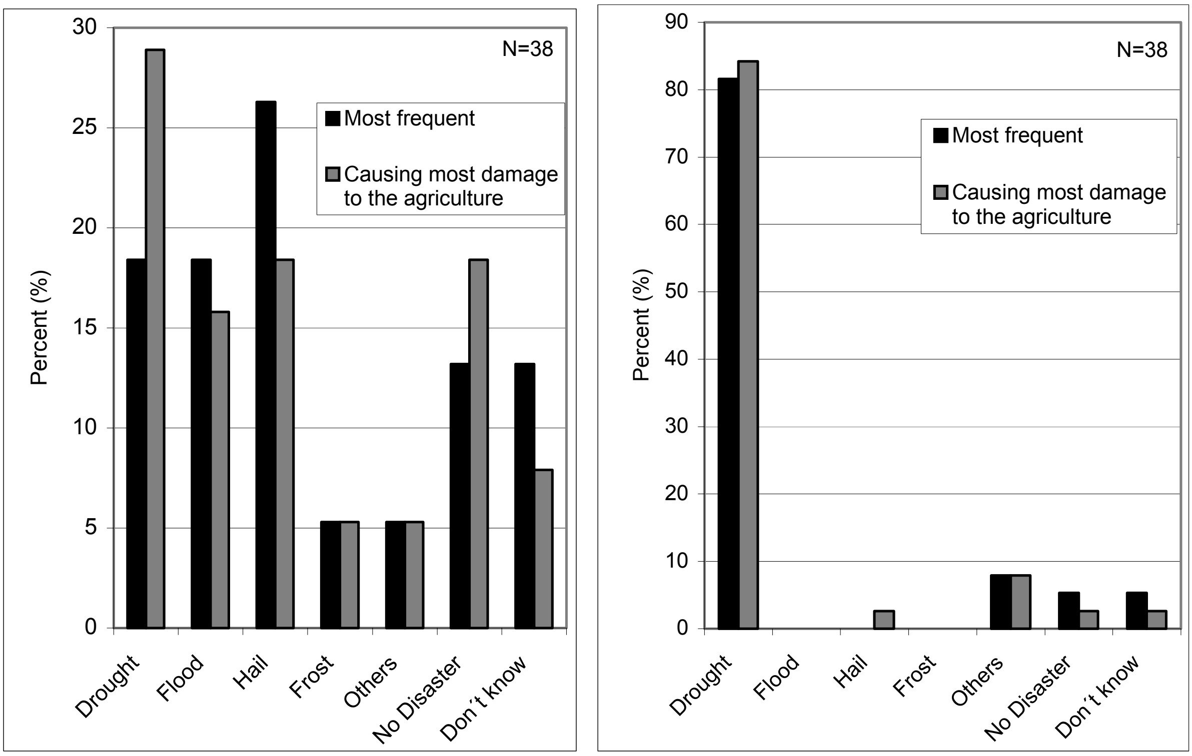



*Figure 14 a and b. The graphs present the disasters in the 1980's (a) and in recent years (b).*

"Do you feel any changes in the weather now compared to 20 years ago?" was another question in the questionnaire. 34% thought it has become warmer, 32% thought it has become drier and 24% believed it has become both warmer and drier. 8% of the farmers thought that no change had occurred, and the last 2% mentioned seasonal temperature fluctuations. According to the farmers the temperature change is most obvious during the winter. One farmer noticed the temperature change during winter as followed: "Before the water was frozen in the bucket that was used to carry water in" (female, 59 years old). Many farmers, during both individual interviews and group discussion, explained that they used to dress in thick woollen clothes when they were young, but now a day they only wear thin cotton clothes.

The *climate game* that was used in the group discussion presented the same results. Figure 15 describes how the male group in Danangou thought that the climate has changed the last 40 years. This picture was chosen because it represents the farmers' general perception of climate change during this period. They all agree that the temperature has increased continuously during the period while the other factors fluctuate more. "Now the weather is more uncertain and varies more" (male, 70 years old). This was mentioned both during the structured interviews and the group discussions.

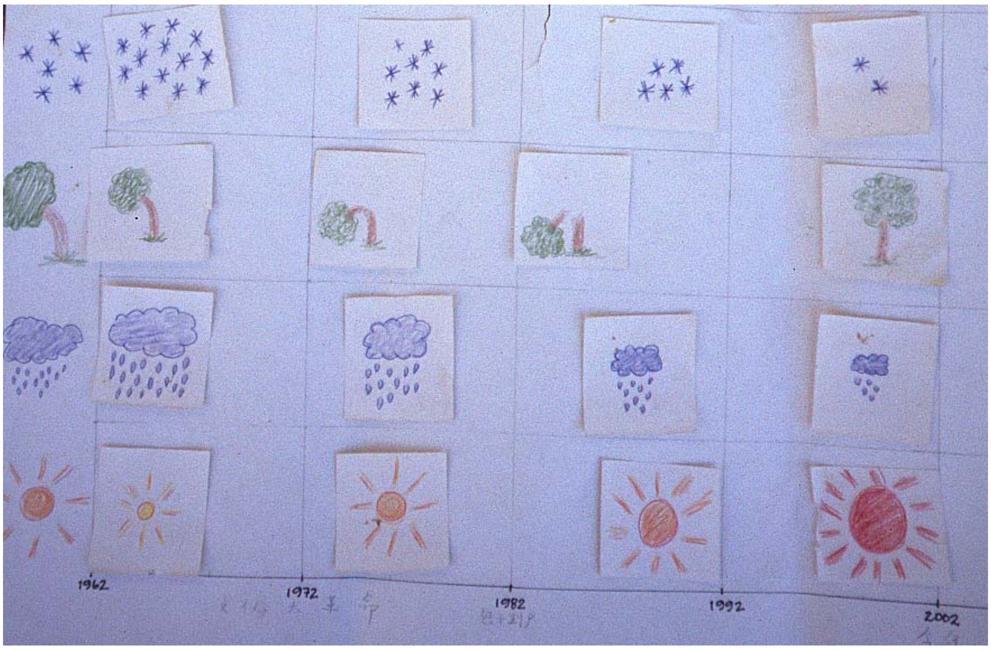



*Figure 15. The climate game displays the climate changes in the past. The x-axis is divided into four ten years period (1962-2002) and the y-axis is divided into four groups. Starting from the top: snow, wind, rain and temperature. Male group discussion in Leipingta. Photo: Sundberg, May 2002.*

The future climate was also described during the group discussion. The general opinion of the future climate is that it will be even warmer with less snow. It will rain more and be less windy. The farmers believe that the trees they have planted will result in more rain in the future: “The leaves can absorb the moisture in the air. If you follow science it will rain more” (female group discussion). Figure 16 present the different groups opinion of optimal weather for agriculture. The optimal weather was described as: warm, small-middle rains with a regular frequency, some wind and some snow. A gender difference can also be noticed in figure 16. The women tend to rank everything higher than the men. Men in Leipingta depart from the gender difference when they describe how much snow they would prefer. Both women and men explained: “snow is good for people’s health”. The snow also increases the soil moisture, and prevents pests (group discussions).

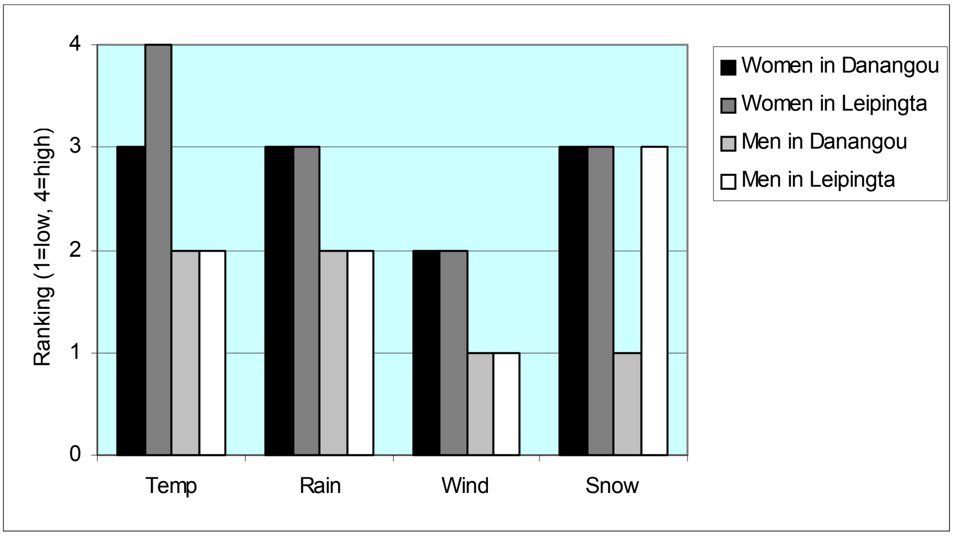



*Figure 16. Optimal weather for agriculture.*

## Farmers' perception compared with climatic records

Farmers' ability to perceive the climate was studied in figure 17 where the farmers' comments about weather events were compared to seasonal precipitation data.

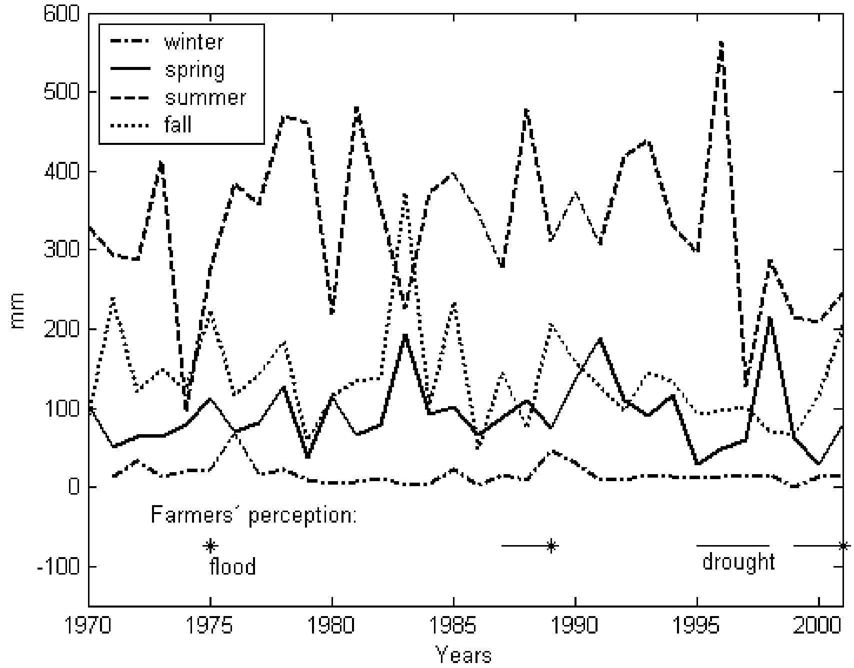



*Figure 17. Seasonal precipitation from Ansai weather station related to farmers' perception of climate. In the bottom of the graph information from the farmers are presented. The line present drought while the dot means flood.*

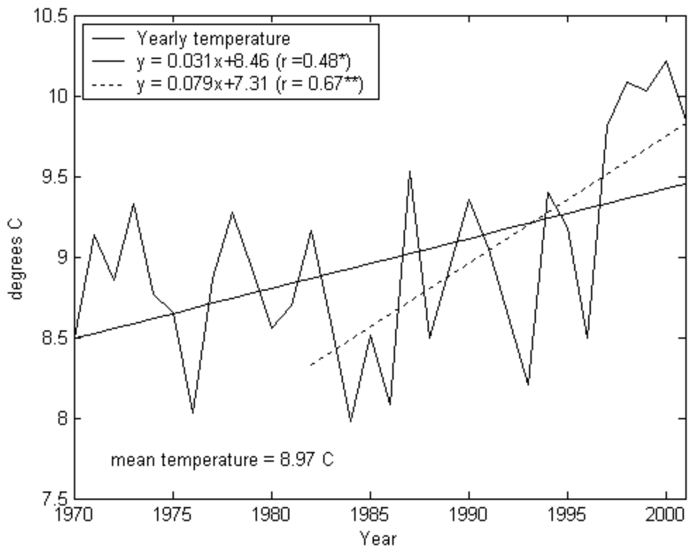
***Floods***

During in-depth interviews and group discussions farmers have mentioned a big flood that broke the dam in the river around 1975. No such extreme event can be found in either the seasonal or daily data until July 1977, when it rained 177 mm in two days. One respondent remembered that a big rainstorm took place in the summer of 1989. Two days in July it rained more than 50 mm in 24 hours according to the data. Last year (2001) in lunar calendar June 20$^{th}$ there was a rainstorm as severe as the one in 1989 (in-depth interviews). In the solar calendar it would correspond to the end of July or beginning of August. In the middle of August it rained 69 mm during two days.

***Droughts***

During the 1980's a severe drought lasted for 3 years (in-depth interview). One farmer remembered that the drought lasted from 1987-1989. The seasonal data shows that spring 1986-1988 was dry as well as summer 1987. A drought also occurred from October 1995 to June 1996 (in-depth interview). This agrees with the daily data. The winter 1995-96 and spring 1996 was very dry, while it rained a lot during the summer 1996. It is also mentioned that 1996, -97 or –98 was very dry (in-depth interviews). It can clearly be seen in the data that 1997 was extremely dry. The last three years have been very dry according to the farmers (in-depth interviews and group discussions). Since spring 1998 it has been dry according to the data.

***Temperature***
One farmer remembers that the highest temperature last year was measured on lunar calendar May 20th and was 28-30°C. In the solar calendar this corresponds to the end of June or beginning of July. The highest temperature 2001 was found on July 15th and was 28.8°C. The farmers also mentioned that this year and last year has been very warm (in-depth interviews) and that the weather is warmer and dryer now compared to the 1980's (questionnaire and group discussions). It is confirmed by the data (figure 17 and figure 18). Figure 18 shows that during the time period the farmers were asked about, the temperature has increased significantly. Both during group discussions and in the questionnaire the farmers have said that it is warmer in the winter today and that they wear thinner clothes in the winter. This is very interesting to note since it can be seen in table 2 that the increasing temperature trend is strongest during winter.




* = 95% significance level, ** = 99% significance level according to student's t-test

*Figure 18. The temperature has increased significantly during the last 30 years. The trend is even stronger in the 20-year period the farmers were asked about (1982-2002). The graph shows mean yearly temperature from Ansai weather station.*

***Seasonal calendar***
The climate calendar was compared to climate data and found to be accurate in general. The temperatures are all a little bit higher than measured data, but the seasonal changes are presented correctly. The wettest period according to the farmers appear to be one to two months later in the year compared to climatic records. In the measured data the driest period of the year definitely occurs during winter (figure 6) while the farmers say it is during spring, which can be seen in the climate calendar (table 7). One explanation is that the farmers need rain during spring when they plant, but not in the winter. During the growing period, when the summer monsoon comes, there is also a large need of rain, but not to the same extent in fall.

The farmers have a good perception of the climate. From these results it can be seen that during recent years the farmers can remember detailed information about the weather. Further back in time they remember extreme events. The farmers also have a good apprehension of a general year and of long-term trends.

## 4.3 LAND USE CHANGES IN RELATION TO VARIATIONS IN CLIMATE

### Crops

The farmers defined agriculture as planting crops. Livestock is not included (in-depth interviews). The agriculture calendar (table 8) presents a normal planting year for the farmers in Danangou watershed.

*Table 8. Agriculture calendar according to the farmers. (Two male farmers, in-depth interviews, April 2002; checked by Mr. Hou, May 2002)*

| **Seasons** | | | ***Spring*** | | | ***Summer*** | | | ***Autumn*** | | | ***Winter*** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Solar Months** | Feb | Mar | April | May | June | July | Aug | Sept | Oct | Nov | Dec | Jan |
| **Lunar Months** | Jan | Feb | Mar | April | May | June | July | Aug | Sept | Oct | Nov | Dec |
| **The Chinese names of the 24 units used in the lunar calendar** | Lichun, Yushui | Jingzhe, Chunfen | Qingming, Guyu | Lixia, Xiaoman | Mangzhong, XiaZhi | Xiashu, Dashu | Liqiu, Chushu | Bailu, Qiufen | Hanlu, Chuanjian | Lidong, Xiaowue | Daxue, Dongzhi | Xiaohan, Dahan |
| **Planting time** | | | Foxtail millet<br>Soybean<br>Every crop that can be harvest in less than 60 days can be planted | | All kinds of crops; foxtail and pearl millet, soybean, potatoes, corn. Mangzhong means, "busy to plant" | Buckwheat | | | | | | |
| **Harvest time** | | | | | | | | Pearl millet | Foxtail millet<br>Everything can be harvest | Grind the grain | | |
| **Irrigation** (Adding water) | They add water when the land is dry | | | | Most irrigation is used | | | | | | | |
| **Fertilizer** | | | • Natural fertilizer before planting, or with the seeds<br>• $NH_4CO_3$ with the seeds<br>• Chemical urea carbamide when the crops are ~1m high | | | Phospate fertilizer with the seeds | | | | | | |
| **Pesticide** | They use it when they see the pest, almost always in July | | | | | 'DDT', and if that does not work they use '1605' | | | | | | |

The men in Danangou say that now a day they plant earlier because of warmer weather (group discussion). Table 8 displays the six main crops in this area and according to Mr. Hou (in-depth interview, May 2002) these crops are chosen because they are resistant to droughts. Among these crops buckwheat and corn are most dependent on the rainfall while soybean and millet are least sensitive. The crops dependency of the rain was also discussed with Prof. Li, specialized in grass and forest ecology (in-depth interview, April 2002) and two farmers (in-depth interviews). They all agree that the timing of the rainfall is more important than the amount of rain. They were asked to rank the crops according to how dependant they are on the timing on the rainfall (table 9). They all agree that millet is least sensitive. It can be seen that Prof. Li and Mr. Hou rank the same, while the farmers disagree and have more difficulties with deciding which one is most sensitive. None of the interviewed farmers can read or write. An explanation could be that the educated professor and research assistant define according to their academic knowledge, while the farmers define according to their experience and the crops they plant.

*Table 9. Ranking of the crops sensitivity to the timing of the rainfall*

| Ranking* | *Prof. Li* | *Respondent 42* | *Respondent 6* |
|---|---|---|---|
| **1** | Buckwheat | Soybean | Corn |
| **2** | Potatoes | Buckwheat, potatoes and sorghum | Potatoes |
| **3** | Corn | | Buckwheat |
| **4** | Soybean | | Pearl millet |
| **5** | Pearl millet | Pearl millet | Foxtail millet |
| **6** | Foxtail millet | Foxtail millet | |

*1 is most dependant and 6 is least dependant.

The relation between crops and climate was also discussed during the group discussions where one farmer said: “Our agriculture is based on the climate”. They also mentioned millet’s resistance to drought and explained that it used to be their main food until the 1990’s, when better transportation in China made rice accessible to the food market in this region. These days they mainly plant vegetables. During the structured interviews the farmers were asked about their main crop (cover the largest area) today and 20 years ago. A transition from mainly planting millet to planting different kinds of crops was identified (figure 19). 58% of the farmers changed their main crop between 1997 and 2002.

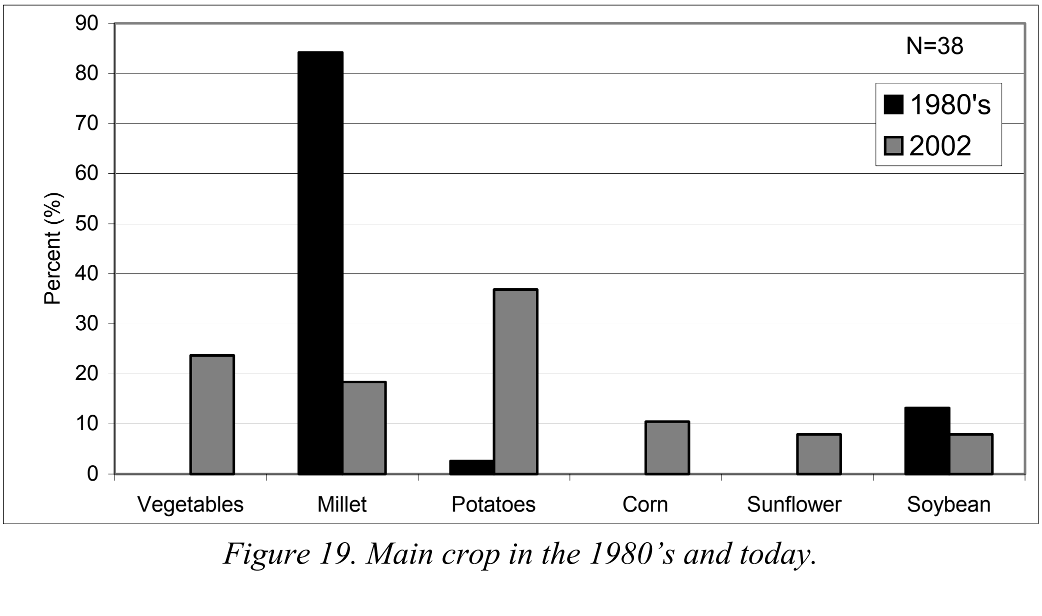



*Figure 19. Main crop in the 1980’s and today.*

The farmers were also asked to explain why they had changed. The answers were later categorized into 5 groups (figure 20). Economical values, including better price and higher yield, stands for 63% (N=30) of the changes. In other words the farmers have changed to cash crops. Table 9 shows that these cash crops are more sensitive to rainfall variability.

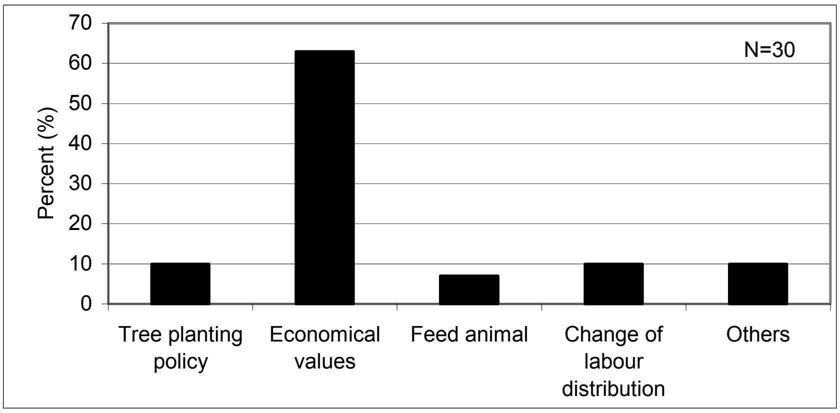



*Figure 20. The graph presents the reasons why the farmers have changed their main crop during the last 20 years. This figure is only based on 30 farmers since 8 farmers did not change their main crop since the 1980's.*

To be able to get a picture of what the agriculture is most dependent on, the farmers were first asked to choose the most important thing for their main crop to grow well. This question was open-ended. 79% answered fertilizer, 10% could not choose only one factor, 5% said pesticides, 3% adding water and 3% answered rainfall. In other words, the farmers thought that fertilizer was most important when no alternatives were given. The next two questions was close-ended (question with fixed alternatives) and included 5 factors that the farmers had to rank according to their importance to their main crop today (2002) and 20 years ago. Table 10 shows that fertilizer was still ranked very high, but rainfall suddenly became very important. The same number of farmers ranked rainfall and fertilizer as the most important factor influencing their crops today.

*Table 10. Ranking of factors that influences the agriculture*

| Ranking* | *1980's* | *Today (2002)* |
|---|---|---|
| **1** | Rainfall | Fertilizer and rainfall |
| **2** | Fertilizer | |
| **3** | Labour | Labour |
| **4** | Topography | Topography |
| **5** | | Adding water |

*1 is most important and 5 is least important.

One explanation could be that when the farmers get the open-ended question they only think of things that can be influenced by them. As one farmer explained: " I plant the potatoes, add the fertilizer and then I wait until harvest" (male, 66 years old). Rainfall on the other hand is nothing they can change. They are used to the climate and the lack of rain. The result shows that they are aware of the rainfalls importance to the crops. During the group discussions the farmers also mentioned the importance of rainfall even when planting trees. The reason adding water is not included in the ranking in the 1980's (table 10) is because millet was the main crop and was mainly planted on rain fed hill slope land.

## Agricultural methods

The agriculture methods were received through an in-depth interview with a key informant from Danangou village.

***Plastic cover***

The government employed experts from Shandong Province to introduce the plastic cover to the farmers. Even the poorest farmer in the village can afford to use these methods. The same methods are used in both villages.

There are two different kinds of plastic cover.

1. *Di mo* (land plastic) is the thinnest one and it is used directly on the soil. The local government introduced this method around 1982-83 with a promise that it would increase the yield. At first the farmers did not accept the new method, but after trying it on a very small land they found it successful. Today all the farmers in Danangou village use it. It is mainly used on the vegetables, potatoes and corn.

2. *Peng mo* (shelter plastic) is thicker and not used directly on the soil, but attached to wooden bows. It makes it possible to plant earlier, since the plastic protects from low temperature. This method is mainly used to raise seedling of vegetables. The local government introduced this method in the 1990's, and every farmer in Danangou village use it.

***Rotation***

The increasing population and the government's prohibition to cultivate new land stopped the rotation between cultivated land and fallow land in 1966. Today all land that can be used to plant crops on is cultivated, and only rotation between the crops is used. Yearly rotation is used for all crops except potatoes that can be planted two year in a row on the same land. This method has been used for generations.

***Ploughing***

Up to the 1970's the farmers spread the seeds and then covered them by ploughing, but this was change in the 1970's. A government extension taught the farmers that they should first plough the land, then spread the seeds in the channels and thereafter cover the seeds. The employee explained that this would increase the yield and the soils capacity to conserve water and fertilizer. The informant agrees that this method works better. Today it is used when planting millet and buckwheat.

***Intercropping***

The local government encouraged them to start using this method in the 1960's. During three years in the 1970's this method was used with potatoes and corn. They also made some tests mixing foxtail millet and corn. It can only be used on flat land and the informant explains that the lack of flat land makes this method unrealistic.

## Tree planting policy and land area change

The tree planting policy that forbids planting crops on the hill slope land was mentioned frequently during both individual interviews and group discussions. The Chinese government has told the farmers to plant trees on the hill slope since 1990. It is a project focusing on developing the western part of the country. The aim is to prevent soil erosion on the Loess Plateau. The farmers did not start to plant trees in large scale until three years ago, when the local government promised them food and money as compensation. During the group discussions the farmers were also asked to comment on this policy: ”The policy is good, planting trees conserves soil and water. The trees planted last year are all alive, but the government did not give us the food. We cannot earn money from anywhere else. According to the TV the policy is good” (male group discussion). The general opinion is that planting trees is good to the soil, but they are upset because they never received the compensation. They want to have a dialogue with the local government about where and what kind of trees should be planted. A suggestion from the farmers is to plant fruit trees or other kinds of economic trees that can give the next generation an income. As it is now the farmers’ might not be able to continue planting trees since they do not get an income from it (in-depth interviews; Mr. Hou, oral communication, May 2002; group discussions). Some farmers have already started to plant on hill slope land again. The consequences of this policy can be seen in table 11 which shows how the land area used for cropping, especially hill slope land, has diminished during the last 20 years. The flat land area has increased, but it is still only a small fragment of the land that can be irrigated (figure 21 (a)).

*Table 11. Change of cultivated land area between 1982 and 2002*

| | ***Total land area**** *($m^2$/person)* | | ***Total land area*** *($m^2$/person)* | | ***Mean total land area*** *($m^2$/person)***, with variations in brackets*** |
|---|---|---|---|---|---|
| | *Hillslope* | *Flat* | *Irrigated* | *Rainfed* | |
| **1982** | 3960 | 290 | 180 | 4060 | (4240-4250) ~ 4245 |
| **2002** | 580 | 410 | 200 | 950 | (990-1150) ~ 1070 |
| **2002-1982** | -3380 | 120 | 20 | -3110 | -3175 |
| **Land area change in percent** (%) | -85% | 41% | 11% | -77% | -75% |

* In Danangou they measure the land in *mu*. One *mu* was originally defined as “the area a cow can cultivate in one day”, but today one *mu* equals 666.7 $m^2$ (in-depth interviews).

The channel used for irrigation in Danangou village was built in 1958. The farmers have to pay a yearly fee to use the water from the channel (in-depth interview). The water from the irrigation channel is distributed to the fields through smaller handmade channels (figure 21 (b)).

*Figur 21 a and b. Danangou village. A typical kitchen garden (a). Small irrigation channels are used to distribute the water to the cultivated flat land located along the river (b). Photo: Sundberg, May 2002.*

During one of the group discussions it was mentioned that a part of the irrigation channel was destroyed by a gas-pipe explosion, and never rebuilt by the local government. This is a possible explanation to the results in figure 22 that shows that fewer farmers in Danangou village can use irrigation today compared to 20 years ago. The farmers in Leipingta had no irrigation in the 1980's, but today 44% can use irrigation. Altogether this mean that 74% of the farmers can use irrigation compared to 61% 20 years ago.

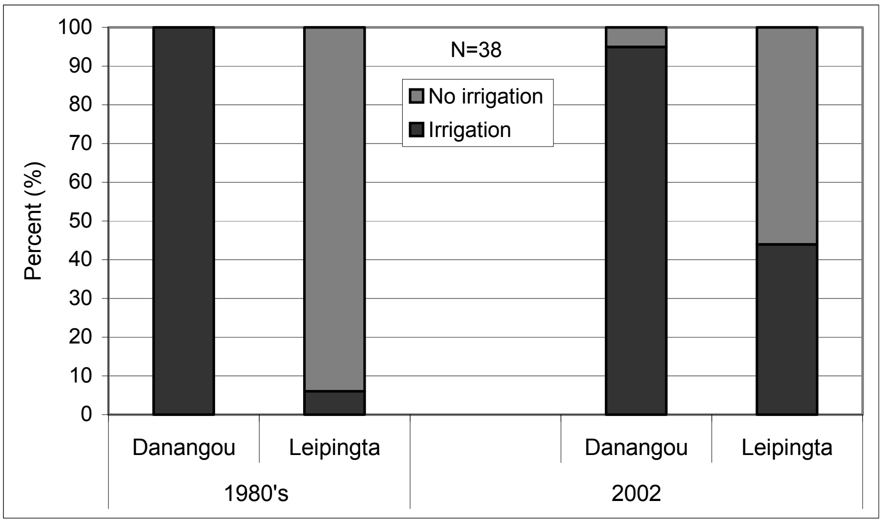



*Figure 22. Farmers' possibility to use irrigation in the 1980's and today.*

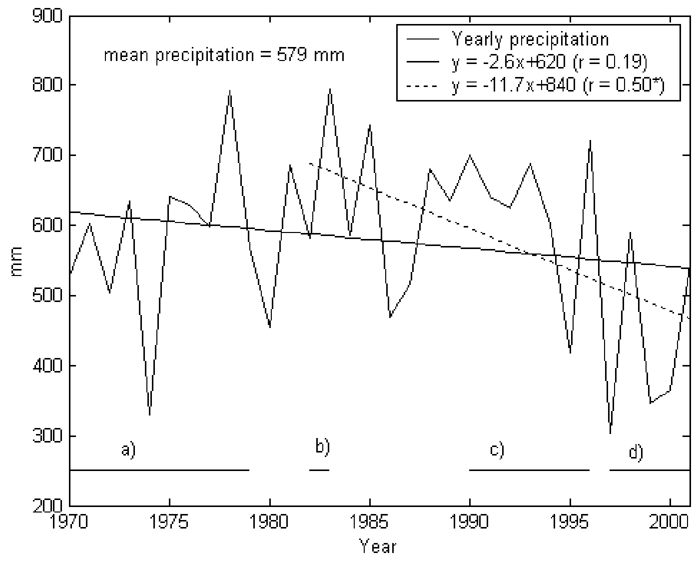
## Income sources

The men prefer planting crops and do off-farm work in the spare time, while the women prefer off-farm work because they feel that farming is the worst kind of job. As it is today the women plant while the men do off-farm work. The women want to plant vegetables since they believe it is warmer now. Today 79% of the interviewed households in the watershed have off-farm work. Examples of off-farm work are transportation, construction work and small businesses. 18% started with off-farm work 1982 and 41% started with it after 1997. 26% of the farmers plant fruit trees today. There is no clear pattern in when the farmers started or stopped planting fruit trees. 26% of the farmers raise livestock today. It was found that in 1982 16% started with livestock and 8% started 2001. During the time period 1998-2001 33% stopped with livestock.

Everyone is still working with agriculture, but mainly in combination with livestock, planting fruit trees or off farm job. During the structured interviews the farmers were asked what they would like to work with in the future. 5% answered planting crops, 16% live stock, 13% planting trees, 21% off-farm work and 24% want to plant crops in combination with the alternatives mentioned above. 13% have no future plans. It is mainly younger male that do not know what to do in the future: "I can think but not reach my dreams" (male group discussion).

## Land use changes in relation to climatic records

Figure 23 shows a summary of the land-use changes that has occurred in Danangou watershed the last 30 years in relation to yearly precipitation data.




* = 95% significance level according to student's t-test

*Figure 23. Land-use changes compared to yearly precipitation from Ansai weather station.*

a) In the 1970's a new method of planting was introduced. During three years in the 1970's intercropping was used (in-depth interview). Except in 1974 there was a lot of rain during the 1970's compared to the last few years, according to the climate data. No clear connection with the climate can be seen.

b) In 1982 18% of the farmers started with off-farm work and 26% with livestock. In 1982-83 they also started to use the plastic cover *di mo* (in-depth interview). The years around the period were not unusually dry.

c) In the 1990's another kind of plastic cover, *peng mo*, was in introduced (in-depth interview). The decreasing rainfall trend can be seen in the 1990's. Especially in the last part of the decade it was very dry, according to the data.

d) During the last years (1997-2002) more than half, 58%, of the farmers changed their main crop, 13 out of 15 livestock keepers stopped raising livestock and more than 40% started with off-farm work. In 2001 8% started to raise livestock. In the data it can be seen that this period of time has been very warm and dry.

All the land use changes mentioned by the farmers can be linked to governmental policies. Governmental employees introduced the agricultural methods. In 1982 a land reform took place and the *household responsibility system* was implemented. In recent years the government have introduced the tree planting policy. Because of this the farmers have started to plant trees on the hill slope in large scale during the last three years (in-depth interview). No clear connection between climate variations and land use changes can be seen from the results. The government has a stronger influence on the land use in Danangou than the climate.

## Farmers possibility to prepare to future climate variations

90% of the farmers have TV. 79% of the farmers get their weather information from TV and 81% of them trust it. All of them say that they use this information. For example, if it will be cold they will not open the plastic that covers the crops. If it is supposed to rain they could cover the vegetables (group discussions) and if there is supposed to be a rainstorm 11% said that they could dig a channel that drains the water around the house. 8% answered that they could also dig or rebuild the small channels on the hill slope land and 3% mentioned that they could make a small dam on the hill slope to prevent the water from washing away the crops. 37% of the farmers arranged their work and their planting time depending on the forecast. The last and most frequent applied preparation was also mentioned during the group discussions.

During the first two group discussions in Danangou the farmers were given some scenarios: "What would you do if the weather forecast on TV said that there would be no rain next spring?" The women answered that they would plant crops resistant to drought, while the men would choose a type of crop depending on when the rain comes. "What would you do if there was continuous middle rain for half a month?" They said that they have no method to protect their crops.

They have many interesting ideas of how to improve the living conditions in the village: dam, terraces, plant economic trees (for example fruit trees), raise livestock, build a water factory on the mountain (there is a mountain spring a few kilometres from the village). Unfortunately it all requires economic support from the local government: for example they need to rent a tractor to build the terraces. Last year they wrote a project proposal concerning building a dam. They need 600 000 RMB (1 RMB = 1.2 SEK, Forex October 2nd 2002) to build the dam, but the local government refused. The farmers believe that the government only cares about collecting taxes and does not care about them and their way of life (group discussion).

The men think that the future of the village depends on the society and how much help they receive from the local government. They would prefer governmental help instead of working in town. "A job in town would only help us, not the next generation. If the government help us to build a dam and terraces it will also help our grandchildren" (male group discussion). The water in the dam could be used to irrigate and raise fish. They suggest that instead of paying governmental taxes, this money should be used in their village. They pay 5 RMB each year to build roads, but no roads are built in their village. They think education and off-farm work will be important for the next generation. "I do not want my children to live in Danangou, it is to hard to live here". There is no future in farming (female group discussions) (figure 24).

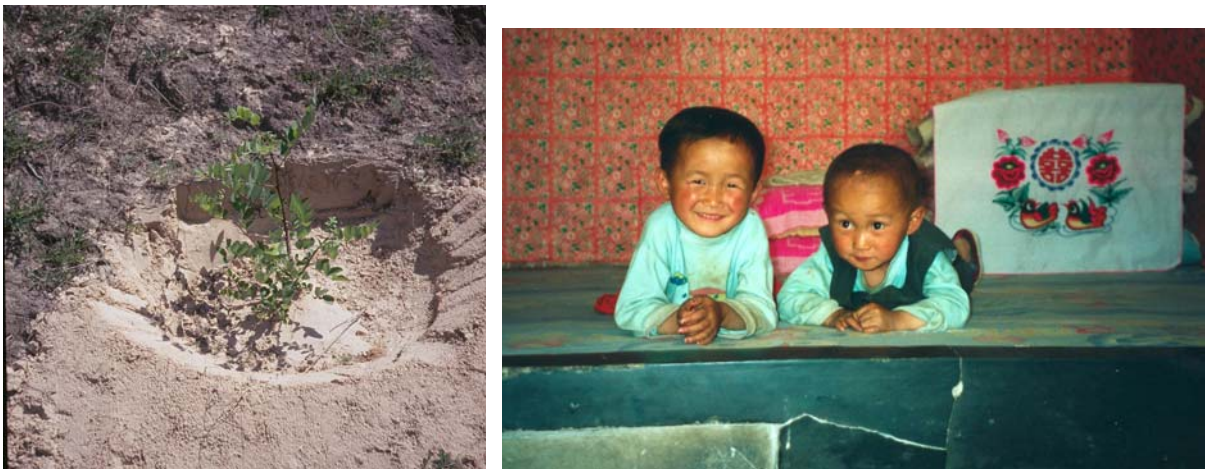


*Figure 24 a and b. "Can you develop your village by only planting trees?" (female group discussion). A newly planted tree (a) and Leipingta's future (b). Photo; Sundberg, May 2002 (a) and Hageback, May 2002 (b).*

# 5. DISCUSSION

It is important to look at the results in the light of the method used. In the first part of this chapter some difficulties with the methods used are recognized. In the second part of the chapter the results are discussed.

## 5.1 METHOD

Disadvantages and limitations of EOF analysis and interviewing have been discussed while describing the methods (chapter 3). The possible sources of errors and other difficulties that were not mentioned under the method will now be discussed.

### Climate data analysis

A lot of data was missing in the local rainfall data set and the SST. The linear interpolation is a source of error especially concerning the precipitation. Precipitation does not change linearly in time. If a heavy rain only lasts one day, it will not be re-created correctly in the interpolation in case this day is missing in the data set. A way to improve the interpolation is to also regard rainfall data at surrounding stations as a complement to the time-dimension. Daily values of surrounding stations were not available though and could therefore not be considered.

During the regional rainfall analysis six stations were used (figure 7). The station located the furthest northwest (Yinchuan) show the same monsoon pattern, but the amount of rain is smaller than in the other stations. A test was performed using only five stations (excluding Yinchuan) to see if the results were different. The difference was merely higher means and therefore it was decided to use all six stations. It is not surprising that the Yinchuan station has a lower amount of precipitation, since this region is situated on the northwest border of the summer monsoon. It also shows the difficulties in classifying different climate regions and to ascertain their boundaries. In this study the region is chosen mainly according to the location within decided latitudes and longitudes.

### Interview

There are many different ways of conducting interviews and just as many different outcomes. Interviewing is a method that requires cooperation from a person, usually a total stranger. No matter how well prepared you are, you will not know if it will be a successful interview until it is over. It is important to keep in mind that the collected data are personal opinions and sometimes it can be very hard or even impossible to distinguish what is right or wrong. Since the data is based on human interaction it is not possible to determine if or to what degree sources of errors has influenced.

Conducting interviews in a foreign language, where the questions need to be translated into English and then into Chinese, involves many steps where mistakes can be made. This was counteracted by back translation and discussing the interviews the same day to minimize mistakes and misunderstandings between the interviewer and the translator. Dr. Qiu (oral communication, April 2002), who has interviewed the farmers in the study area thought that the main problem would be the local accent, since our translators came from another part of China. This was kept in mind and another local student came with us the first few times. Typical local expressions and units were also discussed with Mr. Wu, a research assistant at Ansai station (oral communication, April 2002).

Teamwork is essential to obtain good results. It is preferable to work with the same translator through the entire field study, since the translating requires much individual effort and it takes awhile to achieve good teamwork. Discomfort between the interviewer and the translator may influence the respondent. We did not have the opportunity to keep the same translator during the entire fieldwork, but we changed translators in between two separate parts of the field study. Another reason why it is very important to cooperate and discuss together with the translator is because of the language and culture differences. The translator needs to know the purpose of every question. An example is that there are two words in Chinese that can be used for crops. One of them includes vegetables and we decided to use this one. Respondents' interpreted irrigation differently, so to make sure that they included all the water that was added to their land the translator suggested using *adding water* instead of *irrigation*.

There are many reasons why the respondent could choose to give inaccurate data. The following examples are discussed by Bernard (1995):

- The respondents report what they suppose happened instead of what they actually saw.
- They simply cannot remember and usually the respondents feel like they have to answer all the questions.
- The respondent may say what they think the interviewer wants to hear in order not to offend that person.
- Sad but true, they might want to mislead the interviewer and decide to lie.

The accuracy of the data was controlled by: using different kinds of interview methods, interview as many as time allowed and, when possible, comparing the data with earlier research.

There are many things to keep in mind while constructing and asking a question. A good question is short, simple and without values (Bernard, 1995). Hageback (2001) presents a brief guideline on how to conduct interviews (September 23rd 2002: http://www.gvc.gu.se/stipendium/Intervjumetodik.html).

Answering questions involving the past is difficult and results in estimations. The questions about the past in the questionnaire were related to a well-known event (discussed in the method). The questions were phrased so that the farmers should understand if it was two time periods that they should compare or just two specific years, but still different person may recall differently.

There were two main reasons why the group discussions concerning the climate questions concluded the field study. The first reason was that topics not covered in the questionnaire could be discussed. Secondly, there were certain words and expressions that contained information that could have influenced the remaining fieldwork, for example the question about global warming.

Other things that can have influenced the farmers are for example, paying the farmers and the presence of foreigner. Due to the limit of the field study Mr. Knutsson (oral communication, February 2002) and Dr. Qiu (oral communication, April 2002) suggested to focus the interviews on the household heads, middle aged men, since they were presumed to be more concerned about crop productivity and land area. Focusing on men may angle the results, so a few control interviews with women were conducted to be able to detect any gender differences.

To be able to analyse the data statistically in SPSS the questions had to be coded into categorize. Some of the open-ended questions had answers that could be categorized by the authors, for example question 28 and 29 (appendix) was categorized into spring and summer rainfall. The spring rain was defined as rainfall until the middle of April (lunar calendar). The farmers also referred to this period as planting time. The definition of summer rain was rainfall after the middle of April also referred to as growing time. The categorizing and the coding were done manually which means that the interpreters influenced the final result to a certain degree. Only the questions that were phrased the same were included from the test interviews, although the order of the questions were still changing at this stage.

# 5.2 RESULTS

## Climate data analysis

### *Local and regional climate*

The rainfall can differ much within a small region. Topography, synoptic system and local system are some of the factors that also influence the precipitation (Prof. Dong, oral communication, April 2002). This can be seen in the results when comparing local and regional rainfall (table 1 and table 3). In this context it is interesting to note the weak increasing rainfall trend during spring in Ansai. Once again it shows how local the rainfall distribution can be. It points out the importance of local scale studies when rainfall is a variable.

The decreasing rainfall trend is weak during the 32-year period (figure 9). The year-to-year variations are larger and the trend could be due to natural variations. The different result from the 20-year period strengthens this interpretation. Prof. Wang, Beijing University, has studied 120 years of rainfall in eastern China. He has discovered a 20-30 year oscillation, but no trend (oral communication, April 2002). According to Chen et al. (1994) and Qin (2002) the rainfall in this region is decreasing though. This makes is hard to draw any conclusions about future rainfall.

The increasing temperature trend in Ansai (table 2) agrees well with other research in the region (Chen et al*.,* 1994; Qin, 2002). The increase in temperature will be higher in higher latitudes and more obvious in winter (Prof. Wang, oral communication, April 2002). Global warming can in other words be seen on the local level. No one knows how the warm trend in China will affect the precipitation pattern. So far no changes have been seen (Prof. Wang, oral communication, April 2002). According to Chen et al. (1994) the thermal difference between the mainland and the ocean in East Asia has been reduced during the last 40 years. This results in a weaker summer and winter monsoon that could explain the decrease of rainfall.

### *The relation between regional rainfall and SST*

The relationship between precipitation in China and SST is very complex (Prof. Zhai, oral communication, April 2002; Prof. Ren, oral communication, April 2002). Many factors influence the precipitation on scales ranging from local to global. It is therefore difficult to find a strong correlation between precipitation and one of the factors (for example SST). In light of this the strongest correlation of 0.44 between precipitation in Shaanxi and SST in the Niño 3.4 region (table 6) has to be considered, when investigating factors influencing the precipitation in this region.

A reason of the low correlation between precipitation in Shaanxi and SST in Bay of Bengal and South China Sea could be that the ocean regions are too small. Larger ocean regions or global SST are usually connected to the entire or a major part of China (Xue, 2001; Yu et al., 2001; Zhang and Qian, 2001). A relationship might be found between regional precipitation in Shaanxi and the Indian Ocean or the western equatorial Pacific. Due to the time consuming work with preparing the data it was decided not to expand the ocean regions in this study.

The explanations of the physical processes behind the correlation between precipitation in China and SST found in earlier research does not correspond with each other (Ding, 1994; Zhang et al., 1999). Once again the complexity of the system has to be pointed out. According to Zhang et al. (1999) the precipitation over the East Asian region is greatly affected by the western Pacific subtropical. The rainfall area generally appears along its northwestern edge, where the warm humid airflow from the south meets the cold dry air flowing from the north. During the El Niño mature phase the subtropical high is strengthened and shifted westward during all four seasons. This leads to positive precipitation anomalies north of the northern edge (situated around 30 °N) of the subtropical high in summer. This agrees with the results obtained in this study where positive SST anomalies in the Niño 3.4 region, indicating an El Niño event, lead to more rain in the Shaanxi region.

Zhang et al. (1999) also says that the northern part of China is likely to be influenced by the variations of the Indian monsoon. El Niño causes a weakening of the Indian monsoon, which in turn means a weakened monsoon flow across the Bay of Bengal. Less transport from this important moisture source may cause less precipitation in the northern part of China. According to Ding (1994) the subtropical high over the western Pacific is usually weaker with a more easterly position than normal during the onset years of El Niño. The onset year can be recognized with positive SST anomalies in the eastern equatorial Pacific Ocean. This limits the northward transport of moisture and the summer rainfall in China becomes less than normal. These theories do not agree with the results from this study.

The theories above show that SST anomalies influence the climate in many ways. Different consequences of this might counteract each other in a region. An example from the theories above is that El Niño strengthens the East Asian monsoon, but weakens the Indian monsoon. Northern China is influenced by both these monsoons and it is therefore difficult to predict the outcome. Depending on the prevailing circumstances different factors are dominating. For example the influence from El Niño may differ depending on which phase it is in. None of the researchers have studied the relationship between SST and precipitation in such a small region as Shaanxi. As discussed above precipitation is a very local occurrence.

Researchers also disagree if there is a time lag between precipitation over China and SST. Prof. Wang (oral communication, April 2002), for example, does not think that there is a time lag in the relation between precipitation and El Niño, even though some researchers according to Prof. Wang have found a correlation between El Niño and the summer monsoon precipitation the following year. In this study no time lag has been found between precipitation in the Shaanxi region and SST. It indicates that the processes involved are faster than one month. This is usually the case with atmospheric processes. A time lag would have been caused by ocean processes, which have longer time scales (Chen, oral communication, August 2002).

There are many other factors that contribute to the complex relationship between precipitation and SST. The onsets of an El Niño event differ for example. It can start in the central Pacific and move to the east or it can start in the eastern Pacific and move to the west. Different onset patterns probably influence the precipitation differently. Also, high SST anomalies in the spring might not influence the precipitation as much as an autumn high SST anomaly (oral communication with Prof. Zhai, April 2002).

In this study possible SST trends were not investigated, neither global climate trends. Much research has already been conducted and it was considered to be sufficient to study earlier research. This study is focused on local variations and how they are affected by larger scale variations.

To summarize the results from the climate data analysis it can be said that the climate in Ansai is getting warmer and drier. The drying trend is uncertain though. Large annual variations make it likely to be just a natural variation. There is a relationship between precipitation and SST, but it is complicated. It is difficult to connect precipitation in a small region directly to SST. It might be necessary to connect precipitation to the synoptic circulation and then investigate a relationship with SST. More comprehensive studies have to be done to be able to draw a conclusion of how the precipitation in the Shaanxi region is affected by SST and the processes behind this relation.

## Farmers' perception of the climate

### *Difficult interview questions*

Difficulties occurred when the farmers were supposed to define the seasons, which are displayed in the climate and agriculture calendars (table 7 and table 8). The farmers defined the seasons differently in the climate and the agriculture calendar. Vedwan and Rhoades (2001) conclude that farmers most likely notice climate changes that influence their crops. One explanation could therefore be that the climate calendar was constructed with a farmer who planted apple trees, while the agriculture calendar was made by farmers with potatoes as the main crop. Another explanation could be that the farmer constructing the climate calendar had a higher level of education and therefore defined the seasons from academic knowledge. The farmers constructing the agricultural calendar tried to define the seasons according to own experience based on the agriculture.

Another very difficult topic was rainfall. The rainfall questions were changed and rephrased many times. The farmers had difficulties describing changes in intensity and duration. The final rainfall questions were kept very simple or close-ended. Although the final questions (appendix, question 30 and 31) were very simple the farmers' insecurity is seen in figure 13 and the rain type definitions.

An interesting discovery is that it is mainly men who answer "do not know" (figure 13 and figure 14). It was expected that it would be the men who knew most about the agriculture, since they usually make the decisions about the land. An interpretation is that it is a result of the transfer to off-farm work. It is mainly the men who leave the farm, while the women stay home and take care of the planting.

### *Climate variations and optimal climate*

The farmers think that drought occurs more frequently today than 20 years ago (figure 14). This agrees with Qian and Zhu's (2001) results. Drought is also the disaster that causes most damage to their agriculture according to the farmers in Danangou watershed. This coincides with research in which it has been found that drought disasters cause the largest economic loss among disasters (Qian and Zhu, 2001). The strong agreement among the farmers could be explained by the last three very dry years. One interpretation of figure 14 has already been mention in the results. Alternative interpretations could be that there was not only one major disaster that occurred in the early 1980's or that the disasters during this period were less harmful. Perhaps some farmers' remember the year 1982 while others describe the 1980's.

The *climate game* was constructed so that a general picture of the climate in the past could be received. The four different levels were not defined, for example in specific temperatures. The main purpose was to reflect the climate changes. In general the farmers agree that it is raining less today than 20 years ago, but they cannot specify the change since the variability of the rainfall is large. Temperature is increasing continuously. This agrees with both earlier research and the climate data analysis conducted in this study, as discussed above.

The farmers' description of the optimal weather (figure 16) shows that increasing temperature in combination with more rain is good. In other words a warmer climate is seen as something favourable. It would prolong the growing season and result in higher yields. Unfortunately GCM modelling on global warming (Wang, 2001) has shown that by 2050 the net balance between precipitation and evapotranspiration will be negative. This would cause water deficit. It can also be seen from the farmers' answers that the combination of a temperature increase and an increase of precipitation is important. The uncertainty of predicting precipitation that has been discussed earlier should be kept in mind (Prof Ren, oral communication, April 2002). The farmers also want more snow, even though they already explained that increasing temperature leads to less snow. It indicates that their optimal weather is not a realistic opinion. It is only a wish.

***Farmers' perception compared with Ansai climate records***
It is difficult to relate farmers' memory of floods to the rainfall data (figure 17). An example is that several farmers have mentioned a flood that broke the dam around 1975. In the climatic records no such extreme rainfall event has been found until 1977. An interpretation is that the farmers remember the wrong year, but it does not necessarily have to be true or at least not the only explanation. Rainfall is a very local event as discussed above. The rain amount can differ between Danangou watershed and Ansai weather station located about 7 kilometres away. The dam breakage could also very well have been caused by a rainstorm upstream the river. Another reason to consider is that the flood could have been part of the 9.3% missing rainfall data.

Due to uncertainty when translating lunar calendar to solar the comparison with the climate records was difficult. The numbers of days the lunar and solar months are displaced in relation to each other vary from year to year. As discussed above the farmers have trouble defining the seasons and that together with the difference between lunar and solar calendar also makes it difficult to compare the climate calendar with climate data. In general the climate calendar (table 7) corresponds well with climatic records. The temperatures in the climate calendar are all a little bit higher than in the data. An explanation to this is that the farmers perceive day temperatures, while often working outside on the fields in the sun. The temperatures in the data are averaged from day and night values. It is very interesting to see how well the farmers can describe the climate trends. They all agree that it is warmer today compared to 1980's, which is confirmed by significant trends in the climatic records (table 2). During winter the increasing temperature trend is most obvious according to both the farmers' stories and the data.

In the data there are other events that the farmers have not mentioned. One explanation could be that the farmers primarily remember events that influence their agriculture (Ovuka and Lindqvist, 2000). This can be seen especially clear in the climate calendar, where the driest period appears during spring according to the farmers but in winter according to the data. In winter the farmers do not need rain and do not care if it rains or not. In spring though, they eagerly wait for the rain, since they cannot plant their crops until the rain comes. The farmers also define the wettest period as one or two months later than what is shown in the climatic records. The monsoon rain comes during July and August, which is the growing period of the crops. Then a lot of water is needed even though rainstorms and floods are not welcome. A month later, during the wettest period according to the farmers, it is time to harvest and the rain is more inconvenient to them. Another explanation could be that the farmers and the scientific definition of wet and dry period differ. The scientific definition is based on the rainfall amount at Ansai rainfall station, while the farmers' definition is based on a wider conception including the entire hydrological cycle. There are many physical factors, for example soil moisture and run-off that may contribute to the farmers' perception and explain the displacement of one to two months.

The study of the farmers' perception of climate has shown that the farmers in Danangou watershed agree on a warming and drying trend. The warming trend is most noticeable during winter. Flooding conditions are less common in recent years, while it has been persistent drought the last three years. In this study nothing have been found that contradict earlier research (Messing and Hoang Fagerström, 2001), in which it has been found that farmers remember details three years back in time. Further back they remember extreme events. To this we can add that the farmers also have a good perception of general climate conditions and long-term climate trends.

## Land use changes in relation to variations in climate

### *Land use changes*

The change of main crop (figure 19) shows that today the farmers plant crops that are less resistant to droughts. Today potato is the main crop of more than a third of the farmers. One explanation could be that their living situation has changed drastically during the last 20 years, mainly due to governmental policies, as for example the tree planting policy. The farmers have a very limited crop area that is mainly located on the flat land, where it is easier to irrigate. It could also be a combination of the factors mentioned above and that potato is the only crop that the farmers rotate with a two-year interval. The transportation to this part of China is also better and the farmers can buy a lot of the food on the market. The farmers have transferred from planting food crops to cash crops.

Looking at the tree planting policy from the farmers' point of the view, giving up most of their cropland and never receive the compensation they were promised, it is understandable that the farmers are upset with the local government. The farmers have realized the importance of planting trees, but suggest that economical trees should be planted instead so that it can result in some income. As it is today the local government has through restrictions forced the farmers to find other income sources. The farmers have transferred towards more diversified income sources. They are no longer solely dependant on agriculture and off-farm work is the main income for most of the farmers.

### *Land use changes in relation to climatic records*

A change of the land use would not occur because of a single weather event, but ought to be caused by climate change on a longer time scale. This makes it hard to connect a specific land use change to the climate, especially in the beginning of the period (figure 23). To relate an event in the early 1970's to the climate, data from the 1960's is needed.

The only time a land use change can be related to the climate in this study is during the last three years. During the last 20 years it has become drier and drier and the last three years there has been severe drought. During the same three years changes in main crop and income sources has made them less dependent on agriculture and therefore the climate.

Roncoli et al. (2001) discuss results indicating that diversification, non-farm income sources and growing drought resistant crops are some ways of coping with climate variability. Crop diversification is an adaptive response to global warming that has been identified in China (Reilly and Schimmelphennig, 1999 and references there in). Other factors also have to be considered, when looking for an explanation to the land use changes in Danangou. According to Chen et al. (2001) the new *household responsibility system* has advanced China's agriculture and changed the land-use structure. The tree planting policy is another reform that has drastically limited the crop area. Today the farmers cannot earn their living only from cultivating the small fraction of flatland. This is without doubt the biggest reason of the transfer from agriculture to off-farm work that has occurred the last three years. The climate could be an additional reason, but how big influence it has on the farmers in Danangou watershed cannot be distinguished in this study.

***The future and farmers' possibility to prepare to climate variations***

As mentioned in the introduction the agriculture on the Loess Plateau is very dependent on the summer monsoon precipitation and very vulnerable to climate change. A challenging task for researchers is to predict variations of the rainfall and apply it on local level. A primary question is if the predicted forecast can be distributed to the farmers. Secondary, is this information useful to the farmers? In Danangou watershed 9 of 10 farmers have TV. Today 8 of 10 farmers trust the received weather forecast from TV. In other words it is possible to reach the farmers with information. As the situation is today the farmers only receive weather forecasts for the next 1-2 days and it is mainly used to plan the work the coming day. They do not have the knowledge to prepare to monthly or seasonal forecasts, as was seen when they were given different scenarios. It should be considered that in the present situation the main income source, off-farm work, is not dependent on the climate to the same extent as agriculture.

In many ways the farmers contradict them selves. The negative effect of off-farm work is that many farmers have to leave the village to find jobs and they do not know for how long they will have the job. In other words the income is not as reliable as from agriculture. It is interesting to see that the men, who do most of the off-farm work, would prefer planting crops, while the women, who do the planting today, would prefer off-farm work. On the other hand they all think that planting has a very low status. Their future plans indicate that they are realistic about their own future plans, but still dreaming of a better future for their children. They all agree that the best for their children would be to get an education and move from the village.

To add up the results of the land use in relation to climate variations it can be seen that the farmers in Danangou watershed have adapted in terms of income sources, agricultural methods and type of cultivated land. They are now less dependent on the climate. This adaptation is mainly caused by governmental policies. "Before we can build the western economy we have to build the environment" is a slogan used in China (Dr. Xie, oral communication, September 2002). Due to the limitations of this study it cannot be concluded to what extent the government has considered climate when implementing the policies. It is interesting to note though, that the farmers are aware of climate variations and their perception indicates their crops dependency of the climate. As a farmer said: "The climate is the nutrient of the crop" (male, 36 years old). The farmers' dependency on the precipitation makes it important to be able to predict future changes. It is necessary to study large-scale conditions to understand the physical processes behind precipitation distribution. It is just as important to study the local-scale rainfall variations to perceive the impact on local level. Predictions are only usable to the farmers in Danangou watershed in combination with a suitable proposal of preparations, adapted to the specific area.

Combining all the results and impressions, Danangou as a self-sufficient agricultural village in the past is now developing towards a suburb to Ansai town. The farmers have many long-term ideas on how to develop the village, but they are dependent on the local government to realize these ideas. This study has shown that to be able to prepare for future climate changes a better understanding of the farmers' needs is necessary. This demands a good cooperation between scientists, the government and the farmers (figure 25).

*Figure 25. Farmers planting potatoes in Danangou village. Photo: Sundberg, May 2002*

# 6. CONCLUSIONS

- Local temperature has increased with 1°C during the last 32 years. The increase is strongest in winter (2°C).

- During the last 32 years local precipitation has decreased with 14% (2.6 mm/year), while regional precipitation has decreased with 19% (1.8 mm/year) during the last 49 years. The interannual variability is larger. The last 20 years there is a significant decreasing trend (95% significance level) in local precipitation (-11.7 mm/year).

- The strongest correlation (0.44 with 95% significance) between regional precipitation and SST was found in the Niño 3.4 region during the summer. This indicates that the El Niño phenomena have an influence on the Shaanxi region.

- Farmers' perception of climatic variations corresponds well with the climatic records. They can give detailed descriptions of the weather the last few years. Further back in time they recognize trends and remember extreme events. They think it has become warmer, especially during winter. It has also become drier and the last three years have been very dry.

- The government has a stronger influence, in terms of the farmers' choice of cropping system, than climate variations on the land use in Danangou watershed.

- During the last 20 years the farmers have transferred from being dependent on agriculture to a more diversified livelihood due to governmental reforms. This adaptation makes them less vulnerable to climate variations.

- The farmers' restricted living situation gives them few possibilities to prepare to future climate changes without governmental help. The farmers have many ideas on how to develop the village, but they need financial support from the government to accomplish them.

# 7. IMPLICATIONS AND FUTURE RESEARCH

## 7.1 IMPLICATIONS

Due to the nature of this study it is appropriate, in addition to the scientific discussion, to also discuss a few implications of the results. From our observations and experiences in Danangou watershed a few suggestions, on developing the village, can be addressed to the local government of Zhengwudong Township.

The results indicate that the farmers are susceptible to governmental policies and dependant on financial support from the government to improve the living conditions in the village. The farmers want a dialog with the decision makers to discuss possible developments of the village. A better cooperation resulting in a positive development of the village would benefit both parties.

A more sustainable forest policy could be developed together with the farmers. As the situation is today the farmers are forced to leave the agriculture in search of other (off-farm) income sources. A consequence of this is that the planted trees are mismanaged and will eventually die. The farmers suggest that more economic trees should be planted. This would give the farmers an income source and motivate them to manage the forestry better, which in turn would lead to better soil and water conservation and a land use more adapted to the climate.

The agriculture could also be improved. The warmer and drier climate during the last 20 years observed by the farmers and confirmed in the data analysis makes it desirable to repair the irrigation channel. This would make the farmers less dependant on the rainfall and secure some of the crop productivity. Another way to improve the yield is to build green houses, so called *da peng*. These are common in other villages in the area. The farmers in Danangou watershed explained that the shape and the limited size of each farmer's flat land prohibit *da pengs* in Danangou. *Da pengs* could be of interest in Danangou through encouraging the farmers to start cooperation's or exchange land areas.

## 7.2 FUTURE RESEARCH

While carrying out the study, many interesting sidetracks and improvement were exposed. Due to the objectives and limited time it was impossible to investigate them further. Here follows some recommendations of future research regarding this study.

There are many ideas of improvements that could lead to a better understanding of precipitation and its relation to SST. EOFs can be calculated for all the seasons or months. The correlation could be different in different seasons. It could also be worth looking at different indices instead of SST. Indices might give better correlation with precipitation in the region. It could be the case that it is impossible to get a strong correlation while trying to connect precipitation in a small region directly with SST. Instead the synoptic circulation could be used as a middle step for example blocking high, the western Pacific high and the westerly jet. Another suggestion is to try to connect the regional precipitation with larger ocean areas, for example the entire Indian Ocean or the western Pacific Ocean.

This field study focused on a small watershed. To receive more comprehensive result that can be generalized beyond the study area a large number of randomly chosen farmers from different villages should be interviewed. The results indicate that in some cases women and men tend to answer differently. More detailed studies on different groups, for example gender, could be of interest. Another sidetrack is to investigate the usability of the different interview methods to receive the best combination for this kind of research.

Our results imply that the farmers only remember detailed data for a few years back. The last three years have been very dry and this year, 2002, has so far been wetter than normal. A closer study of these extreme years and how it has affected the farmers could result in a better understanding to which degree climate variations impact in comparison to the governmental policies.

# REFERENCES

Alapaty K, Raman S, Mahanity U C and Madala R V (1995), *Sensitivity of monsoon circulations to changes in sea surface temperature*, Atmospheric Environment 29:2139-2155

Berg L B (1998), *Qualitative research methods for the social sciences*, Allyn and Bacon, Boston, pp 290

Bernard H R (1995), *Research methods in anthropology-qualitative and quantitative approaches*, AltaMira press, London, pp 585

Busuioc A, Chen D and Hellström C, (1999), *Temporal and spatial variability of precipitation in Sweden over the 1890-1990 interval*, SWECLIM, Department of Physical Geography, Göteborg, pp 7-10

Carlsson M (2000), *Farmer's knowledge in land evaluation- A case study of land suitability in a small cathcment affected by erosion on the Chinese Loess Plateau,* Swedish University of Agricultural Sciences, International office, Uppsala, pp 53

Chen L, Shao Y and Ren Z, *Climate change in China during the past 70 years and its realation to the monsoon variations.* In: Climate Biosphere Interaction*:* Biogenic Emissions and Envirionmental Effects of Climate Change, Zepp R G (ed, 1994), John Wiley and Sons, New York, p 31-49

Chen L, Wang J, Fu B and Qiu Y (2001), *Land-use change in a small catchment of northern Loess Plateau, China*, Agriculture, Ecosystems and Environment 86:163-172

Ding Y (1994), *Monsoons over China*, Atmospheric Sciences Library, Kluwer Academic Publishers, Netherlands, pp 419

Domrös M and Peng G (1988), *The climate of China*, Springer- Verlag, Berlin, pp 361

Dong M, Li Y and Shen W (1999), *Validation study of the East Asian climate simulated by CCM2*, Acta Meteorologica Sinica 13:291-303

Dong M, Zwiers F and Ye Z (2000), *A preliminary validation study of the seasonal forecast of CCMA model over China*, Acta Meteorologica Sinica 14:268-279

Emery W J and Thomson R E (1998), *Data analysis methods in physical oceanography*, Elsevier Science Inc, New York, pp 634

EROCHINA (2000/2001), S*oil erosion project-final report*, contract number: ERBIC18CT970158, Netherlands, pp 89

FAO-UNESCO (1997), *Soil map of the world: VIII, north & central Asia,* Unesco, Paris

Fu B, Chen L, Ma K, Zhou H and Wang J (2000), *The relationships between land use and soil conditions in the hilly area of the Loess Plateau in northern Shaanxi, China*, Catena 39:69-78

Gong D-Y and Wang S-W (2000), *Severe summer rainfall in China associated with enhanced global warming*, Climate Research 16:51-59

Hsieh C (1973), *Atlas of China*, McGraw-Hill, New York, pp 282

Huang R, Li X, Yuan C, Lu R, Moon S-E and Kim U-J (1998), *Seasonal prediction experiments of the summer droughts and floods during the early 1990's in East Asia with numerical models,* Advances in Atmospheric Sciences 15:433-446

Höglund L (1998*), Länder i fickformat nr 811 Kina,* Utrikespolitiska Institutet, TryckOffset AB, Stockholm, pp 56

IPCC (1998), *The regional impacts of climate change: an assessment of vulnerability,* Cambridge University press, NY, pp 517

Johnston T and Chiotti Q (2000), *Climate change and the adaptability of agriculture: a review,* Journal of the Air and Waste Management Association 50:563-569

Kjellgren B (2000), *Kinakunskap*, Studentlitteratur, Lund, pp 287

Lau K-M and Wu H T (2001), *Principal modes of rainfall and sea surface temperature variability of the Asian summer monsoon: A reassessment of the monsoon-ENSO relationship*, Journal of Climate 14:2880-2895

Liu G (1999), *Soil conservation and sustainable agriculture on the Loess Plateau: Challenges and prospects*, Ambio 28: 663-668

Luo Q and Lin E (1999), *Agricultural Vulnerability and adaptation in developing countries: the Asia-Pacific region*, Climatic Change 43:729-743

Magistro J and Roncoli C (2001), *Anthropological perspective and policy implications of climate change research,* Climate Research 19:91-96

Messing I and Hoang Fagerström M H (2001), *Using farmers' knowledge for defining criteria for land qualities in biophysical land evaluation,* Land Degradation & Development 12:541-553

National Climate Center (2000), *An assessment system for impact of climate anomaly on socio-economic aspects,* National key project (1996-2000): Studies on short-term climate prediction in China, subproject 3, Beijing, China, pp 28

Ovuka M and Lindqvist S (2000), *Rainfall variability in Murang'a district, Kenya: meteorological data and farmers' perception,* Geografiska Annaler 82 A(1):107-119

Pallant J (2001), *SPSS Survival Manual*, Open University Press, Philadelphia, pp 286

Park W-S and Oh I S (2000), *Interannual and interdecadal variations of the sea surface temperature in the East Asian Marginal Seas*, Progress in Oceanography 47:191-204

Pärt-Enander E and Sjöberg A (1998), *Användarhandledning för MATLAB 5*, Elanders Gotab, Stockholm, pp 501

Qian W and Zhu Y (2001), *Climate change in China from 1880 to 1998 and its impact on the environmental condition*, Climate Change 50:419-444

Qin D H (2002), *Assessment on environmental change in western China,* China Sciences press, Beijing, Volume 1, pp 29-67

Qiu Y, Fu B, Wang J and Chen L (2001), *Soil moisture variation in relation to topograpghy and land use in a hill slope catchment of the Loess Plateau, China,* Journal of Hydrology 240:243-263

Ramage C S (1971), *Monsoon meteorology*, International Geophysics series, Academic Press, New York, Volume 15, pp 296

Reilly J M and Schimmelpfennig D (1999), *Agricultural impact assessment, vulnerability and the scope for adaptation*, Climatic Change 43:745-788

Ribot J C, Magalhães A R and Panagides S S (1996), *Climate variability, climate change and social vulnerability in the semi-arid tropics*, Cambridge University Press, Great Britain, pp 175

Roncoli C, Ingram K, and Kirshen P (2001), *The costs and risks of coping with drought: livelihood impacts and farmers responses in Burkina Faso*, Climate Research 19:119-132.

Rosmuller C (1999), *Socio-economic aspects of catchment management planning for small watershed on the Chinese Loess Plateau,* Erosion and soil and water conservation group, Wageningen Agricultural University, Wageningen, pp 24

Smit B and Cai Y (1996), *Climate change and agriculture in China*, Global Environmental Change 6:205-214

Svensson C (1999), *Empirical orthogonal function analysis of daily rainfall in the upper reaches of the Huai river basin, China*, Theoretical and Applied Climatology 62:147-161

Wang F (1997), *Impacts of climate change on cropping system and its implication for agriculture in China,* Acta Meteorological Sinica, 11:407-415

Wang F (2001), *Some advances in climate warming impact research in China since 1990,* Acta Meteorological Sinica, 15:496-507

Wang J, Fu B, Qiu Y and Chen L (2001) *Soil nutrients in relation to land use and landscape position in the semi-arid small catchment on the Loess Plateau in China,* Journal of Arid Environments 48:537-550

Wang H (2002), *The instability of the East Asian Summer Monsoon – ENSO relations*, Advances in Atmospheric Sciences 19:1-11

Vedwan N and Rhoades R E (2001), *Climate change in the Western Himalayas of India: a study of local perception and response*, Climate Research 19:109-117.

Wei F, Zhang X and Cao H (2000), *A method for predicting seasonal precipitation anomaly distribution in summer over China*, Acta Meteorologica Sinica 14:307-315

Weiss S R (1994), *Learning from strangers- The art and method of qualitative interview studies*, The Free Press, New York, pp 246

Xue F (2001), *Interannual to interdecadal variation of East Asian Summer Monsoon and its association with the global atmospheric circulation and sea surface temperature*, Advances in Atmospheric Sciences 18:567-575

Yu R, Zhang M, Yu Y and Liu Y (2001), *Summer monsoon rainfalls over Mid-Eastern China lagged correlated with global SSTs*, Advances in Atmospheric Sciences 18:179-196

Zhang R, Akimasa S and Masahide K (1999), *A Diagnostic Study of the impact of El Niño on the precipitation in China*, Advances in Atmospheric Sciences 16:229-241

Zhang W and Qian Y (2001), The relationships between variations of sea surface temperature anomalies in the key ocean areas and the precipitation and surface air temperature in China, Advances in Atmospheric Sciences 18:194-308

Zhao Z, Gao X and Luo Y (2000), *Investigations on short term climate prediction by GCMs in China*, Acta Meteorologica Sinica 14:108-119

## Oral communication

Chen D, Physical Department, Göteborg University, Göteborg, Sweden, 2002

Dong M, Section of Modelling, National Climate Center, Beijing, China, April 2002

Fu C, Institute for Atmospheric Physics, Chinese Academy of Sciences, Beijing, China, August 2002

Gao G, Section of Impact Assessment and Applied Climatology, National Climate Center, Beijing, China, April 2002

Hou X L, research assistant at Ansai research station of soil and water conservation, Ansai, China, May 2002

Knutsson P, Human Ecology Section, Göteborg University, Göteborg, Sweden, 2002

Li D, Institute of Soil and Water Conservation, Yangling, China, April 2002

Qiu Y, Natural Resource and Environmental Department, Beijing Normal University, Beijing, China, April 2002

Ren G, Section of Climate Change, National Climate Center, Beijing, China, April 2002

Wang S, Physical Department, Beijing University, Beijing, China, April 2002

Wu R, research assistant at Ansai research station of soil and water conservation, Ansai, China, April 2002

Xie Y, Natural Resource and Environmental Department, Beijing Normal University, Beijing, China, 2002

Zhai P, Section of Diagnostic and Prediction, National Climate Center, Beijing, China, April 2002

## Data sources

Regional precipitation: Prof. Li, Physical Department, Beijing University, China, 2001

SST data, March 2002: www.cdc.noaa.gov/coads/products.html

Niño 3.4 indices, April 4th 2002:
www.cpc.ncep.noaa.gov/products/monitoring_and_data/oadata.html

## Internet

Hageback J (2001), September 23rd, 2002:
http://www.gvc.gu.se/stipendium/Intervjumetodik.htm

IPCC, September 15th 2002: http://www.grida.no/climate/ipcc_tar/wg2/412.htm

# APPENDIX

## QUESTIONNAIRE

| Code | Date | Note taker | Latitude (N) | Longitude (E) | Elevation | Accuracy |
|---|---|---|---|---|---|---|
| | | | | | | |

Starting time: ______________

### Background information

1. Name: ______________________________________________________________________

2. Age: ___________ 3. Gender: ____________________________________________________

4. Have you gone to school? _______________________________________________________
4a. Yes – How many years? _______________________________________________________
4b. No – Can you read or write? ____________________________________________________

5. How many people belong to this family? __________________________________________

6. How many years have you lived in this village? ____________________________________

7. From what kinds of job do you get your income today?

| Jobs | Started | Stopped |
|---|---|---|
| Planting crops | | |
| Animals/livestock | | |
| Fruit trees | | |
| Off-farm job | | |
| | | |

8. How is your living standard compared to the others in the village?

| Time | Rich | Average | Poor |
|---|---|---|---|
| Today | | | |
| 1982 | | | |

9. Do you have a
a) TV b) Tractor c) Telephone

*10. What kind of house?*
*a) cave house b) stone house c) brick house*

## Crops

11. How much cropping area do you have?

| Time | Number of people sharing the land | Hill slope (mu) | | Flat land (mu) | |
|---|---|---|---|---|---|
| | | Rainfed | Adding water | Rainfed | Adding water |
| Today | | | | | |
| 1982 | | | | | |

12. How do you add water to the land today? ________________________________________

13. From where do you take the water today? ________________________________________

14. How did you add the water to the land 20 years ago? ______________________________

15. From where did you take the water 20 years ago? __________________________________

16. Which is your main crop (largest area) today? _____________________________________

17. How long has this been your main crop? _________________________________________

18. Twenty years ago, what was your main crop? _____________________________________

19. Why did you change? _______________________________________________________

20. Today, what is the most important thing your _______________(main crop) needs to grow well? ______________________________________________________________________

21. Today, rank the following things according to how important they are for your ____________(main crop) to grow well? 1 is the most important and 5 is the least important.

__ Labour ______________________________________________________________
__ Adding water _________________________________________________________
__ Rainfall ______________________________________________________________
__ Fertilizer _____________________________________________________________
__ Topography (slope degree) _____________________________________________
__ ____________________________________________________________________
__ All the things are as important

**If no change of main crop:**
22.Twenty years ago, was it the same?

______________________________________________________________________
______________________________________________________________________

**If change of main crop:**

23. Twenty years ago, rank the following things according to how important they are for your _____________(main crop) to grow well? 1 is the most important and 5 is the least important

__ Labour ____________________________________________________________________
__ Adding water ______________________________________________________________
__ Rainfall __________________________________________________________________
__ Fertilizer ________________________________________________________________
__ Topography (slope degree) _________________________________________________
__ ___________________________________________________________________________
__ All the things are as important

## Weather

24. How do you get information about the weather forecast? ___________________________

25. Do you trust it? __________________________________________________________

26. Do you think this information is useful? ______________________________________
If yes, how do you use it? ____________________________________________________

27. Do you feel any changes in the weather now compared to twenty years ago? ___________
______________________________________________________________________________

## Rainfall

28. In which period is it most important that it rains for your crops? ____________________

29. Why? ______________________________________________________________________
______________________________________________________________________________

30. In recent years, what is the main rain type in this period?
a) small rain b) middle rain c) heavy rain d) rainstorms e) don't know

31. Twenty years ago, what was the main rain type in this period?
a) small rain b) middle rain c) heavy rain d) rainstorms e) don't know

32. In recent years, how much does it rain in this period compared to twenty years ago?
a) more b) less c) the same d) don't know

33. In recent years, are there any other changes of the rainfall in this period compared to twenty years ago? ___________________________________________________________

## Disasters

34. What kinds of agricultural disasters have happened in this area? ______________________

35. In recent years, which agricultural disaster happens most often?
a) drought b) flood c) hail d) frost e) ____________________

36. Twenty years ago, which one happened most often?
a) drought b) flood c) hail d) frost e) ____________________

37. In recent years, which one cause most damage to your crops?
a) drought b) flood c) hail d) frost e) ____________________

38. Twenty years ago, which one caused most damage to your crops?
a) drought b) flood c) hail d) frost e) ____________________

## Future

39. What do you want to work with in the future?

______________________________________________________________________________

40. Where do you want to live in the future?

______________________________________________________________________________

Ending time: ________________

## Comments

______________________________________________________________________________
______________________________________________________________________________
______________________________________________________________________________
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